Chapter

The Floristic-Holistic Method for Arid, Semiarid, and Subhumid Areas: A Tool for the Revaluation of Floristic Diversity, Conservation, and Protection of the Ecosystem

Cynthia C. González, Antonella M. Lista, Cristian Silva, Mauricio A. Joffe, Gastón E. Ponce, Patricia L. Simón and Magdalena Llorens

Abstract

The valorization of methods for comprehensive data collection is one of the fundamental tools to establish concrete bases and is applicable to lines of work in conservation, preservation, and protection of ecosystems. During the last 20 years, from the Botany Laboratory and Herbarium Trelew, we have valued the Floristic-Holistic Method that we have been adapting, for flora surveys. Method is intensively used in some Argentine provinces of arid, semiarid, and subhumid zones of the South American Arid Diagonal (Santa Cruz, Chubut, Río Negro, Neuquén, Mendoza, and arid islands of the Patagonian Atlantic coast). This revaluation focuses its importance on not only providing information on ecological parameters (bare soil, topsoil, living plant cover, and dead plant cover), richness, equitability, and floristic diversity, but also on status, conservation, botanical types, biological forms, adaptations, plant density, percentages of protected species, potential invasions of exotic species, forage productivity, and animal receptivity. The information is comprehensive and adaptable to different situations, applicable to different plant associations, types of terrain, and landscape units (open and closed mount, shrubby steppes, subshrubs, grasses, wastelands, rocky fields, peladales, and all kinds of modified areas). The method thus holistically conceptualizes ecosystem goods and services, allowing their study at different scales.

Keywords: flora, method, south American arid diagonal, grasslands, mount, steppe

1. Introduction

The natural grasslands of the arid and semiarid zones are nonarable land due to climatic, edaphic, or topographic limitations, which are covered by native and/or naturalized vegetation. They can be used as fodder for domestic and wild livestock, as well as to extract water and wood, and for recreational purposes [1]. Likewise, a characteristic of the natural grasslands of Argentine Patagonia (as well as much of the South American Arid Diagonal) is that different biological forms coexist (shrubs, subshrubs, herbaceous eudicots, and grasses) [2–4]. In these ecosystems, it is necessary to use an ecological evaluation method that considers the different biological forms that make up that plant community and that allows differentiating the forms present regardless of whether they are foragers or not, and whether they are present in all seasons of the year or not. That is, the method must reflect the comprehensive diversity present in the area, beyond the uses assigned to each of the species that make up the identified diversity indices (such as wild herbivory or livestock).

Starting in 1995, the Herbarium Trelew work team, referred in the following sections as HTW, used a variety of methods in the field for the flora censuses carried out, according to specific work requirements. Then, starting in 2002, the Pastoral Value Method [2–4], known in the following sections as PVM, is integrated into the methodologies to calculate the ecological parameters considering results and data obtained from the structure of the vegetation, forage productivity, and livestock receptivity.

From 2005 to 2009, it was adapted by the HTW work team gradually the way in which the data were collected based on: the need to generate specific data for the different lines of work that made up the HTW (research, project development, education, professional training, university training, and environmental services), the characteristics of arid and semiarid zones, the floristic composition observed, the field experience by the work staff, the observations in the floristic interactions, and the bases of conservation and preservation to be considered on the identified vegetation units and landscape units. The PVM was thus transformed into a post for obtaining and assessing new results and new horizons of botanical interpretation, expanding data collection not only to considerations of vegetation structure, forage productivity, and animal receptivity, but also to considerations of the type holistic ones related to plant ecology and eco-physiology for arid, semiarid, and subhumid zones. There is a change in the observation for data collection, moving from an exclusive livestock and productive approach to a multidisciplinary botanical, biological, ecological, physiological, and environmental approach, thus considering a new conservationist and protectionist point of view of the environments to evaluate.

In the PVM, the observations focus on the recording, which plants are available for livestock consumption, not only if they are young branches but also the height of the grazing animal and annual plants are not considered in the survey. On the other hand, in the Floristic-Holistic Method, called in the next sections as FHM, the entire flora is surveyed, regardless of the height of the plants or whether it is a young or old branch, focusing the observation mainly on the data of plants considering the presence and if they are alive. Starting in 2010, the FHM began to take hold, which is used to date in the active lines of work of the Botany Laboratory and HTW.

Since the 1990s, by the HTW work team, the published qualitative and quantitative methods have been adapted based on the experimental requirements with the aim of obtaining a modified method that has a conservationist and protectionist vision of the flora of the surveyed sites. It was also sought that the exposed method be useful to different types of applications in the field and diverse scopes in different areas of science. In this way, a method is obtained that considers and groups several methods in a complete way, feasible for application and analysis, applicable in terrestrial ecosystems for arid, semiarid, and subhumid zones, taking into account the visualization and understanding requirements of existing ecological dynamics and relationships to consider when making decisions on conservation, protection, planning, and management, which allow sustainable use of ecosystem goods and services in a systemic and holistic way. It is intended to express the path traveled both in field work and in office work in the last two decades by the HTW, based on the integration of qualitative and quantitative methods used historically, as they were adapted based on the experimental requirements, in view of the creation of the Floristic-Holistic Method that points toward a conservationist and protectionist vision of the flora of the surveyed sites.

2. Environmental characterization of census areas

Argentina's Arid Diagonal is defined by climatic-geographical aspects as an arid strip of latitudinal distribution that includes cold deserts (high Andean and Patagonian) and warm ones on the eastern Andean slope in the shadow of rains. The typification of mesic-aridic soils in the high Andes and Patagonia and thermo-aridic in low Andean pockets and plains and the phytogeographic and syntaxonomic diversity give it an identity that differentiates it from the rest of the dry areas of the world. These aspects also allow Arid Diagonal to be granted the condition of bio-climate entity [5].

Argentina's Arid Diagonal [5] (**Figure 1**) is defined as referring exclusively to the distribution in Argentina of the South American Arid Diagonal. It extends through 17° latitude between 27° and 44°S, south of 45°S (**Figure 1**), and precipitation is from the Pacific and occurs throughout the year. From the particularities, it is characterized by two climatic regimes: Tropical to the north and Mediterranean to the south of 35°S and in the high mountain range, determined by the influence of the anticyclones of the Atlantic and the Pacific, by the climate of mesic-aridic soil in the high Andes and Patagonia and thermal-aridic in the foothills and plains. On the other hand, Diagonal Árida Argentina includes six associated phytogeographic regions: Altoandina, Puna, Payunia, Patagonia, Cardonal, and Mount [5]. By relating the regimes to the soils and the phytogeographic regions present, the cold and warm deserts that comprise it can be recognized: cold deserts (Altoandino, Puna, Payunia, and Patagonia) and hot deserts (Cardonal and Mount).

3. Materials and methods

Floristic surveys were carried out with various methods along different sectors of Argentina's Arid Diagonal, perfecting this method from 1344 transects, with 260,000 base data that will later be expanded to other derived data and a sampling effort of 403,200 steps (403.2 kilometers) surveyed. This distance was covered on foot, lowering a rod every three steps to take a census of all the flora present. The set of transects represents the environmental evaluation of the flora of the regions over two decades, integrating 21 years of sampling (between 2001 and 2022).

Considering the geographical distribution of the transects, 181 correspond to transects carried out in the province of Santa Cruz, 780 in Chubut, 23 in Río Negro, and 360 in Mendoza. Taking into account the geographical positions of each transect, results from census areas belonging to the high Andean, puna, payunia, patagonia, cardonal, and mount regions were included for the evaluation of the method [5]. Specifically for the bioclimatic zones raised within the South American Arid Diagonal

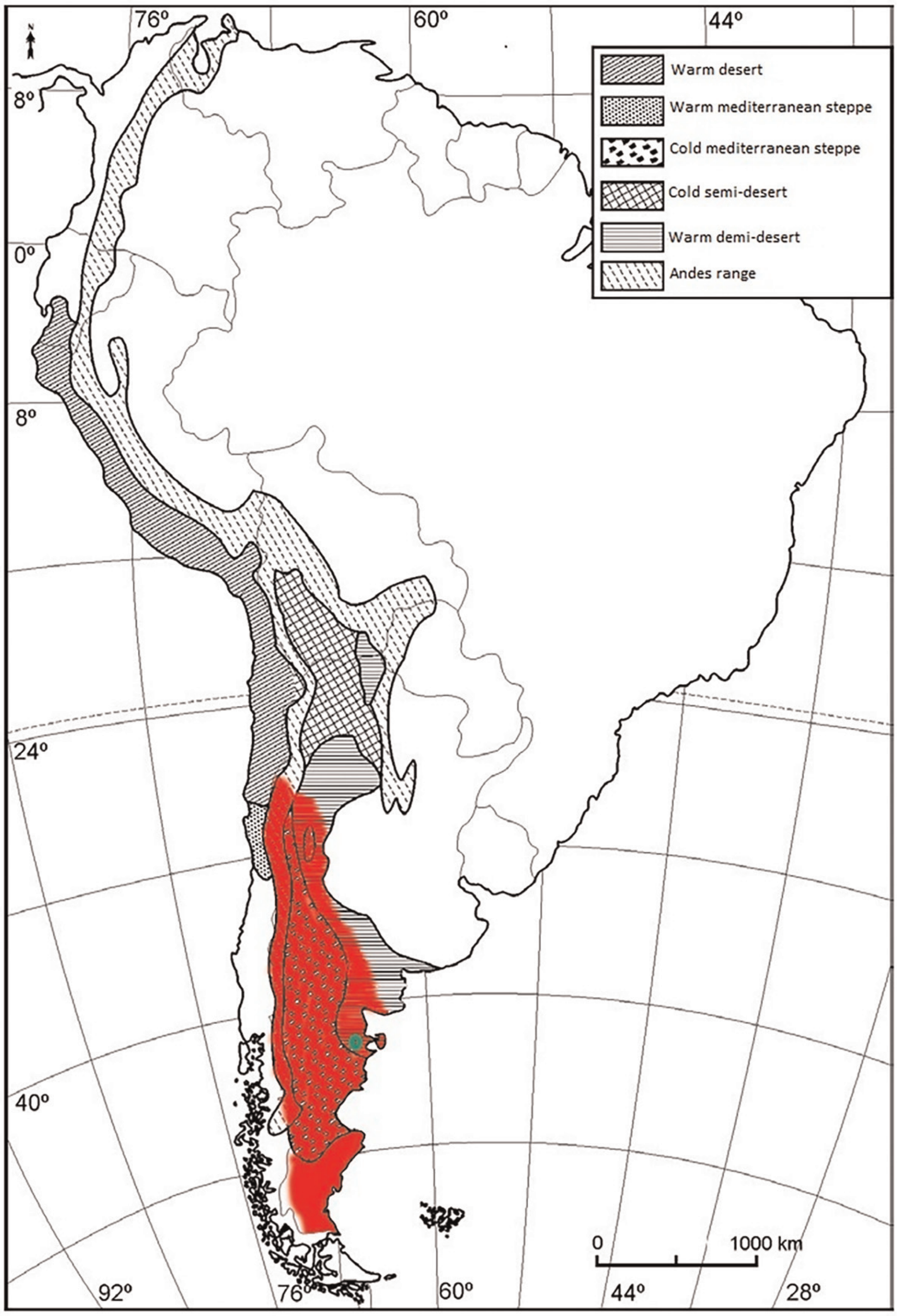

Figure 1.
Distribution of rainfall and physiognomies in the area of the South American Arid Diagonal. Taken from [5]. In red, areas where flora censuses were carried out with the proposed method. The green dot indicates a simultaneous census area with the Floristic-Holistic Method (FHM) and the Pastoral Value Method (PVM).

[5], 555 transects belonging to the cold Mediterranean steppe, 545 to warm semideserts, and 158 to the Andean range are recognized (**Figure 1** and **Table 1**). Considering hot and cold environments of the total number of transects, 545 correspond to hot desert transects and 713 to cold deserts.

It is worth mentioning that the method was applied in different ecological areas, such as:

- In the province of Santa Cruz, 161 transects were considered in the central plateau area, 7 in the humid Magellanic steppe area, 8 in the dry Magellanic steppe area, and 26 in the "Mata Negra" scrub area.

Ecological areas according to INTA	Phytogeographic areas	Bioclimatic entity of the South American arid diagonal	Usage factor (UF-%)
South Mount	Mount	Warm semidesert	25–35
North mount	Mount	Warm semidesert	30–50
Coast	Patagonia and mount	In warm semidesert and Cold Mediterranean steppe	25–35
Steppe (Saws and Central Plateaus)	Patagonia and payunia	Cold Mediterranean steppe	25–35
Steppe (Saws and Western Plateaus)	Patagonia and payunia	Cold Mediterranean steppe	30–50
Gramineous steppe (Pre-mountain range)	Puna, patagonia and high Andean	Andes range	40–60

Table 1.
Use factor in the different ecological areas, phytogeographic areas, or bioclimatic entities surveyed.

- In the province of Chubut, 259 transects were considered in the mount area, 499 in the steppe, six in the pre-mountain range area, and three in the Andean forest area.
- In the province of Río Negro, 23 transects are considered that corresponds entirely to the mount area.
- In the province of Mendoza, 151 transects from the Andean area, 61 from the steppe area, and 92 from the mount area were evaluated.

For the development of the method, different situations were taken and it came to be taken as the most powerful and relevant method to evaluate the flora, including plants, fungi, lichens, and macroalgae (such as macroalgae of the genus *Chara,* very common in pond areas in semideserts) in different situations. We have tested the use of the method for studies of general plant biodiversity, for comparison between different landscape units and for comparison of the same landscape unit throughout the different seasons of the year (spring, summer, autumn, and winter) or throughout of several years, to calculate the receptivity of domestic and/or wild animals, to evaluate the degrees of degradation over the years, or the passive or active ecological restoration of land, to know the degree of conservation of an area, to assess the loss of diversity/productivity/receptivity of flood-prone areas where dams or weirs will be built or where the water course will be diverted, in areas that have suffered clearing, fires or changes in land use, including for opening to livestock or agricultural barrier or road diversions, industrial effluent impacts, and for monitoring loss of native species and/or biological invasions concrete and/or potential, and for mining studies, for evaluation of studies of direct and indirect impacts of various kinds, for studies of ethnobotanical uses, etc. In all cases, the method has proven to be the most powerful for comprehensive assessments of the flora.

4. Description of the floristic-holistic method (FHM)

This proposal combines several types of sampling in a single comprehensive methodology. This method combines the point intercept line with the Point Centered Quadrants Method [6] and the Pastoral Value Method (PVM) [2–4].

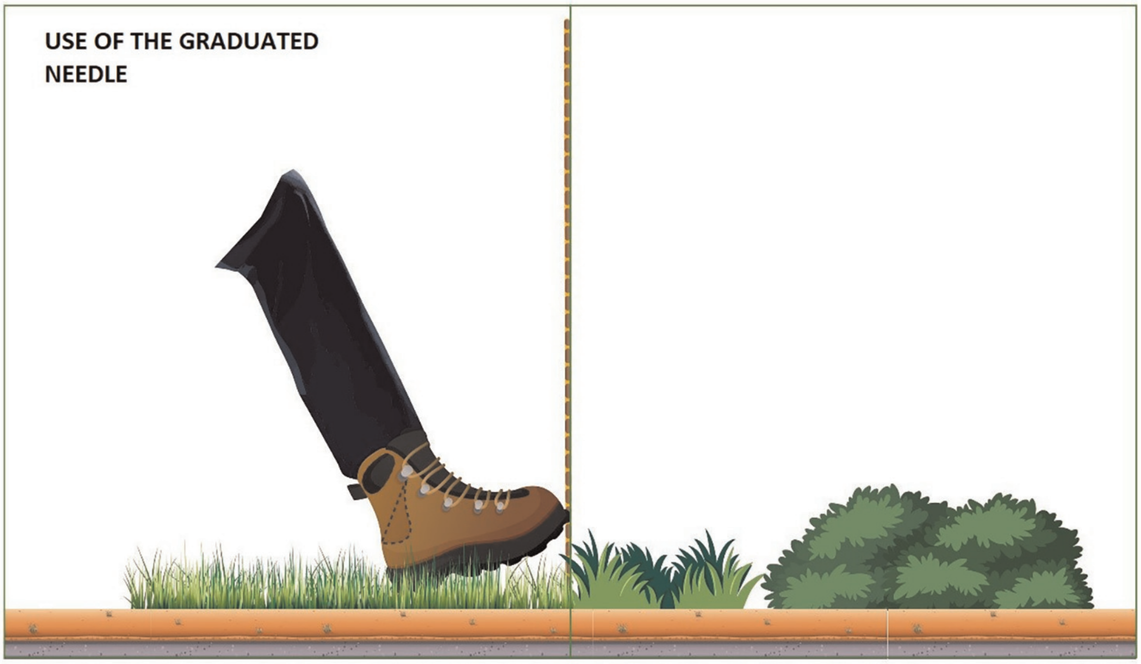

Figure 2.
Location and use of the metal needle. Modified from [2, 3].

For data collection in the field, the types of environments must be recognized, classifying the vegetation by its physiognomy and by the dominant aspects, highlighting those that make the greatest contribution to the total coverage.

The Floristic-Holistic Method (FHM) consists of randomly locating the first point of the transect, and the rest of the points are located on an imaginary line at a fixed distance. Each transect had 100 equidistant points, whose distance was equal to 3 paces (1 pace = 1 meter). To ensure a good census of vegetation, data collection is avoided near fences, roads, or areas disturbed by the passage of vehicles, or in patches that are not representative of the vegetation.

To perform the reading, a metal needle 1 m long and 5 mm in diameter is used. The needle is stuck in the ground at the height of the toe of the shoe (**Figure 2**) and vegetation records are taken along the needle, noting suitable forms for it.

To place the needle at each point, you look at the reference point, thus avoiding choosing where to place it.

All living plants are taken as the focus of observation, regardless of whether they are forage, ephemeral, or annual. Thus:

- If a live plant or branch is touched directly (regardless of whether or not it is accessible to herbivores), the number of touches observed circled should be noted. A touch is considered to be one or more contacts of the live portions that occur for every 1 cm of the needle, if the contacts occupy 2 cm, they are considered 2 touches, and so on (**Figure 3**). The presence and the number of touches, if it is alive, are relieved.

- If the species or part contacted is dead, an "X" surrounded by a circle should be noted and it is considered dead standing (**Figure 4**).

Due to the superposition of different biological forms in the vertical structure, one or more plant species can be recorded in the same reading.

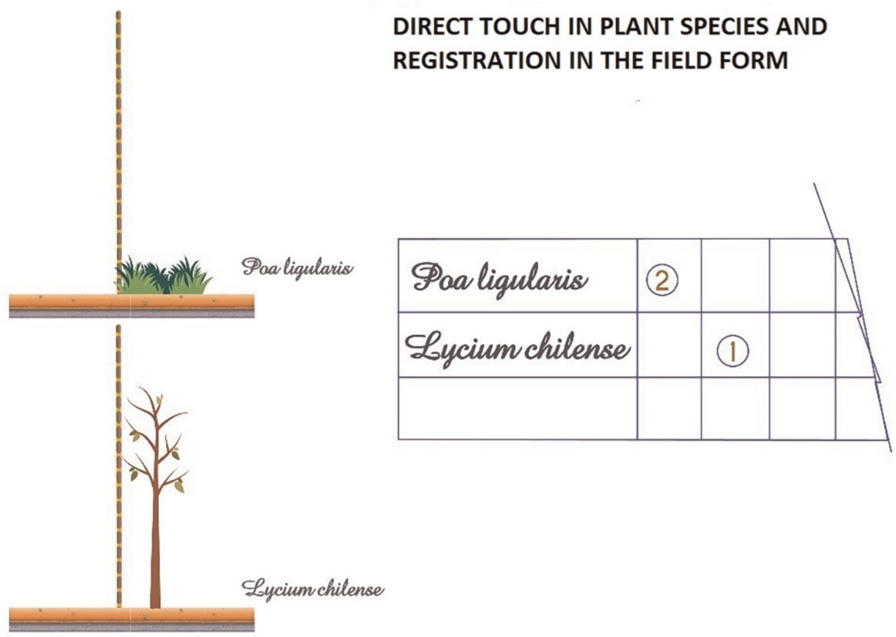

Figure 3.
Direct touch on perennial plant and a living portion of the plant. Modified from [2, 3].

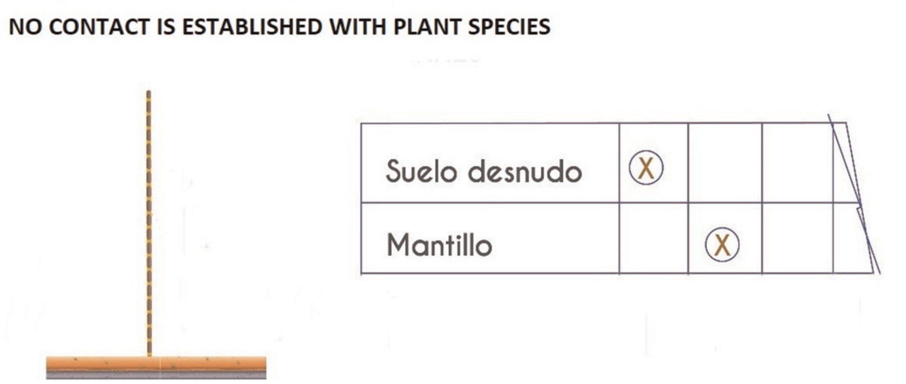

Figure 4.
Direct contact of bare soil, mulch, rock, or erosion pavement. Modified from [2, 3].

- If there is no direct contact with living plant species along the needle. And in the event that the direct contact of the needle is bare soil, topsoil (dead or decomposing plant material on the surface), rock (rocky outcrops or large clasts), or erosion pavement (high percentage of stones of different surface sizes), it is recorded with an "X" surrounded by a circle. Then, the closest plant in the four quadrants is observed, which one is noted (without circling the number of touches, since the touch is indirect) (**Figure 5**). The indirect touch is relieved only on living plants.

From the information obtained in each transect, the attributes of the soil and vegetation are summarized:

Bare or unvegetated ground: Sum of points where the needle directly touched bare ground, rock, topsoil, and other surface soil attributes.

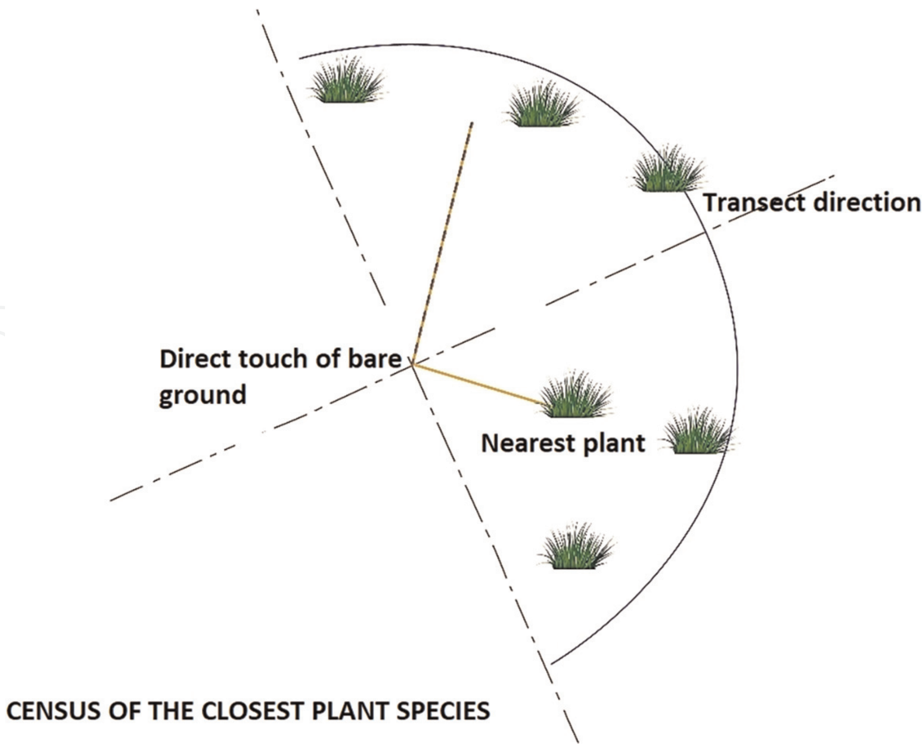

Figure 5.
When the needle touch bare soil, mulch, rock, or erosional pavement, the closest species of the four quadrants is counted. Modified from [2, 3].

Dead plant material: Sum of points where the needle directly touched a dead plant in a living position or pieces of dead branches not incorporated into the soil.

Litter: Sum of points where the needle directly touched mulch or decomposing dead plant material incorporated into the soil (broken branches, leaves, seeds, remains of flowers, and fruits).

Coverage by species (CoSp): Number of points in which a species has been found (the closest plants are not included). Since the points are 100, the coverage can be expressed as a percentage. To facilitate its computation, the mark or number of touches of directly touched plants is circled on the spreadsheet.

Total relative plant cover (TRPC): Sum of the cover (Co) of plant species. It would be the number of points where the rod directly touched a living plant (closest plants are not included). Since the points are 100, the coverage can be expressed as a percentage. To facilitate its computation, the mark or number of touches of directly touched plants is circled on the spreadsheet.

Total absolute plant cover (TAPC): Sum of all the covers of the species.

Specific plant coverage (SPC—touches by species): Total number of contacts of the rod with a species (the number of touches that has been recorded for each species (direct touch) is added). Percentage expression of the relationship between the number of touches made to a species (TSp) and that of total touches (TT) made to all the species registered in the 100 sampled points: SPC = (TSp x 100)/TT.

For this point, it is recommended to follow the updated names of the species according to the catalog of vascular plants of the southern cone [7].

Cover by biological forms (CBF): Percentage of total cover or by species that correspond to the different biological forms (shrubs, herbs, grasses, trees, succulents, and thallophytes).

Cover by biological types: Percentage of total cover corresponding to the type of plant according to the classification of the large groups of plants (Bryophyta, Lycophyta, Monilophyta, Gymnosperms (Gnetophyta, Coniferophyta), angiosperms (Monocotyledons, Eudicots, Basal Angiosperms, Magnolides), fungi (Mucoromycota, Ascomycota, Basidiomycota, etc.), lichens.

With respect to monocotyledons, they can be grouped into gramineous and non-gramineous monocots. As for lichens, the species itself, their growth form (crustaceans, foliose, and fruticulous), the type of thallus (homogeneous or heterogeneous structure), and/or the substrate in which they live (saxicolous, terrestrial, etc.) can be considered as corticultural, follicultural, or zoobiotic.

Coverage by biological status: Percentage of total coverage or by species that corresponds to the different types of status in plants (native nonendemic, endemic, introduced non-feral, native feral). At this point, the IUCN red list of treated species (https://www.iucnredlist.org/) and checklist of CITES species (https://checklist.cites.org/#/en) can be considered, as well as legislation national. In the case of Argentina, we used resolution 84/2010 (red list of endemic species of Argentina—https://www.argentina.gob.ar/normativa/nacional/resoluci%C3%B3n-84-2010-165,374) and resolution 109/2021 (list of invasive, potentially invasive, and cryptogenic exotic species—https://www.argentina.gob.ar/normativa/nacional/resoluci%C3%B3n-109-2021-348,718), both resolutions of the Ministry of Environment and Control of Sustainable Development of the Nation.

Coverage by biotype or type of life: Percentage of total coverage or by species that corresponds to the different types of plants (annuals, biennials, perennials, and multiennials).

Coverage by botanical families: Percentage of total coverage or by species that corresponds to the different botanical families (Alliaceae, Apiaceae, Asteraceae, Cactaceae, Fabaceae, Poaceae, and so on).

Coverage Raunkiaer biological forms: Percentage of total coverage or by species that correspond to the different life forms according to Raunkiaer [8]. This classification is based on the position of the shoot buds, and this is an adaptive character because growth depends on the buds once the adverse season is over. Five main categories are distinguished in this classification:

1. Therophytes or annual plants: Spend the adverse period in the seed stage.

2. Hydrophytes: Shoot buds in the water (they can be floating or fixed in the mud).

3. Geophytes or cryptophytes: Vegetative buds are below ground level.

4. Hemicryptophytes: Vegetative buds are found at surface level.

5. Camephytes plants whose vegetative buds are found in the aerial parts, but below 25 cm in height.

6. Phanerophytes: Plants with vegetative buds located in the aerial part above 25 cm in height. In addition, the Phanerophytes, according to their height are divided into nanophanerophytes (plants up to 2 meters high), microphanerophytes (plants between 2 and 8 meters high), mesophanerophytes (plants from 8 to 30 meters high) and megaphanerophytes (plants more 30 meters high).

7. Epiphytes: Plants that live on other plants.

They can also be quantified according to adaptation (xerophytes, mesophytes, hydrophytes, and so on) and organ modifications (plants with rhizomes, tubers, bulbs, foliar thorns, cauline thorns, napiform roots, and so on).

Plant-specific density: Number of plants per hectare. Number of times a plant appears every 100 direct hits on a 100 meters transect. It is calculated from the number of plants recorded in the transect and considering the length of each transect (100 meters).

Shanon-Weaver Diversity Index: It is calculated from the proportions (p_i) of each species (i) in the total sample of individuals. It is calculated using the following formula: $H = -\Sigma p_i \log_e p_i$. Where H is the logarithmic measure of diversity, and p_i = proportion of individuals of species i with respect to the total number of individuals (i.e., the relative abundance of species i). It can be said that the Shannon diversity index measures (the reciprocal of) the probability of selecting all the species in the proportion that they exist in the population; that is, it measures the probability that a sample selected at random from an infinitely contains exactly n_1 individuals of species 1, n_2 of species 2, … and n_s individuals of species S [9–11].

The diversity value (H) generally varies between 1.5 and 3.5 and rarely exceeds 4.5 [12]. It is worth mentioning that the maximum diversity (Hma x = lnS) is reached when all species are equally present. On the other hand, the value of H is bounded between 0 and ln(s), which tends to zero in communities with little diversity and is equal to the logarithm of the species richness in communities with maximum equality [13].

Equity: It allows knowing the degree of regularity with which individuals are distributed among species. It is calculated using the following formula: E = H/ln S.

Where H is the diversity index and S is the number of species (specific richness). Evenness approaches zero when one species dominates all others in the community and approaches 1 when all species share similar abundances [13].

Wealth: Number of recorded species.

Species Quality index (SQI): Specific quality index that has been assigned to each species as a result of the evaluation of its degree of acceptability by livestock, the period in which it is used, and its nutritional value (in Ref. to [2, 3]). But many other species surveyed by our HTW team based on more than 25 years of field observation in different areas with different conditions and different levels of degradation are also recorded. **Table 2** presents a list of species with their SQI.

Pastoral Value (PV): The value of the pastoral value determines the amount of forage available at the livestock level. It is calculated based on its floristic composition, and the quality and quantity of the species that compose it (in the census considering only living plants and those of forage value).

The following formula was used: PV = (0.2 x Σ (Tsp x SSI) x TAPC)/TT.

where TSp = Touches per species, SQI = Specific Quality Index, TAPC = Total absolute plant cover, TT = Total Touches. The constant 0.2 is used to keep the range of pastoral values between 0 and 100. Note: Once the census calculations have been carried out, the pastoral values (PV) are obtained per transect carried out. Subsequently, the average PV (PVp) is calculated for each surveyed environment.

Use Factor (UF): The concept of use factor corresponds to the percentage of available forage that can be grazed by livestock to allow sustainable production over time. This factor varies with the type of vegetation in each area, the climatic conditions, and the vigor of the most important forage plant species. These values for each environment were developed by researchers from the National Institute of Agricultural Technology (INTA Trelew, Chubut, Argentina), according to what was

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Biological form	Botanical family	Name	IE	Biological form	Botanical family	Name	IE
Herb	Rosaceae	*Acaena spp.*	3	Bush	Zygophyllaceae	*Larrea spp.*	0
Bush	Verbenaceae	*Acantholippia seriphioides*	2	Herb	Fabaceae	*Lathyrus magellanicus*	2
Bush	Asteraceae	*Acanthostyles bunifolius*	2	Herb	Malvaceae	*Lecanophora sp.*	3
Herb	Fabaceae	*Adesmia aff philips*	0	Herb	Brassicaceae	*Lepidium spp.*	2
Bush	Fabaceae	*Adesmia boronioides*	0	Grass	Poaceae	*Leptochloa crinita*	3
Herb	Fabaceae	*Adesmia capitellata*	2	Herb	Asteraceae	*Leuceria achillaefolia*	1
Herb	Fabaceae	*Adesmia corymbosa*	2	Bush	Loranthaceae	*Ligaria cuneifolia*	0
Herb	Fabaceae	*Adesmia gutullifera*	0	Grass	Poaceae	*Lolium perenne*	1
Herb	Fabaceae	*Adesmia longipes*	2	Bush	Solanaceae	*Lycium ameghinoi*	1
Herb	Fabaceae	*Adesmia lotoides*	2	Bush	Solanaceae	*Lycium chilense*	5
Herb	Fabaceae	*Adesmia quadripinnata*	1	Bush	Solanaceae	*Lycium gillesianum*	3
Herb	Fabaceae	*Adesmia retrofracta*	3	Bush	Solanaceae	*Lycium tenuispinosum*	2
Bush	Fabaceae	*Adesmia trijuga*	3	Succulent	Cactaceae	*Maihuenia patagonica*	0
Herb	Fabaceae	*Adesmia villosa*	2	Succulent	Cactaceae	*Maihueniopsis darwinii*	0
Bush	Fabaceae	*Adesmia volckmanii*	3	Herb	Malvaceae	*Malvella leprosa*	2
Grass	Poaceae	*Agropyron spp.*	2	Herb	Fabaceae	*Medicago lupulina*	1
Grass	Poaceae	*Agrostis spp*	5	Herb	Fabaceae	*Medicago sativa*	3
Grass	Poaceae	*Alopecus magellanicus*	1	Herb	Oleaceae	*Menodora decemfida*	1
Grass	Poaceae	*Ammophila arenaria*	0	Bush	Oleaceae	*Menodora robusta*	1
Herb	Primulaceae	*Anagallis alternifolia*	1	Herb	Loasaceae	*Mentzelia albecens*	3
Bush	Fabaceae	*Anarthrophyllum desideratum*	1	Herb	Loasaceae	*Mentzelia parvifolia*	0
Bush	Fabaceae	*Anarthrophyllum rigidum*	3	Bush	Polygalaceae	*Moninna dyctiocarpa*	3
Grass	Poaceae	*Aristida mendocina*	5	Bush	Plantaginaceae	*Monthea aphylla*	0
Grass	Poaceae	*Aristida spegazzinii*	0	Grass	Poaceae	*Muhlembergia asperifolia*	0

Biological form	Botanical family	Name	IE	Biological form	Botanical family	Name	IE
Herb	schoepfiaceae	*Arjona spp.*	2	Bush	Verbenaceae	*Mulguraea aspera*	5
Grass	Poaceae	*Arrehenatherum elatius*	1	Bush	Verbenaceae	*Mulguraea ligustrina*	5
Herb	Fabaceae	*Astragalus spp.*	0	Bush	Verbenaceae	*Mulguraea scoparia*	3
Bush	Amaranthaceae	*Atriplex spp.*	3	Bush	Verbenaceae	*Mulguraea tridens*	3
Bush	Apiaceae	*Azorella caespitosa*	1	Herb	Bryophyta	*Mosses*	0
Bush	Apiaceae	*Azorella microphylla*	0	Bush	Asteraceae	*Mutisia retrorsa*	0
Bush	Apiaceae	*Azorella prolifera*	2	Bush	Asteraceae	*Nardophyllum bryoides*	0
Bush	Apiaceae	*Azorella monantha*	0	Bush	Asteraceae	*Nardophyllum chiliotrichioides*	1
Bush	Asteraceae	*Baccharis darwinii*	3				
Bush	Asteraceae	*Baccharis divaricata*	3	Grass	Poaceae	*Nasella spp.*	3
Bush	Asteraceae	*Baccharis salicifolia*	2	Bush	Asteraceae	*Nassauvia aculeata*	1
Bush	Asteraceae	*Baccharis spartioides*	0	Bush	Asteraceae	*Nassauvia axillaris*	1
Herb	Asteraceae	*Baccharis tenella*	2	Bush	Asteraceae	*Nassauvia glomerulosa*	2
Bush	Berberidaceae	*Berberis microphylla*	1	Bush	Asteraceae	*Nassauvia ulicina*	0
Herb	Calyceraceae	*Boopis anthemioides*	2	Grass	Poaceae	*Nassella longiglumis*	4
Bush	Nyctaginaceae	*Bougainvillea spinosa*	0	Grass	Poaceae	*Nassella tenuis*	2
Bush	Asteraceae	*Brachiclados caespitosa*	2	Grass	Poaceae	*N. tenuissima*	0
Bush	Asteraceae	*Brachyclados lyciodes*	2	Herb	Brassicaceae	*Nasturtium officinale*	3
Bush	Asteraceae	*Brachyclados megalantus*	2	Herb	Solanaceae	*Nicotiana spp.*	1
Bush	Polygalaceae	*Bredemeyera microphylla*	4	Herb	Amaryllidaceae	*Notoscordum gracile*	1
Grass	Poaceae	*Briza reniformes*	0	Herb	Onagraceae	*Oenothera spp.*	0
Grass	Poaceae	*Bromus brevis*	2	Herb	Iridaceae	*Olsynium spp.*	2
Grass	Poaceae	*Bromus catharticus*	5	Herb	Oxalidaceae	*Oxalis compacta*	1

Biological form	Botanical family	Name	IE	Biological form	Botanical family	Name	IE
Grass	Poaceae	*Bromus setifolius*	3	Grass	Poaceae	*Panicum urvilleanum*	1
Grass	Poaceae	*Bromus unioloides*	3	Grass	Poaceae	*Pappostipa ameghinoi*	1
Bush	Scrophulariaceae	*Buddleja spp.*	4	Grass	Poaceae	*Pappostipa chrysophylla*	1
Herb	Loasaceae	*Caiophora pulchella*	0	Grass	Poaceae	*Pappostipa humilis*	0
Herb	Portulacaceae	*Calandrinia affinis*	2	Grass	Poaceae	*Pappostipa ibari*	3
Herb	Calceolariaceae	*Calceolaria spp.*	2	Grass	Poaceae	*Pappostipa major*	0
Thallophyte	Teleochistaceae	*Caloplaca sp.*	0	Grass	Poaceae	*Pappostipa psilantha*	3
Herb	Calyceraceae	*Calycera spinulosa*	2	Grass	Poaceae	*Pappostipa speciosa*	2
Herb	Brassicaceae	*Cardamine cordata*	3	Bush	Fabaceae	*Parkinsonia precox*	3
Herb	Asteraceae	*Carduus thoermeri*	1	Thallophyte	Parmeliaceae	*Lichens*	0
Herb	Cyperaceae	*Carex argentina*	1	Succulent	Cactaceae	*Parodia submammulosa*	0
Herb	Cyperaceae	*Carex gayana*	2	Bush	Caryophyllaceae	*Paronichya chilensis*	0
Herb	Cyperaceae	*Carex subantártica*	1	Herb	Asteraceae	*Parthenium hysterophorus*	1
Herb	Caryophyllaceae	*Cerastium arvense*	3	Herb	Asteraceae	*Perezia recurvata*	1
Bush	Asteraceae	*Chuquiraga aurea*	1	Bush	Ericaceae	*Pernettya mucronata*	0
Bush	Asteraceae	*Chuquiraga avellanedae*	2	Herb	Boraginaceae	*Phacelia spp.*	2
Bush	Asteraceae	*Chuquiraga erinacea sp. erinacea*	2	Bush	Apocynaceae	*Philibertia candolleana*	1
Bush	Asteraceae	*Chuquiraga erinacea sp. Hystrix*	2	Grass	Poaceae	*Phleum pratense*	2
Bush	Asteraceae	*Chuquiraga rosulata*	2	Grass	Poaceae	*Phragmites australis*	0
Herb	Asteraceae	*Cirsium vulgare*	0	Herb	Brassicaceae	*Physaria mendocina*	2
Bush	Ranunculaceae	*Clematis montevidensis*	4	Herb	Loasaceae	*Pinnasa bergii*	2
Bush	Euphorbiaceae	*Coliguaja integerrima*	0	Grass	Poaceae	*Piptochaetium napostense*	5
Bush	Rhamnaceae	*Colletia spinosissima*	1	Herb	Plantaginaceae	*Plantago patagonica*	1
Bush	Rhamnaceae	*Condalia microphylla*	0	Herb	Plantaginaceae	*Plantago sp.*	3

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Biological form	Botanical family	Name	IE	Biological form	Botanical family	Name	IE
Herb	Convolvulaceae	*Convolvulus arvensis*	4	Bush	Lythraceae	*Pleurophora patagonica*	3
Herb	Poaceae	*Cortaderia spp*	0	Grass	Poaceae	*Poa holciformis*	0
Bush	Malvaceae	*Corynabutylon bicolor*	2	Grass	Poaceae	*Poa lanuginosa*	3
Herb	Boraginaceae	*Cryptantha globulifera*	1	Grass	Poaceae	*Poa ligularis*	5
Bush	Asteraceae	*Cyclolepis genistoides*	1	Grass	Poaceae	*Poa pratensis*	3
Herb	Cyperaceae	*Cyperus sp.*	2	Grass	Poaceae	*Poa spiciformis*	5
Grass	Poaceae	*Dactylis glomerata*	3	Grass	Poaceae	*Polypogom australis*	0
succulents	cacti	*Denmozoa rhodacantha*	0	Grass	Poaceae	*Polypogon monspeliensis*	4
Grass	Poaceae	*Deschampsia flexuosa*	2	Herb	Portulacaceae	*Portulaca spp.*	3
Herb	Brassicaceae	*Descurainia pimpinelifolia*	2	Bush	Fabaceae	*Prosopidastrum angusticarpum*	1
Herb	Brassicaceae	*Diplotaxis tenuifolia*	3	Bush	Fabaceae	*Prosopidastrum globosum*	3
Bush	Rhamnaceae	*Discaria articulata*	0	Bush	Fabaceae	*Prosopidastrum striatum*	3
Grass	Poaceae	*Distichlis spp.*	1	Bush	Fabaceae	*Prosopis alpatacus*	2
Succulents	Cactaceae	*Echinopsis leucantha*	0	Bush	Fabaceae	*Prosopis denudans*	2
Herb	Cyperaceae	*Eleocharis pseudoalbibracteata*	4	Bush	Fabaceae	*Prosopis flexuosa*	0
Bush	Ephedraceae	*Ephedra chilensis*	3	Bush	Fabaceae	*Prosopis strombulifera*	2
Bush	Ephedraceae	*Ephedra ocherata*	3	Bush	Asteraceae	*Proustia cuneifolia*	3
Bush	Ephedraceae	*Ephedra triandra*	0	Bush	Asteraceae	*Pseudognaphalium vira vira*	4
Herb	Equisetaceae	*Equisetum bogotense*	2	Herb	Asteraceae	*Psyla tenella*	0
Herb	Equisetaceae	*Equisetum giganteum*	2	Herb	Ranunculaceae	*Ranunculus peduncularis*	1
Grass	Poaceae	*Eremium erianthus*	5	Bush	Rhamnaceae	*Retanilla patagonica*	2
Herb	Geraniaceae	*Erodium cicutarium*	5	Herb	Polygonaceae	*Rumex acetosella*	0
Herb	Phrymaceae	*Erythrante lutea*	1	Grass	Poaceae	*Rytidosperma spp.*	5
Bush	Asteraceae	*Eupatorium bunifolium*	3	Bush	Amaranthaceae	*Salicornia ambigua*	0

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Biological form	Botanical family	Name	IE	Biological form	Botanical family	Name	IE
Bush	Asteraceae	*Eupatorium patens*	3	Bush	Amaranthaceae	*Salsola kali*	1
Bush	Euphorbiaceae	*Euphorbia collina*	0	Bush	Lamiaceae	*Salvia cuspidata*	5
Herb	Convolvulaceae	*Evolvulus sericeus*	0	Bush	Amaranthaceae	*Sarcocornia spp.*	1
Bush	Solanaceae	*Fabiana denudata*	2	Bush	Anacardiaceae	*Schinus johnstonii*	1
Bush	Solanaceae	*Fabiana patagonica*	1	Bush	Anacardiaceae	*Schinus marchandii*	1
Bush	Solanaceae	*Fabiana peckii*	1	Bush	Anacardiaceae	*Schinus roigii*	1
Grass	Poaceae	*Festuca argentina*	0				
Grass	Poaceae	*Festuca arundinacea*	2	Bush	Asteraceae	*Senecio albibracteata*	1
Grass	Poaceae	*Festuca australis*	3	Bush	Asteraceae	*Senecio filaginoides*	0
Grass	Poaceae	*Festuca kurtziana*	1	Bush	Asteraceae	*Senecio spp.*	1
Grass	Poaceae	*Festuca magellanica*	1	Bush	Fabaceae	*Senna aphylla*	2
Grass	Poaceae	*Festuca pallescens*	2	Grass	Poaceae	*Setaria spp.*	4
Grass	Poaceae	*Festuca pyrogea*	1	Herb	iridaceae	*Sisyrinchium spp.*	2
Bush	Frankeniaceae	*Franquenia patagonica*	1	Herb	Solanaceae	*Solanum sarrachioides*	1
Herb	Rubiaceae	*Galium richardianum*	2	Herb	Asteraceae	*Sonchus oleraceus*	5
Herb	Fabaceae	*Glycirrhyza astragalina*	0	Herb	Malvaceae	*Sphaeralcea miniata*	2
Bush	Asteraceae	*Pentaphorus glutinosus*	0	Herb	Malvaceae	*Sphaeralcea sp.*	3
Bush	Asteraceae	*Grindelia spp.*	0	Grass	Poaceae	*Sporobolus rigens*	0
Bush	Asteraceae	*Gutierrezia solbriggi*	3	Bush	Euphorbiaceae	*Stillingia patagonica*	0
Herb	Amaryllidaceae	*Habranthus jamesonii*	2	Bush	Amaranthaceae	*Suaeda divaricata*	0
Herb	Ranunculaceae	*Halerpestes cymbalaria*	1	Herb	Brassicaceae	*Sysimbrium altissimum*	2
Bush	Asteraceae	*Haplopappus pectinatus*	0	Herb	Asteraceae	*Tagetes mendocina*	3
Herb	Fabaceae	*Hoffmannseggia spp*	3	Tree	Tamaricaceae	*Tamarix ramossisima*	3

Biological form	Botanical family	Name	IE	Biological form	Botanical family	Name	IE
Grass	Poaceae	*Hordeum comosus*	3	Herb	Asteraceae	*Taraxacum officinale*	2
Grass	Poaceae	*Hordeum hallophylum*	2	Bush	Asteraceae	*Tessaria absinthioides*	1
Herb	Asteraceae	*Hyalis argentea*	0	Bush	Rosaceae	*Tetraglochin alatum*	1
Herb	Apiaceae	*Hydrocotyle ranunculoides*	2	Bush	Rosaceae	*Tetraglochin ameghinoi*	2
Herb	Asteraceae	*Hypochaeris chilensis*	2	Bush	Rosaceae	*Tetraglochin caespitosum*	2
Herb	Asteraceae	*Hypochaeris sp.*	1	Grass	Poaceae	*Trichloris crinita*	4
Herb	Asteraceae	*Hysterionica jasionoides*	2	Herb	Asteraceae	*Trichocline sinuata*	0
Grass	Poaceae	*Jarava ambigua*	0	Herb	Fabaceae	*Trifolium repens*	1
Grass	Poaceae	*Jarava neaei*	2	Grass	Poaceae	*Trisetum longiglume*	1
Grass	Poaceae	*Jarava psylantha*	3	Grass	Poaceae	*Trisetum spicatum*	1
Herb	Juncaceae	*Juncus spp.*	2	Herb	Amaryllidaceae	*Tristagma patagonica*	2
Bush	Verbenaceae	*Junellia chritmifolia*	3	Herb	Asteraceae	*Tymophylla pentachaeta*	1
Bush	Verbenaceae	*Junellia connatibracteata*	1	Tree	Fabaceae	*Vachellia caven*	3
Bush	Verbenaceae	*Junellia minutifolia*	1	Herb	Valerianaceae	*Valerian spp.*	2
Bush	Verbenaceae	*Junellia seriphioides*	1	Herb	Scrophulariaceae	*Verbascum thapsus*	4
Bush	Verbenaceae	*Junellia spisa*	1	Herb	Plantaginaceae	*Veronica anagallis-aquatica*	3
Bush	Verbenaceae	*Junellia thymifolia*	2	Herb	Fabaceae	*Vicia nigricans*	2
Grass	Poaceae	*Koeleria sp.*	1	Herb	Asteraceae	*Xanthium spinosum*	0
Herb	Asteraceae	*Lactuca serriola*	4	Herb	Amaryllidaceae	*Zephyranthes gillesiana*	2
Bush	Zygophyllaceae	*Larrea ameghinoi*	1	Bush	Fabaceae	*Zuccagnia punctata*	0

Table 2.
Specific Quality Index (SQI) of the most common species in the surveyed areas.

Ecological areas	Forage availability (Kg Dry Matter/hectare)
South mount	13.30 × PV
North mount	15 × PV
Coast	12.26 × PV
Steppe (Saws and Central Plateaus)	14.05 × PV.
Steppe (Saws and Western Plateaus)	9.58 × PV
Gramineous steppe (Pre mountain range)	9.16 × PV

Table 3.
*Forage availability in the different ecological areas. To see the equivalence in phytogeographic areas or bioclimatic entities, see **Table 1**.*

established in similar environments in other parts of the world [14], and the evaluation of different productive situations in different environments [2–4], see **Table 1**.

Receptivity Estimate: It is calculated from the determination of the forage productivity and the intensity or degree of use, which is called the Use Factor (UF) of each ecological area [15]. The INTA Trelew carried out censuses with forage harvest in different ecological areas, from which it determined different linear regression models of the forage availability of herbaceous and 20% woody forage (FAHWF 20%) [2–4], See **Table 3**.

Recommended load: For the analysis, the measured pastoral value is used to estimate forage availability, and to determine the recommended load, the corresponding Use Factor (UF) of the same was calculated and the forage to be hypothetically consumed by the cattle is computed and divided by 300 kilos of dry matter per year (KgMS/year), which consumes 1 Ovine Livestock Unit (OLU or UGO in Spanish by "Unidad Ganadera Ovina"), which corresponds to a capon of the Merino breed of 40 kg of live weight. On the other hand, you can take the Equivalent Patagonic Sheep (EPS or EOP in spanish by "Equivalente Oveja Patagónico"), which corresponds to the average annual requirements of a Corriedale sheep of 49 kg of live weight at service, sheared in September. That gestates and weans a live 20 kg lamb at 100 days of lactation. This corresponds to 2.79 mega calories of metabolizable energy per day [16]. Then, it is possible to estimate the stocking rate in other categories [2, 3], be they sheep (dry sheep, breeding sheep, lamb, ram, etc.), cattle (bull, dry cow, breeding cow, heifer, calf, etc.), goats (castrón, dry goat, breeding goat, goating, etc.), horses (horse, filly, dry mare, breeding mare), rabbit, hare, etc. (**Table 4**). It is also possible to calculate the stocking rate considering the square league, which is a measure widely used in some regions by farmers. It is important to remember that 1 square league is equal to 2330.99 hectares.

Vegetation map: These data must be accompanied by a satellite image, in order to calculate the number of hectares occupied by each environment and thus have the animal load data. Normally, the processing and analysis of available satellite images are carried out in the office. Based on the electromagnetic radiation reflected and emitted by all the elements present on the earth's surface, it is possible to obtain a map of plant forms present in a region, which is obtained from the conceptual classification of the environmental variability present, which can be measured in a satellite image by combining bands of different wavelengths.

The way in which each of the elements reflects or emits radiation has to do with its particular characteristics (chemical composition, surface roughness, moisture

Category	Olu (or Ugo)	Category	Olu (or Ugo)
Capon	1	Breeding cow (400 kg)	12
breeding sheep	1.2	Dry cow	9
Sheep (Milk tooth—2 teeth)	0.73	Heifer (1st service)	11
Lamb (2 teeth–4 teeth)	1	Bull (600 kg)	11
Sheep (Baby tooth—2 teeth)	0.85	Calf (150–250 kg)	5.5
Lamb (2 teeth–4 teeth)	1.15	Calf (250–350 kg)	7.2
ram in maintenance	1.15	Dry goat	0.8
ram in service	1.5	Breeding goat	1.1
Sheep (first gestation period)	0.92	Goating, cabrilla, or kid	0.4
Sheep (second gestation period)	1.1	Castron or castrated goat	1.25
Dry sheep	0.83	Equines. Studs	15

Table 4.
Livestock equivalences according to categories and species, taken from [2–4].

content, reflective properties, etc.); this behavior is unique for each coverage type and is called a spectral signature.

Sentinel T19HEB images, etc. can be used. Images with low cloudiness should be chosen. A combination of false-color composite (FCC) can be made of bands 11-8-4, and the area of the image that will be of interest should be cropped. Then, through exhaustive visual analysis of a variety of compositions and spectral features of the image, the information that allows the best discrimination of the categories of interest is selected. In short, the image must be analyzed using combinations of bands based on the spectral behavior of the vegetation. In this way, through the application of unsupervised and supervised digital classification techniques, the first map of plant formations is generated.

Finally, it is important to note that the classification of the multispectral image implies categorizing the reflectances present in the image in statistical terms. This involves reducing the measurement scale of a continuous variable (reflectances) to a nominal or categorical scale (classes of information), that is, transforming the original image into another image whose pixels no longer reflect values of electromagnetic energy or physical variables (such as radiance or reflectance), but categories or classes of information (types of vegetation).

5. Comparison between the floristic-holistic method and the pastoral value method

To analyze how much the data obtained with the FHM deviate from the data obtained with the PVM [2, 3], five field transects were carried out with each method. To avoid census errors, both methods were performed on each transect line at the same time and they were recorded on separate forms (**Figure 6**). The surveys were carried out in 2015, in a mount area that bio-climatically corresponds to the warm semidesert in Ref. [5] (**Figure 1**: Green Point). They were carried out in the "El Moro" livestock establishment, Telsen Department, Province of Chubut, and 120 km north of

Figure 6.
Field survey. Observe the data collection with two spreadsheets at the same time (each spreadsheet corresponds to each one of the methods).

the city of Trelew and is accessed by provincial route N°. 8 (**Figure 1**. Green point). The area is between 30 and 50 meters above sea level and is characterized by having average rainfall that averages 150 mm per year. Winds prevail from the west sector, sometimes reaching speeds greater than 80 km per hour. The average annual temperature is 13–14°C [17].

The "El Moro" establishment is located in the biogeographical province of Austral Mount. It is characterized by the constant presence of the "Jarillas," shrubs belonging to the Zigofiláceas family. The Zygophyllaceae species with the greatest representation in the study area are the "Jarilla" *Larrea divaricata* and the "Jarilla fine" *Larrea nitida,* as well as the "Jarilla creeping" *Larrea ameghinoi.* These plants reach one or two meters in height, or less (in very windswept areas), and grow scattered, leaving clearings where herbs develop at the right times. Among the shrubs that grow associated with Jarillas, the "Alpataco" *Prosopis alpataco*, the "Mata sebo" *Monttea aphylla*, the "Monte negro" *Bougainvillea spinosa*, the "Pichana" *Senna aphylla*, and the "Chirriadora" *Chuquiraga erinacea ssp hystrix,* among others. Other important components of the Austral Mount are they are the representatives of the family Cactaceae, the grasses, and other herbaceous plants.

According to the censuses carried out, both methods showed the same values of bare soil (average 43.8%), plant cover (26.6%), dead plant material (standing dead) 21.2%, and litter 8.4%. Analyzing the biological forms, it was observed that herbs were found between 3.5 and 4.2%, grasses between 16 and 18.5%, respectively, shrubs between 73 and 76.8%, and cacti between 13.5 and 4.5% (**Table 2**). Regarding the comparison of both methods, it can be observed that the differences are slight, but a

Biological form	Floristic-holistic method (FHM)	Pastoral value method (PVM)	Difference (FHM-PVM)
Herbs	3.55	4.24	0.69
Grasses	16.03	18.52	2.49
Shrubbery	76.87	73.16	−3.72
Cacti	3.55	4.55	1.00

Table 5.
Comparison of biological forms in both methods.

tendency to overestimate grasses (difference of 2.49%) and underestimate shrubs (difference of 3.72%) is observed in the PVM (see **Table 5**).

Analyzing forms and biological types together, a slight difference was observed between both methods (**Table 1**). For all forms, it was observed that the percentage was less than 0.5% between both methods, except in perennial grasses, where the percentage was 1.61% higher in PVM, and in shrubs, which was 3.87% lower in PVM (see **Table 6**).

On the other hand, the status showed that native species ranged between 51.3 and 55.3%, endemic species between 35.7 and 38.6%, and introduced species between 8.9 and 10%. Comparing both methods, a difference between 1 and 4% was observed between both methods (see **Table 7**). Recording the greatest differences between native species is probably due to the fact that in this category "native species" has the highest number of registered species compared with "endemic species" and "introduced species."

Form and biological type	Floristic-holistic method (FHM)	Pastoral value method (PVM)	Difference (FHM-PVM)
Annual herbs	1.84	2.20	0.36
Annual grasses	6.96	7.85	0.88
Perennial Herbs	1.71	2.04	0.33
Perennial grasses	9.07	10.68	1.61
Shrubbery	76.08	72.21	−3.87
Subshrubs	0.79	0.94	0.15
Cacti and succulents	3.55	4.08	0.53

Table 6.
Comparison of forms and biological types in both methods.

Status	Floristic-holistic method (FHM)	Pastoral value method (PVM)	Difference (FHM-PVM)
Native plants	55.32	51.33	−3.99
Endemic plants	35.74	38.62	2.88
Introduced plants	8.94	10.05	1.11

Table 7.
Comparison of the status of both methods.

Taxonomic type	Floristic-holistic method (FHM)	Pastoral value method (PVM)	Difference (FHM-PVM)
Eudicots	83.84	81.32	−2.52
Monocots	16.16	18.68	2.52

Table 8.
Comparison of taxonomic type in both methods.

Analyzing the taxonomic type, it was observed that eudicots range between 81.3 and 83.8%, and monocots between 16.1 and 18.6% (see **Table 8**). Comparing both methods, it is observed that the PVM would be overestimating monocots by 2.5% and underestimating eudicots by 2.5%. It is precisely the same trend that has been observed above, a slight tendency to underestimate shrubs (eudicots) and overestimate grasses (monocotyledons).

Nineteen botanical families were registered. For the taxonomic identification of the plants, the names of the families accepted in the catalog of vascular plants of the southern cone [7] were used. The traditional designations for the names of the families: Compositae, Cruciferae, Gramineae, Leguminosae, and Umbelliferae have been replaced by those accepted in more recent publications [18] as Asteraceae, Brassicaceae, Poaceae, Fabaceae, and Apiaceae, respectively.

The analysis of the botanical families showed that there is a dominance of 5–6 families (Zygophyllaceae, Poaceae, Solanaceae, Verbenaceae, Fabaceae, Amaranthaceae) over the rest of the families, but that dominance is different if it is analyzed by a method or on the other (See **Table 9**).

The MFH analysis showed a dominance of the families Zygophyllaceae and Solanaceae (both with 18.79%). Then, Poaceae (16.03%), Fabaceae (13.93%), Verbenaceae (12.22%), Chenopodiaceae (8.41%), Cactaceae (3.55%), Asteraceae (2.5%), and Geraniaceae (1.45%) and the rest of the families represented in less than 1%. The MVP analysis showed a dominance of the Poaceae family (18.52%), along with Solanaceae (16.48%), Verbenaceae and Zygophyllaceae (both 14.44%), Fabaceae (13.65), Chenopodiaceae (8.95%), Cactaceae (4.08%), Asteraceae (2.67%), Geraniaceae (1.57%), Anacardiaceae (1, 26), and the rest of the families represented in less than 1%.

On the other hand, comparing both methods, it was observed that most of the botanical families they show a difference of less than 0.5%. But comparing the values of the differences, it was recorded that this difference is 2.2–2.4% higher in the families Poaceae and Verbenaceae for the MVP and 2.3% lower in Solanaceae, and 4.35% lower in Zygophyllaceae for the MVP (**Table 8**). These differences may be due to the fact that in the census of the PVM the presence of Zygophyllaceae would be underestimated due to the fact that the number of touches is not counted, but rather it is only registered with an "X" as a non-forage. Regarding the Solanaceae family, it could be slightly underestimated with the PVM because the needle touched non-forage portions of it. And finally, again a slight tendency to overestimate grasses (Poaceae) and some species of Verbenaceae is observed.

The diversity index (Shanon-Weaver) was similar in both methods (FHM 1.05, and PVM 0.99), showing a percentage difference of 0.06. Plant density showed different values in both methods. The FHM calculation resulted in 3420 plants/ha, and the MVP showed 3100 plants/ha. The difference of both methods is 320 plants/ha. This difference is quite significant and may be due to the number of touches each plant has.

Identified families	Floristic-holistic method (FHM)	Pastoral value method (PVM)	Difference (FHM-PVM)
Poaceae	16.03	18.52	2.49
Verbenaceae	12.22	14.44	2.22
Amaranthaceae	8.41	8.95	0.54
Cactaceae	3.55	4.08	0.53
Anacardiaceae	0.91	1.26	0.35
Loasaceae	0.13	0.31	0.18
Asteraceae	2.50	2.67	0.17
Rosaceae	0.66	0.78	0.12
Geraniaceae	1.45	1.57	0.12
Apiaceae	0.53	0.63	0.10
Caryophyllaceae	0.53	0.63	0.10
Plantaginaceae	0.13	0.16	0.03
Cyperaceae	0.13	0.16	0.03
Calyceraceae	0.13	0.16	0.03
Boraginaceae	0.13	0.16	0.03
Nyctaginaceae	1.05	0.94	−0.11
Fabaceae	13.93	13.65	−0.28
Solanaceae	18.79	16.48	−2.31
Zygophyllaceae	18.79	14.44	−4.35

Table 9.
Comparison of botanical families in both methods.

It is worth mentioning that in the VPM 637 total touches were recorded (direct forage touches + indirect forage touches + the touches corresponding to the direct and indirect "Xs"). On the other hand, in the MFH, 761 total touches were recorded (direct touches + indirect touches).

The analysis of forage availability and pastoral value, by the MVP, revealed the following data: The pastoral value ranged between 3.3 and 11.72 (average 5.78), and the average forage availability of 76.85 Kg dry matter/hectare. Showing a usable forage availability (with a use factor of 30%) of 23.06 Kg dry matter/hectare, this value would be giving a stocking rate of 0.08 OLU/ha or 0.04 EPS/ha. This would be equivalent to 200 capons per league or 400 sheep per league.

On the other hand, the MFH showed a pastoral value that ranged between 3.7 and 15.3 (average 9.27), and the average forage availability was 140.69 Kg dry matter/hectare. The usable forage availability (with a use factor of 30%) of 42.21 Kg dry matter/hectare. This last value would give a stocking rate of 0.14 OLU or 0.08 EPS/ha.

Comparing both methods, an important difference between the methods is observed (see **Table 9**). The pastoral value calculated by the FHM shows a value higher than that calculated by the PVM (37.6% higher), and the estimate of forage availability and stocking rate shows a value 45.3% higher than that calculated by the

Forage parameters	Floristic-holistic method (FHM)	Pastoral value method (PVM)	Difference (FHM-PVM)	Difference (FHM-PVM) expressed in %
Pastoral value	9.27	5.78	3.49	37.64
Forage availability (kg dm/ha)	140.69	76.85	63.84	45.38
Usable forage availability (use factor 30%)	42.21	23.06	19.15	45.38
Ovine livestock unit (Olu)	0.14	0.08	0.06	45.38
Equivalent patagonic sheep (Eps)	0.08	0.04	0.04	45.38

Table 10.
Comparison of pastoral value, forage availability, and stocking rate for both methods.

PVM (see **Table 10**). These differences will lie in the way of recording the data by both methods. In the FHM, all touches are recorded, while in the PVM, all forage touches are recorded but not all non-forage touches.

In nature, domestic grazers coexist with the natives and they all have different ways of feeding, some cut, others browse, uproot, rough, etc., and they also select what they most want and consume at different heights. Anyone would assume that the larger the animal, it could graze at higher altitudes, but this is not always the case in nature, there are many medium-sized and small-sized grazers and/or browsers that graze at high altitudes, as can be seen in small- and medium-sized rodents (guinea pigs, tuco-tucos, mice, hares, rabbits, and maras), and various species of birds, lizards, etc., which can be seen at the top of the bushes consuming flowers, fruits, and leaves (**Figures 7–11**), but also in the very intricate interior of the bushes, both sites are inaccessible to domestic livestock, but are inaccessible to many species of wildlife.

On the other hand, branches and thorns of shrubs were observed, non-forage parts by MVP, heavily browsed, debarked, and in some cases cut (**Figure 10**) by rodents. It is worth mentioning that the cutting of rodent branches is recognized because it is always a bevel cut. The most heavily barked shrubs were those of *Bougainvillea, Condalia, Lycium, Prosopis, Prosopidastrum,* and *Schinus species.* Despite long hours of observation and on numerous occasions, we were unable to determine whether this bark is consumed by rodents or they only perform this action to wear down and sharpen their teeth. But it is important to note that this action of debarking branches occurs more intensely in times of great drought and when there is not much forage supply and living flora. It is worth mentioning that in MVP, the person in charge of carrying out the sampling is the one who decides if the plant and/or part of the plant is edible or not, and if it is accessible or not for livestock. Therefore, in the FHM, by surveying everything that is alive, regardless of whether it is forage or not, this bias is avoided. The diversity of plant species in the arid and semiarid zones of Patagonia is crucial to cushion the effects of drought on the functioning of ecosystems [19]. Among the most important conclusions, they observed that ecosystems with a greater diversity of plant species are more likely to have species that are more tolerant to drought and, in addition, can make more efficient use of available resources due to the complementarity and synergistic interactions between the species.

Figure 7.
Detail of debarked branches at the base of the Prosopidastrum striatum *trunks.*

6. Virtues, advantages, and scope of the floristic-holistic method (FHM)

Among the most representative virtues of the FHM we can mention the following: it is a simple, practical method applicable to different types of land and low cost, and does not have negative effects on the ecosystem since it is not required to harvest materials or alter the feet of the species, and also combines quantitative and qualitative characters.

Figure 8.
Detail of bevel-cut twigs typical of rodents in Prosopidastrum striatum. *Note in the figure that they are upper branches, and are at a height of about 1 meter.*

Figure 9.
*Intensely browsed and debarked spines of alpataco (*Prosopis alpataco*). Notice rodent droppings on the floor.*

Figure 10.
*General view of Mata Amarilla (*Anarthrophyllum rigidum*—Family Fabaceae) heavily browsed.*

Whatever the application of interest and the type of environment to survey, it is necessary to have at least one experienced botanist with extensive knowledge of the flora. If necessary, field support technicians must also be prepared to assist in data collection and registration. As for office work, its planning and management are important, given that data analysis is long and complex, also requiring a prepared and trained team.

Based on its structure and work methodology, the method allows comparing a great diversity of biological, ecological, and environmental situations. For example, when it is necessary to carry out studies of general plant biodiversity (**Figure 12**), floristic composition (**Figure 13**), for comparison between different

Figure 11.
*Detail of bevel cut (*Anarthrophyllum rigidum*—Family Fabaceae) evidencing browsing by rodents (in this case it is rabbits).*

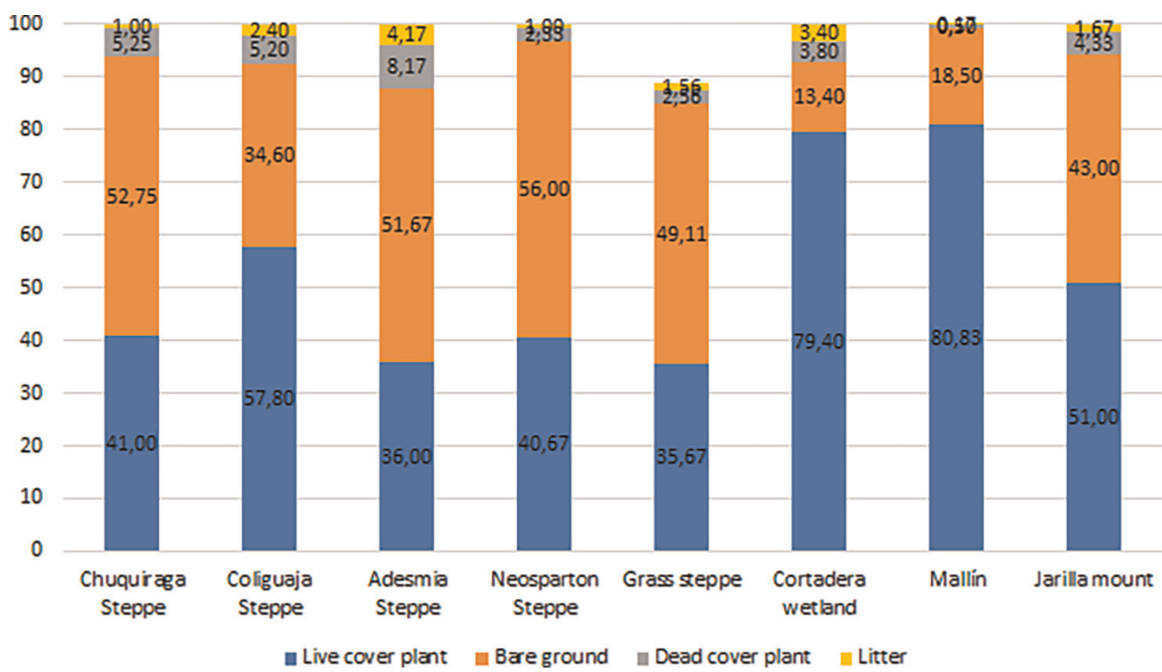

Figure 12.
Main ecological parameters in different environments of the cold Mediterranean steppe of Chubut. Values are expressed in percentages. Summer sampling 2012.

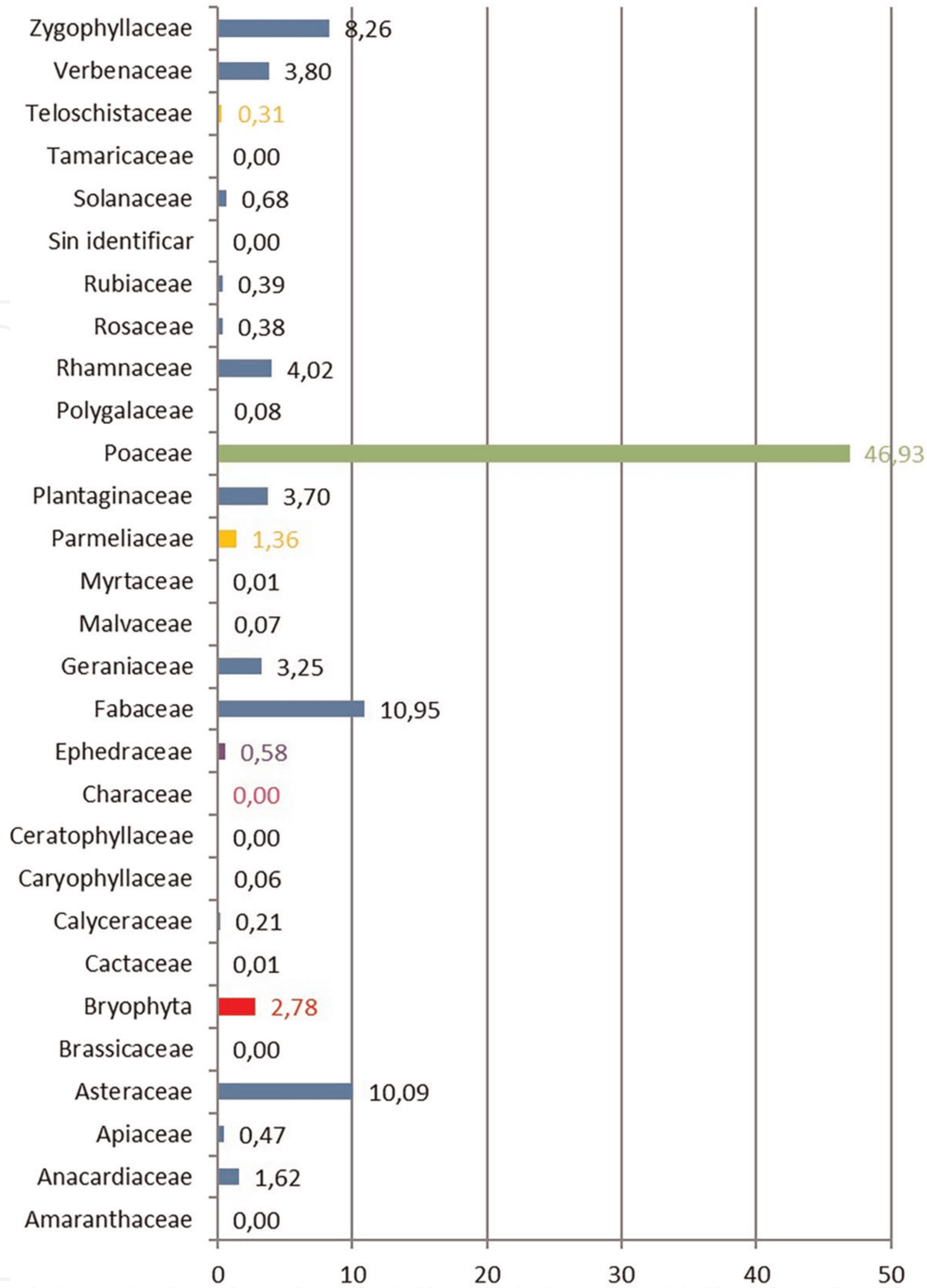

Figure 13.
Floristic composition by botanical families (%) for a baseline of a wind farm (renewable energies). Eudicotyledonous families in blue, monocots (Poaceae) in green, gymnosperms (Ephedraceae) in violet, lichenized fungi (Parmeliaceae and Teloschistaceae) in orange, and mosses (Bryaceae) in red. Mount environment in the warm semidesert, Province of Río Negro. Fall 2019 sampling.

landscape units (**Figure 14**), for comparison of the same landscape unit along the different seasons of the year (spring, summer, autumn, and winter—**Figure 15**) or over several years (**Figures 16–19**).

Data collection also applies to calculate the receptivity of domestic and/or wild animals (**Figure 17**), to assess the degrees of degradation over the years, or the passive or active ecological restoration of land (**Figures 18** and **19**), also to know the degree of conservation of an area, also to evaluate the loss of diversity/productivity/receptivity of flood-prone areas where dams or weirs will be built or where the watercourse will be diverted, and also in areas that suffered volcanism (**Figure 16**), fires (**Figure 18**), and/or clearing (**Figure 19**).

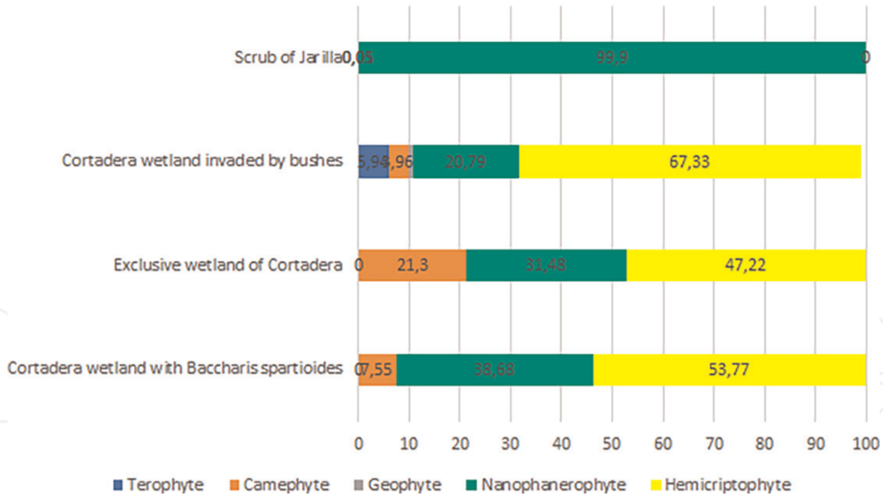

Figure 14.
Raunkiaer adaptive strategies, in different environments surveyed in the mount (warm semidesert) and high steppe (Andean range) of the province of Mendoza. 2019 Winter Samplings.

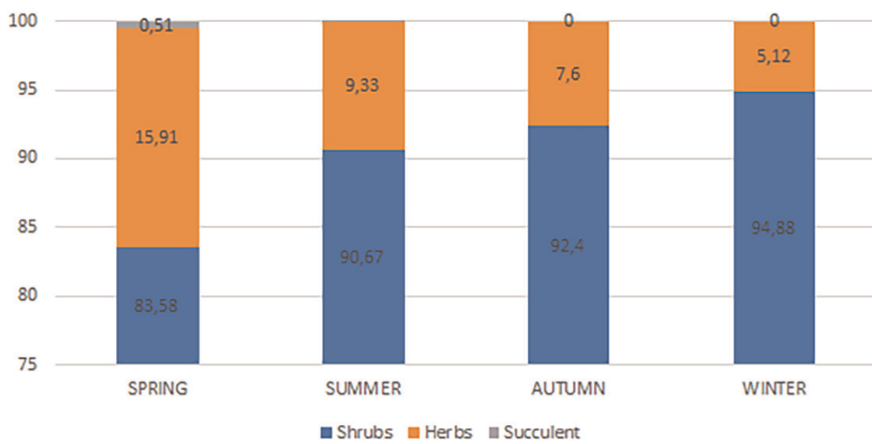

Figure 15.
Biological forms of the Neosparton steppe environment, which corresponds to the warm semidesert of Mendoza, expressed as a percentage. Samplings 2019.

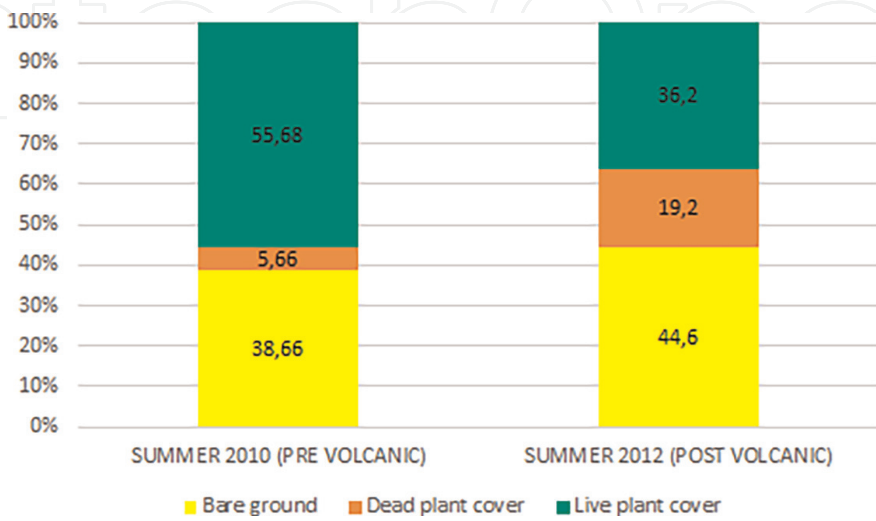

Figure 16.
Variation of biological forms in response to a volcanism event in the Mediterranean steppe of Chubut. Samplings at summer 2010 and 2012.

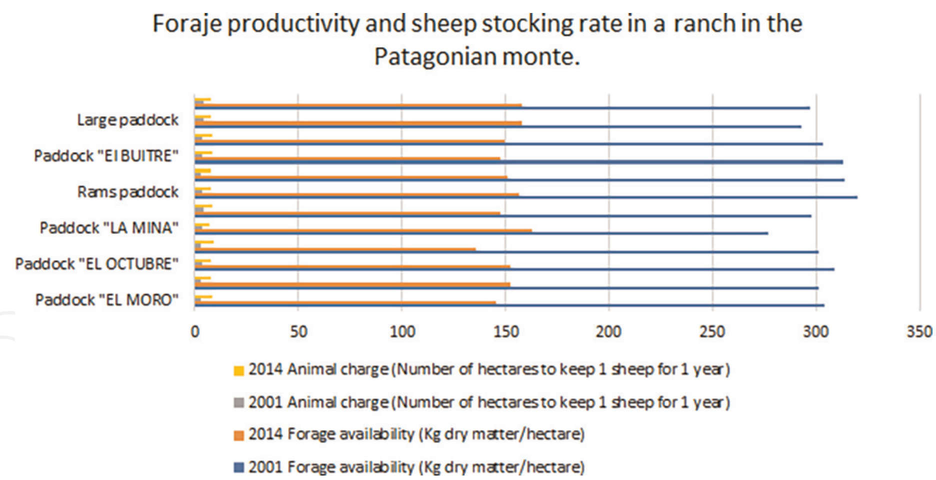

Figure 17.
Forage availability (in kilos of dry matter per hectare) and stocking rate (in sheep livestock units per hectare (OLU/ha)). Sampling in 2001 and 2014 for a stay in Mount Chubutense (warm semidesert). Related to an extensive impact activity (extensive livestock use). The names correspond to the denomination of the registered tables.

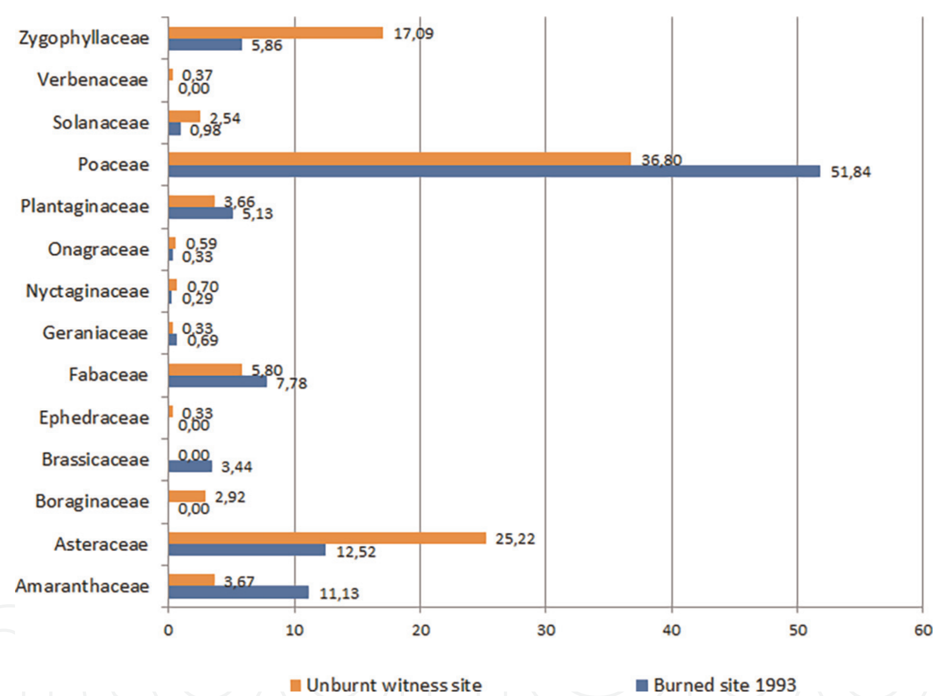

Figure 18.
Botanical families were identified in a burned site with 21 years of passive ecological restoration in comparison with a neighboring non-burned area (reference ecosystem). Samplings 2014 for a forest area (warm semidesert) of Chubut.

Applies to calculate changes in land use include for opening to livestock or agricultural barrier or road diversions, impacts of industrial effluents (**Figure 20**), and for monitoring the loss of native species and/or specific biological invasions and/or potential, for mining studies, for evaluation studies of direct and indirect impacts of various kinds, for studies of ethnobotanical uses (**Figure 21**), etc. As seen in the results presented, the FHM also allows:

- The visualization of all existing biological forms (**Figures 12–15**), valuing plant ecological relationships and recognizing in turn interactions with the fauna

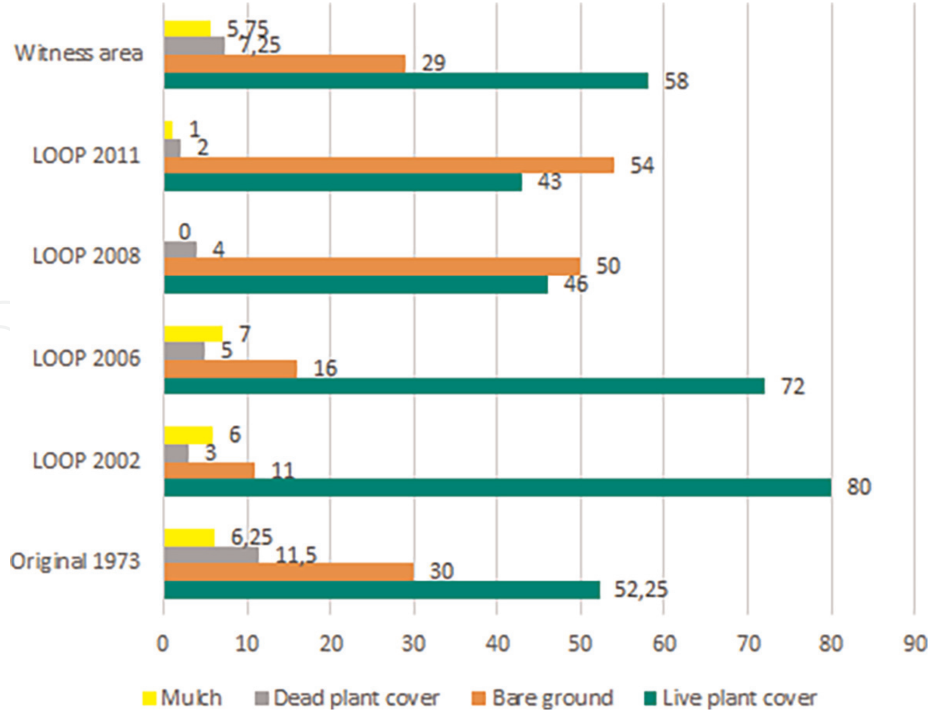

Figure 19.
Percentage representation of the ecological parameters recorded for an area of cold Mediterranean steppe in the province of Santa Cruz with a chronological comparison of 38 years to monitor a passive restoration process on a punctual disturbance due to intensive impact activity (gas pipeline). The trunk area (1973) corresponds to the initial clearing for the work of a gas pipeline, the following loops of different years, which correspond to new clearings to expand the capacity of the gas pipeline, and the witness area is a neighboring area where there was never any clearing.

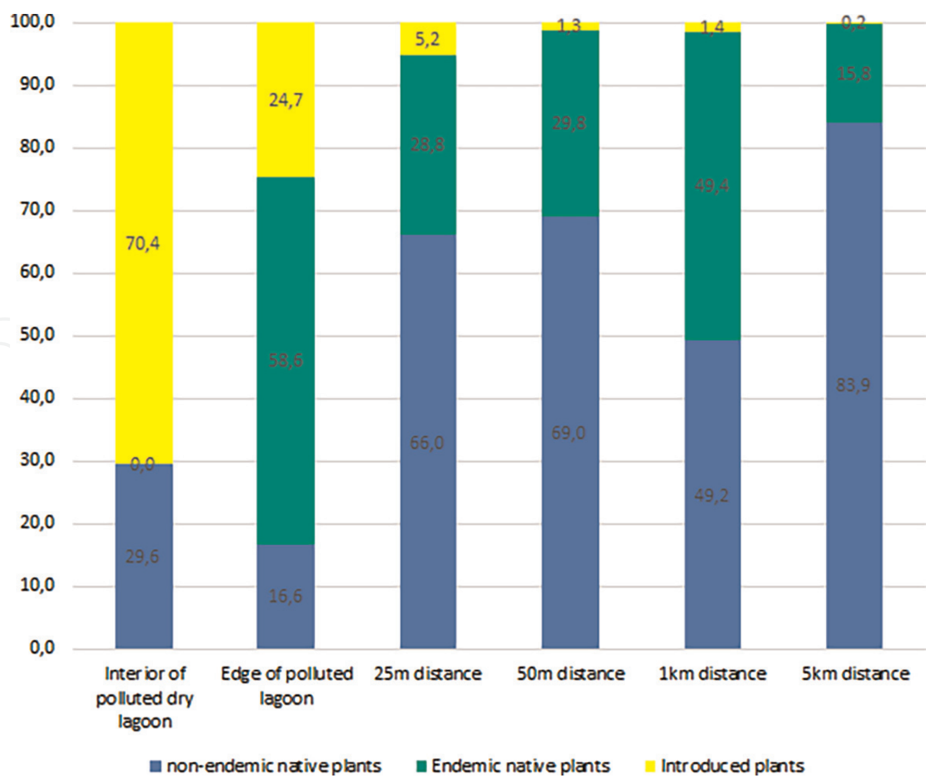

Figure 20.
Status in (%) of the surveyed plants according to a gradient of environmental contamination by industrial effluents with heavy metals. Border corresponds to the area of maximum contamination, then 25 meters, 50 meters, and the control at 5 km (reference ecosystem). Samplings 2014, 2015, and 2016 correspond to a forest area (warm semidesert), the province of Chubut. Note that in the area of greatest contamination there is a greater proportion of introduced species.

present in the sites surveyed, such as habitat use, use of biological corridors, herbivore, parasitism, symbiotic relationships, among others.

- To present the comprehensive plant stratification of the different phytogeographic units that make up the South American Arid Diagonal (**Figures 12–15**).

- Obtain specific data on ranges of environmental parameters that influence the distribution of species, being able to obtain, for example, data on the distribution of species, genus, family, and order by minimum and maximum height (in meters above sea level). The analysis for other parameters is applicable according to the tools used in the field, and it is possible to add to each transect, in addition to the geographic positioning data, values of relative humidity, ambient humidity, and incidence of solar radiation, among others (**Figures 12–18**).

- Analyze the status of areas of the direct and indirect impact regarding possible atmospheric contamination, infiltration into the ground, the presence of contaminants in receiving bodies (soil and/or water), and bioaccumulation of heavy metals, among others, in comparison with reference ecosystems (**Figure 20**).

- Obtain comparative data between disturbed areas and impacts and reference ecosystems (sites belonging to the phytogeographic units without disturbances or with minor impacts, which keep the ecological parameters of the bibliography stable) and carry out an analysis considering the time factor, being able to diagram, plan, and program prevention and mitigation measures for different types of impacts (regardless of their intensity, frequency, durability, or scale) (**Figures 16–19** and **20**).

- Obtain specific data for progress studies, analysis of desertification processes, clearing, and post-fire damage, thus obtaining a concrete database for decision-making, environmental management plans, and monitoring and contingency plans in a clear practical way applicable to the field (**Figures 16–21**).

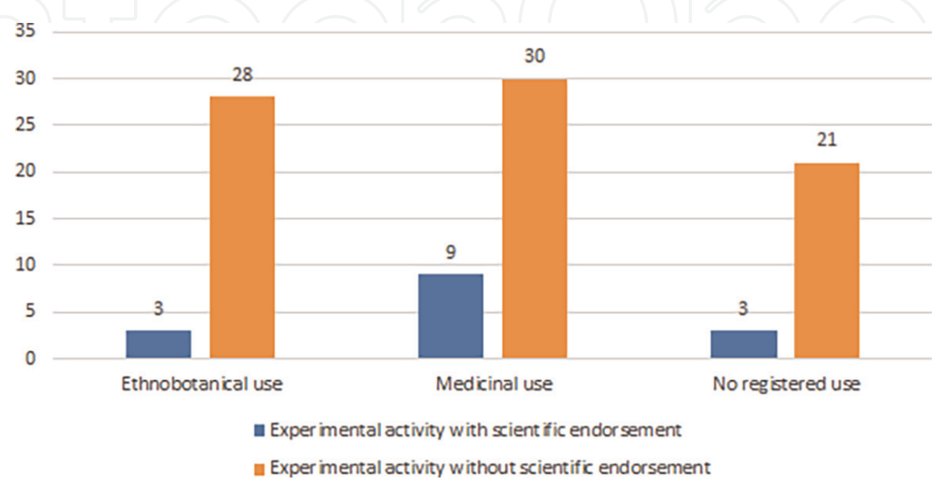

Figure 21.
Analysis of uses of plants based on data on plant cover, associated botanical uses, medicinal and others with and without scientific verification. Samplings 2013, 2014, and 2015, in Paso de Indios, cold Mediterranean steppe of Chubut.

- Work on territories subjected to anthropogenic activities with intensive impacts (1st, 2nd, and 3rd category mining, conventional and non-conventional oil extraction, renewable energy generation, and distribution of electricity and gas) as well as anthropogenic activities with extensive impacts (sheep, goat, horse and cattle farming, and agriculture including monocultures) (**Figures 17** and **19**).

- Carry out monitoring of the state of conservation and preservation of ecosystems, both applied to the conservation of species (in relation to their uses as ecosystem goods and services) and applied to the preservation of species (in relation to the intrinsic value of each species) (**Figures 12–15**, **17** and **19**).

- Obtain sociocultural assessments of the ecosystem goods and services related to the flora of a particular site (**Figure 21**).

- It provides the state, productive, and extractivist sectors with the necessary tools to revalue the flora that makes up a fundamental link for the conservation and preservation of the South American Arid Diagonal (**Figures 16–19**).

- The identification of biological and environmental indicators advances in invasive/exotic/introduced species, advances in adventitious species, and advances in naturalized species (**Figures 13**, **14**, and **20**).

- Establish the diagram (since it allows evaluating the reference ecosystem), planning (since it allows evaluating the progress situation), and progress and results (since it allows analyzing the results after the first reproductive season, first flowering season, first seed bank generation station, and its temporary advances) for remediation, rehabilitation, and ecological restoration work, given the plasticity in data collection (**Figures 13–16** and **17**).

- The analysis of compost composition and biological crusts, deepening the knowledge of seed banks (**Figure 13**).

- Evaluate the productivity of cultivation areas of both native flora and productive species (**Figure 17**).

- The analysis of the state of conservation and preservation of fresh and saline mallines, key areas for productivity, water balance, and biodiversity of Argentina's Arid Diagonal, being also sites highly impacted by oil, mining, and livestock activities (**Figures 14**, **17**, and **19**).

- Assess the recovery of biodiversity comprehensively with respect to the reference ecosystems (**Figures 14** and **16–21**).

- Evaluate the response based on obtaining ecological parameters in relation to tolerance gradients against stress situations, fundamentally against water stress.

- It offers the technician in the field the possibility of adapting the data collection according to the stated requirement, it allows the collection of data in different topographies of the land, thus favoring fieldwork. In turn, the data collection structure favors teamwork for cabinet determinations (**Figures 16–21**).

- The generation of specific databases on the current state of the flora of the surveyed environments, being able to generate scientific dissemination material, scientific communications, environmental education work at all educational and social levels, community work, analysis work economic sociocultural for Latin America (**Figures 16–21**).

- The generation of databases in vulnerable rural areas with scarce resources for environmental management and policy that require knowledge of their ecosystem goods and services by virtue of their sustainable use (**Figures 16–21**).

- The consideration and staging for the different actors involved in the academic, political, economic, social, institutional, and cultural spheres of the role of the flora in the environments to be studied, thus considering the environmental commitments through treaties, agreements, and agendas that Argentina assumes worldwide in consideration of the environmental situation, in relation to the objectives of sustainable development and the problems to be faced with respect to climate change.

- The generation of direct and indirect jobs, as well as the training, education, and improvement of the technical team, promotes the condition of inter and multidisciplinary teams.

- Promote community production, participation, and intervention projects, thus favoring the environmental commitment of rural communities and urban communities in relation to the flora of the places they inhabit.

- The conservation, restoration, and study of fragile ecosystems, favoring the development of planning and territorial ordering, are fundamental in the fulfillment and application of the current environmental policies of the country.

7. Conclusions

1. The methodology proposed by the FHM allows comprehensive data collection that provides multidisciplinary tools for the characterization of the plant ecology of the South American Arid Diagonal.

2. The advantages of FHM over other qualitative and quantitative methods for biological and environmental characterization have been demonstrated in the last two decades through fieldwork by the HTW team.

3. The application of the FHM in different landscape units and vegetation units allows us to offer concrete prevention, planning, and mitigation responses to the current environmental problems of the South American Arid Diagonal.

4. The methodological characteristics of the FHM allow this method to be replicated in the South American Arid Diagonal as well as in other arid, semiarid, and subhumid areas of the world.

5. The dynamics of the FHM allow the concrete formation of work groups both in the field and in the office, promoting and strengthening training and scientific unity.

6. The dynamics of the FHM allow scientific dissemination and community work as tools in raising awareness and environmental policies at a social, cultural, and economic level.

7. The presentation of the FHM to the global scientific community constitutes a tool for the comprehensive and holistic assessment of our plant ecosystems.

8. Final considerations

The valorization of the Floristic-Holistic Method stands out not only for the contributions and scope of the method, but also as a basic method against the main environmental problems, related to problems associated with the South American Arid Diagonal. Some of the problems are soil loss, water deficit, changes in use, clearing, affectation of native forests, conservation of protected natural areas, urban and rural planning, land use planning, zoning, environmental impact assessment processes and strategic environmental assessment, clearing, overgrazing, overlapping land use, loss of native vegetation, modifications in heterogeneous vegetation, affectation, and conservation of flora species protected by national and international regulations. As mentioned before, the Floristic-Holistic Method allows the environmental management of the ecosystem goods and services of the territories, the importance of international conventions and treaties, the international and national flora protection regulations, and the sustainable development goals (SDGs), within which is, among others, the conservation of ecosystems, as one of the fundamental aspects on which to develop science, technology, and lines of research.

Considering the 21 years of data collection, the results are encouraging. The Floristic-Holistic Method allows establishing new horizons (in terms of considerations and scope) for phyto-ecological field studies for arid, semiarid, and subhumid zones. Methods that guarantee the sustainable use of ecosystem goods and services, that allow environmental planning and evaluation in different types of territories, that minimize and mitigate possible impacts, and that favor technical scientific knowledge and development considering the zonal human resource are key tools for an environmental development that considers all the actors involved.

Concrete, applicable, and practical databases also favor decision-making, the sociopolitical cultural context of Latin America, policies, plans, and programs by the states, which integrate scientific and technical visions together with the needs of an environment, which consider the human actor as the main positive and negative modifier, as well as a generator of new paths, with a holistic horizon and sustainable in the vision of our environment.

General objectives

- Introduce the Floristic-Holistic Method to the global scientific community.

- To propose this methodology as an integral method to evaluate floristic biodiversity, ecological parameters, and eco-physiological parameters applicable to different types of landscape units, environment units, and vegetation units in arid, semiarid, and subhumid zones.

Particular objectives

- Explain in detail how the Floristic-Holistic Method is applied as a methodology in the field.
- Explain the application of the method in different types of environments, landscapes, and plant physiognomies.
- Explain the importance of comprehensive methods for the biological and environmental analysis of our ecosystems.
- Explain the usefulness of the Floristic-Holistic Method in the Argentine Arid Diagonal, and the importance of environmental characterizations in arid, semiarid, and subhumid zones in the post of their conservation and preservation.
- Explain how to calculate from the Floristic-Holistic Method, the common ecological parameters (bare soil, live and dead plant cover, litter, diversity index, evenness, specific richness, and plant density).
- Explain how the FHM allows evaluating the floristic composition detailing the botanical families, biological forms, types of life, and the classic and non-classical botanical types, such as macroalgae, lichenized, and non-lichenized fungi.
- Explain how the FHM evaluates through status and how it allows considering the protection of species at the international (IUCN and CITES) and national levels.
- Explain how the FHM allows to evaluate the eco-physiological aspects that other methodologies do not allow to contemplate in the data registry.
- Explain how it is also possible through the FHM to calculate the forage availability, the pastoral value, and how it also allows estimating the livestock receptivity of a region.
- Compare the Floristic-Holistic Method with the Pastoral Value Method, evaluating its comprehensive characterization in comparison with the utilitarian characterizations of other methodologies.
- Evaluate the advantages and disadvantages of the method based on the analysis of the results obtained in the last two decades of field implementation of the FHM.

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Author details

Cynthia C. González[1*], Antonella M. Lista[1], Cristian Silva[1], Mauricio A. Joffe[1], Gastón E. Ponce[1], Patricia L. Simón[1,2] and Magdalena Llorens[1,2]

1 Trelew Botany and Herbarium Laboratory, Trelew Campus, Faculty of Natural Sciences and Health Sciences (FCNyCS), National University of Patagonia San Juan Bosco (UNPSJB), Trelew, Chubut, Argentina

2 National Council for Scientific and Technical Research (CONICET), Argentina

*Address all correspondence to: cynthiacgonzalez@yahoo.com.ar

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