Report "The ecosystem services provided by Latvian natural grassland medicinal and aromatic plants"

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Content

Introduction

In recent years the attention towards the recognition of the benefits provided by natural parks and protected areas to local populations and visitors, has been underlined by numerous studies by important international organizations, including the Secretariat of the Conservation on Biological Diversity (CBD) Program of Work on Protected Areas, the Economics of Ecosystems and Biodiversity, World Wildlife Fund (WWF), International Union for Conservation of Nature's (IUCN) World Commission on Protected Areas and the Nature Conservancy. What emerged clearly from these studies is that the benefits deriving from the protection and safeguarding of wilderness are much higher than the costs associated with their establishment and care. According to the estimates of the World Bank, the sustainable management of a natural area can guarantee a very high return in economic terms: 100 dollars worth of services for every dollar invested.

At a methodological level, although the concept of the value of the externalities of a community heritage has been known for over 30 years, it cannot be said that there is a unified economic methodology to define the value of nature, biodiversity and elements of flora and fauna. Different ways of evaluating the natural environment can be experimented, for example some authors identify two modalities: flow of qualitative services and flow of qualitative-quantitative services (Grillenzoni and Grittani, 1994) where the first type is mainly evaluated with the direct modality called contingent evaluation. Contingent evaluation is a methodology to assess the value that a person gives to a certain good, either material or immaterial. Usually it is split in, will to pay (WTP) or will to accept (WTA) such as the willingness to incur expenses to enjoy or to provide a certain (public) good/service. The second type of value is estimated as the sum of the previous value with the values generated by economic activities linked to the natural asset. What is certain is that there is a value, not simply monetizable, but that must be made explicit and every time you can demonstrate how much a natural environment is worth, you take a step forward in its protection. Today, thanks to tourism and the access of millions of visitors to protected areas, it is easy to understand the value of nature by the general public and by politics, but it is very difficult to explain why to protect one or more specific areas, one or more particular biotopes or natural formations, or even one specific species of flora or fauna. Probably the best interpretation of the reason lies in the value of these entities in the conservation of global biodiversity.

Biodiversity is a concept that seems quite difficult to explain to the public, and it is complex to explain its immense and contingent value for mankind. Even though biodiversity is quite an everyday refrain either in media or in policy initiatives, it is not easy to understand by the everyman why it is important to safeguard such a species, perhaps not very interesting or visible, and the environment which it inhabits. In the report context the environment is natural grasslands.

In the case of medicinal, we can instead say that it is a little easier to do this type of reasoning and then transfer it to the rest of the world of nature of the living beings that populate it. Medicinal plants are our medicines, we need them for health. This concept is strongly reinforced by the recent pandemic period, where the use of natural medicine against a virus and the stress caused by the situation, has been the one of the few solutions. Medicinal and aromatic plants (MAPs), thanks to their richness in terms of useful substances, are a direct link between biodiversity and value for humanity.

About 300,000 plant species are known in the world, but only 15% of them have been fully described from a biochemical point of view (De Luca *et al.* 2012). In the research work about 100,000 chemical structures have been isolated and identified from the plant kingdom and each species has its own unique bouquet of secondary compounds, which generally shows high intra-specific variation (Hartmann, 1996). Over the millennia, man has learned to use these plants for purposes other than food and mainly for purposes of improving health and treating disease, and to date there are 33,443 species of higher plants used for these purposes (Medicinal Plant Names Services, Kew Botanical Garden) to which we have to add hundreds of species of fern and mosses, including macroscopic fungi and algae. We are facing a potential of millions of different compounds, largely undiscovered, that can help the mankind of the future to face the changes the planet is undergoing. Again, back to the pandemic, they seem very strategic as a heritage for future generations.

The heritage undoubtedly has a value for mankind in such a sense both material (in terms of products) and immaterial (in terms of services). First, the natural areas have always been a source of MAPs obtained by wildcrafting. Globally it is estimated that the wild harvesting of MAPs is still of great importance both for local economies and for the international market. The quantity of products from wildcrafting, compared to cultivation, is very difficult to determine. Some sources (Schippman *et al.*

2006) indicate that although most (60-90%) of the material traded is declared of cultivation origin, but in terms of number of species, the opposite is true. Furthermore, the analysis of the market that passes through customs all over the world does not take into account self-consumption which is certainly a factor that is anything but secondary. Regarding self-supply and self-consumption, this is close to non-monetary and informal economies, but remains rooted in many cultures linked to rural environments throughout Europe. In addition to the benefit deriving from the use of natural products, the habitual user enjoys the added value that comes from self-preparation, consisting of the well-being perceived when he is in nature to collect, but also from the satisfaction of the service aimed at the own person. These values are difficult to evaluate directly, and the aim of this study is to bring them into evidence.

Of course, we should start from a point if we want to specify a value of a given resource by determining a stock of biomass. Determining the stock of a particular species present in nature, and then its value, is a step that is anything but easy to carry out. Fairwild Foundation (www.fairwild.org), a non-governmental organization in the last twenty years deals with the collection of wild plants (both food and non-food use) has developed a complex procedure, which is based on combining both the distribution of the target species in the collection area, and the density of the same, also indicating the biomass that each individual produces. The process that brings to assessment of a resource depends a lot on its abundance and its vulnerability, being more precise as much as the plant is threatened by harvesting.

In the case of the present study, to combine two sampling methods has been the chosen method allowing a reliable estimate distribution and density/abundance thus defining the most likely density, referred to per square meter of the target plants. Determining the real on-the-ground number of specimens, on the other hand, is considered not useful for this study scope. Once the number of plants is likely determined, through the weighing of a given number of individuals it is therefore possible to calculate that biomass. The biomass expressed in kg/m^2 or kg/ha multiplied by an economic value gives us the economic value of the material. What value applies to this calculation is something that is worth some detailed explanation.

It must be said that evaluating a natural environment with the direct method, or the sum of the flow of quantitative services/goods provided by the environment itself, is certainly a gross understatement, especially when compared to an agricultural production environment, where specialized cultivation can defeat any comparison. Therefore, the evaluation must be carried out consistently, with the method of the flow of quali-quantitative goods/services. Then the goods that the environment provides as a "biomass" must necessarily be translated into a “product with a high service content”, as it can be considered a finished product. In other words, it will be necessary to estimate the weight of the collected material, not for its generic, and difficult to determine, market value, but to adopt a value referring to a product in its consumption phase, finally not a bulk product approach but a “per serving” approach. In any case we will keep both, bulk and per serving method, for a better understanding.

There are many perspectives to define the value of the natural resources and nature itself. One is to evaluate quantities and calculate economic value to measure provision service of MAPs from in this case natural grasslands described below. Another option is to figure out demand for the service by local society or even globally. Cultural traditions or practices to use MAPs are well studied topics, however there are very few quantitative studies of current demand for the ecosystem service worldwide. There are some publications from Africa or Asia (Rahman *et al.* 2012, Asamoah and Wiafe 2016), but almost nothing about the situation in Europe. In Latvia we have some initial studies of current MAPs usage done based on folklore materials (Sile *et al.* 2020) and ethnobotanical research (Simanova *et al.* 2020, Prūse *et al.* 2021). The ethnobotanical research has shown that there are long traditions of wild-collection of MAPs in Latvia for various purposes, e.g., medicinal, food, ethnoveterinary. However, the studies do not include quantitative information on the number of plants collected in the wild. The report tries to fill the information gap by including unique social survey data that represents the country-wide MAP usage situation in Latvia. It includes quantitative results of plant consumption and additional information that explains the consumption habits of natural grassland MAP usage.

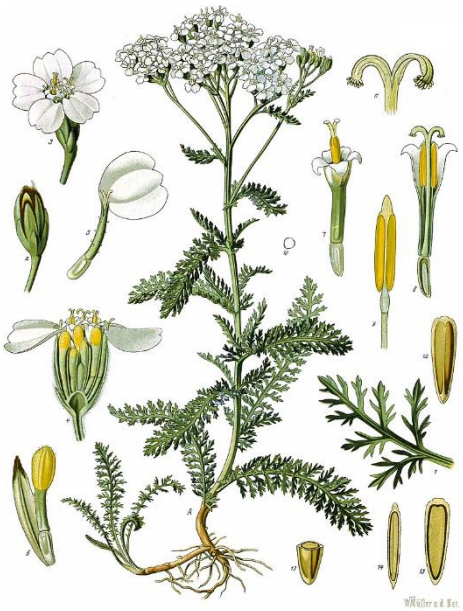
The grassland plants with medicinal or aromatic value

Grassland plants with the highest medicinal potential were selected. Here we list the species that have been the subject of the study with the most important and consolidated properties, reported both in ancient texts (Mattioli, Clusius, Besler) then confirmed by more recent studies or literature listed in Annex 1.

The selection of species was based upon the following points:
- well established information from anecdotal or scientific literature about medicinal or health use of the plant.
- information not supported by official documents, but whose popular use is known and there are no health risks for the person using it.

Beyond this introduction it is very interesting to see how broad the popular pharmacopoeia relating to medicinal plants is. It is also surprising that the same plants, widely distributed in Europe, have the same uses in common among very different and distant societies.

***Achillea millefolium* L. – *Asteraceae* family**



Geographical distribution: widespread Asia and Europe

Habitat: grows well on calcareous soil, common in grasslands, roadsides from seashore to alpine environments. Characteristic species in moderately wet or dry grasslands in different plant societies.

Drug: aerial parts with flowers

Active substances: chamazulene, flavonoids, terpenes

Uses and properties: flowers and the whole herb is used as tea, essential oil is used for liquors (yellow type) or as for chamomile (blue type), rich in chamazulene.

***Agrimonia eupatoria* L. – *Rosaceae* family**

Geographical distribution: northern hemisphere, Europe

Habitat: grows well on calcareous soil, common in grasslands, shrublands, on forest borders, roadsides, and open river slopes

Drug: aerial parts

Active substances: tannins, flavonoids, triterpenes, phytosterols

Uses and properties: fresh and dried herb are consumed as tea. Astringent- cicatrizant- hypoglycaemic properties, used for internal and external disorders, such as pharyngitis, gastroenteritis, and intestinal inflammations, conjunctivitis, dermal and oral irritations.

***Aegopodium podagraria* L. - *Apiaceae* family**

Geographical distribution: originating from Eurasia, naturalized in North America

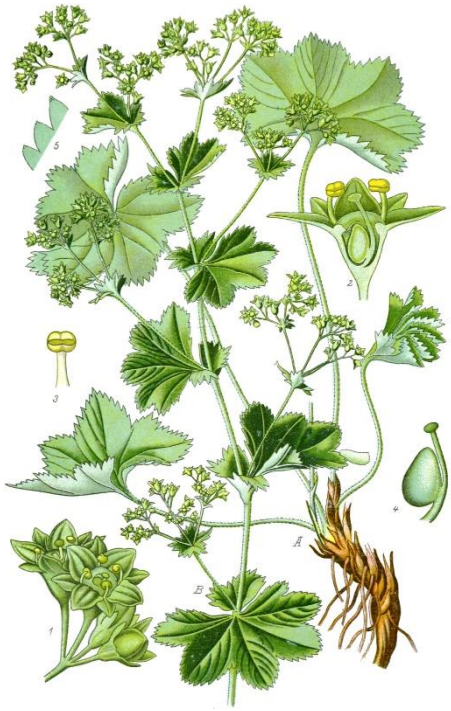
Habitat: damp woods, slopes, shrubland, loam soils and rich in nitrogen

Drug: entire plant

Active substances: essential oil, carotene, saponins

Uses and properties: raw young leaves and stems are consumed in salad or cooked as greens. Thanks to its soothing property, in the traditional medicine, it is applied after insect sting, and is used for the treatment of gout and rheumatism.

***Alchemilla* spp. - *Rosaceae* family**



Geographical distribution: Europe, Northern America, and Asia

Habitat: grow in acid alpine and subalpine grassland, mountain hay meadows; in Latvia can be found at any type of habitats except wetlands.

Drug: entire plant

Active substances: tannins, flavonoids

Uses and properties: the plant is edible, in England is used to prepare the Easter herb pudding. The species are indicated for the treatment of diarrhoea, sedation, and analgesic actions; also, diuretic, and purifying properties.

***Artemisia campestris* L. – *Compositae* family**

Geographical distribution: originating from Asia, now distributed in North America, widely present in Asia, North Africa, and Europe

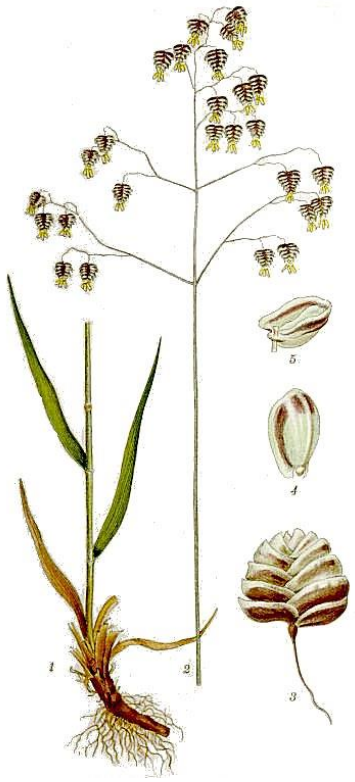
Habitat: grasslands, meadow, forest glades and forest edges, and grows mainly on dry soils, dry pastures, gravelly field, in the calcareous rock fields and barren grounds

Drug: flowers and leaves

Active substances: alkaloids, saponins, terpenes, coumarins, flavonoids, phenolic acids and essential oil

Uses and properties: antimicrobial, antioxidant, cytotoxic, insecticidal, anti-venomous activities, used as hypoglycaemic, cholagogue, choleretic, digestive, depurative, antilithiatic, and for the treatment of obesity and to decrease cholesterol; digestive, respiratory, cutaneous, and genital diseases

***Briza media* L. - *Poaceae* family**



Geographical distribution: western Europe, North America

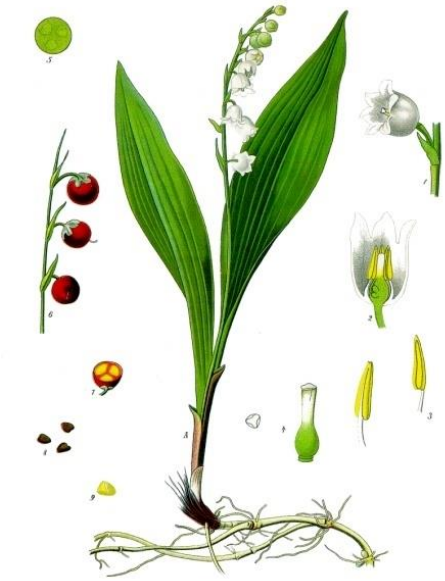
Habitat: dry and calcareous, also moist, and acidic grassland, semi-natural calcareous pastures, scree slopes, quarry spoil and road verges, and has been recorded from old meadows and enclosed pastures

Drug: aerial parts

Active substances: Phytoecdysteroid compounds, flavonoids, astragalin

Uses and properties: used in the treatment of diabetes, deterrent to insect predators, cholagogue and spasmolytic activities

***Convallaria majalis* L. – *Asparagaceae* family**



Geographical distribution: Northern hemisphere

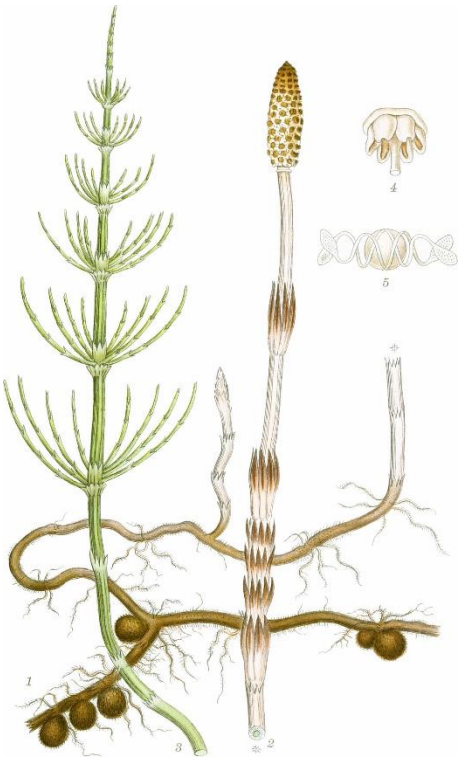
Habitat: slopes, shaded shrublands and forestry areas

Drug: flowers, leaves, rhizome

Active substances: cardiac glycosides (convallatoxin), steroid saponosides, essential oil

Uses and properties: diuretic, cardiotonic uses, with an action similar to that of the Digitalis sp.

***Equisetum arvense* L. – *Equisetaceae* family**



Geographical distribution: Northern temperate regions

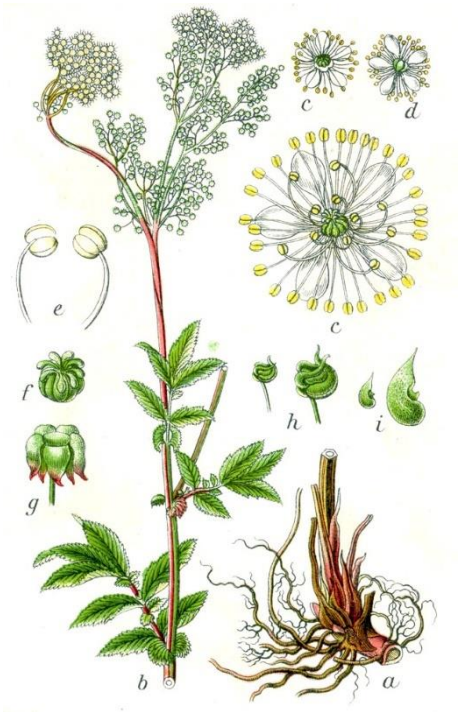
Habitat: dry soils, along the roads, in set-asides, and grasslands from the seaside to the mountains

Drug: infertile aerial parts

Active substances: silicic acid, flavonoids, saponins, phytosterols, ascorbic acid

Uses and properties: the buds are eaten boiled and fried. Diuretic and remineralizing, anti-inflammatory, cicatrizant, used as a teeth whitener

***Filipendula ulmaria* L. – *Rosaceae* family**



Geographical distribution: Eurasia, North America

Habitat: wide range of shore types, mesic and moist areas in grasslands, forests

Drug: flowers, flower tops

Active substances: flavone derivate (spiraeoside), salicylates, essential oil, tannins

Uses and properties: flowers and leaves are used as a flavouring for herb beers, mead, claret wine, liqueurs, and stewed fruits, and as tea. Anti-inflammatory, diuretic, and antispasmodic activities. Used in the treatment of articular pains.

***Filipendula vulgaris* L. - *Rosaceae* family**

Geographical distribution: Eurasia

Habitat: dry meadows, south-facing slopes, forest meadows, alpine meadows, pastures, chalky soils, riverside meadows, and steppes

Drug: flowers, flower tops

Active substances: flavanol glycosides, ellagitannins

Uses and properties: young leaves are used in soups and salads; antirheumatic, antipyretic, anti-ulcer properties

***Fragaria viridis* Weston – *Rosaceae* family**

Geographical distribution: Eurasia

Habitat: aspen-birch groves, on open grassy mountain slopes, on edges and glades of mountain forests, in meadows, and in meadow steppes

Drug: fruits, leaves

Active substances: ellagitannins, phenolics, anthocyanins, flavanols, essential oil

Uses and properties: antioxidant, anti-inflammatory, antibacterial, anti-allergic, antidiabetic, and cancer preventive properties

***Galium verum* L. – *Rubiaceae* family**

Geographical distribution: Europe

Habitat: from the seaside to the mountains, slopes, along the roads, dry grasslands, dunes

Drug: flower tops, aerial parts

Active substances: asperuloside, asperuline, tannins, flavonoids

Uses and properties: used as a vegetable rennet and as a colourant; edible fruits; diuretic, antispasmodic, styptic, astringent

***Geum rivale* L. – *Rosaceae* family**

Geographical distribution: North America, temperate regions of the Northern hemisphere

Habitat: along roads, in mixed hardwood forest, grasslands, on river and ditch sides, humid soils and rich in nitrogen

Drug: roots and leaves

Active substances: tannins, ellagitannins and gallotannins, triterpenes, sterols, and flavonoids, as well as small amounts of essential oil, phenolics

Uses and properties: roots are used for flavouring wine and liquors, leaves are eaten as salad, or cooked; astringent, anti-inflammatory and antiseptic agents, used for the treatment of diarrhoea, stomach complaints, febrile diseases, gingivitis, and inflammation of mucous membranes.

***Glechoma hederacea* L. – *Lamiaceae* family**

Geographical distribution: native to Eurasia, introduced and widespread in the USA, Canada, Europe, New Zealand, Western and Northern Asia

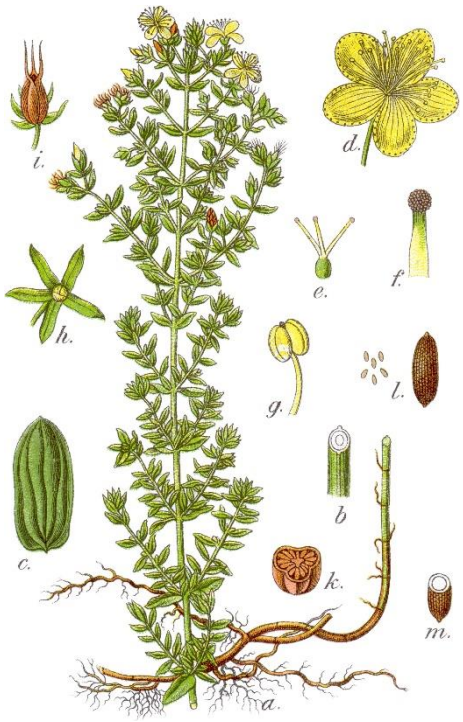
Habitat: hills and low mountainous zones of temperate Europe, from the sea level to the Alps, slopes, tolerant to shade and drought, edge of pastures, damp-heavy and fertile soils, woodlands, hedgerows, moist meadows

Drug: aerial parts

Active substances: essential oil, tannins, organic acids, resin, terpenoids

Uses and properties: fresh or dried leaves are used for making tea, leaves and young shoots are eaten fresh or cooked. Antibacterial activity of the extract, anti-inflammatory activity of the essential oil, furthermore, used for the treatment of cough and asthma; the drug also has tonic and diuretic properties.

***Hypericum perforatum* L. – *Hypericaceae* family**



Geographical distribution: Eurasia, North Africa

Habitat: along roads, in borders of forests, wasteland, slopes, grasslands, set-asides, shrublands, on river banks

Drug: flower tops

Active substances: naphtodiantrones (hypericin), phloroglucinols, flavonoids (rutin, hyperoside), biflavones, phenylpropanoids, proanthocyanidins, tannins, essential oil

Uses and properties: dried herbs or flowering tops sometimes are used as a tea, cicatrizant and soothing, anti-inflammatory, stomachic, antidepressant effect

***Linaria loeselii* Schweigg – *Plantaginaceae* family**

Geographical distribution: endemic of the Baltic region

Habitat: coastal dunes, coastal meadows, salinity tolerant, oligotrophic

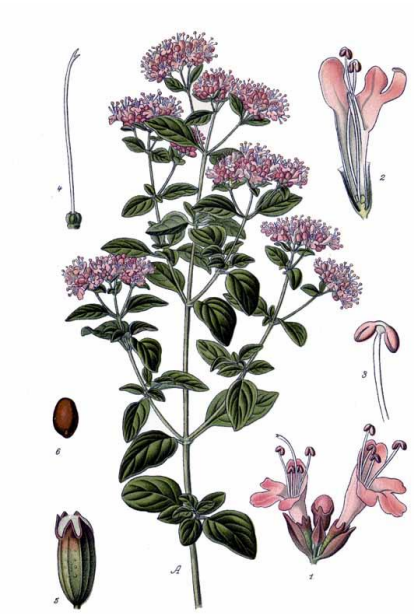
Drug: aerial parts, leaves

Active substances: iridoids (linaride, linarioside, antirrhide, antirrhinoides), pheophytin a, cyclohexene-carboxylic acids

Uses and properties: anti-inflammatory, antioxidant, anticoagulant and neuroprotective activities, antitumor effects

Notification! Because of the lack of information concerning drug, active substances, uses and properties of *Linaria loeselii*, we report *L. purpurea* hallmarks, on account of the similarity with *L. loeselii*.

***Origanum vulgare* L. – *Lamiaceae* family**



Geographical distribution: Mediterranean region, Eurasia

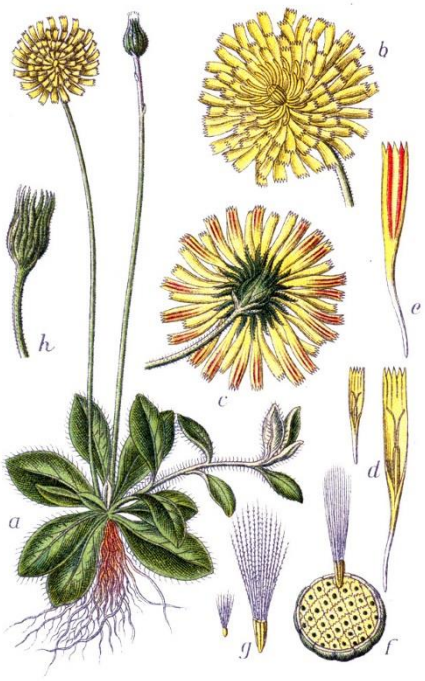
Habitat: along the woods, streets, and lawns, in dry grasslands, on riverbank slopes, prefers calcareous soils and sunny areas

Drug: aerial parts

Active substances: essential oil, flavonoids, tannins,

Uses and properties: flavouring, fresh or dried leaves are steeper for tea; digestive, antispasmodic, diuretic, stomachic, balsamic

***Pilosella officinarum* W.F.Schultz & Sch.Bip. – *Compositae* family**



Geographical distribution: native to Britain and Europe, some species were introduced in New Zealand and North America, temperate regions

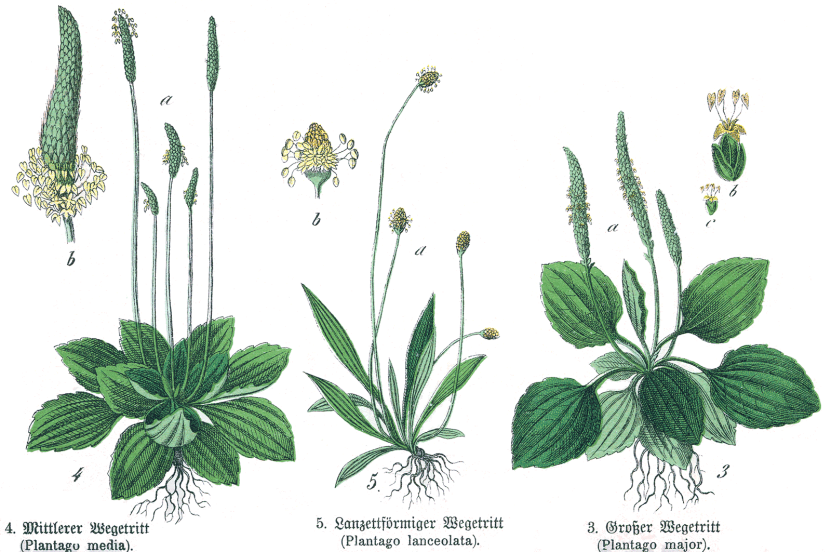
Habitat: grows in dry pastures, pine forests, on forest edges, and dunes

Drug: aerial parts and rhizome

Active substances: phenolic acids (chlorogenic, dicaffeoylquinic acids), coumarins, flavonoids, sesquiterpene lactones, terpenoids, phytosterols

Uses and properties: herbal tea, diuretic, antipyretic, anti-inflammatory, and antimicrobial effects, used in the treatment of skin problems, kidney problems, gastric and intestinal illnesses

***Plantago lanceolata*, *Plantago major*, *Plantago media* - *Plantaginaceae* family**



Geographical distribution: whole Europe, North and Central Asia. The main import comes from Eastern Europe

Habitat: grows in grasslands, temperate regions, sunny-humid places, clay soil that is rich in nitrogen

Drug: entire plant

Active substances: mucilage (polysaccharides), tannins, flavonoids

Uses and properties: leaves without the fibrous strands are used in salads, dried leaves are used for making tea, seeds are used like sago or in meals. Roots are also edible. Leaves are used externally in treating skin inflammations, malignant ulcers, cuts, stings, and conjunctivitis. Internally, they are traditionally used for otolaryngological treatments and bronchopulmonary infections. Also, diaphoretic and antirheumatic use.

***Polygala vulgaris – Polygalaceae* family**

Geographical distribution: Europe

Habitat: dry grasslands, set-asides, along roads, base-rich soil, calcareous sand-dunes

Drug: entire plant

Active substances: saponins, gaulterina

Uses and properties: expectorant, is used for the treatment of bronchitis, bronchial asthma, diuretic and promotes milk production in cows

***Potentilla anserina, Potentilla argentea, Potentilla erecta – Rosaceae* family**

Geographical distribution: Asia, Europe, North America, prevalent in Northern Hemisphere and temperate regions.

Habitat: typically confined to the colder areas, acid grasslands

Drug: entire plant - rhizome (*P. anserina*), rhizome (*P. erecta*)

Active substances: tannins, polyphenols, flavonoids, terpenoids

Uses and properties: rhizomes (*P. erecta*) and leaves (*P. anserina*) are used as a tea, roots can be eaten raw, candid, fried, roasted or boiled, also used in soups and stews (*P. anserina*). Astringent action, used for the treatment of diarrhoea, anti-inflammatory and cicatrizant (external use) properties, antioxidant and antimicrobial activities.

***Primula veris – Primulaceae* family**

Geographical distribution: Northern temperate regions, Central Asia, Europe

Habitat: pastures, meadows, open deciduous and mixed deciduous-coniferous forests

Drug: rhizome and roots, flowers

Active substances: flavonoids, essential oil, carotenoids (flowers); triterpenoid saponins (roots and rhizome)

Uses and properties: leaves are eaten raw in salads or used as a substitute for tea, flowers are used in salad, canned food, pickles, as a garnish or fermented into liquor. Expectorant action, used in the treatment of bronchitis, respiratory problems, asthma. For external use: as mouthwash, for the treatment of bruises, stings, cracks

***Prunella vulgaris – Lamiaceae* family**

Geographical distribution: Northern Asia, Northern Hemisphere, Europe

Habitat: meadows and forest edges in cold areas, alpine meadows, shrublands, close to water

Drug: aerial parts

Active substances: tannins, polysaccharides, essential oil, triterpenoids, sterols, flavonoids, coumarins, phenolic constituents

Uses and properties: used as tea, health-promoting food, leaves are used as raw or cooked in salads and soups; tonic, stomachic, antiseptic, cicatrizant properties; antioxidant, anti-inflammatory activities and used for the treatment of fevers, diarrhoea, and sore mouth (in Chinese tradition)

***Sedum acre, Sedum telephium - Crassulaceae* family**

Geographical distribution: native of Eurasia, naturalized in North America (*S. acre*)

Habitat: spread everywhere, grows in ruins, walls, stony and sunny places, in dry forests, slopes, dunes, grasslands, along railways

Drug: leaves

Active substances: tannins, mucilage, alkaloids, flavonoid glycosides

Uses and properties: leaves are dried and grounded for a spicy seasoning (S. acre). Cicatrizant, anti-inflammatory, rubefacient properties; used for the treatment of ulcers, abscesses, whitlows, fistulae

***Solidago virgaurea – Compositae* family**

Geographical distribution: North America, Europe

Habitat: dry forests, shrublands, slopes, clearcuts, forest edges

Drug: flowering tops

Active substances: essential oil, flavonoids, triterpenoid saponins, phenolic acids

Uses and properties: antioxidant, anti-inflammatory properties, diuretic, cicatrizant, astringent, used in the treatment of stomatitis and sore throats; and also used as a colorant

***Stachys officinalis – Lamiaceae* family**

Geographical distribution: Europe

Habitat: humid grassland, clearing in the woods, loam, and clay soil

Drug: leaves, flowers, occasionally roots

Active substances: flavonoids, iridoids, tannins, saponins, traces of essential oil

Uses and properties: leaves and flowering tops are used for making a beverage; stomachic, expectorant, cicatrizant, tonic properties

***Taraxacum officinale – Compositae* family**

Geographical distribution: warmer temperate zones of the Northern Hemisphere

Habitat: grasslands, along roads, set-asides, open woods

Drug: root, entire plant

Active substances: potassium, fructose, inulin, mucilage (roots); sesquiterpenes lactones, flavonoids, potassium, taraxalisine (entire plant)

Uses and properties: leaves are eaten raw or cooked as salads, roots are eaten raw; depurative, diuretic, choleretic actions, used in the treatment of the digestive disorders and rheumatism (as a depurative)

***Thymus ovatus – Labiateae* family**

Geographical distribution: Central Europe, Mediterranean region

Habitat: grassland, gravelly soil, dry pine forests, on river valleys, along roads and railways

Drug: aerial parts

Active substances: essential oil, triterpenes, flavonoid glycosides, rosmarinic acid

Uses and properties: leaves are used for flavouring salads, sauces, soups, fish, poultry etc. and for making tea; expectorant, carminative; antioxidant, antibacterial, antifungal essential oil properties

***Tragopogon pratensis – Compositae* family**

Geographical distribution: native to Eurasia and North Africa, then introduced in North America

Habitat: grassland, along roads and railways, humid habitats, from sandy to clay loam, prefers sunny areas

Drug: root

Active substances: inulin, mucilages, triterpenic saponosides, poliphenolic acids (aerial parts)

Uses and properties: the whole plant is edible, buds, roots and leaves are eaten cooked; young leaves, shoots and diced roots are used in salads. Thanks to the presence of inulin, that lends a sugary taste, root is recommended for diabetics. The extract has detoxifying properties and stimulates appetite and digestion, moreover, is used for the treatment of gallbladder disease. The root has astringent, diuretic, depurative, expectorant, and stomachic properties.

***Vaccinium vitis-idaea – Ericaceae* family**

Geographical distribution: Northern Hemisphere, Northern temperate region, Central Europe, Canada, Russia

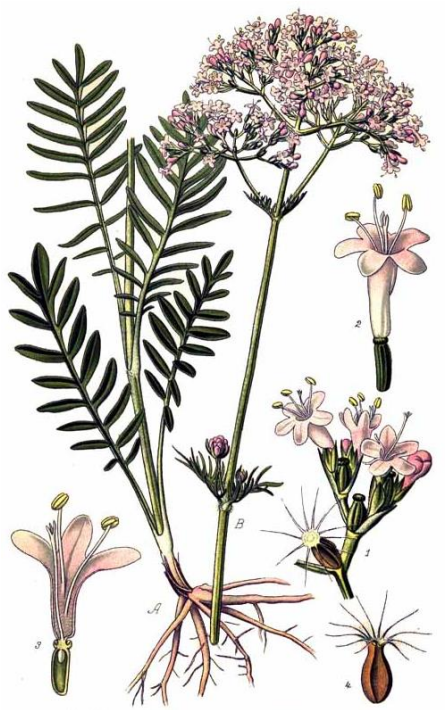
Habitat: moist to dry pine forests, bogs, heathlands, meadows, and tundra from low to alpine elevations, on acid soils

Drug: fruits, leaves

Active substances: anthocyanosides, tannins, organic acids (fruits), phenolic glycosides (arbutin), flavonoides (leaves)

Uses and properties: fruits are edible used for making sauces, tarts, jellies; astringent, anti-inflammatory, antiseptic urinary, glucose-lowering

***Valeriana officinalis – Caprifoliaceae* family**



Geographical distribution: Eurasia, North America

Habitat: shrublands, humid areas, along ditches, moist grasslands, on waterbody coasts

Drug: root, rhizome

Active substances: essential oil, iridoids/valepotriates, flavonoids, alkaloids

Uses and properties: used as herbal tea, root extract and essential oil are used for flavouring several food and beverages; sedative, antispasmodic, somniferous activities; used in the treatment of anxiety/nerves problems, convulsion, gastric spasms, insomnia

***Veronica chamaedrys*, *V. spicata* - *Plantaginaceae* family**

Geographical distribution: Northern temperate region; V. spicata is native to western Asia, distributed in Europe except in the West, where it is less frequent, and Northern America.

Habitat: sparse woods, mountain areas. Calcareous-rich shallow-soil lowland systems, often on dry grasslands or slopes

Drug: aerial parts with flowers

Active substances: flavonoids, tannins, chlorogenic acid, caffeic acid, iridoid glycosides, essential oil

Uses and properties: leaves are used as a substitute for tea; it is used as a stomachic, to stimulate appetite, because of the soothing property it is used for the treatment of bronchial and asthma disorders.

***Viola tricolor* – *Violaceae* family**

Geographical distribution: Eurasia

Habitat: common on the edges of cultivated fields, roadsides, in dunes, sandy set-asides, grasslands

Drug: entire plants, aerial parts with flowers

Active substances: salicylic acid, phenol carboxylic acids, mucilage, tannins, flavonoids, saponins, coumarins, anthocyanidins, carotenoids

Uses and properties: flowers are used as condiment in salads or as an attractive garnish; depurative, diuretic, analgesic, eudermic, anti-inflammatory, used for the treatment of dermatosis, rheumatism, urinary apparatus problems

Economic assessment of medicinal plants in grasslands: direct hypothesis

Evaluation of stocks of medicinal plants in grasslands

Investigated grasslands, their localization and selection criteria

The report is focused is semi-natural grassland habits. Almost all EU protected grassland habitats found in Latvia are semi-natural (the term natural is used only by following the tradition of the scientific language in Latvia) that requires extensive management (mowing or grazing without fertilizing and other improvement). Semi-natural grasslands (unlike cultivated grasslands) are biologically very diverse and repetitive extensive use has a key role in their existence (Rūsiņa 2013). However rapid changes in traditional agricultural practices especially since the 1950s most of semi-natural grassland habitats [further in the text: natural grassland] including their plant diversity have directed close to the disappearance of this historically typical landscape element in Latvia. Natural grasslands covered 30% in the 19th century (Rūsiņa 2013), but nowadays they occupy less than 1% of the total area of Latvia (Rūsiņa 2017). Natural grasslands are the most endangered group of habitats in Latvia according to the latest report about protected species and habitats in EU (Dabas aizsardzības pārvalde 2019).

GrassLIFE project (LIFE16NAT/LV/262) aims to improve the conservation status of five priority grassland habitats that are protected at the EU level. One specific project objective is to improve the economical perspective of sustainable grassland use by identifying and marketing the grassland-products with high added value, alternative options of agricultural or non-agricultural use of priority grasslands and their services. Our task in GrassLIFE was to investigate ecosystem services of MAPs as one of the natural grassland services with unknown market potential.

Natural grassland selection for field studies of MAPs was focused on five grassland habitat types targeted by GrassLIFE. They are the following EU protected grassland habitats:

- 6120* Xeric sand calcareous grasslands
- 6210* Semi-natural dry grasslands and scrubland facies on calcareous substrates
- 6230* Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in Continental Europe)
- 6270* Fennoscandian lowland species rich dry to mesic grasslands
- 6530* Fennoscandian wooded meadows

The field study methodology required information from high quality natural grasslands to investigate their MAPs diversity, biomass, and market potential. We assumed that high quality grasslands have the most typical vegetation and structure. The problem was to select grasslands for field studies when there is no systematic database of grasslands arranged by classified quality measures in Latvia. Therefore, the only chance was to call highly experienced grassland habitat experts and ask them to give a list of high-quality grasslands that they know. The experts were asked to share cadastral numbers of grassland, type of grassland and if known then also contact information and name of the grassland owner or maintainer. The territorial limit was the border of Latvia knowing that natural grasslands are scattered and rarely distributed in the country. Six grassland habitat experts (Baiba Strazdiņa, Baiba Galniece, Anete Pošiva-Bunkovska, Maija Medne, Solvita Rūsiņa, Viesturs Lārmanis) send the asked information of 51 grassland territories in total.

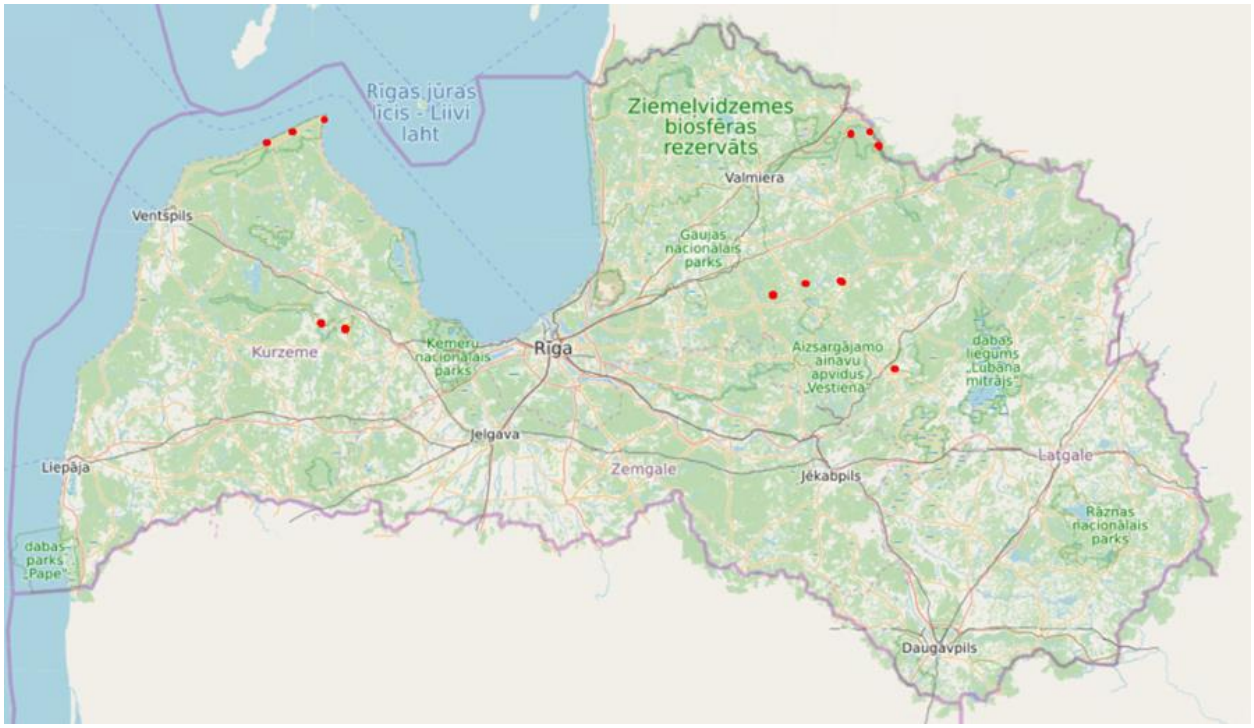


Figure 1. Locations (red dots) of studied grasslands in Latvia. Background: Open Street Map.

To select the final 15 grasslands (3 grasslands for each habitat type) information of their location and contacts of owner or maintainer was relevant. Grasslands without contact information were skipped (except two sites). Regions where residual grasslands formed clusters suitable for one full day field expedition were selected due to rational logistic reasons. Selected grasslands formed three clusters that belong to Kurzeme region, North-Vidzeme region and Central-Vidzeme region (Figure 1). Whole list of the studied grasslands, their type, location, and date of field visit is shown in Annex 2.

Methodology of field studies

The timeframe for grassland studies was limited. The grassland investigation required to collect field data when grasslands have reached their highest biomass and blooming state that is usually around summer solstice or just after it. It is the same period when mowing starts in permanent grasslands. The field studies required data collection before mowing or grazing actions that reduce plant biomass of grasslands. Due to the shortage of field study period and dependency on good weather (at least three days before field visit no rain), data of all 15 grasslands were collected in two seasons (Annex 2) - in 2019 (25.-27.06., 11.07.) and 2020 (16.-17.06., 03.07.).

Methodology of the field study consisted of four parts each aimed for specific data collection that were completed within one field visit per grassland site. The parts were 1) Full description of EU protected grassland habitat; 2) Counting of MAP species and diversity; 3) Evaluation of MAP distribution; 4) Biomass assessment of MAPs.

Full description of EU protected grassland habitat
The description of each grassland was done according to common and standardised methodology in Latvia that is used for mapping and describing EU protected grassland habitats. The methodology is published in interpretation manual of EU protected habitats in Latvia (Auniņš 2013). The work was done in all investigated grasslands by certified grassland habitat expert Rūta Abaja. The full description of the grasslands was done to compare similarity of grasslands within each habitat type to support other data explanation later.

Counting of MAPs species and diversity
Before counting MAPs, grassland experts went through the whole grassland polygon and made a list of all MAPs that were present. The list helped to remind what should be counted in the counting plots, evaluation plots of the plant spread and what plants should collect for biomass assessment. Plants that

are with medicinal or aromatic use and grow in grasslands in Latvia were listed before the field study by Andrea Primavera (Annex 3). Detailed description of each plant has summarised in the Chapter: *The grassland plants with medicinal and aromatic value*.

Next step was to find three counting plots in the grassland. It was done by throwing a little sampling frame (25x25 cm) behind the shoulder and looking where it lands. In the place where it lands, the counting plot was made. Counting plot was 1x1 m in size, divided in 16 smaller squares (25x25 cm). MAP counting was done in four smaller squares arranged in diagonal within the counting plot (Figure 2). Average value of counted plant individuals within the four smaller squares where the latter extrapolated to one m2 (size of each counting plot). Afterwards, the average value of three counting plots were extrapolated to the size of the grassland polygon thus gaining the number of individuals of each MAP species per grassland. Before counting each plot was photographed and the photo was marked with an ID number - the same as for the counting plot.

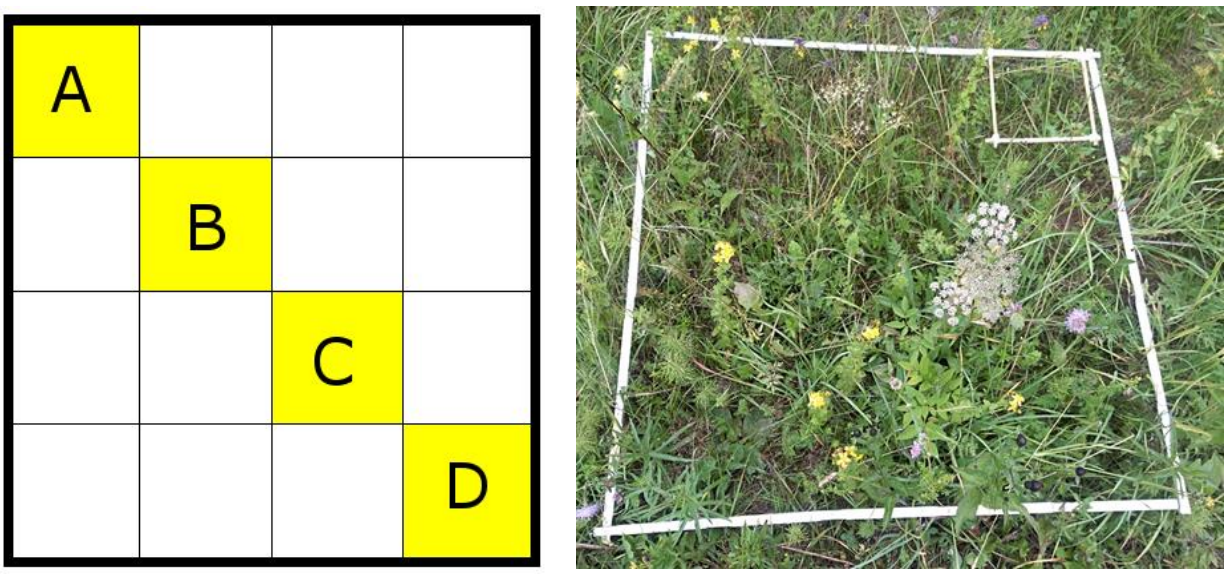


Figure 2. Design of counting plot on the left. Yellow squares illustrate squares in which plant counting was carried out. On the right: The counting plot in a field with a sampling frame used for plant counting both in the counting plot and for evaluation of distribution.

Distribution of MAPs

The small 25x25 cm frame was used also to collect data for evaluation of MAP distribution in grasslands. The small frame was 20 times thrown behind the shoulder in various directions of the grassland. Each place where it lands MAPs were counted within the little frame. The plants were counted according to their species included in the list of Annex 3. For example, *Filipendula ulmaria* - 3 individuals, *Achillea millefolium* - 2 individuals etc. After data collection an average number of each plant species were calculated from measures in 20 little distribution plots. The average value was extrapolated to the particular grassland.

Biomass assessment of MAPs

In each grassland, 10 samples were collected from each of the identified MAPs. Mostly, the aerial part was collected, but in some cases only roots or leaves were collected. Only plant parts with medicinal or aromatic use mentioned in pharmacopoeia or respectable literature and with the world market value were collected. List of the plants and their parts with medicinal or aromatic use are added in Annex 3. The list was used to choose which part of the plant to collect for biomass assessment. The harvested plants were weighed on analytical scales (accuracy up to 0,01 g) to determine the average weight of the green biomass of 10 plants in the lab during the same day of field study. The plants were transported in cool containers packed in separate plastic bags to the lab. To each plastic bag identification number of the grassland was added. Later the green biomass was recalculated to dry biomass according to the 5:1 principle (5 kg of fresh per 1 kg of dry biomass) by Europam standard. Need of recalculation from green biomass to dry biomass was determined by market price of medicinal or aromatic plants that is usually based on dry material of plants. Selection of 10 plants was followed by principles that give higher market

value of plants. Therefore, plants with better vitality and larger biomass were selected for weighting. Only herb layer plants were collected for biomass assessment. Trees and bushes with medicinal or aromatic use are not possible to evaluate according to the methodology.

Data analysis

The data collected with both methods were entered in an MS Excel matrix, organized by columns (species) and rows (type of environment). The data collected with the 1 m^2 square method were then analysed using the software functions, highlighting for each species, the maximum, minimum, and average number of individuals. The average value of individuals was then reported by surface (1 / m^2) to estimate the productivity per hectare. The data collected with the random 25x25 cm method were equally analysed with the absolute values of individuals for each sampling and average values for each environment. The mean numbers of individuals per species detected with the 1 m^2 square method and the mean values of the detection with the random 25x25 cm method were then compared with the correlation method. Correlation was carried out in R program. The purpose of the comparison was to evaluate whether the species diversification found in the spots was very different from the random 25x25 cm samplings carried out in the same environment and grassland. The correlation coefficients among two methods were positive and varied from 0.14 to 0.97 in each habitat therefore it can be argued that the biodiversity found in the 1 m^2 square spots is sufficiently confirmed also for the extension of the grassland plot under the study.

Stocks on grassland and its economic value

Abundance and species richness

The data collected in the different sampling environments with the two methods gave a clear picture of the presence, distribution, and density of MAPs in the grasslands. The average data of the fresh weight detected also gave an idea of the biomass with potential usefulness detected in the sampling areas. The species richness is quite constant among the habitats, ranging between 15 and 19 species of MAPs in each, 6120 being the least rich and 6230 the most "biodiverse" regarding these plants (Table 1).

Each species has a characteristic abundance in each grassland and each grassland in turn can be rich in MAPs. Some plants have proved to be more plastic and adaptable to various natural grasslands, thus turning out to be more frequent on average, e.g.: *Achillea millefolium, Plantago lanceolata, Pilosella officinarum, Alchemilla sp., Veronica chamaedrys* were found to be present in all the natural grasslands considered. Other species are less widespread and more linked to specific grasslands and absent in the others, e.g.: *Fragaria viridis, Stachis officinalis, Valeriana officinalis*. As for the abundance, the numbers referring to one hectare of grassland have been extremely variable, with a minimum of 50 individuals, up to a maximum of 10550, therefore with a density close to that of a crop (in general among the 15000 and 30000 plants per hectare).

The MAP species with the highest density, arbitrarily identified as > 5000 individuals per hectare, are five species (*A. millefolium, P. officinarum, Potentilla erecta, Filipendula vulgaris, Veronica spicata, Thymus ovatus*). The other species, on the other hand, are present with densities ranging from 50 to 3380 individuals per hectare, where present. For all studied high quality natural grasslands, however, the average presence of about 1843 individuals of MAPs per hectare was found as the average of all values, with a minimum of 1475 (in 6270) to a maximum of 2123 (in 6120). Both frequent and abundant species are *A. millefolium, P. officinarum, V. chamaedrys*.

Table 1. Species richness and average abundance of all medicinal plant species in studied grassland habitats (Abbreviation: MAPs - medicinal and aromatic plants)

Code of EU protected grassland habitat type	Species richness of MAPs	Average MAPs abundance	First three the most abundant species
6120	15	2123	*Pilosella officinarum, Veronica spicata, Thymus ovata.*
6210	18	1843	*Achillea millefolium, Veronica chamaedrys, Filipendula vulgaris*
6230	19	1961	*Achillea millefolium, Potentilla erecta, Pilosella officinarum*
6270	17	1475	*Achillea millefolium, Veronica chamaedrys, Taraxacum officinale*
6530	18	1807	*Achillea millefolium, Veronica chamaedrys, Filipendula vulgaris*

"Medicinal biomass" and theoretical yield

Assuming that someone every year goes to collect the entire population of MAPs present in the grasslands, and process these products into commercial goods, we could build a theoretical value of the production of these habitats and therefore directly assign an economic potential to them. To do this, it will be enough to multiply the number of plants by the average weight, derived from the sampling, to have a useful biomass and to attribute a price to it.

For this purpose, the useful parts of the plant have been weighed and the fresh weight obtained will be used to derive the dry weight of a potential product. It should be noted that in the various environments due to the competition existing in the grass cover, individuals reach limited sizes compared to a pure crop, moreover, variability from one year to another is expected. The fresh weight values found in the sampled specimens were extremely variable, ranging from 1.9 g / individual of the average *Briza media*, up to 270 g / individual of the *P. erecta* (average of all 49.15 g). Even within the same species there is a variability linked to the interaction between genotype and environment. Taking the species with the highest frequency as a reference (e.g., *A. millefolium and V. chamaedrys*) we can observe a fair variability of the weight in the different environments. *A. millefolium* has a constant weight in the habitats 6210, 6120, 6230, and 6530 (min 42.5; max 86.5; average 54.31 g), but in 6270 it reaches just 5.5 g. While *V. chamaedrys* despite being a less variable species it has an average weight in the various habitats of 8.55 g, with a minimum in 6230 of about 4.1 g.

In terms of useful biomass, considering the complex of medicinal entities, we observe from a minimum (different from 0) of 0.340 kg/ha (*V. chamaedrys*) up to a maximum of 2,514 kg/ha (*P. erecta*) of fresh raw material. The average on all species is about 41 kg/ha fresh, while significant weights are achieved by plants that produce large biomass (*P. erecta*, average 595 kg/ha) or are very abundant (*A. millefolium*, average 294 kg/ha).

The analysis of the complex of the "wild production" of MAPs returns very interesting data. Overall, the different grasslands have a very similar production potential with an average of 1522 kg/ha of MAPs and a maximum of 3200 kg/ha for 6230 and a minimum of 578 kg/ha for 6270. If these values are compared with an average production in the Baltic area of cultivated MAPs, we see that the value produced by grassland is close to about 30-40% of a specialized crop, which is an extraordinarily high value given close to zero input content of a natural environment. Obviously, a comparison between the two systems cannot go further given that in terms of profitability, specialized cultivation certainly has the advantage of mechanization of production, in particular, those of harvesting.

Estimating an economic value of the grassland MAPs provision service

Many populations still today rely on the collection of material from natural environments for their subsistence or to increase domestic cash flow. The supply chain is very simple, with the collector at the base, usually a woman, child or elderly person, who goes to collect the product in nature, prepares it in a simple way and for example cleaning it and putting it to dry, and once it reaches a certain stock delivers it to a collection centre, usually owned by an agent, who then delivers it to local wholesalers, then national wholesalers / exporters and where it is launched in the world market. The material collected per unit of collector / family is generally small, between 10 and 100 kg, more rarely it reaches 1000 kg per season (personal communication given by agents of Albducros in Northern Albania, 1999). Wild harvesting is a point-like activity that respects the irregular spread of the plants being collected in the environment. According to the data illustrated above, to reach 100 kg (considered the average of all species) 2.5 ha of natural environment are required to be covered inch by inch to harvest the quantity. The knowledge of the territory and the concentration of work in the points with greater abundance optimizes the time, which in any case is a relevant factor.

Let us now try to translate biomass values into market values. For this purpose, the current market values in Europe of herbs obtained from various sources were considered (Annex 4). Some values were provided by Fippo (Italian Federation of Medicinal and Aromatic Plants - www.fippo.org) and Assoerbe (Italian association of herb industry www.assoerbe.eu) and other privileged sources in Europe (Europam. European Herbs Grower Association - www.europam.net). These prices are average prices observable and detectable on the market for periods of not less than three years. They refer to a raw material, dried, without special processing or preparation, presented as a collector would do to their local agent. The prices considered vary from a minimum of 4.5 EUR/kg up to a maximum of 16 EUR/kg, depending on the species. The lowest prices are for plants that are normally obtained from industrial cultivation and therefore boast a low production cost. The higher prices, on the other hand, refer to more valuable and less productive species, not cultivated or not cultivable, and whose cultivation is still to come. For some species it was not possible to find an official price even from the sources consulted, because the market is erratic or very localized. For these species it was decided to arbitrarily adopt, but not far from reality, a standard price that derives from a price for medicinal herbs that have similar characteristics on the market, both in terms of availability, volumes, use and production. This price is equal to 11 EUR/kg (2021). The market value always refers to the value of the dry product. The transformation from fresh field-weighted biomass to dry product was done using the factor 5:1 (5 kg of fresh per 1 kg of dry product). This unique factor is the one universally adopted for technical and legal reasons within Europam.

Table 2. Comparison between natural grassland habitats by their potential MAPs biomass and economic value of the MAPs provision service (Abbreviation: MAPs - medicinal and aromatic plants)

Code of EU protected grassland habitat type	Estimated dry matter of all MAPs, kg/ha	Total economic value of the MAPs provision service from MAPs biomass, euro/ha
6120	257,07	380,86 €
6210	275,88	487,26 €
6230	643,61	1322,58 €
6270	149,68	234,40 €
6350	193,47	342,65 €
Average	**303,94**	**553,55 €**

The economic values found show great differences, also in relation to the different distribution and abundance of the plants (Table 2). It therefore ranges from a minimum of 0.12 EUR/ha up to a maximum of 1105.98 EUR/ha. The average of the minimum values, other than zero is 15.60 EUR/ha while the

average of the maximum values is 141.42 EUR/ha. The plants with the highest value were obviously those with the highest biomass: *P. erecta*, for example, has an average of 262.26 EUR/ha with a maximum of 1105.98 due to both the abundant biomass and the expected good market price. Certain economic evidence is also given by plants less appreciated by the market but very widespread: the *A. millefolium* for example has an average of 84.79 EUR/ha, despite being a plant that is grown and sold at relatively low prices. The economic value of individual environments is extremely variable, due to the combination of abundance and market value of the dwelling species (Table 2). The "richest" environment in economic terms was found to be 6230 with a good 1322.58 EUR/ha of potential production. The poorest, on the other hand, is 6270 with 234.40 EUR/ha of productivity. The average value between the various environments, for all collections, was 553.55 EUR/ha.

We can make a comparison with some typical crops of Latvia to compare the "yield", albeit theoretical, of a grassland compared to the more common farmlands. For example, we can compare the production of crops such as summer wheat, caraway, buckwheat, and chamomile. In Latvia, the profitability referred to 1 ha of cultivation is summarized in the Table 3 below.

Table 3. Example of biological agricultural production and its market value in Latvia (Source: SIA "Field and Forest" company, 2020)

Crop	Yield, kg	Estimated price, euro/kg	Rentability of the yield, euro/ha
summer wheat	2800	0,18 €	504,00 €
buckwheat	650	0,65 €	422,50 €
caraway	1150	1,80 €	2070,00 €
chamomile	270	9,50 €	2565,00 €
potato	20000	0,37 €	7400,00 €

It is clearly evident that a grassland left alone can deliver the same value as for simple grains, and cannot compete with high value crops, as, in the example other cultivated MAPs and potatoes.

Value of a cup of tea and economic side effects

One way to highlight the value of a cup of tea, is undoubtedly to valorise the good not as much as its primary form, the one with which the farmers / collectors offer it to the industrial market, but in its final form, that is, the one we are used to buying in a shop. The concept is to give a value to the product not "per kg" but "per serving", or portion. The added value that is usually achieved through passages along an industrial chain, with many passages that often also go to the detriment of quality. The value of the serving is the value that remains virtually to the one who collects and prepares the product for himself or for his family, friends, acquaintances.

The social survey carried out among families (described in the next Chapter) shows that the quantities collected are actually very small, since even the intake of infusions is not always a daily occurrence, but often it is a question of discontinuous habits and therefore the harvest necessary to satisfy the family needs is a few dozen grams. Nonetheless, speaking of potential values, this does not at all reduce the value obtainable from a natural environment, especially if supported by educational campaigns aimed at promoting the consumption of spontaneous herbs and using natural spaces in a "productive" and therefore more intensive way, with the benefit of both direct (consumption of safe natural products) and indirect, with the performance of outdoor activities with physical workout.

To highlight the present value, we will always start with the biomass produced in the plots. The value of the biomass will then be processed into virtual portions, and these valued at market price by referring to products on the market of medium / high value. Given that, reasonably, because the product coming from such a short supply chain, collected in uncontaminated environments, it is assumed should fall into this category.

If we look at the products in filter bags, the content of the bags varies from 1.2 g up to 2 g, depending on the formula or type of product, which, based on the specific weight, influences the filling. If we can assume that a homemade product can be dosed with a teaspoon, we will see that the weight of this is close to 1.5 g. Therefore from 1 kg of product you can have up to 600 portions of herbal infusion.

From observation of the prices of the product on the market, a portion of herbal tea, without considering the cost of the serving, is about 0.22-0.24. The data collected in a short investigation done in Latvian supermarkets in 2021. Therefore, making a consideration, it must be repeated, with a theoretical value, dividing the kilograms of product that I collect per hectare by the obtainable portions (assumed in the average value of 1.5 g / portion), imagining that from each environment I get a mix of ideal infusion herbs, I can obtain a value-added product that generates a given income on teas and herbal infusions showed a value slightly lower expressed as euro / hectare. It should be noted that the added value is given by the "work" that the consumer, who lives in the countryside, tourist or hikers does, by going to collect the product for himself directly in the field. And the same crafter / user benefits twice from this: once for the product he creates, the second, for the direct benefits from the activity carried out outdoors. The theoretical values are therefore represented in the Table 4.

Table 4. Value of the MAPS provision service generated by the grasslands and calculated upon potential MAP tea servings per season (Abbreviation: MAPs - medicinal and aromatic plants)

Code of EU protected grassland habitat type	Estimated dry matter, kg/ha	Estimate MAPS tea servings, piece	Total economic value of the MAPs provision service from cups of the MAP tea, euro/ha
6120	257,07	17137,91	4113,10 €
6210	275,88	18392,33	4414,16 €
6230	643,61	42907,47	10297,79
6270	149,68	9978,79	2394,91 €
6350	193,47	12898,33	3095,60 €
Average	303,94	20262,97	4863,11 €

The added value that is created according to this type of calculation is far greater than most of the large-area crops that are carried out in the Latvian farmland shown in Table 3. It must also be said that to bring agricultural land to the production of value, it is necessary to invest a certain amount of money, in technical means and agricultural inputs, often coming from non-renewable sources. If we want, for example, to introduce the assessment of the life cycle of a specific agricultural product, surely the productivity of grasslands would once again return very interesting values that undoubtedly require serious reflection on their conservation.

Economic assessment of medicinal plants in grasslands: indirect hypothesis

Besides the field surveys, a study on family uses of MAPs was carried out. The aim of the investigation was to ascertain the current demand of the ecosystem service of MAPs in Latvia and link the information as much as it is possible to the plants growing and offered by grasslands and thus calculating value of the grasslands indirectly through consumption of MAPs.

Methodology of social survey

Data of MAP current use in the population of Latvia was gained by social survey. Questions and criteria of participant selection for the survey were defined by authors of the report. However, the social survey was practically organized through a company "Latvijas Fakti" that is specialised in carrying out public opinion polls and surveys in Latvia and other Baltic states. The received data represented MAP use in Latvia during the summer of 2020.

Criteria for participant selection

To ensure that the survey's objective of gaining representative data of current MAP usage in Latvia, it was crucial to fulfil the following criteria:

- Audience of the survey is inhabitants of Latvia at age 18-74 (at least).
- The survey must be offered in two languages - Latvian and Russian.
- The survey results contain answers at least from 1000 respondents.
- The survey results represent answers from both genders and all included age groups equally.
- The survey results represent answers from all main regions of Latvia - Kurzeme, Zemgale, Latgale, Vidzeme and Riga equally.

The survey was organized through a computer-based questionnaire sent to the participants therefore involvement of older or younger participants was limited according to potential respondent use of computers daily. The survey availability in Latvian and Russian languages was necessary due to the bilingual population in Latvia. One thousand respondents are the standard of respondents used for social surveys to represent the situation at the country level in Latvia.

The survey questions

The social survey contained 23 main questions, 8 sub-questions and 1 free choice question. The questions were organized in two main blocks. One block contained questions that give data of MAP use of respondents, another block contained questions that characterise respondents in general. The general questions asked the following information of respondents: gender, age (full years), language used in family, level of education, current occupation, current residence, childhood residence.

Questions related to MAP use were further divided into two subdivisions. The first subdivision aimed to figure out the tea consumption of six plants per year that grow in natural grasslands and are the most familiar grassland medicinal plants in Latvia. The question was: How many cups of the plant tea (pure tea without other plant admixture) did You drink during last year? The question was asked about the following six plants: caraway (*Carum carvi*), St John's-wort (*Hypericum sp.*), cowslip (*Primula veris*), lady's mantle (*Alchemilla sp.*), meadowsweet (*Filipendula ulmaria*), Colt's-foot (*Tussilago farfara*). The questions were combined with pictures of each of the plants.

The second subdivision was aimed at gaining data on overall habits of MAP use. It included such questions as:

- Do you use medicinal plants?
- What other medicinal plants do you use? (Except the six mentioned plants)
- In which form do you use teas? (mixed teas, single plant teas)
- What is your favourite tea plant?
- For what purposes do you use medical plants?
- Are you collecting herbs in nature? How much? What plants?

- Do you grow medical plants in the garden or field? What plants?
- Are you selling the collected/grown plants? At what price do you sell them?
- Are you buying medical plants? Where do you buy them? What plants?
- Where did your knowledge of medicinal plants come from?

The social survey ended with a specific question: Please name the most important herb of the meadow for you! The purpose of the question was to gain information about plants that are the strongest meadow symbols in Latvia. This information could help to present natural grasslands and their values better in GrassLIFE project.
At the very end of the survey, respondents had a chance to give their feedback on the survey if they wished in a free text form.

Data analysis

Received database of the social survey answers was necessary to prepare before data analysis. Pre-preparation was needed for answers on questions that were given in free text. These answers were necessary to classify for further data analysis. Some of the answers were not usable due to inappropriate answers on the question. Data of collected or grown medicinal plant amounts were the most challenging because answers were given in various units and for fresh or dry plant material. The data were re-calculated to grams and expressed as dry plant material in the further analysis. Another challenge was to identify correct plant names in free text answers. Many of the medicinal plants have locally used names that differ from scientifically defined common plant names in Latvian or Russian language. Sometimes the same name can be used for two or even three various plant species. For further data analysis only clearly identified plant names according to their scientific name were included in further analysis.
Percentage of respondents indicating any given answer were calculated and the significance of the frequencies of answers between groups were calculated by Chi-squared tests in program R.

Social and cultural habits of medicinal and aromatic plant use

Demographical data of the respondents

In total 1031 respondents filled the survey, out of those 593 were women and 438 men. 49 % of the respondents reside in one of the regions in Latvia – Latgale (13 %), Vidzeme (11 %), Kurzeme (12 %), Zemgale (12 %), 34 % in Riga and 17 % in Pierīga. 34 % of respondents live in capital city Riga, 33 % in other town and 33 % in villages and rural areas. Respondents' ages ranged between 18 and 74 years. Majority of respondents speak Latvian in the family (68 %), and 26 % speak Russian. 5% speak both Latvian and Russian in the family. 1 % of respondents mentioned other languages are spoken at home. Over half of the respondents (51 %) occupation is trained professional / clerk, 13 % are upper or middle managers, 12 % are skilled laborers, 9 % are retired or disabled, 5 % are Housewives/husbands or on maternity/paternity leave, 5 % are unemployed and 4 % are self-employed or employers. Most of the respondents describe their living environment as a town (46 %) followed by capital (34 %). 6 % live in farmsteads and 15 % in villages. 1 % marked the living environment as "other". Most of the respondents in childhood lived in towns (45 %) and capital (23 %). 20 % of respondents lived in farmsteads (20 %) and 19 % in villages. 1 % marked the living environment as "other".

Proportion of respondents using medicinal plants

Most of the respondents (70.8 %) use MAPs, but 29.2 % do not. Several factors significantly affected MAP use, including region of residence, level of urbanisation of place of residence, gender, language spoken at home. 86 % of women use MAPs whereas only 50 % of men use MAPs. 59 % of inhabitants of Riga use MAPs, but users of MAPs residing in other regions exceed 71 %. 72 % of respondents residing in other towns than Riga uses MAPs, and 81 % of respondents living in villages and rural areas use MAPs. 78 % of respondents who speak Latvian in the family use MAPs, whereas 50 % of respondents speaking Russian with family use MAPs. Living environment plays an important role in determining whether a person does or does not use MAPs. The largest proportion of MAP users are in groups which grew up in farmsteads and live there nowadays.

Occupation and education did not significantly influence whether a person use or do not use MAPs in general. Degree of urbanisation has a negative correlation with MAP use and living in less urban areas increases MAP use. Largest proportion of MAP users (88%) were among people who have grown up in farmstead and currently live in farmstead (Table 5). Much lower percentage of people use MAPs if they have lived in Riga in their childhood and live there currently (53 %).

Table 5. Percentage of respondents using medicinal plants for any purpose based on their childhood and current urbanisation level

		Current residence				
		farmstead	village	town	Riga	**Average**
Childhood residence	farmstead	88%	83%	83%	80%	**84%**
	village	83%	76%	78%	82%	**80%**
	town	83%	78%	70%	61%	**73%**
	Riga	81%	83%	78%	53%	**74%**
	Average	**84%**	**80%**	**77%**	**69%**	

Favorite plant for preparing tea

Respondents were asked to enter their favourite plant used for preparing tea. Most often respondents mentioned peppermint (23 % of respondents), followed by chamomile (10 %) and linden (7 %) (Figure 2). The rest of the species were mentioned by less than 1% of respondents. In total respondents mentioned 44 species indicating an individual preference of plants.

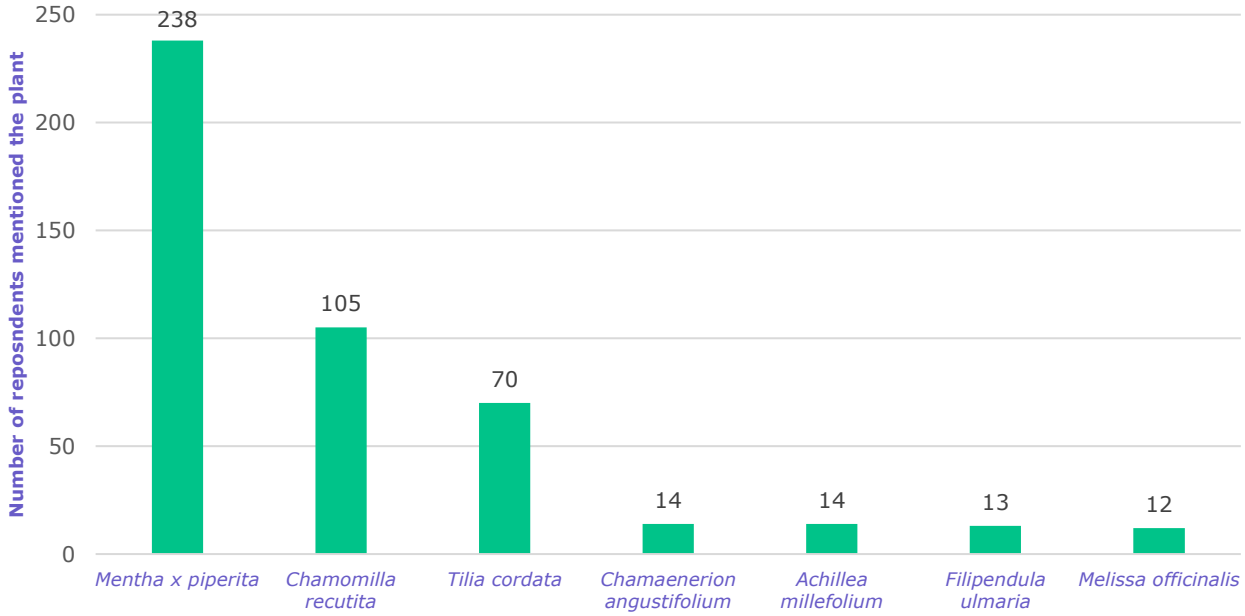


Figure 2. Species of plants reported as favourite tea plant by more than 10 respondents.

Consumption of the six most familiar grassland herbal MAPs

Respondents were asked how many cups of caraway, cowslip, St. John's-wort, lady's-mantle, meadowsweet, colt's-foot tea do they drink per year. All the mentioned plant teas were consumed by 6 - 10 % of respondents (Figure 3). Across respondents who consume tea from the given plant species, the largest number of cups consumed yearly on average is of caraway - 25.5 (Figure 4).

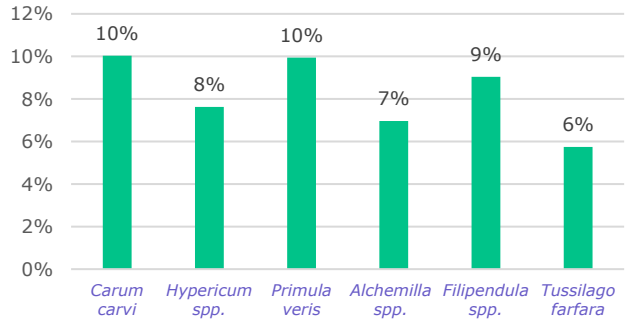


Figure 3. Percent of respondents indicating they drink tea prepared from the given plant.

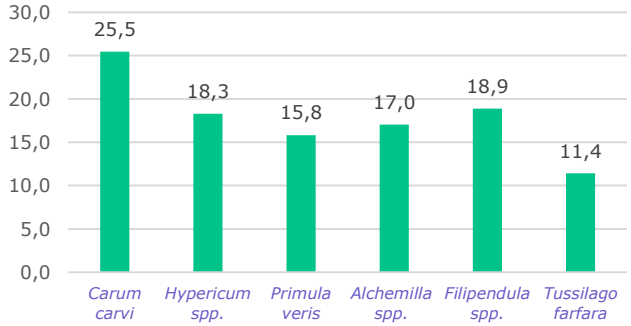


Figure 4. Average number of cups consumed per year by respondents who drink tea of the given plant species.

Respondents were asked to name other medicinal plants beyond caraway, cowslip, St John's-wort, Lady's-mantle, meadowsweet, colt's-foot. In total 114 plant species were mentioned (Annex 5) 7.5 % of respondents mentioned linden (*Tilia cordata*) 7.3 % use chamomile (*Chamomilla recutita*), 5.9 % use peppermint (*Mentha x piperita*), 4.4 % use yarrow (*A. millefolium*), followed by other species (Figure 5).

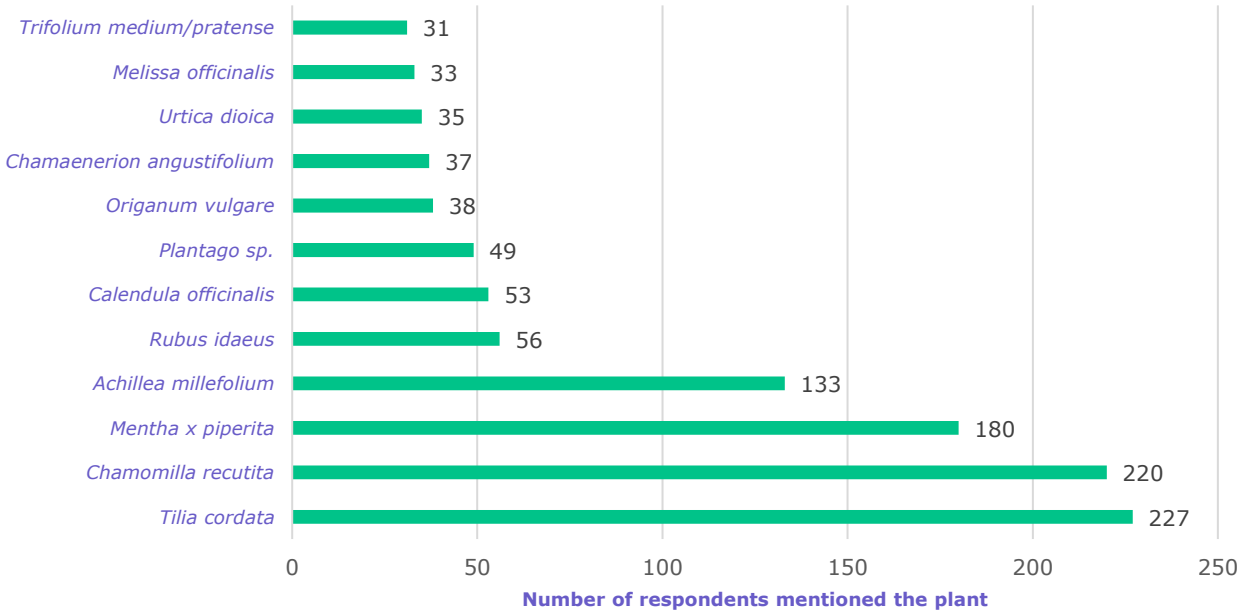


Figure 5. Species named by ≥1 % respondents when asked what other medicinal plants beyond caraway, cowslip, St John's-wort, lady's-mantle, meadowsweet, colt's-foot they use.

Habits and traditions of MAP usage in contemporary Latvia

People use MAPs for several reasons. 44% of respondents use them for well-being daily, 15 % use them in sauna rituals, 45 % use in case of illness and 36 % for disease prevention. 6% of respondents use MAPs for all the above purposes.

36 % of all respondents and 51 % of respondents using MAPs, collect them in the wild. Factors influencing whether MAP users collect plants in the wild are region of residence, level of urbanisation, gender, age, occupation.

Only 35 % of MAP users who reside in Riga collected MAPs in the wild, while it rose to 51 - 65 % for people living in other regions. Living in the capital city did significantly affect the number of people collecting MAPs in the wild but living in other towns or villages / rural areas had a similar rate of MAP collectors - 56 % and 57 % respectively. 55 % of women and 40 % of men using MAPs collect them in the wild. Employment status did significantly affect how many of the MAP users collect them in the wild: 46 - 57 % employed persons and unemployed persons collect MAPs, but a larger proportion of students and housemakers >75%. Language spoken at home significantly affects how a large proportion of MAP users collect them in the wild: 54 % of Latvian speakers and 37 % Russian speakers. Level of urbanisation of current residence, and childhood residence significantly influence MAP collection among MAP users. 82 % of respondents living in farmstead in childhood and 63 % living in farmstead currently use MAPs. Collection drops with a level of urbanisation to 35 % and 34 % among respondents currently living in the capital.

Most often collected species in the wild are linden (20% of respondents), peppermint (13 %), yarrow (12 %), cowslip (10 %) and meadowsweet (9%). In total respondents have mentioned 80 species which they collect in the wild (Figure 6).

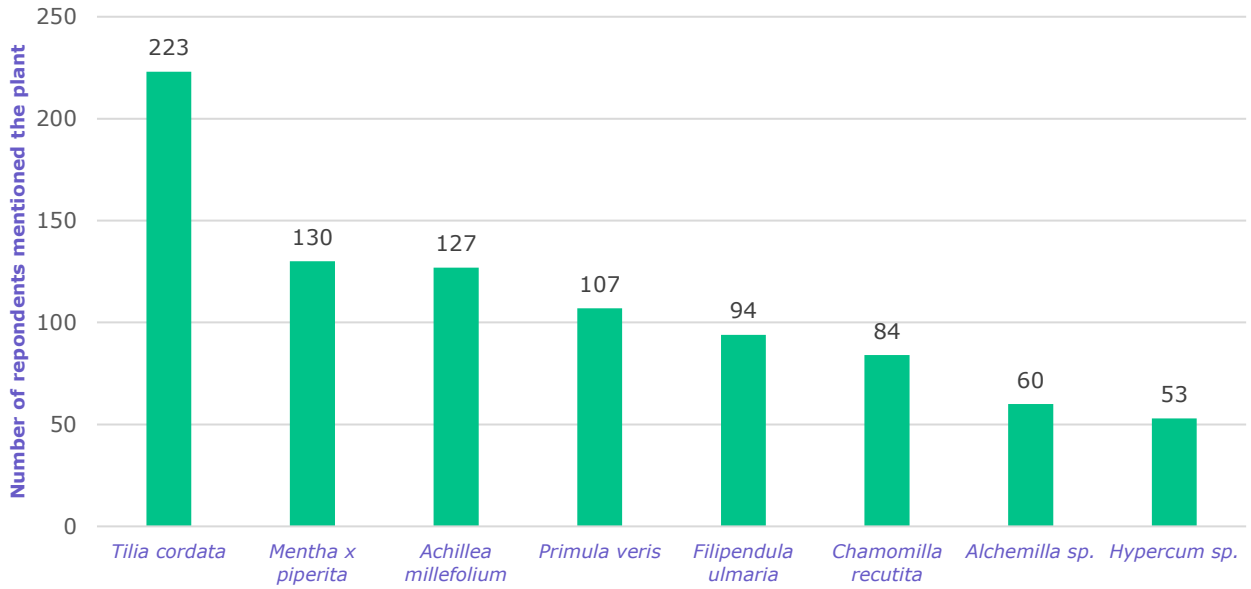


Figure 6. Species which more than ≥0.5 % respondents named as species they collect in the wild.

On average respondents who do collect MAPs in the wild collect 438 g of MAPs per year. Among MAP collectors, none of the demographic factors influence the amount of collected plants in the wild. On average MAP collectors spend 7h annually collecting MAPs. Only 0.29 % of the respondents sell MAPs collected in the wild. 0.19 % sell MAPs grown in the garden and those same persons also sell MAPs collected in the wild. The price for selling 100 g of product ranged from 1.34 Eur to 12.5 Eur. 43 % of respondents using MAPs grow them in the garden. Gardening MAPs is significantly affected by region of residence - 29 % inhabitants of Riga using MAPs grow them, but 37 to 56 % of people grow MAPs in other regions of Latvia. 43 % of inhabitants of towns other than Riga grow MAPs and 51 % of people residing in rural areas. Whether MAP users grow MAPs does not depend on their gender or level of education.

67 % of medicinal plant users buy them. 56 % of MAP users buy MAPs in pharmacies, 24 % in grocery stores, 16 % in farmers markets and 16 % directly from plant collectors and growers, 1% reported other sources. 76 MAP species were reported as being bought. Most popular are chamomile (16 % of respondents), peppermint (8 % of respondents), and linden (6% of respondents) (Figure 7).

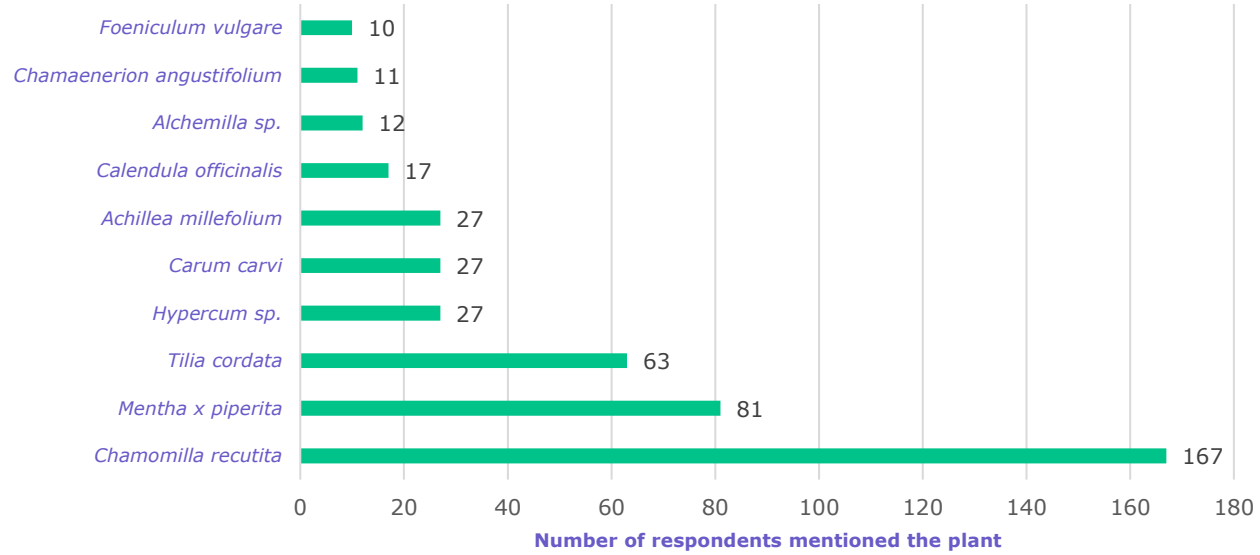


Figure 7. The most popular medicinal and aromatic plants purchased by >1 % of respondents.

The main source of knowledge on MAPs and their uses comes from within the family - 71 % MAP users admit family as the main resource. Respondents also use books (36%) and internet (44 %) and other mass media (16 %) for their reference. 12 % reported they do not have any special sources of knowledge.

The plant – grassland symbol of Latvia

Respondents were asked to name a meadow plant which is most significant to them. In total 93 plant species were mentioned (Figure 8). Among the most popular species are *Leucanthemum vulgare* and *Centaurea cyanus*, which have symbolic and ritual meaning rather than medicinal. Moreover, *C. cyanus* is not a grassland plant, but a crop weed! Another popular species is *C. recutita* which has high medicinal value but does not occur in natural meadows in Latvia (species can be found in gardens and fields, in agricultural fields as weed, in wastelands and along roadsides).

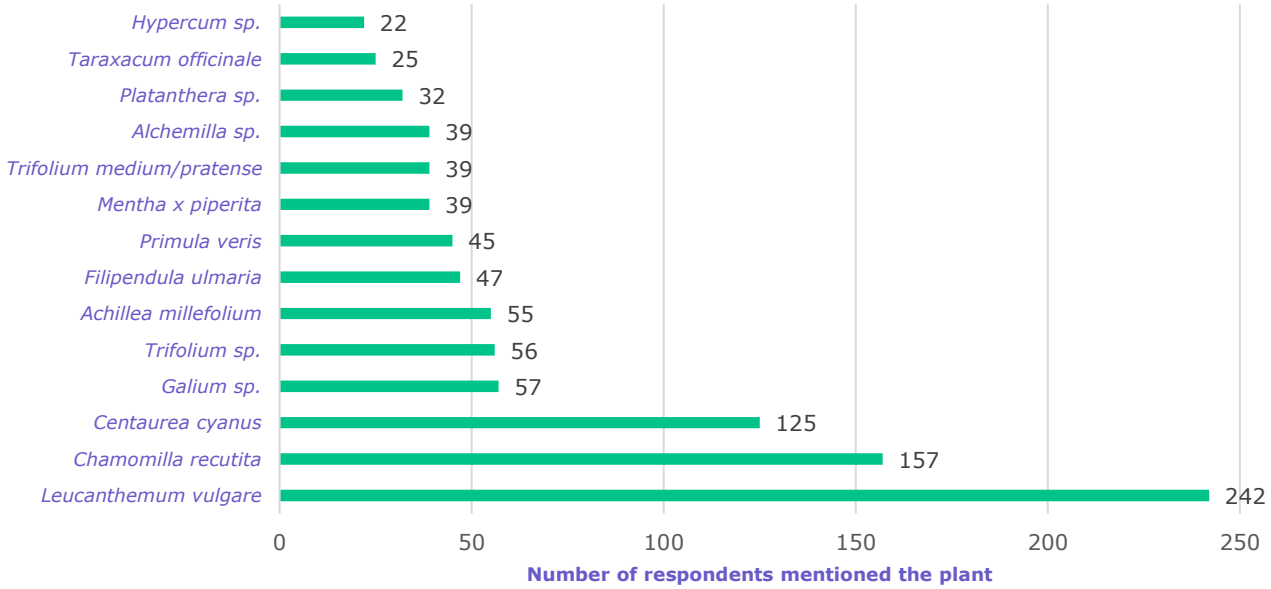


Figure 8. The most symbolic meadow plants reported by > 2 % of respondents.

Grasslands as gene's bank for new drug discovery

The study determining the value of grasslands has highlighted a lot of unpublished and useful information. First, the high-quality natural grasslands and their variants, are an important sanctuary of "medicinal biodiversity" of great interest, primarily for study and basic research purposes but also for applied research aims and, of course, with evident economic issues. More than 50 MAP species were identified in the 5 different natural grasslands, including herbaceous, shrubs and small tree plants. Amongst them, 37 herbaceous species were selected as well known and established in scientific literature or reported in popular practice (safe to use) and were analysed for their abundance and distribution. The plant abundance and distribution were measured using two different sampling methods. One method was done using $1m^2$ square, to obtain analytical data on density and flora composition on a given spot. Another, using random 25x25 cm sampling, was used to get a figure on plant distribution in the area. The data of both methods were statistically correlated and efficacious in describing the biodiversity.

The data of the density and distribution of MAPs, in terms of frequency of number of species, was discovered to be unusually homogeneous across the various grasslands and their variants. It emerged from the study that in all studied habitats of natural grasslands there are from 15 to 19 species of MAPs. The most MAPs rich grasslands were the 6230 ex-aequo. The less MAPs rich, but not significantly, was 6120.
The distribution of species varies across grassland types and only few species were present in all cases; the latter are well known to be particularly flexible and adaptable to many peso-climatic conditions. Some species were linked only to one specific grassland type. The number of individuals of a specific species varies greatly in every different grassland. The total number of individuals of all species may vary between 1475 and 2123 (as average) per hectare, as maximum values. In rare cases, some species reach density close to the regular density in a cultivated field (around 10000 individuals per ha).

But what varies a lot is certainly the biomass produced, which, depending on the species and the richness of the soil in the different areas studied as well as on current and historical management practice, may or may not be significant on a productive scale. The productive scale is considered an organized form of systematic wildcrafting, that seems barely practicable. In some cases, the biomass in each situation of species/grassland types is very inconsistent. Although this does not diminish the importance of grasslands as arenas of interest for the study of MAP species and especially for drug discovery.

In terms of economic value, a direct comparison was made between large crops, normally feasible when a grassland is converted to agriculture, and the potential for using grasslands as it is, as source of wildcrafted MAPs. Obviously, the method of direct comparison between large crops and wild harvesting is limited. The average value of 553 euros/ha of MAPs has been extrapolated from wildcrafting seems comparable with the one of regular farmed grains (504 euros/ha). Nonetheless, the approaches and costs of achieving such productions are largely different and as such are incomparable situations.

The aim of this study was not to compare farming and grassland management in a simple cost/income approach, but to find a new way to gain insights regarding the value of a natural habitats. It is important to consider that a given ecosystem is not a simple factor of production of biomass destined for industrial uses and therefore valued as a market of commodity-like items, but something capable of providing value-added products, and valued added activities, even with a social meaning. To do that we have to change our perspectives starting from the economic point of view. For example, besides the material benefit due to the collection of wild products, we can consider the addition of value through activities that clearly contribute to the physical and mental well-being of the person practicing it. The consumer is used to buying ready-made products at the supermarket and without knowing their origin and the conditions in which they were prepared. But it is evident that the consumers today want to be informed more and more about what they buy and indeed tend to go up the production chain to "self-appropriate", and not simply buy, certain goods at their origin (e.g., purchasing groups, producer networks and consumers).

The act of going to a natural environment and collecting herbs, preparing them, storing them, and using them, for oneself or offering them, giving them to others, is undoubtedly an act that is likely to be economically increased of value and therefore linked to the value of the natural sites of which is discussed into this study. The value generated by the act of self-preparing and serving a cup of tea can be reasonably represented through the value of commercial high quality herbal tea preparation. Translating the weight value found in several hypothetical tea servings, the output value of a natural grassland bounces up significantly to 4863 euro/ha, without considering the benefits of such activity for people practicing it.

The social survey has shown that the use of MAPs, and the culture of a cup of natural tea done with wildcrafted herbs, is still important to Latvian inhabitants. The interviewed people testified to know 114 different species of MAPs. Even if lifestyle is deeply changed in the latter years, the culture of MAPs remains well rooted in rural living people. Urbanized people are largely influenced by the culture of purchasing but still know MAPs and their benefits. In fact, 70% of people living in the countryside and small towns, know and use MAPs, especially women, and that behaviour looks independent from personal culture and education. The number of users drops to 50% in Riga where people lost their connection with the natural environment, but still remains a good share. Some trends on global interest for nature wildcrafting and foraging, will surely influence the future of this sector and global growth for natural product use can witness it.

Conclusions

Summary of research results

- High quality natural grasslands contain from 15 to 19 species of MAPs in Latvia.
- The most species rich grasslands of MAPs are 6230 and the least rich was 6120.
- Yarrow (*Achillea millefolium*), mouse-ear hawkweed (*Pilosella officinarum*), germander speedwell (*Veronica chamaedrys*) are the most common and abundant MAPs found in all of the studied natural grassland habitats.
- The largest fresh biomass of the grassland medicinal plants was provided by tormentil (*Potentilla erecta,* average 595 kg/ha) that includes the whole plant including roots, and aerial part of yarrow (*A. millefolium*, average 294 kg/ha) with flowers.
- The highest MAP productivity and estimated economical value was identified in 6230 grassland type (1322,58 EUR/ha by biomass data; 10297,79 EUR/ha by tea serving data), but the lowest in 6270 habitat (234,40 EUR/ha by biomass data; 2394,91 EUR/ha by tea serving data).
- Biomass value of MAPs produced by high-quality grasslands is close to about 30-40% of cultivated medicinal plant production in Baltic area, but the grasslands can deliver the same value as for simple grains such as summer wheat or buckwheat.
- Economic value of natural grassland MAPs based on tea serving calculations demonstrated far greater value (4863,11 EUR/ha in average) than most of the large-area crops cultivated in the Latvian farmland.
- Demographic factors correlating with Latvian inhabitant usage of MAPs are region of residence, level of urbanisation in place of residence, gender and language spoken at home.
- The largest MAP users are Latvian inhabitants which grew up in farmsteads and live there nowadays, the opposite situation is with persons living in Riga since childhood where lives the largest proportion of non-users of medicinal plants.
- Linden (*Tilia cordata*), yarrow (*A. millefolium*), meadowsweet (*Filipendula ulmaria*) are Latvia's inhabitant most favoured grassland MAPs.
- Data on caraway, cowslip, St. John's-wort, lady's-mantle, meadowsweet and colt's-foot questionary of yearly the plant teacup consumption showed that caraway (*Carum carvi*) is the most consumed tea of the mentioned grassland MAPs, followed by St.John's-wort (*Hypericum sp.*) and meadowsweet (*F.ulmaria*) by consumption amounts and cowslip (*Primula veris*) by proportion of Latvian inhabitants drinking the tea.
- Around 1/3 of Latvian inhabitants (around 50% of all MAP users) collect medicinal plants in the wild. Six of the eight the most often collected MAPs in wild are grassland plants with linden (*T. cordata*) on top of them. Next five are yarrow (*A. millefolium*), cowslip (*P. veris*), meadowsweet (*F. ulmaria*), lady's-mantle (*Achemilla sp*.) and St. John's-wort (*Hypericum sp*.).
- Around 2/3 of MAP users in Latvia buy medicinal plants and a bit more than half of them do it in pharmacies.
- Knowledge of MAPs and their usage in Latvia has strong tradition on inheritance transferred from one family member to another reported by 71% of the survey respondents referring the same proportion to the whole population of Latvia.
- Oxeye daisy (*Leucanthemum vulgare*) is clearly the dominant plant – symbol of grasslands in Latvia mentioned by around 1/5 of current Latvian inhabitants.

Final message of the report

The research work has revealed how natural environments such as high-quality grasslands can provide great wealth in terms of plant biodiversity and in particular of a biodiversity that constantly generates opportunities for the development of mankind. The challenges we face, which the current pandemic situation has dramatized, such as the fight against climate change, the fight against new pathogenic organisms such as viruses, or against old pathogenic organisms, which have become dangerous aggressors of humans, pass through new solutions. Plants and their enormous genetic biodiversity, which also corresponds to a great chemical biodiversity, could be a source of natural remedies and low ecological impact to many needs that we can foresee or even not yet foreseeable. The defence and preservation of natural environments finds its main motivation in this theme but not only. More and more in evaluating a given physical resource we must not only evaluate and monetize the flow of the resource generated raw materials but also and necessarily the flow of services. It includes intangible and not easily monetized goods, such as the emotional state of the person who finds himself in touch with the natural landscape. Therefore, if we talk about biomass as a source of active ingredients, such as MAPs present in natural grasslands, we cannot think of a value generated from the mere trade of those biomass, whose value is certainly small and does not justify the grassland exploitation. We must first imagine the value of those products as if they were delivered directly to the final consumer and then consider per unit of consumption. The value is therefore generated both by the material, but also by the service connected with its preparation. Picking herbs, drying, hand cleaning, tea brewing, are all actions that have a value that we can represent with the "per serving concept". But even with this procedure, which brings the value generated by a grassland to over 10 times the value of the starting biomass, we risk underestimating the value of this environment. However, we should also consider the value that is generated in terms of well-being, including real well-being, both physical and mental, carried out by outdoor activities, as is the collection of wild herbs. Workout, solar radiation that activates the vitamin D responsible for the efficiency of the immune system, the production of melatonin, which together increase the physical well-being and the mood of the person. Little or nothing can be said instead of the emotional well-being that comes from contact with nature, but the benefit that the psyche reverberates on the soma is also certain. Some researchers are trying to study the effect of nature contact in person with mental distress or healthy, showing improvement on psychical situation practicing Shinrin-yoku (Furuyashiki *et al.* 2019). These studies seem to be promising and will change the way of understanding relationship between nature and humans.

With this study we have attempted to determine an economic value of the grasslands, proceeding both with the method of the flow of materials and products, and considering the flow of services related to the products themselves. We believe that the work has shown sufficiently and broadly that the value of MAPs obtainable from natural grasslands justifies their conservation both by looking at the monetized benefits and through the flow of goods generated, and by the potential of related services. The latter are more difficult to systematize and analyse in a scientific way, even if more and more, even in modern medical science the usefulness and benefit of contact with nature is evident and therefore its protection is increasingly essential, in the waiting to be able to develop a method to better understand the nature of the relationship between man and the natural environment.

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Moreover, we wish to express gratitude to all the studied grassland owner of their welcome and permission to do the field studies on their land. Thanks to them and their ancestor effort of the natural grassland correct maintenance we still have those very few high-quality natural grasslands left embellishing and saving the biodiversity and resources for current and future health care by MAPs and within them hidden a new drug discovery potential.

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ANNEX 1

Bibliography of the Chapter: The grassland plants with medicinal or aromatic value

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ANNEX 2

List of studied grassland sites, their type, location, and date of field study

No.	EU habitat number	Site name	Geographical coordinates	Region of Latvia	Date of field study
1.	6270*	Lielkrūzes	X:618091; Y:6338322	Central-Vidzeme	11.07.2019.
2.	6210*	Lielkrūzes	X:618655; Y:6337921	Central-Vidzeme	11.07.2019.
3.	6230*	Veclipši	X:604482; Y:6337365	Central-Vidzeme	11.07.2019.
4.	6230*	Krogi 2	X:403904; Y:6396715	Kurzeme	25.06.2019.
5.	6210*	Uši	X:416368; Y:6401668	Kurzeme	25.06.2019.
6.	6230*	Koijas	X:393815; Y:6392312	Kurzeme	26.06.2019.
7.	6210*	Drubazas	X:415088; Y:6321826	Kurzeme	26.06.2019.
8.	6120*	Reibiķi	X:424432; Y:6319590	Kurzeme	27.06.2019.
9.	6120*	Tilikas krogs	X:632904; Y:6391424	North-Vidzeme	26.06.2019.
10.	6210*	Tilikas krogs	X:633416; Y:6391414	North-Vidzeme	27.06.2019.
11.	6530*	Vekši	X:622543; Y:6396044	North-Vidzeme	16.06.2020.
12.	6530*	Marsi	X:629498; Y:6396630	North-Vidzeme	16.06.2020.
13.	6530*	Tilikas krogs	X:633337; Y:6391156	North-Vidzeme	17.06.2020.
14.	6270*	Smiltaines	X:639327; Y:6304161	Central-Vidzeme	03.07.2020.
15.	6270*	Stiebri	X:591965; Y:6332931	Central-Vidzeme	03.07.2020.

ANNEX 3

List of medicinal and aromatic plants studied for the field measurements

Species name of medicinal or aromatic plant	Collected plant part with medicinal or aromatic use
Aegopodium podagraria	young leaves
Achillea millefolium	aerial with flowers
Agrimonia eupatoria	aerial with flowers
Alchemilla spp.	flowers
Artemisia campestris	aerial with flowers
Anthemis tinctoria	flowers
Briza media	flowers
Carum carvi	seeds
Convallaria majalis	root
Equisetum arvense	aerial part
Filipendula ulmaria	aerial with flowers
Filipendula vulgaris	aerial with flowers
Fragaria vesca	leaves, fruits
Fragaria viridis	leaves
Galium verum	aerial with flowers
Geum rivale	roots
Glechoma hederacea	aerial part
Helichrysum arenarium	aerial with flowers
Hypericum perforatum	10 cm of upper part with flowers
Linaria loeselii	aerial part
Origanum vulgare	aerial with flowers
Pastinaca sativa	root
Pilosella officinarum	aerial with flowers
Plantago lanceolata	leaves
Plantago major	leaves
Plantago media	leaves
Polygala vulgaris	aerial with flowers
Polygonum bistorta	root
Potentilla anserina	root, aerial part (whole plant)
Potentilla argentea	aerial part
Potentilla erecta	root, aerial part (whole plant)
Primula veris	flowers, roots
Prunella vulgaris	aerial part
Rosa canina	rosehips, seeds oil
Rosa rugosa	shoots, berries
Sedum acre	aerial part
Sedum telephium	aerial part
Solidago virgaurea	aerial part
Stachys officinalis	aerial part
Taraxacum officinale	whole plant
Tragopogon pratensis	roots, young upper aerial parts
Thymus ovatus	aerial part
Vaccinium vitis-idaea	leaves, fruits
Valeriana officinalis	roots
Veronica chamaedrys	aerial part
Veronica officinalis	aerial part
Veronica spicata	aerial part
Viola canina	flowers
Viola tricolor	aerial part

ANNEX 4

Current market value in Europe of the studied medicinal and aromatic plants, including harvesting information that makes them as product in the market and attracts for cultivation

Plant species	Harvested part	Harvesting time	Product	Product uses	PhEU	Market value	Price, euro/kg (premium)	Price, euro/kg (mainstream)	Fitness for cultivation
Achillea millefolium	aerial with flowers	flowering	dried material/essential oil	tea, herbal products, medicines	x	large	8	4,5	5
Aegopodium podagraria	young leaves	young plants	twigs, leaves	tea, vegetable, foraging		traditional	8	0	3
Agrimonia eupatoria	aerial with flowers	flowering	dried material	tea, herbal products	x	niche	€ 31,50	€ 4,50	5
Alchemilla spp.	aerial with flowers	flowering	dried material	tea, herbal products	x	medium	€ 52,50	€ 7,50	5
Artemisia campestris	aerial part	flowering	dried material	tea, herbal products, herbal beverages		traditional	€ 38,50	€ 5,50	3
Briza media	flowers	flowering	dried material	tea		traditional	€ 126,00	€ 18,00	NA
Convallaria majalis	whole plants	flowering	dried material	pharmaceuticals		medium	€ 70,00	€ 10,00	4
Equisetum arvense	aerial part	summer, sterile stems	dried material	tea, herbal products	x	large	€ 45,50	€ 6,50	2
Filipendula ulmaria	aerial with flowers	flowering	dried material	tea, herbal products	x	niche but developing	€ 36,75	€ 5,25	4
Filipendula vulgaris	aerial with flowers	flowering	dried material	tea, herbal products		medium	€ 59,50	€ 8,50	3
Fragaria viridis	leaves, fruits	before flowering or after fruit harvest	dried material	tea, herbal products		medium (as *F. vesca*)	€ 42,00	€ 6,00	5
Galium verum	aerial with flowers	flowering	dried material	tea, herbal products, cheese making		niche	€ 77,00	€ 11,00	4
Geum rivale	roots/aerial parts	flowering	dried material	tea, herbal products		niche/traditional	€ 112,00	€ 16,00	NA
Glechoma hederacea	aerial part	flowering	dried material	tea, beer brewing, beverages		medium	60,00	12,00	4
Hypericum perforatum	aerial with flowers	flowering	dried material	tea, herbal products, herbal beverages	x	large	€ 38,50	€ 5,50	5
Linaria loeselii	aerial with flowers	flowering	dried material	tea		traditional	€ 126,00	€ 18,00	NA
Origanum vulgare	aerial with flowers	flowering	dried material/essential oil	tea, herbal products, food flavouring, herbal beverages	x	high/commodity	€ 56,00	€ 8,00	5

Plant species	Harvested part	Harvesting time	Product	Product uses	PhEU	Market value	Price, euro/kg (premium)	Price, euro/kg (mainstream)	Fitness for cultivation
Pilosella officinarum	aerial with flowers	summer, flowering	dried material	tea, herbal products		medium	€ 91,00	€ 13,00	4
Plantago lanceolata	leaves	before flowering	dried material	tea, herbal products	x	large	€ 31,50	€ 4,50	5
Plantago major	leaves	before flowering	dried material	tea, herbal products		large	€ 52,50	€ 7,50	4
Plantago media	leaves	before flowering	dried material	tea, herbal products		large	€ 35,00	€ 5,00	4
Polygala vulgaris	aerial with flowers	flowering	dried material	tea, herbal products	x	niche	€ 63,00	€ 9,00	2
Potentilla anserina	root, aerial part	flowering	dried material	tea, herbal products		developing	€ 77,00	€ 11,00	NA
Potentilla argentea	root, aerial part	flowering	dried material	tea, herbal products		traditional	€ 84,00	€ 12,00	NA
Potentilla erecta	root, aerial part	flowering	dried material	tea, herbal products		developing	€ 77,00	€ 11,00	3
Primula veris	flowers, roots	flowering	dried material	tea, herbal products	x	large	€ 91,00	€ 13,00	4
Prunella vulgaris	aerial with flowers	flowering	dried material	tea, herbal products	x	medium	€ 59,50	€ 8,50	3
Sedum acre	leaves	summer, flowering	fresh material	herbal products, medical devices		niche	€ 35,00	€ 5,00	NA
Sedum telephium	leaves	summer, flowering	fresh material	herbal products, medical devices		medium	€ 35,00	€ 5,00	4
Solidago virgaurea	aerial with flowers	flowering	dried material	tea, herbal products	x	medium	€ 52,50	€ 7,50	4
Stachys officinalis	aerial part	flowering	dried material	tea, herbal products	x	medium	€ 27,00	€ 5,00	3
Taraxacum officinale	roots/leaves	before flowering	dried material	tea, herbal products, food flavouring, herbal beverages	x	large	€ 70,00	€ 10,00	5
Thymus ovatus	aerial part	flowering	dried material	tea, herbal products	x	developing	€ 56,00	€ 8,00	4
Tragopogon pratensis	roots, young upper areal parts	young plants	fresh material	vegetable, foraging		traditional	€ 14,00	€ 0,00	3
Vaccinium vitis-idaea	leaves	summer	dried material	tea, herbal products		large	€ 98,00	€ 14,00	1
Valeriana officinalis	root	winter	dried material	tea, herbal products	x	commodity	€ 38,50	€ 5,50	5
Veronica chamaedrys	aerial with flowers	flowering	dried material	tea, herbal products		traditional	€ 52,50	€ 7,50	NA
Veronica spicata	aerial part	flowering	dried material	tea, herbal products		developing	€ 52,50	€ 7,50	4
Viola tricolor	flowers	flowering	dried material	tea, herbal products	x	developing	€ 45,50	€ 6,50	NA

Abbreviation: PhEU – Plant is/not registered in European Pharmacopoeia; NA – no information available of the plant cultivation fitness

ANNEX 5

Freelisted medicinal plants, their use habits and the symbol of meadow mentioned by respondents of the social survey (n=1031), data collected by "Latvijas Fakti", Year 2020

MAP (medicinal or aromatic plant) species	Number of respondents mentioned use of the MAP	Number of respondents collecting the MAP in wild	Number of respondents growing the MAP in field or garden	Number of respondents purchasing the MAP	Number of respondents mentioned the plant species as the most significant meadow plant
Acer platanoides	0	2	0	0	0
Achillea millefolium	133	127	12	27	55
Acorus calamus	2	1	0	1	0
Aegopodium podagraria	1	0	0	0	0
Aerva lanata	0	0	0	1	0
Aesculus hippocastanum	3	2	0	0	0
Agrimonia eupatoria	1	0	0	0	0
Agrostis sp.	0	0	0	0	12
Alchemilla sp.	0	60	9	12	39
Allium sativum	2	0	4	2	0
Aloe vera	5	0	0	2	0
Althaea officinalis	1	0	0	1	0
Amorphophallus	0	0	0	0	1
Anethum graveolens	5	0	6	2	0
Antennaria dioica	0	0	0	0	3
Anthriscus sylvestris	0	0	0	0	1
Apium graveolens	0	0	1	0	0
Arctium lappa	1	1	1	0	0
Arctostaphylos uva-ursi	6	1	0	9	0
Armoracia rusticana	1	0	0	0	0
Aronia sp.	0	0	1	0	0
Artemisia abrotanum	0	0	1	0	0
Artemisia absinthium	16	3	5	7	0
Artemisia dracunculus	0	0	1	0	0
Artemisia vulgaris	11	11	1	0	3
Aspalathus linearis	1	0	0	1	0
Azadirachta indica	1	0	0	0	0

MAP (medicinal or aromatic plant) species	Number of respondents mentioned use of the MAP	Number of respondents collecting the MAP in wild	Number of respondents growing the MAP in field or garden	Number of respondents purchasing the MAP	Number of respondents mentioned the plant species as the most significant meadow plant
Bellis perennis	0	1	1	0	8
Betula sp.	9	8	0	1	3
Bidens sp.	2	0	0	1	0
Bidens tripartita	0	0	0	1	0
Borago officinalis	0	0	1	0	0
Calendula officinalis	53	19	58	17	4
Callisia fragrans	0	0	0	0	1
Calluna vulgaris	5	9	0	0	0
Camellia sinensis	2	0	0	2	0
Campanula glomerata	0	0	0	0	1
Campanula patula	0	0	0	0	1
Campanula sp.	0	0	0	0	7
Cannabis sativa	2	0	0	1	0
Carum carvi	0	4	3	27	9
Centaurea cyanus	8	3	2	1	125
Chaenomeles japonica	1	0	1	0	0
Chamaenerion angustifolium	37	37	0	11	14
Chamomilla recutita	220	84	113	167	157
Chelidonium majus	8	4	3	1	1
Chenopodium sp.	0	0	0	0	1
Cichorium intybus	1	1	0	0	0
Cirsium arvense	0	0	0	0	1
Cirsium sp.	0	0	0	0	1
Cistus incanus	0	0	0	1	0
Citrus limon	1	0	0	1	0
Comarum palustre	1	1	0	0	0
Convallaria majalis	0	0	0	0	1
Coronaria flos-cuculi	0	0	0	0	1
Corylus avellana	4	1	0	0	0
Cosmos sp.	0	0	0	0	1
Crataegus sp.	6	1	2	5	0
Cuminum cyminum	0	0	0	0	1

MAP (medicinal or aromatic plant) species	Number of respondents mentioned use of the MAP	Number of respondents collecting the MAP in wild	Number of respondents growing the MAP in field or garden	Number of respondents purchasing the MAP	Number of respondents mentioned the plant species as the most significant meadow plant
Curcuma longa	0	0	0	1	0
Cymbopogon citratus	1	0	0	1	0
Dactylorhiza baltica	0	0	0	0	1
Dactylorhiza sp.	0	0	0	0	1
Dianthus deltoides	0	0	0	0	1
Dracocephalum moldavica	3	1	2	0	0
Echinacea sp.	8	0	5	4	0
Equisetum arvense	1	1	1	1	0
Equisetum sp.	6	2	0	3	0
Eruca vesicaria ssp. sativa	0	0	1	0	0
Eucalyptus sp.	2	0	0	1	0
Euphrasia sp.	1	0	0	2	0
Filipendula ulmaria	0	94	3	6	47
Filipendula vulgaris	0	0	0	0	1
Foeniculum vulgare	8	0	0	10	0
Fragaria vesca	12	12	0	1	1
Fragaria viridis	1	0	0	0	0
Galium sp.	4	2	0	0	57
Galium verum	0	0	0	0	3
Ginkgo biloba	1	0	0	0	0
Glycyrrhiza glabra	0	0	0	1	0
Gramineae	0	0	0	0	5
Harpagophytum procumbens	1	0	0	0	0
Helianthus annuus	0	0	0	0	1
Helichrysum arenarium	4	1	0	4	1
Hepatica nobilis	0	0	0	0	2
Hibiscus rosa-sinensis	1	0	0	1	0
Hippophae rhamnoides	3	0	0	3	0
Humulus lupulus	3	1	1	0	0
Hypercum sp.	0	53	4	27	22
Hyssopus officinalis	0	0	1	0	0
Impatiens noli-tangere	0	1	0	0	0

MAP (medicinal or aromatic plant) species	Number of respondents mentioned use of the MAP	Number of respondents collecting the MAP in wild	Number of respondents growing the MAP in field or garden	Number of respondents purchasing the MAP	Number of respondents mentioned the plant species as the most significant meadow plant
Inula sp.	1	0	0	1	0
Iris sp.	0	0	0	0	1
Juniperus communis	3	1	1	0	0
Kalanchoe sp.	0	0	1	0	0
Knautia arvense	0	0	0	0	4
Lamium album	5	8	1	0	0
Lathyrus sp.	1	0	0	0	0
Lavandula sp.	10	1	6	2	1
Ledum palustre	1	1	0	0	0
Leonurus sp.	9	1	6	5	1
Leucanthemum vulgare	1	1	0	0	242
Levisticum officinale	0	0	3	0	0
Lycopodium sp.	1	2	0	1	1
Malus domestica	5	0	1	0	1
Medicago sp.	1	0	0	1	1
Melampyrum sp.	0	0	0	0	1
Melilotus officinalis	1	0	1	0	0
Melilotus sp.	0	0	0	0	2
Melissa officinalis	33	10	43	6	0
Mentha aquatica	4	2	0	0	0
Mentha x piperita	180	130	254	81	39
Myosotis sylvatica	0	0	0	0	1
Nepeta cataria	3	2	2	1	0
Nigella sativa	0	0	1	0	0
Ocimum basilicum	0	1	4	0	0
Oenothera biennis	0	0	0	0	1
Orchis sp.	0	0	0	0	4
Origanum vulgare	38	20	32	3	2
Oxycoccus sp.	5	4	0	4	0
Padus avium	2	0	0	0	0
Paeonia sp.	1	1	0	0	0
Panax ginseng	1	0	0	1	0

MAP (medicinal or aromatic plant) species	Number of respondents mentioned use of the MAP	Number of respondents collecting the MAP in wild	Number of respondents growing the MAP in field or garden	Number of respondents purchasing the MAP	Number of respondents mentioned the plant species as the most significant meadow plant
Papaver dubium	0	0	0	0	1
Papaver somniferum	1	0	0	0	0
Papaver sp.	0	0	0	0	18
Petroselinum crispum	2	0	2	0	0
Philadelphus sp.	3	3	1	0	0
Phleum sp.	0	0	0	0	2
Picea abies	0	1	0	0	0
Pimpinella anisum	2	0	0	0	0
Pinus sylvestris	20	18	0	9	1
Piper nigrum	1	0	0	1	0
Plantago lanceolata	1	1	0	0	0
Plantago sp.	49	17	3	4	16
Platanthera bifolia	0	0	0	0	1
Platanthera sp.	0	0	0	0	32
Populus tremula	1	1	0	0	0
Potentilla anserina	1	0	0	0	0
Potentilla erecta	0	0	0	0	1
Potentilla sp.	2	0	0	0	0
Primula farinosa	0	0	0	0	5
Primula veris	0	107	7	9	45
Prunus cerasus	1	0	1	0	1
Prunus domestica	0	0	0	0	1
Pulsatilla vernalis	0	0	0	0	1
Pyrus communis	0	0	0	0	1
Quercus robur	6	0	0	3	3
Rhaponticum carthamoides	0	0	0	1	0
Rheum sp.	0	0	1	0	0
Ribes nigrum	15	6	6	1	0
Ribes rubrum	1	0	0	0	0
Ribes sp.	0	1	1	0	0
Rosa rugosa	0	0	1	0	0
Rosa sp.	19	3	3	5	1

MAP (medicinal or aromatic plant) species	Number of respondents mentioned use of the MAP	Number of respondents collecting the MAP in wild	Number of respondents growing the MAP in field or garden	Number of respondents purchasing the MAP	Number of respondents mentioned the plant species as the most significant meadow plant
Rubus caesius	2	1	1	0	0
Rubus chamaemorus	0	2	0	0	0
Rubus idaeus	56	34	12	7	3
Rudbeckia sp.	0	0	1	0	0
Rumex sp.	0	0	0	0	3
Ruta graveolens	0	0	1	0	0
Salvia officinalis	13	5	15	9	1
Salvia rosmarinus	0	0	1	0	0
Sambucus nigra	5	3	4	1	0
Schisandra chinensis	1	1	0	0	0
Secale cereale	0	0	0	0	1
Senna sp.	1	0	0	0	0
Silybum marianum	5	0	0	1	0
Sorbus aucuparia	8	7	1	0	0
Spinacia oleracea	0	0	1	0	0
Symphytum officinale	1	0	2	1	2
Syringa sp.	1	0	0	0	0
Tagetes sp.	0	0	0	0	1
Tanacetum vulgare	4	4	0	1	1
Taraxacum officinale	7	5	0	2	25
Thlaspi arvense	2	1	0	0	0
Thymus sp.	28	22	10	6	3
Thymus vulgaris	4	3	10	0	1
Tilia cordata	227	223	12	63	8
Trifolium hybridum	0	0	0	0	1
Trifolium medium/pratense	31	33	1	4	39
Trifolium repens	2	2	0	0	12
Trifolium sp.	12	12	0	0	56
Trollius europaeus	0	0	0	0	1
Tussilago farfara	0	39	0	8	8
Urtica dioica	35	26	2	4	1
Vaccinium myrtillus	17	14	1	1	0

MAP (medicinal or aromatic plant) species	Number of respondents mentioned use of the MAP	Number of respondents collecting the MAP in wild	Number of respondents growing the MAP in field or garden	Number of respondents purchasing the MAP	Number of respondents mentioned the plant species as the most significant meadow plant
Vaccinium vitis-idaea	9	10	0	1	2
Valeriana officinalis	17	4	0	8	7
Verbascum sp.	7	7	2	0	5
Veronica sp.	1	1	0	0	1
Viburnum opulus	1	0	1	0	0
Vicia cracca	0	0	0	0	4
Viola tricolor	1	0	0	1	0
Zingiber officinale	9	0	0	2	0

Abbreviations: **Species name in bold** – common grassland plants in Latvia; Species name in grey colour – plants that do not grow naturally in Latvia; Rows in yellow mark plant species that was mentioned as the most significant meadow plant by one or more respondents in the social survey.