Mid-symposium excursions

33 EVS 2025 – Vegetation of Europe

Diversity, Dynamics, Conservation, and Restoration

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EXCURSION 1. COLFIORITO WETLANDS, THE HIGH PLAINS OF MONTI SIBILLINI (CASTELLUCCIO DI NORCIA) AND NORCIA

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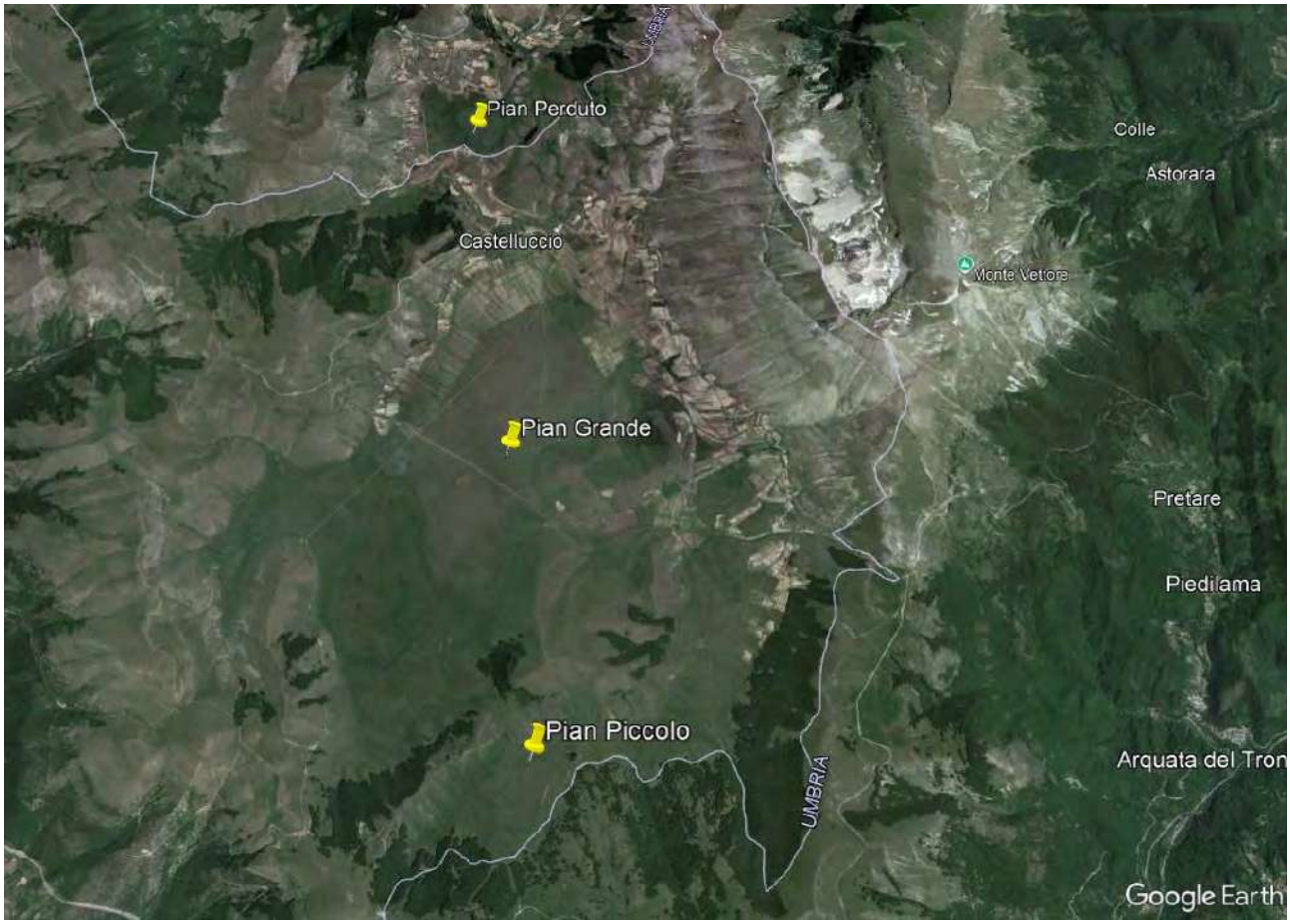
PLATEAUS OF CASTELLUCCIO DI NORCIA



Location

Coordinates: 42.8265°N, 13.1873°E

Altitudinal range: 1275-1335 m a.s.l.

Introduction

This system of plateaus (Piano Grande, Pian Piccolo, and Pian Perduto) is in the Monti Sibillini National Park in the Central Apennines. The National Park extends for 71437 hectares between the Regions Umbria and Marche. The landscape is dominated by the limestone massif of the Apennine chain. The

Sibillini mountain range has unique characteristics, such as karstic plateaus, glacial formations, and deep gorges and valleys. Most of the peaks in the area exceed 2000 m a.s.l., the highest being Monte Vettore (2476 m a.s.l.), which dominates the view from the plateaus. The small village of Castelluccio is located on a small hill between Pian Grande and Pian Perduto. The area was already inhabited during the Roman period, while the village dates to the 13th century, when a small castle was founded by the inhabitants of Norcia to defend the pasturelands and protect their territory. The village was severely hit by the seismic events of 2016-17.

Climate

The climate is classified as Alpine-Mediterranean (upper supratemperate bioclimatic belt), with continental influences due to its high altitude. Winters are long, with frequent and abundant snowfall and mild summers. The average year temperature is 6-8 °C, and annual precipitations range between 800 and 1200 mm, being mostly concentrated in autumn and winter. Strong winds often batter the wide plateau and the surrounding mountains (Pedrotti 1982a).

A view of the Pian Grande and Fosso Mergani, with a doline visible on the left side of the photo.

Geology and geomorphology

The Sibillini mountain range consists of a succession of sedimentary rocks of marine origin, mainly limestones, and marls in the western area, sandstones and marls in the eastern area, and a small portion of the northwestern area. The genesis of Monti Sibillini started over 200 million years ago (Jurassic) with the beginning of the accumulation of calcareous sediments in a carbonate marine platform under climatic conditions similar to those of today's tropical seas. Approximately 150 million years ago, the entire area was characterized by deep-sea carbonate sedimentation with no terrigenous contribution. Subsequently, the sediments became increasingly marly (limestone mixed with clay) in response to the uplift and emergence of the western areas of the Sibillini Mountains due to the opening of the Tyrrhenian Sea. The lands that began to emerge started to be eroded by atmospheric agents, driving to the formation of terrigenous sediments (sand and clay), which were then transported towards the sea where they were deposited, mixing with the carbonate sediments.

Over millions of years, the marine sediments consolidated, becoming rock. Seven million years ago, the Apennine orogeny (uplift of the Apennine chain) started and brought to the rising of the Western sector of the Sibillini mountains. The easternmost portion, however, became a deeper environment subject to terrigenous sedimentation due to submarine gravitational currents, which deposited sandy debris (Laga Formation). The eastern area was also raised in the lower part of the Pliocene until it emerged. After the formation of the Apennine chain (2-3 million years ago), the area was affected by a distensive tectonic phase (still ongoing) with the formation of numerous fractures (faults) that delimit various lithological units which are still moving. Over millions of years, this movement has created large tectonic basins, such as those of Castelluccio and Norcia. The most evident of these fractures is the fault "Cordone del Vettore", also known as the "Strada delle Fate", which is clearly visible on the western side of Monte Vettore. In over two million years, this fault has lowered the western sector by over 2000 meters, forming the Castelluccio Plateaus (Coltorti & Farabollini 1995).

The extensional tectonic processes are still ongoing and are responsible for the local seismic activity, which in 2016 severely affected the area, causing numerous fatalities and huge damage, as well as phenomena of hydrogeological instability and modifications of the underground hydrological system.

The plateaus of Castelluccio di Norcia have a tectonic origin but were shaped on the surface by exogenous processes, mainly karstic, that formed the current landscape. The alteration and chemical dissolution of carbonate rocks due to surface runoff and infiltration of carbon dioxide-rich waters contribute to creating the local karst landscape, characterized by particular shapes such as caves,

sinkholes, and swallow holes. The most relevant landmark is the “Inghiottitoio dei Mergani”, which drains the waters of the Plateau of Castelluccio di Norcia (Calamita et al. 1982).

An important modeling action was performed by glaciers that repeatedly shaped the area during the Quaternary glacial events, up to about 10,000 years ago. Cirques and glacial valleys with a typical U-shaped profile characterize the surrounding mountains and valleys.

The soil of the plateaus is partly composed of carbonate debris, but in large part (namely in the central part of the plateaus), is constituted by a deep accumulation of decalcified clay resulting from the erosion processes performed by surface water. Therefore, the soil pH ranges between 5 and 7.5 (Cortini Pedrotti et al. 1973).

Flora and Vegetation

The Plateau of Castelluccio is characterized by a high plant diversity due not only to its natural origin but also to the cultural history of the place. The area includes:

Grassland of the *Bromion erecti*

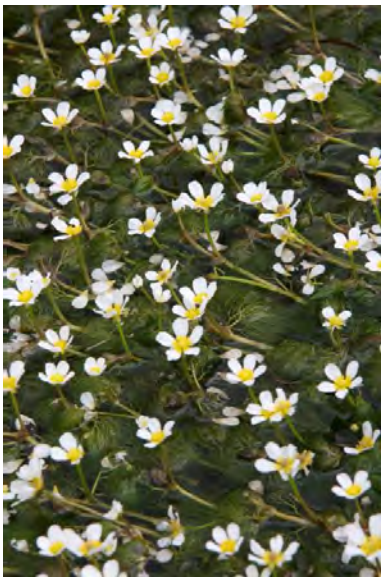
Gentiana verna L.

Tulipa sylvestris subsp. *australis* (Link) Pamp.

1. *Agricultural crops and hay meadows.* The main crops are lentils and barley and form a wide stripe extending from below the village up to the foot of Monte Vettore at Pian Grande. Crops are also at Pian Perduto. The crops are responsible for the spectacular phenomenon that attracts a mass of tourists every year in June, the so-called "Fiorita di Castelluccio di Norcia." In this period, the fields appear coloured with different shades of blue, yellow, red, and white due to the blooming of the crop weeds of the alliance *Scleranthion annui* (Allegrezza & Hruska 1992). The colour red is due to *Papaver rhoeas*, the blue mainly to *Centaurea cyanus, Consolida regalis,* and *Myosotis arvensis,* the white to *Anthemis arvensis, Thlaspi arvense,* and *Bunium bulbocastanum,* the yellow to *Sinapis arvensis.*
2. *Managed meadows.* These meadows of the class *Molinio-Arrenateretea* are regularly fertilized, mowed, and grazed. They include communities of the *Potentillion anserinae,* located between the hygrophilous communities of the *Magnocaricion* and those of the *Ranunculion velutini*, as well as the *Cynosurion cristati.*
3. *Pastures.* The pastures are located on the gentile slope at the foot of the mountains. They are frequented by horses, cattle and sheep throughout the year except from winter. The pastures are sparsely invaded by nitrophilous species. The calcareous and arid pastures belong to *Bromion erecti,* while the acidophilus ones may be framed into *Nardo-Agrostion caninae.* Two associations dominated by *Nardus stricta* are present in this area, the *Polygono bistortae-Nardetum strictae* for the moister sites and the *Filipendulo vulgaris-Nardetum strictae* for the drier ones (Cortini Pedrotti et al. 1973, Pedrotti 1982b).

Carex acuta L.

Fosso Mergani



Ranunculus trichophyllus Chaix

4. *Marshes and aquatic vegetation*. They are located in the lowermost part of the plateau. The most relevant stream is the "Fosso Mergani", which is located in the southern sector of Pian Grande. It originates in the plateau at 1270 m a.s.l. and ends in a sinkhole at 1252 m a.s.l. It collects the surface running water of the entire basin delimited by the surrounding mountains. Two other karstic systems, Pian Piccolo and Pian Perduto, represent blind basins (polje) with smaller dimensions. In all plateaus, there are several scattered dolines and sinkholes seasonally or permanently filled with water. These marshes host several communities referred to *Magnocaricion gracilis* such as *Caricetum gracilis, C. vulpinae, C. vesicariae* and the rare *Caricetum buxbaumii.* "Fosso Mergani" also hosts floating macrophytic communities with *Potamogeton natans*, *Persicaria amphibia,* and *Ranunculus tricophyllus* (Cortini Pedrotti et al. 1973, Pedrotti 1982b, Buchwald 1994).
5. *Relict fen and transition mire communities.* These communities host several rare species (e.g., *Blysmus compressus*, *Carex buxbaumii*, *C. davalliana*, *Eriophorum latifolium*, *Sphagnum* spp.). The plateaus of Castelluccio are the only sites in Region Umbria hosting *Sphagnum subsecundum* (at Pian Piccolo) and *S. platyphyllum* (at Pian Grande). There are three main vegetation aspects: i) *Caricion gracilis* with *Sphagnum* in the wettest area; ii) ecotonal transition towards *Caricion nigrae* on more acidic and organic soil with *Sphagnum, Aulacomnium palustre* and *Polytrichum commune*; iii) *Nardo-Agrostion* grassland under the driest conditions.

The transition mires are dominated by *Carex acuta* and *C. vesicaria*, accompanied by *Agrostis canina, Carex leporina, Deschampsia cespitosa, Galium palustre, Juncus inflexus, Leontodon autumnalis, Bistorta officinalis, Potentilla erecta, Sanguisorba officinalis, Trifolium spadiceum, Veronica scutellata* and bryophytes like *Sphagnum subsecundum, S. platyphyllum, Aulacomnium palustre* and *Polytrichum commune*. The fens are more diverse in term of species richness; the dominant species are *Agrostis stolonifera, Briza media, Calliergonella cuspidata, Carex acuta, C. buxbaumii, C. davalliana, C. flacca, C. hirta, C. panicea, C. viridula, Chara* spp., *Blysmus compressus, Deschampsia cespitosa, Drepanocladus aduncus*, *Eleocharis quinqueflora, Epilobium parviflorum, Equisetum palustris, Eriophorum latifolium, Schedonorus arundinaceus, Hypericum tetrapterum, Juncus articulatus, J. inflexus, Linum catharticum, Parnassia palustris, Potentilla erecta* and *Veronica beccabunga* (Praleskouskaya et al. 2022).

Nature conservation

The Plateaus of Castelluccio are in the Monti Sibillini National Park, which in turn was established in 1993.

The area is also included in the Natura 2000 Network as a Site of Community Importance and Special Protected Area IT5210071 – Monti Sibillini.

Natura 2000 Habitats in the plateaus

6210* Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*)

6230 Species rich *Nardus* grasslands on siliceous substrates in mountain areas

6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

3180 Turloughs

Natura 2000 Habitats in the surrounding area

4060 Alpine and Boreal heaths

5130 *Juniperus communis* formations on heaths or calcareous grasslands

6170 Alpine and subalpine calcareous grasslands

8310 Caves not open to the public

8210 Calcareous rocky slopes with chasmophytic vegetation

9210* Apennine beech forests with *Taxus* and *Ilex*

Threats and pressures

a) *Climate change*. Extremely dry conditions during the summer period have been increasingly frequent in the last twenty years.

b) *Intensive grazing* of large livestock.

c) *Intensive tourism*. A high amount of tourists visits the area during the month of June.

d) *Hydrogeological changes* due to local intense seismic activity

Species list (vascular plants and mosses)

Acer pseudoplatanus
Achillea collina
Achillea millefolium
Agropyron repens
Agrostemma githago
Agrostis canina
Agrostis capillaris
Agrostis stolonifera
Aira elegantissima
Ajuga reptans
Alchemilla colorata
Alchemilla flabellata
Alchemilla monticola
Allium sphaerocephalon
Allium vineale
Alopecurus geniculatus
Alopecurus pratensis
Alyssum alyssoides
Amelanchier ovalis
Anthemis arvensis
Anthemis cretica
Anthemis tinctoria
Anthoxanthum odoratum
Anthyllis vulneraria subsp. pulchella
Aphanes arvensis
Arabis collina
Arabis hirsuta
Arenaria leptoclados
Armeria arenaria
Armeria canescens
Arrhenatherum elatius
Asperula cynanchica
Asphodelus macrocarpus
Astragalus depressus
Astragalus hypoglottis subsp. *gremlii*
Aulacomnium palustre
Avena fatua
Avenella flexuosa
Avenula praetutiana
Avenula pratensis
Bellardiochloa variegata
Bellis perennis
Biscutella laevigata
Bistorta officinalis
Blysmus compressus
Brachypodium genuense
Brachypodium rupestre
Briza media
Bromopsis erecta
Bromus hordeaceus
Bromus secalinus
Bromus tectorum
Buglossoides arvensis
Bunium bulbocastanum
Calliergonella cuspidata
Campanula bertolae
Campanula glomerata
Campanula micrantha
Campanula rapunculoides
Campanula rapunculus
Campanula scheuchzeri
Campanula trachelium
Capsella bursa-pastoris
Cardamine amara
Cardamine amporitana
Cardamine bulbifera
Cardamine kitaibelii
Cardamine pratensis subsp. paludosa
Carduus nutans
Carex acuta
Carex buxbaumii
Carex caryophyllea
Carex cuprina
Carex davalliana
Carex distans
Carex disticha
Carex echinata
Carex flacca
Carex hirta
Carex leporina
Carex pallescens
Carex panicea

Carex vesicaria
Carex viridula
Carex vulpina
Carlina acanthifolia subsp. utzka
Carlina acaulis
Carlina acaulis subsp. caulescens
Carum carvi
Catabrosa aquatica
Centaurea cyanus
Centaurea jacea
Cerastium arvense
Cerastium caespitosum
Cerastium holosteoides
Cerastium pumilum
Cirsium arvense
Cirsium eriophorum
Cirsium lobelii
Clinopodium vulgare
Colchicum alpinum
Consolida regalis
Convolvulus arvensis
Crepis vesicaria subsp. taraxacifolia
Crocus vernus
Cruciata glabra
Cruciata laevipes
Cruciata pedemontana
Cyanus montanus
Cyanus triumfettii
Cynoglossum magellense
Cynoglossum montanum
Cynosurus cristatus
Cynosurus echinatus
Dactylis glomerata
Dactylorhiza incarnata
Dactylorhiza sambucina
Danthonia decumbens
Daphne laureola
Daucus carota
Delphinium consolida
Deschampsia cespitosa
Deschampsia flexuosa
Dianthus carthusianorum
Dianthus deltoides
Dianthus monspessulanus
Dicranum bonjeanii
Digitalis ferruginea
Draba muralis
Drepanocladus aduncus
Drepanocladus polygamus
Eleocharis palustris
Eleocharis quinqueflora
Elymus caninus
Epilobium hirsutum
Epilobium montanum
Epilobium palustre
Epilobium parviflorum
Epipactis atrorubens
Equisetum fluviatile
Equisetum palustre
Eriophorum latifolium
Eryngium amethystinum
Euphorbia amygdaloides
Euphorbia cyparissias
Euphrasia stricta
Fagus sylvatica
Fallopia convolvulus
Festuca centroapenninica
Festuca circummediterranea
Festuca jeanpertii
Festuca rubra aggr.
Festuca rubra subsp. commutata
Festuca stricta subsp. trachyphylla
Ficaria verna
Filipendula vulgaris
Fontinalis antipyretica
Fragaria vesca
Fumaria officinalis
Galeopsis angustifolia
Galium aparine
Galium corrudifolium
Galium debile
Galium lucidum
Galium odoratum
Galium palustre
Galium verum
Genista sagittalis
Gentiana lutea
Gentiana utriculosa
Gentiana verna
Gentianella columnae
Geranium pyrenaicum
Geranium robertianum
Geum urbanum
Globularia cordifolia
Glyceria fluitans
Glyceria maxima
Glyceria notata
Gymnadenia conopsea
Helianthemum nummularium subsp. grandiflorum
Heracleum sphondylium
Heracleum sphondylium subsp. ternatum
Hypericum montanum
Hypericum perforatum
Hypericum richeri
Hypericum tetrapterum
Hypnum cupressiforme
Juncus acutiflorus
Juncus articulatus
Juncus compressus
Juncus conglomeratus
Juncus effusus
Juncus inflexus
Knautia arvensis
Knautia integrifolia
Knautia purpurea
Koeleria cristata
Koeleria macrantha
Koeleria splendens
Lactuca muralis
Lapsana communis
Lathyrus pratensis
Legousia speculum-veneris
Leontodon autumnalis
Leontodon hispidus
Leucanthemum vulgare
Lilium bulbiferum subsp. croceum
Lilium martagon
Linum catharticum
Lithospermum arvense
Lolium perenne
Loncomelos pyrenaicus subsp. sphaerocarpus
Lotus corniculatus
Luzula campestris

Luzula multiflora
Luzula spicata subsp. italica
Lythrum portula
Medicago lupulina
Melampyrum arvense
Mentha arvensis
Meum athamanticum
Milium effusum
Muscari atlanticum
Myosotis alpestris
Myosotis arvensis
Myosotis ramosissima
Myosotis scorpioides
Myosotis sylvatica
Narcissus poeticus
Nardus stricta
Ochlopoa annua
Ophioglossum vulgatum
Ornithogalum gussonei
Ornithogalum umbellatum
Palustriella commutata
Papaver rhoeas
Parnassia palustris
Phleum alpinum
Phleum nodosum
Phleum pratense
Phyteuma orbiculare
Pilosella cymosa
Pilosella officinarum
Plantago argentea
Plantago atrata
Plantago lanceolata
Plantago major
Plantago media
Poa alpina
Poa palustris
Poa pratensis
Poa trivialis
Poa violacea
Podospermum laciniatum
Polygala alpestris
Polygala major
Polygonum aviculare
Polytrichum commune
Polytrichum juniperinum
Potamogeton natans
Potentilla aurea
Potentilla crantzii
Potentilla erecta
Potentilla hirta
Potentilla recta
Potentilla reptans
Potentilla rigoana
Prangos ferulacea
Prenanthes purpurea
Prunella laciniata
Prunella vulgaris
Pulmonaria apennina
Racomitrium canescens
Ranunculus acris
Ranunculus apenninus
Ranunculus arvensis
Ranunculus auricomus
Ranunculus bulbosus
Ranunculus flammula
Ranunculus lanuginosus
Ranunculus millefoliatus
Ranunculus montanus
Ranunculus ophioglossifolius
Ranunculus pedrottii
Ranunculus pollinensis
Ranunculus polyanthemos
Ranunculus repens
Ranunculus serpens
Ranunculus trichophyllus
Rhinanthus burnatii
Rhinanthus minor
Rosa arvensis
Rubus idaeus
Rumex acetosa
Rumex acetosella
Rumex crispus
Rumex nebroides
Salvia pratensis
Sanguisorba minor
Sanguisorba officinalis
Saxifraga bulbifera
Saxifraga granulata
Scabiosa columbaria
Schedonorus arundinaceus
Schoenoplectus tabernaemontani
Scorpidium cossonii
Scorzoneroides autumnalis
Scorzoneroides cichoriacea
Senecio doronicum
Senecio scopolii subsp. floccosus
Silene alba
Silene ciliata subsp. graefferi
Silene italica
Silene latifolia
Silene vulgaris
Sinapis arvensis
Sonchus asper
Sphagnum subsecundum
Sphagnum platyphyllum
Stachys alopecuros
Stachys officinalis
Stachys recta
Stachys tymphaea
Stellaria graminea
Stellaria holostea
Stellaria nemorum
Taraxacum balticiforme
Taraxacum officinale
Taraxacum rubicundum
Thalictrum aquilegiifolium
Thalictrum flavum
Thlaspi arvense
Thlaspi caerulescens
Thymus longicaulis
Thymus serpyllum
Tortula muralis
Tragopogon pratensis
Trifolium alpestre
Trifolium aureum
Trifolium badium
Trifolium campestre
Trifolium dubium
Trifolium fragiferum
Trifolium montanum
Trifolium montanum subsp. rupestre
Trifolium ochroleucum
Trifolium pratense
Trifolium repens
Trifolium spadiceum
Trinia glauca
Trisetum flavescens
Tulipa sylvestris subsp. australis
Urtica dioica
Valeriana officinalis

Valeriana tuberosa
Verbascum longifolium
Verbascum thapsus
Veronica anagallis-aquatica
Veronica arvensis
Veronica beccabunga
Veronica chamaedrys
Veronica scutellata
Veronica serpyllifolia
Veronica teucrium
Vicia cracca
Vicia onobrychioides
Vicia sativa
Vicia villosa
Viola arvensis
Viola canina
Viola eugeniae
Viola palustris
Viola reichenbachiana

Syntaxonomic synopsis

POTAMETEA R. Tx. et Preising 1942
  POTAMETALIA Koch 1926
    Nymphaeion albae Oberd. 1957
      Potametum natantis von Soó 1927
      Polygonetum amphibii Soó 1927
    Ranunculion fluitantis Neuhäusl 1959
      Ranunculetum trichophylli Soó 1927

PHRAGMITO-MAGNO-CARICETEA Klika in Klika et Novák 1941
  PHRAGMITETALIA Koch 1926
    Phragmition communis Koch 1926
      Schoenoplectetum tabernaemontani De Soó 1947
  MAGNOCARICETALIA Pignatti 1954
    Magnocaricion gracilis Géhu 1961
      Caricetion gracilis (Neuhäusl 1959) Oberd. et al. 1967
      Caricetum vulpinae von Soó 1927
      Caricetum vesicariae Chouard 1924
      Caricetum buxbaumii Issler 1932
  OENANTHETALIA AQUATICAE Hejný in Kopecký et Hejný 1965
    Oenantion aquaticae Hejný ex Neuhäusl 1959
      Eleocharitetum palustris Ubrizsy 1948
  NASTURTIO-GLYCERIETALIA Pignatti 1954
    Glycerio-Sparganion Br.-Bl. et Sissingh in Boer 1942
      Glycerietum plicatae Kulczinsky 1928
      Catabrosetum aquaticae Kaiser 1926
      Veronica beccabunga community
      Alopecurus aequalis community

SCHEUCHZERIO-CARICETEA FUSCAE R. Tx. 1937
  CARICETALIA DAVALLIANAE Br.-Bl. 1949
    Caricion davallianae Klika 1934
      Caricetum davallianae Dutoit 1924
      Eriophorum latifolium community
      Blysmus compressus community
      Eleocharitetum pauciflorae Lüdi 1921 [= *Eleocharitetum quinqueflorae* (Zobrist 1935) Braun 1968]

CARICETALIA FUSCAE Koch 1926 em. Br.-Bl. 1949
Caricion fuscae Koch 1926 em. Klika 1934
Carex echinata community

MOLINO-ARRHENATHERETEA R. Tüxen. 1937 em. R. Tüxen 1970
ARRENATERETALIA ELATIORIS Tüxen 1931
Cynosurion cristati Tx. 1947
Cynosuro-Trifolietum repentis Cortini-Pedrotti et al. 1973
Lolio perennis-Cynosuretum cristati Tüxen 1937
MOLINIETALIA COERULEAE Koch 1926
Deschampsion cespitosae Horvatić 1930
Deschampsio-Caricetum distantis Pedrotti 1976
Agrostio stoloniferae-Deschampsietum cespitosae Ujvárosi 1947
FILIPOENDULO ULMARIAE-LOTETALIA ULIGINOSI Passarge 1975
Mentho longifoliae-Juncion inflexi T. Müller et Görs ex de Foucault 2009
Junco inflexi-Menthetum longifoliae Lohmeyer 1953
Juncus inflexus community
Carex hirta community

NARDETEA STRICTE Rivas Goday et Borja Carbonell in Rivas Goday et Mayor López 1966
NARDETALIA STRICTE Preising 1950
Nardo-Agrostion caninae Cortini-Pedrotti et al. 1973
Filipendulo vulgaris-Nardetum strictae Pedrotti 1982
Polygono bistortae-Nardetum strictae Pedrotti 1982

FESTUCO-BROMETEA Br.-Bl. & Tüxen ex Br.-Bl. 1949
BROMETALIA ERECTI Koch 1926
Bromion erecti Koch 1926
Festuco-Koelerietum gracilis Cortini Pedrotti et al. 1973

TRIFOLIO MEDII-GERANIETEA SANGUINEI Müller 1962
ASPHODELETALIA MACROCARPAE Biondi & Allegrezza in Biondi et al. 2014
Cyano triumfettii-Asphodelion macrocarpi Biondi & Allegrezza in Biondi et al. 2014
Senecio scopolii-Asphodeletum macrocarpi Biondi & Allegrezza in Biondi et al. 2014

STELLARIETEA MEDIAE Tüxen, Lohmeyer & Preising ex Von Rochow 1951
APERETALIA SPICAE-VENTI J. Tüxen & Tüxen in Malato-Beliz, J.Tüxen & Tüxen 1960
Scleranthion annui (Kruseman et Vlieger 1939) Sissingh in Westhoff et al. 1946
Sinapio arvensis-Anthemidietum arvensis Allegrezza & Hruska 1992

References

The present description was realized using data from the scientific publications mentioned below, information published on the website of the National Park https://www.sibillini.net, the materials published by the Regional Institution "Umbria" for the management of the Sites of the Natura 2000 Network https://www.regione.umbria.it/ambiente/piani-di-gestione, the data stored in

the Italian Vegetation Database VegItaly https://www.scienzadellavegetazione.it/en/vegitaly-3/, personal knowledge and unpublished material.

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MARSHLAND OF COLFIORITO (PALUDE DI COLFIORITO)

Location

Coordinates: 43.0231°N, 12.8754°E

Altitude: 752 m a.s.l.

Introduction

The Colfiorito Marshland, part of the Regional Park of Colfiorito, is situated between the administrative regions of Umbria and Marche in the Central Apennines. This marshland lies in a depression of a plateau system formed by seven plateaus named “Altipiani Plestini” or “Altifiani di Colfiorito”, with both tectonic and karstic origins. The marshland of Colfiorito is considered one of the most important wetlands in Central Italy due to its unique ecological characteristics (Ballelli et al. 2010). The area is notable for its geology, geomorphology, and biodiversity, hosting a wide variety of plants and animals, particularly insects, birds, and amphibians. Historically, the region was even more important as it featured relict alkaline fens, which were totally destroyed between the 1970s and the 1980s.

Climate

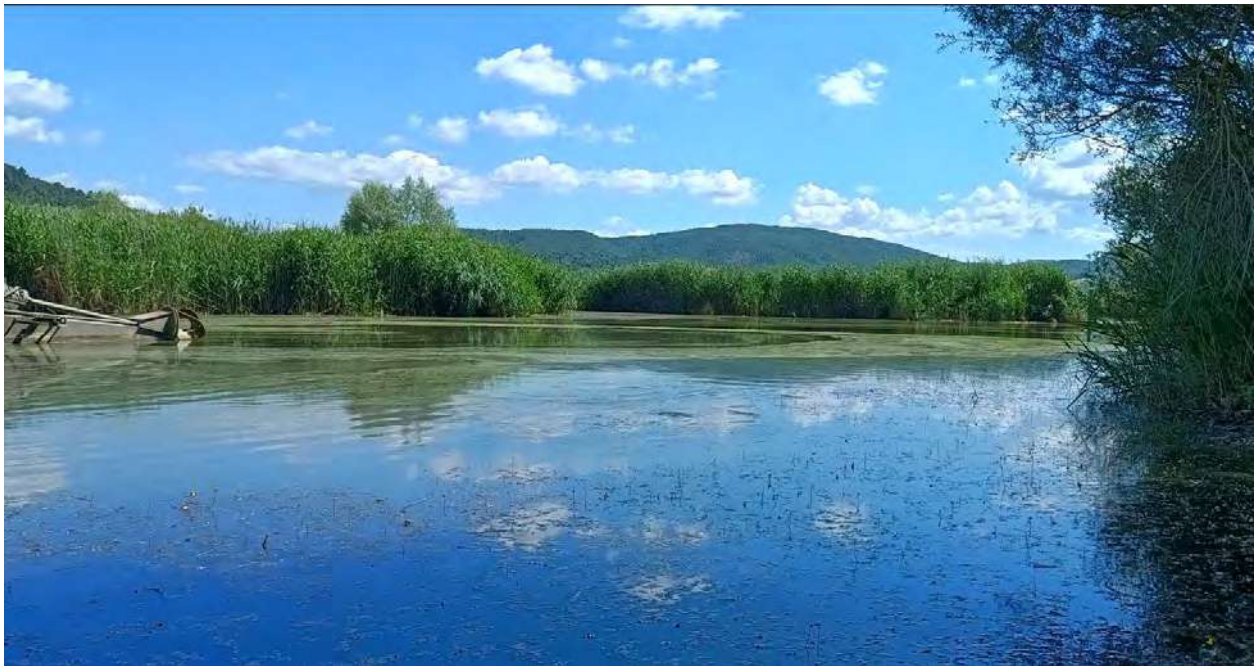
This site falls in the continental biogeographic region and belongs to the lower supratemperate bioclimatic belt. Local climate is characterized by long and relatively cold winter periods. The precipitations are abundant during spring and autumn. The average yearly temperature is 11-13 °C, with an average annual precipitation of 1000 -1100 mm (Tardella et al. 2020).

View of the marshland in the locality "Il Molinaccio" in the summer of 2011. At that time, the population of Nymphaea alba *was in good condition.*

Geology and Geomorphology

The plateau system Altipiani di Colfiorito has a tectonic origin. The earliest geological history of the plateau system is the same as for all this sector of the Apennines, i.e the same described for Castelluccio di Norcia. Its recent geological history starts between the Upper Pliocene and the Lower Pleistocene, when the area experienced significant tectonic activity. Faults, particularly those running in a SW-NE direction, played a crucial role in shaping the landscape. These faults created a network of underground cavities and divided the region into polygonal blocks of horst and graben (range and valley) structures (Gregori 1990). The interaction between anti-Apennine faults and normal Apennine faults led to the fragmentation of the area into several depressions, including the plateau of

Colfiorito. These tectonic events also influenced the hydrographical evolution of the region. The plateaus were occupied by lakes that had either dried up naturally or had been drained by man for agricultural purposes. The present-day marshland of Colfiorito is the remnant part of these ancient lakes (Gregori 1990, Calamita et al. 1998). Also, this area is subjected to active tectonics, as testified by frequent seismic activity. The last significant and very destructive earthquakes occurred in September 1997, when a large area of Central Italy was damaged, and numerous cities and towns were utterly razed to the ground (Calamita et al. 1998).



View of the marshland in the locality "Il Molinaccio" in the summer of 2024. Nymphaea alba *is absent and replaced by* Utricularia australis *and green algae colonies.*

On the Northern part of the marshland is located the most significant karst feature, a sinkhole known as "Inghiottitoio del Molinaccio". It is a large cavity where the water from the surrounding area drains and disappears underground at the speed of 20 liters/min. This natural phenomenon plays a crucial role in the local hydrology, helping to feed important springs such as those of Bagnara, Nocera, and Capodacqua.

The geological substrate is mostly made of calcareous rocks belonging to the Umbria-Marche lithologic succession. The bed of the depressions is occupied by fluvial-lacustrine and lake deposits such as gravel, sand, and clay, while in deeper areas, peaty silt and clay prevail. These sediments originated from the recent and current lake and marsh phases (Materazzi & Pieruccini 2001).

Flora and Vegetation

The plateaus of Colfiorito, as well as the homonymous marshland, are important sites due to their flora and vegetation diversity. They host several rare and protected plant species such as *Alopecurus bulbosus, Carex tomentosa, Dactylorhiza incarnata, Epipactis palustris, Equisetum fluviatile, Juncus hybridus, Nymphaea alba, Ophioglossum vulgatum, Ranunculus flammula, R. ophioglossifolius, Trifolium patens* and *Utricularia australis* (Ballelli et al. 2010). Other noteworthy species once present totally disappeared from the area during the last decades and more are in the brink of local extinction. Among the lost species, we should mention *Eriophorum latifolium, Hippuris vulgaris, Hydrocotyle vulgaris, Menyanthes trifoliata, Potamogeton lucens, P. trichoides, Ranunculus lingua* and *Triglochin palustre.* The local population of *Nymphaea alba* went through a drastic reduction during the last decade.

View of "Palude di Colfiorito" in summer of 2011. The *Schoenoplectetum lacustris* in dark green is well distinct from the *Phragmitetum australis* in light green. In the water there are visible stands dominated by *Nymphaea alba*.

The plant communities of the marsh form several concentric bands of vegetation following the water level. The central and the northern sector of the marshland are permanently occupied by water and therefore host aquatic communities such as the *Nymphaeetum albae* (almost completely disappeared in the last years), the *Myriophylletum verticillati* (also very much reduced in the last

years), the *Utricularietum australis* (in expansion in the last year) and very localized and small sized communities dominated by *Lemna minor, Callitriche stagnalis*, *Ranunculus trichophyllus* and very few other aquatic species. The water surface that remains completely open and occupied exclusively by aquatic plant communities is relatively small, most of it, being not too deep, is occupied by communities dominated by large standing macrophytes such as *Schoenoplectus lacustris* and *Phragmites australis.* The *Schoenoplectetum lacustris* develops in deeper water than the *Phragmitetum australis.* The band external to the *Phragmitetum australis* is occupied by the *Phalaridetum arundinaceae* and *Glycerietum maximae.* Even more externally, in contact with these last communities, there are the associations of the *Magnocaricion* and the wet meadows of the *Ranunculion velutini.* Unfortunately, the communities of the *Magnocaricion* and the wet meadows are very limited in extension due to the presence of crops all around the marshes that limit the expansion of these important communities.

During the last decade the *Schoenoplectetum lacustris* has undergone drastic shrinkage, while the *Phragmitetum australis* is invading all the marshes, leaving little room to other emergent communities.

View of "Palude di Colfiorito" in summer of 2024. The Phragmitetum australis *dominates the marshland. The* Schoenoplectetum lacustris *and* Nymphaeetum albae *are not any longer visible.*

Nature conservation

The Regional Park of Colfiorito was instituted in 1995 with the aim of protecting the Marshland of Colfiorito due to its ecological, botanical, zoological, and cultural significance.

The Altipiani di Colfiorito are also protected under the Ramsar Convention as wetlands of international importance.

The marshland is also included in the Natura 2000 Network being a Site of Community Importance and Special Protected Area IT5210072.

Natura 2000 Habitats in the area

3150 Natural Eutrophic Lakes with *Magnopotamion* or *Hydrocharition*-type vegetation

3270 Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation

3260 Water courses of plain to montane levels with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*)

3180 3180 Turloughs

Natura 2000 Habitats present in the past

3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.

7230 Alkaline Fens

Habitats Natura 2000 in the surrounding area

6210* Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*)

Threats and pressures

Human activities have had an important impact on the flora and vegetation of the site. Since the Romans, there have been several attempts to drain and reclaim the area. During the Roman Empire, the plateau of Colfiorito was occupied by a lake that was finally drained almost completely during the 15th century CE. However, efforts to drain the current marshland of Colfiorito were fortunately never successful (Pedrotti 2019). In the last century, the marshland was threatened by numerous attempts

to expand the croplands. During the 1940s and early 1950s, this wetland was almost completely flooded during the rainy season. At the same time, the reed beds and the bulrushes were periodically burned to support hunting activities. Between 1964 and 1972, the vegetation of a relict mire, hosting species such as *Eriophorum latifolium, Carex panicea*, and *Juncus subnodulosus*, was destroyed and replaced with a plantation of *Populus canadensis*. In the 1970s, hunting was prohibited and this stopped the burning of the area, leading to a doubling of the surface occupied by the reed bed (*Phragmitetum australis*) at the expense of hydrophytic communities and the *Schoenoplecteum lacustris*, while vegetation referred to *Trifolio-Hordeetalia* decreased in extent (Pedrotti 2019, Tardella et al. 2020). In the early 1990s, new water management interventions were introduced to mitigate summer drying-out. Despite these efforts, drying-out events persisted, likely due to reduced precipitation and increased evapotranspiration driven by the spread of the common reed. This spread also led to the accumulation of large amounts of litter, which negatively impacted the wetland ecosystem. Areas once covered by mire vegetation are now occupied by shrub communities. Additionally, the use of fertilizers by local landowners in the surrounding areas has further degraded water quality, resulting in low oxygen concentrations during summer (Orsomando 1998, Tardella et al. 2020).

The main threats and pressures are:

a) *Introduction of exotic species*. The coypu (*Myocastor coypus*) was reported in the Park in 2013. This mammal could be responsible for the sudden decline of some plant species in the marshland, such as *Nymphaea alba* and *Schoenoplectus lacustris*. This rodent has a quite selective diet (Prigioni et al. 2005).
b) *Hydrogeological changes* due to active seismic activity.
c) Agricultural activities. The surrounding areas are used for the cultivation of red potatoes, cereals, and legumes.
d) Climate change: The maximum water level of the marshland is around 4 m. The maximum seasonal fluctuation of the water level is 2.25 m. The risk of completely drying out increases with the increase of dry periods during the year.

Utricularietum australis

Nymphaeetum albae

Species list

(The species list is extracted from the Vascular Flora of the "Altipiani di Colfiorito" by Ballelli et al. 2010)

Abutilon theophrasti
Acer campestre
Acer opalus subsp. obtusatum
Acer pseudoplatanus
Achillea collina
Achillea millefolium
Achillea setacea
Acinos alpinus
Adonis annua
Adonis flammea
Adoxa moschatellina
Agrimonia eupatoria
Agrostemma githago
Agrostis stolonifera
Ailanthus altissima
Ajuga chamaepitys
Ajuga genevensis
Ajuga reptans
Alisma plantago-aquatica
Alliaria petiolata
Allium sphaerocephalon
Allium vineale
Alopecurus aequalis
Alopecurus bulbosus
Alopecurus myosuroides
Alopecurus rendlei
Althaea hirsuta
Alyssum alyssoides
Amaranthus cruentus
Amaranthus retroflexus
Anacamptis pyramidalis
Anagallis arvensis
Anagallis foemina
Anchusa azurea
Anemone apennina
Anemone ranunculoides
Anthemis arvensis
Anthemis cotula
Anthoxanthum odoratum
Anthriscus nemorosa
Anthyllis vulneraria subsp. rubriflora
Aphanes arvensis
Arabis hirsuta
Arctium minus
Arenaria leptoclados
Arenaria serpyllifolia
Aristolochia rotunda
Armeria canescens
Arrhenatherum elatius
Artemisia vulgaris
Arum italicum
Arum maculatum
Arundo donax
Asphodeline lutea
Atriplex patula
Avena sterilis
Ballota nigra subsp. meridionalis
Barbarea vulgaris
Bellevalia romana
Bellis perennis
Berula erecta
Bidens tripartita
Bombycilaena erecta
Botriochloa ischaemum
Brachypodium rupestre
Brachypodium sylvaticum
Briza media
Bromus commutatus
Bromus erectus
Bromus hordeaceus
Bromus inermis
Bromus racemosus
Bromus sterilis
Bryonia dioica
Buglossoides arvensis
Buglossoides purpurocaerulea
Bunias erucago
Bunium bulbocastanum
Butomus umbellatus
Calamagrostis epigejos
Calamintha nepeta
Calendula arvensis
Calepina irregularis
Callitriche palustris
Callitriche stagnalis
Calystegia sepium

Campanula rapunculus
Capsella bursa-pastoris
Cardamine pratensis
Carduus acicularis
Carduus nutans
Carduus pycnocephalus
Carex acuta
Carex distans
Carex elata
Carex flacca subsp. serrulata
Carex flacca. subsp. flacca
Carex hirta
Carex otrubae
Carex pallescens
Carex panicea
Carex riparia
Carex tomentosa
Carex viridula
Carpinus betulus
Carthamus lanatus
Catabrosa aquatica
Centaurea arrigonii
Centaurea calcitrapa
Centaurea jacea
Centaurea jacea subsp. gaudini
Centaurea nigrescens subsp. neapolitana
Centaurea scabiosa
Centaurium erythraea
Centaurium pulchellum
Cerastium arvense subsp. suffruticosum
Cerastium brachypetalum subsp. roeseri
Cerastium brachypetalum subsp. tenoreanum
Cerastium glomeratum
Cerastium glutinosum
Cerastium holosteoides
Cerastium ligusticum
Ceterach officinarum
Chaenorhinum minus subsp. minus
Chenopodium album
Chenopodium hybridum
Chenopodium opulifolium
Chenopodium polyspermum
Chondrilla juncea
Cicer arietinum
Cichorium intybus
Cirsium arvense
Cirsium creticum subsp. triumfetti
Cirsium morisianum
Cirsium tenoreanum
Cirsium vulgare
Clematis vitalba
Clinopodium vulgare
Colchicum lusitanum
Conium maculatum
Consolida regalis
Convolvulus arvensis
Cornus mas
Cornus sanguinea
Corydalis cava
Corylus avellana
Cota altissima
Cota tinctoria subsp. australis
Crataegus monogyna
Crepis neglecta
Crepis sancta subsp. nemausensis
Crepis setosa
Crepis vesicaria
Crupina vulgaris
Crypsis alopecuroides
Cuscuta campestris
Cuscuta epithymum
Cyanus segetum
Cyanus triumfettii
Cymbalaria muralis
Cynoglottis barrelieri
Cynosurus cristatus
Cynosurus echinatus
Cyperus fuscus
Cyperus longus
Cytisophyllum sessilifolium
Dactylis glomerata subsp. glomerata
Dactylorhiza incarnata subsp. incarnata
Danthonia decumbens subsp. decumbens
Dasypyrum villosum
Daucus carota
Deschampsia cespitosa
Diplotaxis erucoides
Dipsacus fullonum
Dorycnium hirsutum
Echinaria capitata
Echinochloa crus-galli
Echinops sphaerocephalus
Echium vulgare
Eleocharis palustris
Elymus caninus subsp. caninus
Elymus repens
Epilobium dodonaei
Epilobium hirsutum
Epilobium parviflorum
Epilobium tetragonum subsp. lamyi
Epipactis palustris
Epipactis palustris
Equisetum arvense subsp. arvense
Equisetum fluviatile
Equisetum palustre
Equisetum ramosissimum
Equisetum telmateia
Eranthis hyemalis
Erigeron canadensis
Eriophorum latifolium (locally extinct)
Erodium cicutarium
Eryngium amethystinum
Eryngium campestre
Euonymus europaeus
Eupatorium cannabinum
Euphorbia
Euphorbia exigua
Euphorbia falcata subsp. falcata
Euphorbia helioscopia subsp. helioscopia
Euphorbia platyphyllos
Fallopia baldschuanica
Fallopia convolvulus
Festuca microphylla
Festuca rubra subsp. commutata

Festuca rubra subsp. juncea
Festuca trichophylla subsp. asperifolia
Filago pyramidata
Fragaria vesca
Fraxinus ornus
Fumana procumbens
Fumaria officinalis
Galega officinalis
Galeopsis angustifolia
Galium mollugo subsp. mollugo
Galium palustre subsp. elongatum
Galium tricornutum
Galium verum subsp. verum
Gaudinia fragilis
Genista tinctoria
Geranium dissectum
Geranium lucidum
Geranium molle
Geranium purpureum
Geranium pyrenaicum
Geranium robertianum
Geranium rotundifolium
Geum urbanum
Glyceria fluitans
Glyceria maxima
Glyceria notata
Gnaphalium uliginosum subsp. uliginosum
Gratiola officinalis
Gymnadenia conopsea
Hedera helix
Helianthemum apenninum
Helianthemum nummularium
Helianthemum salicifolium
Helianthus annuus
Helichrysum italicum
Heliotropium europaeum
Helleborus bocconei
Helminthotheca echioides
Helosciadium nodiflorum
Heracleum sphondylium subsp. ternatum
Hieracium pilosella
Himantoglossum adriaticum
Hippocrepis comosa
Hippuris vulgaris (locally extinct)
Holcus lanatus
Hordeum murinum subsp. leporinum
Hordeum secalinum
Humulus lupulus
Hydrocotyle vulgaris (locally extinct)
Hypericum perforatum
Hypericum tetrapterum
Hypochaeris radicata
Inula britannica
Inula conyzae
Inula salicina
Iris germanica
Iris pseudacorus
Juglans regia
Juncus articulatus
Juncus bufonius
Juncus compressus
Juncus hybridus
Juncus inflexus
Juncus subnodulosus
Juncus tenageja
Juniperus communis
Juniperus oxycedrus
Kickxia elatine
Kickxia spuria
Knautia integrifolia
Knautia purpurea
Lactuca muralis
Lactuca saligna
Lactuca serriola
Lactuca virosa
Lamium amplexicaule
Lamium bifidum
Lamium maculatum
Lamium purpureum
Lapsana communis
Lathyrus annuus
Lathyrus aphaca
Lathyrus hirsutus
Lathyrus ochrus
Lathyrus pratensis
Lathyrus sativus
Lathyrus sphaericus
Lathyrus sylvestris
Lemna gibba
Lemna minor
Lens culinaris
Leontodon autumnalis
Leontodon cichoraceus
Leontodon hispidus
Leontodon rosani
Leontodon saxatilis subsp. saxatilis
Lepidium draba
Leucanthemum vulgare subsp. vulgare
Ligustrum vulgare
Linaria vulgaris
Linum bienne
Linum catharticum
Linum corymbulosum
Linum tenuifolium
Lolium multiflorum subsp. multiflorum
Lolium perenne
Lolium temulentum subsp. temulentum
Loncomelos narbonensis
Lonicera caprifolium
Lonicera etrusca
Lotus corniculatus
Lotus tenuis
Luzula campestris
Lycopus europaeus
Lysimachia nummularia
Lysimachia vulgaris
Lythrum hyssopifolia
Lythrum salicaria
Malva sylvestris
Marrubium vulgare
Medicago arabica
Medicago falcata
Medicago lupulina
Medicago orbicularis
Medicago polymorpha
Melampyrum arvense
Melilotus alba
Melilotus altissima
Melilotus officinalis
Mentha aquatica
Mentha arvensis

Mentha longifolia
Mentha pulegium subsp. pulegium
Mentha x rotundifolia
Menyanthes trifoliata (locally extinct)
Mercurialis annua
Milium vernale subsp. vernale
Minuartia hybrida
Muscari comosum
Muscari neglectum
Myagrum perfoliatum
Myosotis arvensis
Myosotis ramosissima
Myosotis scorpioides
Myriophyllum spicatum
Myriophyllum verticillatum
Narcissus poeticus
Nasturtium officinale
Nepeta cataria
Neslia paniculata
Odontites vulgaris
Oenanthe aquatica
Oenanthe fistulosa
Oenanthe silaifolia
Onobrychis viciifolia
Ononis pusilla
Ononis reclinata
Ononis spinosa
Onopordum acanthium subsp. acanthium
Onopordum tauricum
Ophioglossum vulgatum
Ophrys apifera
Orchis anthroposphere
Orchis papilionacea
Orlaya daucoides
Ornithogalum comosum
Ornithogalum divergens
Orobanche caryophyllacea
Ostrya carpinifolia
Paliurus spina-christi
Panicum miliaceum
Papaver rhoeas
Pastinaca sativa subsp. urens
Persicaria amphibia
Persicaria lapathifolia
Persicaria maculosa
Petasites hybridus
Petrorhagia prolifera
Petrorhagia saxifraga subsp. saxifraga
Phalaris arundinacea subsp. arundinacea
Phaseolus vulgaris
Phelipanche mutelii
Phleum bertolonii
Phleum hirsutum subsp. ambiguum
Phleum pratense
Phragmites australis
Picris hieracioides subsp. hieracioides
Pisum sativum subsp. biflorum
Plantago holosteum
Plantago lanceolata
Plantago major
Plantago media
Plantago sempervirens
Poa
Poa bulbosa
Poa compressa
Poa pratensis
Poa trivialis
Polygala flavescens
Polygonum arenastrum
Polygonum aviculare subsp. arenastrum
Polygonum aviculare subsp. aviculare
Polygonum aviculare subsp. rurivagum
Polygonum bellardii
Populus canadensis
Populus nigra
Populus tremula
Portulaca oleracea
Potamogeton crispus
Potamogeton lucens (locally extinct)
Potamogeton polygonifolius
Potamogeton pusillus
Potamogeton trichoides (locally extinct)
Potentilla reptans
Primula vulgaris
Prospero autumnale
Prunella laciniata
Prunella vulgaris
Prunus avium subsp. avium
Prunus spinosa subsp. spinosa
Pulicaria dysenterica
Pulmonaria apennina
Quercus cerris
Quercus pubescens
Ranunculus arvensis
Ranunculus ficaria
Ranunculus flammula
Ranunculus lingua (locally extinct)
Ranunculus neapolitanus
Ranunculus ophioglossifolius
Ranunculus repens
Ranunculus sardous
Ranunculus trichophyllus
Ranunculus velutinus
Rapistrum rugosum
Reseda luteola
Reseda phyteuma
Rhagadiolus stellatus
Rhamnus cathartica
Rhinanthus alectorolophus
Rhinanthus minor
Ricciocarpos natans
Robinia pseudacacia
Rorippa amphibia
Rorippa sylvestris
Rosa andegavensis
Rosa arvensis
Rosa balsamica
Rosa canina
Rosa corymbifera
Rosa dumalis
Rosa micrantha
Rosa squarrosa
Rubus caesius
Rubus ulmifolius
Rumex acetosa

Rumex conglomeratus
Rumex crispus
Rumex hydrolapathum
Rumex obtusifolius subsp. obtusifolius
Rumex pulcher subsp. pulcher
Rumex sanguineus
Salix alba
Salix apennina
Salix caprea
Salix cinerea
Salix purpurea
Salix triandra subsp. amygdalina
Salix viminalis
Salvia pratensis
Salvia verbenaca
Sambucus ebulus
Sambucus nigra
Sanguisorba minor subsp. balearica
Saponaria ocymoides subsp. ocymoides
Saponaria officinalis
Saxifraga bulbifera
Saxifraga tridactylites
Scandix pecten-veneris
Schedonorus uechtritzianus
Schoenoplectus lacustris
Scilla bifolia
Scrophularia auriculata
Scrophularia canina
Scrophularia scopolii
Scrophularia umbrosa
Scutellaria galericulata
Securigera varia
Sedum album
Sedum hispanicum
Sedum sexangulare
Senecio aquaticus
Senecio inaequidens
Senecio vulgaris
Setaria verticillata
Setaria viridis subsp. viridis
Sherardia arvensis
Sideritis montana
Sideritis romana
Silene flos-cuculi
Silene latifolia subsp. alba
Silene vulgaris
Silybum marianum
Sinapis alba
Sinapis arvensis
Solanum dulcamara
Solanum villosum subsp. alatum
Solidago gigantea
Sonchus asper
Sonchus oleraceus
Sorbus aria subsp. aria
Sorbus torminalis
Sparganium erectum subsp. erectum
Sparganium erectum subsp. neglectum
Spartium junceum
Stachys annua
Stachys germanica subsp. salviifolia
Stachys heraclea
Stachys palustris
Stachys recta
Stachys sylvatica
Stellaria media
Stellaria pallida
Taraxacum officinale
Taraxacum palustre
Teucrium chamaedrys
Thalictrum flavum
Thalictrum lucidum
Thlaspi alliaceum
Thlaspi perfoliatum
Thymelaea passerina
Thymus longicaulis
Tordylium apulum
Torilis arvensis
Tragopogon dubius
Tragopogon orientalis
Tragopogon porrifolius subsp. australis
Tragopogon porrifolius subsp. porrifolius
Tragopogon pratensis
Trifolium alexandrinum
Trifolium arvense
Trifolium campestre
Trifolium dubium
Trifolium fragiferum
Trifolium hybridum subsp. elegans
Trifolium incarnatum subsp. molinerii
Trifolium lappaceum
Trifolium micranthum
Trifolium nigrescens subsp. nigrescens
Trifolium patens
Trifolium pratense
Trifolium repens
Trifolium resupinatum
Trifolium stellatum
Trifolium striatum
Triglochin palustre (locally extinct)
Typha angustifolia
Typha latifolia
Ulmus minor
Urtica dioica
Utricularia australis
Valeriana officinalis
Valerianella coronata
Valerianella dentata
Valerianella echinata
Valerianella eriocarpa
Valerianella locusta
Valerianella rimosa
Verbascum blattaria
Verbascum phlomoides
Verbascum pulverulentum
Verbascum sinuatum
Verbascum thapsus
Verbena officinalis
Veronica anagallis-aquatica
Veronica arvensis
Veronica beccabunga
Veronica catenata
Veronica hederifolia
Veronica serpyllifolia
Vicia cracca
Vicia faba
Vicia incana
Vicia pannonica
Vicia sativa subsp. nigra

Vicia sativa subsp. sativa
Vicia tenuifolia
Vicia villosa subsp. varia
Viola arvensis
Viola odorata
Viola tricolor
Vulpia bromoides
Vulpia ligustica
Vulpia myuros
Xanthium orientale subsp. italicum
Xeranthemum inapertum
Zannichellia palustris

Cirsium creticum subsp. triumfettii (Lacaita) K. Werner. This is a Southern vicariant of *Cirsium palustre*.

Glyceria maxima (Hartm.) Holmb.

Syntaxonomic synopsis

LEMNETEA O. de Bolòs et Masclans 1955
LEMNETALIA MINORIS O. de Bolòs et Masclans 1955
Lemnion minoris de Bolós et Masclans 1955
Lemnetum minoris von Soó 1927
Ricciocarpetum natantis Tüxen *1974*
Utricularion vulgaris Passarge 1964
Utricularietum australis Müller et Görs 1960

POTAMOGETONETEA Klika in Klika et Novák 1941
POTAMOGETONETALIA Koch 1926
Potamogetonion Libbert 1931
Potamogetono pectinati-Myriophylletum spicati Rivas Goday 1964
Myriophylletum verticillati Gaudet ex Šumberová in Chytrý 2011
Nymphaeion albae Oberd. 1957
Nymphaeetum albae Vollmar 1947
Persicaria amphibia community
Ranunculion aquatilis Passarge ex Theurillat in Theurillat et al. 2015
Potamogetono crispi-Ranunculetum trichophylli Imchenetzky 1926
Callitriche stagnalis community

BIDENTETEA Tüxen et al. ex von Rochow 1951
BIDENTETALIA Br.-Bl. et Tüxen ex Klika et Hadač 1944
Bidention tripartitae Nordhagen ex Klika et Hadač 1944
Bidentetum tripartitae Miljan 1933
Chenopodion rubri (Tüxen in Poli et J. Tüxen 1960) Hilbig et Jage 1972
Polygono lapathifolii-Xanthietum italici Pirola et Rossetti 1974

PHRAGMITO-MAGNOCARICETEA Klika in Klika et Novák 1941
PHRAGMITETALIA Koch 1926
Phragmition communis Koch 1926
Glycerietum maximae Nowiński 1930 corr. Šumberová, Chytrý et Danihelka in Chytrý 2011
Iridetum pseudacori Eggler 1933 ex Brzeg et M. Wojterska 2001
Phalaridetum arundinaceae Libbert 1931
Phragmitetum australis Savič 1926
Cyperetum longi (Micevski 1957) Micevski 1963
Schoenoplectetum lacustris Chouard 1924
Typhetum latifoliae Nowiński 1930
MAGNOCARICETALIA Pignatti 1953
Magnocaricion gracilis Géhu 1961
Caricetum gracilis Savič 1926
Caricetum ripariae Máthé et Kovács 1959
Caricetum vesicariae Chouard 1924

OENANTHETALIA AQUATICAE Hejný ex Bálatová-Tuláčková, Mucina, Ellmauer et Wallnöfer in Grabherr et Mucina 1993

Eleocharito palustris-Sagittarion sagittifoliae Passarge 1964

Eleocharitetum palustris Savič 1926

Oenantho aquaticae-Rorippetum amphibiae Lohmeyer 1950

NASTURTIO-GLYCERIETALIA Pignatti 1953

Glycerio-Sparganion Br.-Bl. et Sissingh in Boer 1942

Beruletum erectae Roll 1938

Glycerietum notatae Kulczyński 1928

Rorippo ancipitis-Catabrosetum aquaticae (Oberdorfer 1957) Müller et Görs 1961

Helosciadietum nodiflori Maire 1924

Nasturtietum officinalis Gilli 1971

Sparganietum erecti Roll 1938

Veronica anagallis-aquatica community

MOLINIO-ARRHENATHERETEA Tüxen 1937

TRIFOLIO-HORDEETALIA Horvatić 1963

Ranunculion velutini Pedrotti 1978

Deschampsio-Caricetum distantis Pedrotti 1976

Hordeo-Ranunculetum velutini Pedrotti 1976

POTENTILLO-POLYGONETALIA AVICULARIS Tüxen 1947

Potentillion anserinae Tüxen 1947

Carex hirta community

Carex otrubae community

Galega officinalis community

Gratiola officinalis community

Epilobium hirsutum community

Potentilla reptans community

Mentho longifoliae-Juncion inflexi T. Müller et Görs ex de Foucault 2009

Carici otrubae-Juncetum inflexi Minissale et Spampinato 1985

EPILOBIETEA ANGUSTIFOLII Tüxen et Preising ex von Rochow 1951

ARCTIO LAPPAE-ARTEMISIETALIA VULGARIS Dengler 2002

Balloto-Conion maculati S. Brullo et Marcenò 1985

Urtico dioicae-Sambucetum ebuli (Br.-Bl. in Br.-Bl., Gajewski, Wraber et Wałas 1936) Br.-Bl. in Br.-Bl., Roussine et Nègre 1952

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EXCURSION 2. MARMORE WATERFALLS AND LAKE PIEDILUCO

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Excursion guides: Flavia Landucci and Corrado Marcenò

MARMORE WATERFALLS (CASCATA DELLE MARMORE)

Location

Coordinates: 43.5511°N, 12.7151°E

Altitude: 200-360 m a.s.l.

Introduction

The Marmore Waterfalls are located in Southern Umbria, close to the border with the Region Latium. This complex of waterfalls is formed by the confluence of the River Velino with the River Nera through three jumps; the first jump is 85 m tall, while all the waterfalls together are 165 m. These are the tallest artificial waterfalls in Europe; they were, in fact, constructed during the Roman Empire. The consul Manius Curius Dentatus, in 271 B.C., ordered the construction of a canal (Cava Curiana) to drain the “Lacus Velinus”, an enormous lake and marshland that occupied the

Panoramic view of the first jump of the waterfalls

plain of Rieti. During the Middle Ages, the lack of maintenance of this canal brought a decrease in the water flow due to the continuous deposition of calcium carbonate and the formation of travertine. Therefore, the plain of Rieti began to flood again, causing an increase in problems, including the diffusion of malaria. In 1422, Pope Gregorius XII ordered the construction of a new canal. However, from that time up to the beginning of the 19th century, the difficult regulation of the water flow provoked intermittent floods causing huge damages and numerous casualties in the valley below and even in the city of Terni. These events required repeated modifications to the waterfall's shape (Gregori & Troiani 2005, Lorenzetti 1990).

Currently, the water flows intermittently and is regulated to produce hydroelectric power. Most of the day, only a part of the water from the River Velino (average flow rate 50 m³/s) is diverted toward the waterfall (about 30-50 m³/s). When it is open at the minimum flow, the outcropping rocks and the vegetation below are visible.

The engineering works, and the nature that surrounds and characterizes the Marmore waterfalls have always attracted many tourists and visitors. Among them, many illustrious personalities have visited this place and left their written memories about these waterfalls. E.g., Cicero, Pliny the Elder, Galileo Galilei, Leonardo da Vinci, Vittorio Alfieri, Jean-Baptiste Camille Corot, William Turner, Gioachino Belli, Johann Wolfgang von Goethe, Lord George Byron, etc. The latter described the waterfalls as "horribly beautiful", sharing a paradigmatic example of the romantic perception of "sublime beauty." Between the 17th and 19th Century the Marmore Waterfalls was one of the stops on the way to Rome of the "Grand Tour", the traditional cultural trip through Europe undertaken by young upper-class European men (around the age of 21 years old) (Madonna et al. 2021).

Climate

The Marmore Waterfalls fall in the temperate Mediterranean bioclimatic region, characterized by mild winters (with average temperatures above 0 °C), and warm and dry summers. The average yearly temperature is 14–16 °C, and annual precipitation is around 1100 mm. The rainy season is autumn, while summer is the driest one. However, the area is characterized by a moderately to highly humid microclimate due to the rivers, the waterfalls, and the forests that surround the area (Biondi et al. 2002). Moreover, the bottom of the Nera Valley (Val Nerina) is narrow and shady and remains quite humid all through the year. In this area, in fact, the air is filled with tiny particles of water, i.e. the so-called aerosol phenomenon: the considerable mass of water, falling with a strong impact on the rocks and the ground at the foot of the three falls, tends to shatter into small particles and disperse in the air creating a nebulization effect.

Geology and Geomorphology

The Marmore Waterfalls represent the confluence of the River Velino with the River Nera. The River Velino runs across the Rieti plain, while the River Nera runs in a deep valley (Val Nerina) that ends in the Terni plain. These two plains have a tectonic and alluvial origin, and they have a height difference of 165 m. The two rivers have been always connected somehow; however, since the middle Pleistocene, the deposition of calcium carbonate transported by the river and the accumulation of travertine created progressively the height difference and the almost total closure of the Rieti Plain, with the consequent formation of a big lake, the so-called Lacus Velinus, that was still present at the time of the old Roman Empire (Carrara et al. 1995). Some chronicles of 290 B.C. reported that the water of the Lacus Velinus was flowing out through an extensive drip that overflowed along the edge of the cliff, ending up in the River Nera and, to a lesser extent, through sinkholes. The name "Marmore" itself is derived from the Latin word "marmor," meaning marble, which refers to the travertine rocks that resemble marble.

Flora and Vegetation

The rocky slopes of the Nera Valley, along the road that leads to the Marmore waterfalls, are characterized by a colorful chamaephytic (= shrub) vegetation dominated by *Coronilla emerus* subsp. *emeroides*, *Erica multiflora*, *Cytisus sessilifolius*, *Spartium junceum*, *Osyris alba* and *Asparagus acutifolius.*

The Marmore waterfalls are surrounded by forests mainly dominated by *Ostrya carpinifolia*, ascribed to the association *Scutellario columnae-Ostryetum carpinifoliae*, and those dominated by *Quercus ilex* referred to the association *Fraxino orni-Quercetum ilicis*, linked to calcareous substrates. The European hop-hornbeam (*Ostrya carpinifolia*) forest is usually accompanied by other tree and shrub species such as *Fraxinus ornus, Acer obtusatum, Laburnum anagyroides, Cornus mas, Euonymus europaeus, Ligustrum vulgare* and a species-rich herb layer with *Scutellaria columnae*, *Hepatica nobilis*, *Melittis melissophyllum, Viola reichenbachiana, V. alba* subsp. *dehnhardtii*, *Campanula trachelium, Euphorbia amygdaloides* and *Cephalanthera damasonium.* The Holm oak (*Quercus ilex*) forests appear as mixed forests characterized also by the presence of

Fraxinus ornus, Ostrya carpinifolia, Acer monspessulanum, A. campestre, Cercis siliquastrum and *Pinus halepensis.* Other common species are *Hedera helix, Juniperus communis, J. oxycedrus, Ruscus aculeatus* and *Buxus sempervirens* (Biondi et al. 2002).

The banks of the River Nera are characterized by riparian vegetation forming cool and shady galleries. *Salix alba*, *Populus nigra*, *Alnus glutinosa,* and *Ulmus minor* are the most frequent tree species, accompanied by *Salix purpurea*, *Cornus sanguinea, Sambucus nigra, Corylus avellana, Rubus ulmifolius, R. caesius, Clematis vitalba, Eupatorium cannabinum, Carex pendula* and *Equisetum arvense.*

Communities dominated by *Petasites hybridus* are common at the edges of the riverbed. Common species in these communities are *Aegopodium podagraria, Angelica sylvestris, Brachypodium sylvaticum, Campanula trachelium, Eupatorium cannabinum, Stachys sylvatica, Geranium nodosum*, *G. robertianum*, *Scrophularia nodosa* and *Poa trivialis.*

The borders of the watercourses where the waterflow becomes less intense host large patches of reeds dominated by species of the class *Phragmito-Magnocaricetea* such as *Phragmites australis*, *Helosciadium nodiflorum*, *Veronica beccabunga, Nasturtium officinale* or *Glyceria notata.*

The travertine and humid rocks along the waterfalls are the ideal habitat for numerous ferns, mosses, and liverworts, forming several communities ascribed to the alliances *Adiantion* and *Cratoneurion commutati.* The most frequent fern species in the area are *Adiantum capillus-veneris* and *Asplenium scolopendrium* in the moistest areas, while *Polypodium cambricum, Ceterach officinarum* and *Asplenium trichomanes* are most frequent on the rocks in the surrounding forests. Bryological and mycological studies of the waterfalls allowed to identify as many as 101 different taxa of bryophytes (21 liverworts and 80 mosses, see Poponessi et al. 2020) and 125 species of macromycetes (Venanzoni et al. 2019).

Nature conservation

The Marmore waterfalls are part of the River Nera Regional Park, established in 1995. The area is also included in the in the Natura 2000 Network as a Site of Community Importance and Special Protected Area IT5220017.

Petrifying springs also fall under the remit of the Water Framework Directive (Directive 2000/60/EC) as groundwater-dependent terrestrial ecosystems; their ecological significance is recognized under this legislation, and there is a legal requirement to maintain or improve the status of the ground waters.

The Marmore waterfalls are a well-preserved natural and historical landmark, with conservation efforts focusing on biodiversity, water management, and sustainable tourism. Authorities continue to balance human activities with environmental protection, ensuring the area remains a thriving ecosystem for future generations.

Inside the area open to the public, there is also a small botanical garden realized in collaboration with the University of Perugia for didactic and conservation purposes.

Habitats Natura 2000

7220* Petrifying springs with tufa formation of *Cratoneurion*

91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)

92A0 *Salix alba* and *Populus alba* galleries

6430 Hydrophilous tall herb fringe communities of the plains and the mountains to alpine levels

9340 *Quercus ilex* and *Quercus rotundifolia* forests

A small waterfall with a travertine (tufa) formation. On the right side, typical aspects of *Adiantion* and *Cratoneurion* vegetation

Another small waterfall surrounded by broadleaved forest.

Habitats Natura 2000 in the surrounding area

8310 Caves not open to the public

3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

9540 Mediterranean pine forests with endemic Mesogean pines [The autochthonous origin of *Pinus halepensis* in Umbria is doubtful. In fact, some genetic studies pointed out that this population is closer to that from Israel than to other Italian populations (Schiller & Brunori 1992)].

Asplenium scolopendrium L.

Petasites hybridus (L.) G. Gaertn., B. Mey. & Scherb.

Threats and pressures

a) Increasing tourism. The waterfalls are visited by more than 500,000 visitors every year.

b) Water regulation. The regulation of the water flow prevents the formation of new deposition of travertine.

Species list

Vascular plants

Acer campestre
Acer monspessulanum
Acer obtusatum
Adiantum capillus-veneris
Aegopodium podagraria
Agrostis stolonifera
Ailanthus altissima
Alliaria petiolata
Alnus glutinosa
Anemone apennina
Anemone nemorosa
Angelica sylvestris
Anthriscus sylvestris
Arabis alpina
Arbutus unedo
Arctium lappa
Artemisia vulgaris
Arundo donax
Arum italicum
Asparagus acutifolius
Asplenium trichomanes

Asplenium scolopendrium
Berula erecta
Brachypodium rupestre
Buxus sempervirens
Calystegia sepium
Campanula trachelium
Carex flacca
Carex halleriana
Carex hirta
Carex pendula
Carpinus orientalis
Catabrosa aquatica
Celtis australis
Cephalanthera longifolia
Cephalanthera rubra
Cercis siliquastrum
Ceterach officinarum
Cirsium creticum subsp. triumfettii
Cistus criticus
Clematis vitalba
Clinopodium vulgare
Cornus mas
Cornus sanguinea
Coronilla emerus
Corylus avellana
Cotinus coggygria
Crataegus monogyna
Cruciata glabra
Cyclamen hederifolium
Cyclamen repandum
Cymbalaria muralis
Cytisophyllum sessilifolium
Cytisus villosus
Dactylis glomerata
Daphne laureola
Digitalis micrantha
Dioscorea communis
Elymus repens
Epilobium hirsutum
Epilobium palustre
Equisetum arvense
Equisetum ramosissimum
Equisetum telmateia
Erica multiflora
Erysimum pseudorhaeticum
Euonymus europaeus
Euphorbia spinosa
Festuca heterophylla
Fragaria vesca
Fraxinus ornus
Galium aparine
Galium lucidum
Galium mollugo
Geranium macrorrhizum
Geranium nodosum
Geranium robertianum
Geum urbanum
Glyceria notata
Hedera helix
Helleborus foetidus
Helichrysum italicum
Helosciadium nodiflorum
Hepatica nobilis
Hieracium murorum
Humulus lupulus
Iris pseudacorus
Juniperus communis
Juniperus oxycedrus
Laburnum anagyroides
Lathraea squamaria
Lathyrus pratensis
Lathyrus sylvestris
Lathyrus venetus
Laurus nobilis
Lemna minor
Lemna trisulca
Ligustrum vulgare
Lonicera etrusca
Luzula forsteri
Lythrum salicaria
Melica uniflora
Melittis melissophyllum
Mentha aquatica
Mentha longifolia
Nasturtium officinale

Orchis anthropophora
Orchis purpurea
Orobanche hederae
Ostrya carpinifolia
Osyris alba
Persicaria lapathifolia
Persicaria maculosa
Petasites albus
Petasites hybridus
Phalaroides arundinacea
Phillyrea latifolia
Phragmites australis
Pinus halepensis
Pistacia terebinthus
Pistacia x saportae
Platanthera bifolia
Poa trivialis
Polypodium cambricum
Populus nigra
Populus tremula
Populus x canescens
Potentilla reptans
Primula vulgaris
Prunus avium
Prunus spinosa
Ptilostemon strictus
Pulmonaria vallarsae subsp. apennina
Pyracantha coccinea
Pyrus pyraster
Quercus cerris
Quercus ilex
Quercus pubescens
Ranunculus repens
Ranunculus trichophyllus
Robinia pseudoacacia
Rosa sempervirens
Rubia peregrina
Rubus caesius
Rubus ulmifolius
Rumex obtusifolium
Ruscus aculeatus
Salix alba
Salix eleagnos
Salix purpurea
Sambucus nigra
Satureja montana
Scrophularia umbrosa
Scutellaria columnae
Sesleria nitida
Silene italica
Silene latifolia subsp. alba
Solanum dulcamara
Solidago virgaurea
Sorbus aria
Sorbus aucuparia
Sorbus domestica
Sorbus torminalis
Spartium junceum
Teucrium chamaedrys
Teucrium flavum
Ulmus minor
Urtica dioica
Veronica anagallis-aquatica
Veronica beccabunga
Veronica cymbalaria
Viburnum lantana
Viburnum tinus
Vicia cracca
Viola alba subsp. dehnhardtii
Viola reichenbachiana

Liverworts

Aneura pinguis
Apopellia endiviifolia
Cephaloziella baumgartneri
Cololejeunea rossettiana
Conocephalum conicum
Conocephalum salebrosum
Jungermannia atrovirens
Lejeunea cavifolia
Lophocolea bidentata
Lunularia cruciata
Marchantia paleacea

Marchantia polymorpha subsp. polymorpha
Marchantia polymorpha subsp. montivagans
Marchantia polymorpha subsp. ruderalis
Marchantia quadrata
Mesoptychia turbinata
Pellia epiphylla
Porella platyphylla
Radula complanata
Reboulia hemisphaerica
Solenostoma gracillimum
Southbya tophacea

Mosses

Barbula unguiculata
Brachytheciastrum velutinum
Brachythecium rivulare
Brachythecium rutabulum
Bryum calophyllum
Bryum gemmiparum
Calliergonella cuspidata
Cratoneuron filicinum
Ctenidium molluscum
Didymodon fallax
Didymodon ferrugineus
Didymodon insulanus
Didymodon spadiceus
Didymodon tophaceus
Encalypta streptocarpa
Eucladium verticillatum
Exsertotheca crispa
Fissidens bryoides var. bryoides
Fissidens crassipes subsp. warnstorfii
Fissidens crassipes
Fissidens crispus
Fissidens curvatus
Fissidens exilis
Fissidens osmundoides
Fissidens rufulus
Fissidens serrulatus
Fissidens taxifolius
Gymnostomum calcareum
Homalothecium sericeum
Hydrogonium bolleanum
Hygroamblystegium fluviatile
Hygroamblystegium tenax
Hygroamblystegium varium
Hymenostylium recurvirostrum
Hypnum cupressiforme
Imbribryum mildeanum
Isothecium alopecuroides
Kindbergia praelonga
Leptodon smithii
Leucodon sciuroides
Mnium hornum
Mnium stellare
Orthotrichum diaphanum
Oxyrrhynchium hians
Oxyrrhynchium speciosum
Palustriella commutata
Palustriella falcata
Plagiomnium affine
Plagiomnium cuspidatum
Plagiomnium elatum
Plagiomnium ellipticum
Plagiomnium undulatum
Plasteurhynchium meridionale
Pleurozium schrebei
Pohlia annotina
Polia melanodon
Pohlia wahlenbergii
Pseudoscleropodium purum
Ptychostomum archangelicum
Ptychostomum capillare
Ptychostomum donianum

Ptychostomum imbricatulum

Ptychostomum torquescens

Rhizomnium punctatum

Rhynchostegiella tenella

Rhynchostegium confertum

Rhynchostegium megapolitanum

Rhynchostegium riparioides

Scorpiurium circinatum

Syntrichia leavipila

Tortella inflexa

Tortella tortuosa

Tortula marginata

Trichostomum crispulum

Weissia brachycarpa

Weissia controversa var. controversa

Weissia rutilans

Zygodon rupestris

Pulmonaria vallarsae subsp. *apennina* (Cristof. & Puppi) L.Cecchi & Selvi

Petasites albus (L.) Gaertn.

Syntaxonomic synopsis

PHRAGMITO-MAGNOCARICETEA Klika in Klika & Novák 1941

PHRAGMITETALIA Koch 1926

Phragmition communis Koch 1926

Phragmitetum vulgaris Soó 1927

NASTURIO-GLYCERETALIA Pignatti 1954

Glycerio-Sparganion Br.-Bl. & Sissingh in Boer 1942

Nasturtietum officinalis Gilli 1971

Glycerio notatae-Veronicetum beccabungae Landucci et al. 2020

Helosciadietum nodiflori Maire 1924

MONTIO-CARDAMINETEA Br.-Bl. & Tx. ex Klika et Hadač 1944
MONTIO-CARDAMINETALIA Pawłowski et al. 1928
Cratoneurion commutati Koch 1928

ADIANTETEA Br.-Bl. et al. 1952
ADIANTETALIA Br.-Bl. ex Horvatić 1934
Adiantion Br.-Bl. ex Horvatić 1934

MULGEDIO-ACONITETEA Hadač & Klika in Klika & Hadač 1944
PETASITO-CHAEROPHYLLETALIA Morariu 1967
Petasition officinalis Sillinger 1933
Petasites hybridus community

SALICETEA PURPUREAE Moor 1958
SALICETALIA PURPUREAE Moor 1958
Salicion albae Soó 1930
Salicetum albae Issler 1926
Salicion eleagni Aich. 1933
Saponario officinalis-Salicetum purpureae (Br.-Bl. 1930) Tchou 1946

QUERCETEA ILICIS Br.-Bl. ex A. & O. Bolòs 1950
QUERCETALIA ILICIS Br.-Bl. ex Mol. 1934 em. Riv.-Mart. 1975
Quercion ilicis Br.-Bl. ex Mol. 1934 em. Riv.-Mart. 1975
Cyclamino repandi-Quercetum ilicis Riv.-Mart., Cantó, Fernández-González & Sánchez-Mata 1995 (on decalcified soil)
Fraxino orni-Quercetum ilicis Horvatić (1956) 1958

QUERCO-FAGETEA SYLVATICAE Br.-Bl. & Vlieg. in Vlieg. 1937
QUERCETALIA PUBESCENTIS Klika 1933
Ostryo carpinifoliae-Carpinion orientalis Horvat (1954) 1959
Scutellario columnae-Ostryetum carpinifoliae Pedrotti, Ballelli & Biondi ex Pedrotti, Ballelli, Biondi, Cortini & Orsomando 1980
Asparago acutifolii-Ostryetum carpinifoliae Biondi 1982
POPULETALIA ALBAE Br.-Bl. ex Tchou 1948
Populion albae Br.-Bl. ex Tchou 1948
Carici remotae-Fraxinetum oxycarpae Pedrotti 1970 corr. 1992

Populus canescens community

Alnion incanae Pawlowski in Pawlowski, Sokolowski & Wallisch 1928

Ulmus minor community

Alnenion glutinoso-icanae Oberd. 1953

Aro italici-Alnetum glutinosae Gafta & Pedrotti 1995

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The present description was realized using data from the scientific publications mentioned below, information published on the websites of the Regional Park of the River Nera https://www.parcodelnera.it/, and of the "165 m Marmore Falls" https://www.marmorefalls.it/ita/0/home/, the materials published by the Regional Institution "Umbria" for the management of the Sites of the Natura 2000 Network https://www.regione.umbria.it/ambiente/piani-di-gestione, the data stored in the Italian Vegetation Database VegItaly https://www.scienzadellavegetazione.it/en/vegitaly-3/, personal knowledge and unpublished material.

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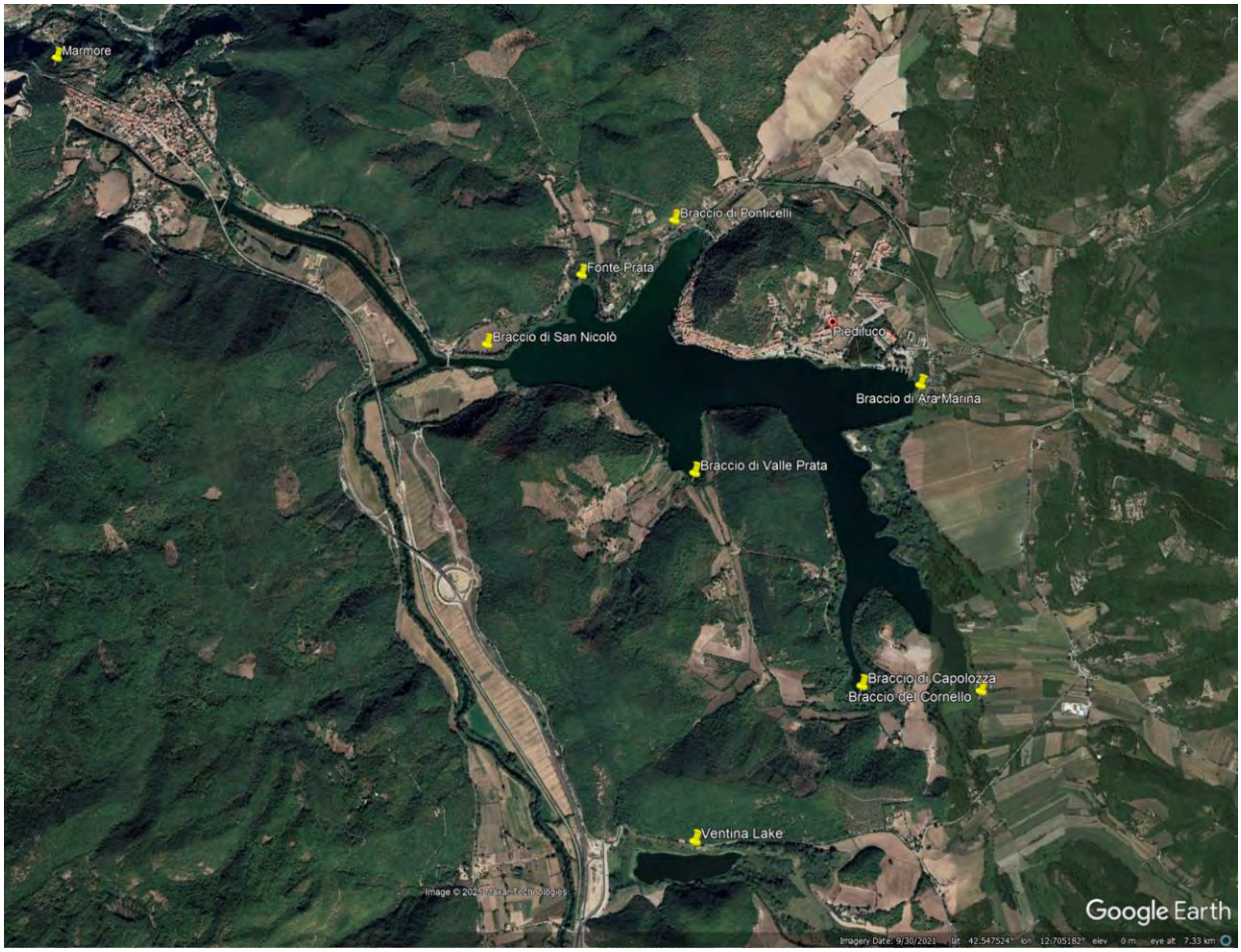
LAKE PIEDILUCO (LAGO DI PIEDILUCO)



Location

Coordinates: 42.5342° N, 12°7617° E

Altitude: 368 m a.s.l.

Introduction

Piediluco is a picturesque lake located at the border between the regions of Umbria and Latium, in the province of Terni. It is the second largest lake in Umbria, with a surface of 1.85 km^2, a maximum depth of 21.5 m and a perimeter of about 13 km. Like the waterfalls, Piediluco represented a popular stop of the European "Grand Tour" between the 17th and 19th century. The local landscape

is fascinating, surrounded by hills and forested mountains. On the northern part of the lake is the village of Piediluco, dominated by an ancient fortress (13th-14th Century) on top of a hill.

View of the Lake from Braccio Capolozza

The shape of Lake Piediluco is the result of a series of transformations that began during the Quaternary (2.6 million years ago) and ended around the XVI century, when the lake acquired today's shape and size. In 1924 the water regime of the lake was transformed and exploited for hydroelectric purposes, and its catchment area was extended from 75 to 2100 Km^2. Its natural tributary is the Fuscello stream. The other two tributaries are man-made canals, one that brings the water from the Velino River and the second one, 42 kilometers long, mostly flowing underground across tunnels conveying part of the waters of the Nera River into the lake. The water inflow and outflow of the lake are nowadays regulated to fulfill the energy needs of the city of Terni. The emissary is the Velino River, which is diverted towards Marmore, where it flows into the Nera River, forming the waterfalls.

During the summer season, the lake undergoes marked thermal stratification, while during the rest of the year, full water circulation occurs. In the last 30 years, there has been a progressive warming of its waters. The differences in temperature in the water column are quite limited in the central part of the lake, but are larger in the southern arms, where the water turnover is slower due to the peculiar shape of the lake and the presence of marsh vegetation. The intake of organic and inorganic substances triggers the growth rhythm of aquatic macrophytes inducing the increase in dissolved oxygen values in the surface layers and the steep decrease of oxygen concentration in the deeper layers due to the greater demand for oxygen by the bacterial communities responsible for algal decomposition. The complex hydraulic regulation system of the lake and the consequent internal hydrological dynamics have induced physical, chemical, and biological modifications of the water body. In the same way, over time, the increase in human activity and industrialization has contributed substantially to the variation of the trophic state of the lake. Overall, Piediluco is classified as a natural eutrophic lake with a tendency towards hypertrophy in the central and southern sectors and mesotrophy in the western sector (Stufara & Sconocchia 2005).

Close to Piediluco is the little Lake Ventina, but only a very small part of it is in the Umbria Region, while most of its surface belongs to the Lazio Region. This small waterbody represents a shrine of biodiversity, hosting all the plant species and communities present at Lake Piediluco and even more.

Climate

Lake Piediluco falls within the temperate Mediterranean bioclimatic region, characterized by mild winters and warm, dry summers. The mean annual temperature ranges between 14 and 16 °C. Its climate is influenced by the proximity to the Apennine Chain, which moderates temperature fluctuations and brings frequent rainfall, especially in autumn and spring. The mean annual precipitation is approximately 1000–1200 mm. (Biondi et al. 2002).

Geology and Geomorphology

Lake Piediluco represents a complex geomorphological system, shaped by tectonic activity, river erosion, sediment deposition, and human intervention during the middle and high Holocene. Together with the lakes Ventina, Lungo, and Ripasollile (located in the Lazio Region), the lake of

Mosaic of vegetation units at Braccio di Ara Marina

Piediluco represents the last remnant portion of the ancient Lacus Velinus, present in the area before the Roman period (4th century BCE). The Lacus Velinus was formed due to tectonic and alluvial processes during the Pleistocene and was drained in Roman times due to the construction of the Marmore waterfalls. Lake Piediluco collects the waters and sediments coming from the Velino River and the surrounding calcareous hills and mountains (Brunamonte et al. 2009).

Its shape is irregular and is characterized by numerous branches, located mainly on the northern and southern shores, with the following names:

- Braccio di Ponticelli: it is the northernmost arm of the lake. It receives the water from the River Nera through the artificial canal "Canale Medio Nera".
- Braccio di Ara Marina: it is in the easternmost part of the lake. It receives the waters of the Fuscello stream.
- Bracci di Cornello and Capolozza: the two southernmost arms. These represent the less deep areas of the lake.
- Braccio di Valle Prata: located opposite the village of Piediluco.

- Braccio di San Nicolò: it is the westernmost and is directly connected to an emissary-tributary canal; this is also one of the shallowest areas of the lake.
- Fonte Prata inlet: it is located between the Braccio di San Nicolò and the Braccio di Ponticelli and is also characterized by shallow waters.

Flora and Vegetation

Lake Piediluco is surrounded by hills covered by mixed forests and dense holm oak forests (the same described for the Marmore waterfalls). Fragmented and often degraded willow and poplar forests referred to the associations *Populetum albae* and *Salicetum albae* characterize various parts of the plain surrounding the lake. Patches of *Salicetum cinereae* occur in the Southern part of the lake, where they are often in contact with the hygrophilous vegetation of the alliance *Magnocaricion gracilis* and host several rare and interesting species, like *Viburnum opalus* and *Frangula alnus.* The southern arms of the lake (Braccio di Capolozza) host remarkable aspects of the *Carici remotae-Fraxinetum oxycarpae*, a riparian forest community which is very rare in Italy (Venanzoni & Gigante 2000).

The marsh and aquatic vegetation are unevenly distributed due to the complex bathymetry of the lake. The central part of the lake is more than 20 m deep and does not allow any aquatic species to grow. The aquatic and marsh vegetation are mainly concentrated in the inlets (called “braccia” = arms) of the lake. The shallower and longer arms are also the richest in terms of aquatic and marsh vegetation. In fact, Braccio del Cornello, Braccio Capolozza, and Fonte Prata inlet host the most interesting plant species and communities. Species that are extremely rare in all central Italy occur in this lake. For example, *Cladium mariscus*, *Epipactis lacustris, Nuphar lutea, Ranunculus lingua,* and *Rumex hydrolapathum*. The vegetation dominated by Nuphar lutea totally disappeared from the Umbria Region, remaining only at Lakes Piediluco and Ventina. Other rare aquatic associations occurring in this territory are *Potamogetonetum natantis* and *Potamogetonetum lucentis.*

The marsh vegetation is mainly represented by communities framed into the orders Phragmitetalia and Magnocaricetalia. The occurrence of the association *Cladietum marisci* is another rare highlight; in fact, in central Italy this community only occurs at Lake Piediluco, Chiusi and close to Viterbo

(Biondi et al. 2002). Another association which is rare in central Italy but is well preserved at Piediluco is the *Caricetum elatae.* The dominant species, *Carex elata*, is here accompanied by species such as *Lysimachia vulgaris*, *Carex acutiformis, Rumex hydrolapathum, Scutellaria galericulata* and *Sparganium erectum.* The presence of these associations is indeed connected with the high concentration of calcium carbonate in the water.

The vegetation of the *Magnocaricion gracilis* with associations like *Cyperetum longi, Caricetum acutiformis* and *Caricetum ripariae* are mostly concentrated on the driest edge of the reed vegetation or along the artificial ditches at the border of agricultural fields.

Nature conservation

Lake Piediluco is included in the Natura 2000 Network as a Special Protected Area IT5220026, which covers an area of approximately 1.67 km². Since the 1980s the lake started to suffer from increasing eutrophication and pollution, which led to a ban of fishing and bathing for many years, creating serious problems for the local economy. Since that time, local institutions have started to study every aspect of the lake in detail, investigating the causes of degradation of the water quality. The lake went through several remediation interventions and depuration projects. Currently, the chemical and physical parameters of the lake are continuously monitored, and the quality of the water has improved significantly. Therefore, fishing and bathing are now allowed.

The complex shape and hydrology of the lake make it a complex ecosystem rich in biodiversity. The fauna of Lake Piediluco is very rich, and the waterbody is frequented by a high number of birds, fishes, amphibians, and invertebrates, whose presence induced the establishment of the local Special Protected Area. This lake was not included in the list of Sites of Community Importance, mainly due to the anthropogenic impacts and pollution problems. However, its flora and vegetation are of remarkable interest not only at the regional level but also for all central Italy from many points of view.

Natura 2000 Habitats occurring in the area

3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.

3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type

7210* Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*

Natura 2000 Habitats occurring in the surrounding area

9340 *Quercus ilex* and *Quercus rotundifolia* forests

92A0 *Salix alba* and *Populus alba* galleries

8310 Caves not open to the public

Threats and pressures

a) *Pollution*. Due to agriculture, fish farming, and increasing tourism

b) *Climate change*. It alters the water stratification due to temperature variations, causing the eutrophication in some parts of the lake.

c) *Invasion of exotic species*. The number of exotic plant and animal species is increasing in the territory.

Nuphar lutea (L.) Sm.

Cladium mariscus (L.) Pohl

Carex elata All.

Species list

Acer campestre
Agrostis stolonifera
Alisma lanceolatum
Alisma plantago-aquatica
Alliaria petiolata
Allium vineale
Althaea officinalis
Angelica sylvestris
Anthriscus sylvestris subsp. nemorosus
Arenaria leptoclados
Argyrolobium zanonii
Astragalus hamosus
Avena barbata
Berula erecta
Bidens frondosus
Bidens tripartitus
Brachypodium distachyum
Brachypodium sylvaticum
Bromus madritensis
Bupleurum baldense
Butomus umbellatus
Callitriche hamulata
Callitriche stagnalis
Calystegia sepium
Carex acutiformis
Carex elata
Carex hirta
Carex leersii
Carex pendula
Carex pseudocyperus
Carex remota
Carex riparia
Carex vesicaria
Catapodium rigidum
Centaurium erythraea
Ceratophyllum demersum
Cirsium arvense
Cirsium creticum subsp. tri-umfettii
Cladium mariscus
Clematis vitalba
Convolvulus cantabrica
Cornus sanguinea
Coronilla scorpioides
Corylus avellana
Crataegus monogyna
Crepis sancta
Cruciata laevipes
Crupina vulgaris
Cyanus triumfettii
Cyperus fuscus
Cyperus longus
Dipsacus fullonum
Echinochloa crus-galli
Elodea canadensis
Epilobium hirsutum
Epilobium parviflorum
Epipactis palustris
Equisetum arvense
Equisetum palustre
Equisetum telmateia
Euonymus europaeus
Eupatorium cannabinum
Euphorbia exigua
Frangula alnus
Fraxinus angustifolia subsp. oxycarpa
Galega officinalis
Galium aparine
Galium mollugo
Galium mollugo subsp. erectum
Galium palustre
Galium parisiense
Geranium dissectum
Geranium robertianum
Geranium rotundifolium
Geum urbanum
Glyceria maxima
Hedera helix

Hippocrepis biflora
Hippuris vulgaris
Humulus lupulus
Hypericum perforatum
Hypericum tetrapterum
Hypochaeris achyrophorus
Iris pseudacorus
Juncus articulatus
Juncus effusus
Juncus inflexus
Leersia oryzoides
Lemna minor
Lemna trisulca
Ligustrum vulgare
Limniris pseudacorus
Linum corymbulosum
Lolium arundinaceum
Lonicera japonica
Lotus corniculatus
Lycopus europaeus
Lycopus exaltatus
Lysimachia arvensis
Lysimachia nummularia
Lysimachia vulgaris
Lythrum salicaria
Medicago lupulina
Medicago minima
Medicago orbicularis
Mentha aquatica
Mentha arvensis
Mentha longifolia
Myosotis laxa subsp. cespitosa
Myriophyllum verticillatum
Myriophyllum spicatum
Nasturtium officinale
Nuphar lutea
Oenanthe aquatica
Oenanthe fistulosa
Pallenis spinosa
Pastinaca sativa subsp. urens
Persicaria amphibia
Persicaria maculosa
Petrorhagia saxifraga
Peucedanum altissimum
Phalaris arundinacea
Phragmites australis
Plantago major
Poa palustris
Poa trivialis
Populus alba
Populus x canescens
Potamogeton crispus
Potamogeton lucens
Potamogeton natans
Potamogeton perfoliatus
Potamogeton trichoides
Potentilla reptans
Poterium sanguisorba
Prunus spinosa
Pulicaria dysenterica
Quercus cerris
Quercus pubescens
Ranunculus lingua
Ranunculus repens
Reichardia picroides
Robinia pseudoacacia
Rosa sempervirens
Rubus caesius
Rubus ulmifolius
Rumex hydrolapathum
Rumex crispus
Ruppia cirrhosa
Sagittaria sagittifolia
Salix alba
Salix caprea
Salix cinerea
Sambucus nigra
Saponaria officinalis
Schoenoplectus lacustris subsp. lacustris
Schoenoplectus lacustris subsp. glaucus
Scorpiurus muricatus
Scrophularia umbrosa
Scutellaria galericulata

Securigera securidaca
Sedum hispanicum
Sedum rupestre
Sedum sexangulare
Sherardia arvensis
Silene latifolia
Solanum dulcamara
Solidago canadensis
Sparganium erectum
Spirodela polyrhiza
Stachys palustris
Stachys romana
Stachys sylvatica
Stuckenia pectinata
Thalictrum lucidum
Trifolium campestre
Trifolium fragiferum
Trifolium pratense
Trifolium repens
Trifolium scabrum
Typha angustifolia
Typha latifolia
Urospermum picroides
Urtica dioica
Utricularia australis
Valeriana officinalis
Verbena officinalis
Veronica anagallis-aquatica
Veronica beccabunga
Viburnum opulus
Viola odorata
Zannichellia palustris

Ranunculus lingua L.

Butomus umbellatus L.

Syntaxonomic synopsis

LEMNETEA O. de Bolòs & Masclans 1955
LEMNETALIA MINORIS O. de Bolòs & Masclans 1955
Lemnion minoris O. de Bolòs & Masclans 1955
Lemnetum trisulcae den Hartog 1963
Lemnetum minoris von Soó 1927

POTAMOGETONETEA Klika in Klika & Novák 1941
POTAMOGETONETALIA Koch 1926
Potamogetonion Libbert 1931
Potamogetonetum pectinati Carstensen ex Hilbig 1971
Potamogetonetum perfoliati Miljan 1933
Potamogetonetum lucentis Hueck 1931
Nymphaeion albae Oberdorfer 1957
Nymphaeo albae-Nupharetum luteae Nowiński 1927
Potamogetonetum natantis Hild 1959

CALLITRICHO HAMULATAE-RANUNCULETALIA AQUATILIS Passarge ex Theurillat in Theurillat et al. 2015
Ranunculion aquatilis Passarge ex Theurillat in Theurillat et al. 2015
Callitriche stagnalis community

CHARETEA INTERMEDIAE F. Fukarek 1961
CHARETALIA INTERMEDIAE Sauer 1937
Charion intermediae Sauer 1937

PHRAGMITO-MAGNOCARICETEA Klika in Klika & Novák 1941
PHRAGMITETALIA Koch 1926
Phragmition communis Koch 1926
Schoenoplectetum lacustris Chouard 1924
Phragmitetum vulgaris Soó 1927
Typhetum angustifoliae Pignatti 1953
Sparganietum erecti Roll 1938
Phalaridetum arundinaceae Libbert 1931
MAGNOCARICETALIA Pignatti 1953
Carici-Rumicion hydrolapathi Passarge 1964
Mentho aquaticae-Caricetum pseudocyperi Orsomando & Pedrotti 1986
Magnocaricion elatae Koch 1926
Caricetum elatae Koch 1926

Cladietum marisci Allorge 1921

Magnocaricion gracilis Géhu 1961

Caricetum ripariae Máthé & Kovács 1959

Caricetum acutiformis Eggler 1933

Cyperetum longi Micevski 1957

BIDENTETEA Tx. et al. ex von Rochow 1951

BIDENTETALIA Br.-Bl. & Tx. ex Klika & Hadač 1944

Bidention tripartitae Nordhagen ex Klika & Hadač 1944

Bidenti-Polygonetum mitis R. Tüxen 1979

Cyperus fuscus community

ALNETEA GLUTINOSAE Br.-Bl. & R. Tüxen ex Westhoff, Dijk & Passchier 1946

ALNETALIA GLUTINOSAE R. Tüxen 1937

Salicion cinereae Müller & Görs 1958

Salicetum cinereae Zolyomi 1931

SALICETEA PURPUREAE Moor 1958

SALICETALIA PURPUREAE Moor 1958

Salicion albae Soó 1930

Salicetum albae Issler 1926

QUERCO-FAGETEA Br.-Bl. & Vlieg. in Vlieg. 1937

POPULETALIA ALBAE Br.-Bl. ex Tchou 1948

Populion albae Br.-Bl. ex Tchou 1948

Populetum albae Br.-Bl. 1931 ex Tchou 1947 *salicetosum albae* (Br.-Bl. 1931) Tchou 1946

Carici remotae-Fraxinetum oxycarpae Pedrotti 1970 corr. 1992

Populus canescens community

References

The present description was realized using data from the scientific publications mentioned below, the materials published by the Regional Institution "Umbria" for the management of the Sites of the Natura 2000 Network https://www.regione.umbria.it/ambiente/piani-di-gestione, the reports published by Regional Agency for the Environmental Protection (ARPA Umbria), data stored in the Italian Vegetation Database VegItaly https://www.scienzadellavegetazione.it/en/vegitaly-3/, personal knowledge and unpublished material.

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