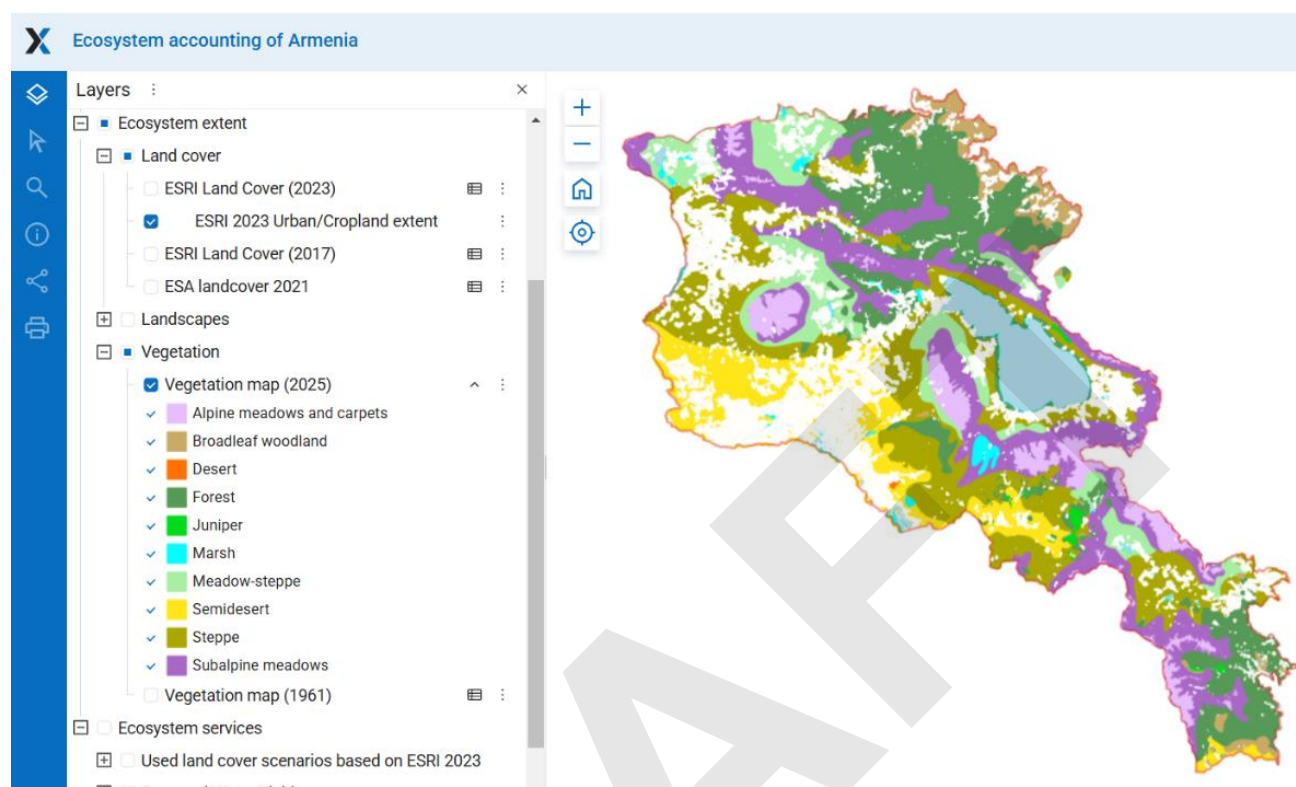


3.2. Provisioning services

The assessment of supplied provisioning ES was made based on the vegetation map created in the project framework excluding crops and built-up areas (Section 2.3.A).



3.2.A. Fodder production on natural pastures and hayfields

Provided ES at country level

The volume of provided ES is equal to the amount of fodder that can be used by livestock without harming pasture condition—that is, the maximum allowable stocking rate. The Government of Armenia Decision No. 389-N of 14 April 2011 (<https://www.arlis.am/DocumentView.aspx?DocID=67394>) defines this value for the main grassland zones in Armenia (Table 32A-1). These values are defined based on the relationship between grassland productivity and livestock demand for forage, so they can also be applied to hayfields. Hereafter, for brevity, we will use the term “pastures” to also include hayfields. Livestock numbers were converted to livestock units (LU), with 1 LU defined as one 500-kg cow.

Table 32A-1. Pasture area required to maintain one livestock unit (LU) for the entire grazing season, as defined in Government of Armenia Decision No. 389-N, and the maximum permissible stocking density recalculated from the mean required pasture-area values.

Grassland types	Pasture area required per LU for the entire grazing season, ha		Maximum allowable stocking rate (LU/ha)
	Range of values	Average	
Alpine	2 - 2.5	2.25	0.44
Subalpine	1 - 1.2	1.1	0.91
meadow-steppe and post-forest grasslands	1.5 - 1.7	1.6	0.63
Steppe	2 - 2.5	2.25	0.44
Semi-desert	6 - 7	6.5	0.15

For the preliminary ES mapping based on the vegetation map, we adopted the values shown in Table 1 for analogous vegetation zones and for open woodlands, we used the steppe-zone value of 0.44. Tree cover (ESRI, 2023) and marshes were excluded from the pasture category. Thus, all calculations of the allowable stocking rate for the different vegetation zones were made for non-woody natural areas (hereafter, “non-woody areas”).

The map of the maximum permissible stocking rate (Fig. 32A-1) shows the amount of the ES provided. Subalpine meadows provide the largest amount of livestock forage (maximum permissible total number of livestock units—389,000 LU), with steppes and grasslands in forest zone contributing a substantial share (161,000 – 230,000 LU). Semi-desert, desert and grasslands in woodland zones provide the least of this ES due to their low productivity and the limited extent of these vegetation zones (Figure 32A-2).

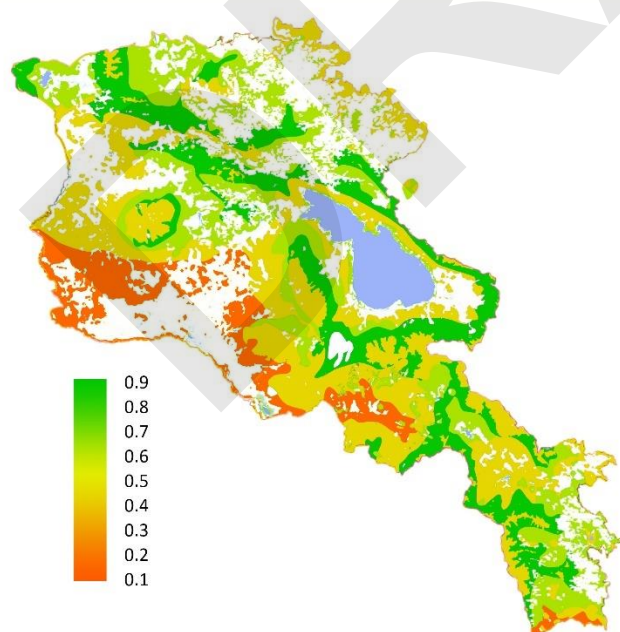


Figure 32A-1. Provided ES of livestock forage production: maximum permissible number of livestock units per hectare (LU/ha)

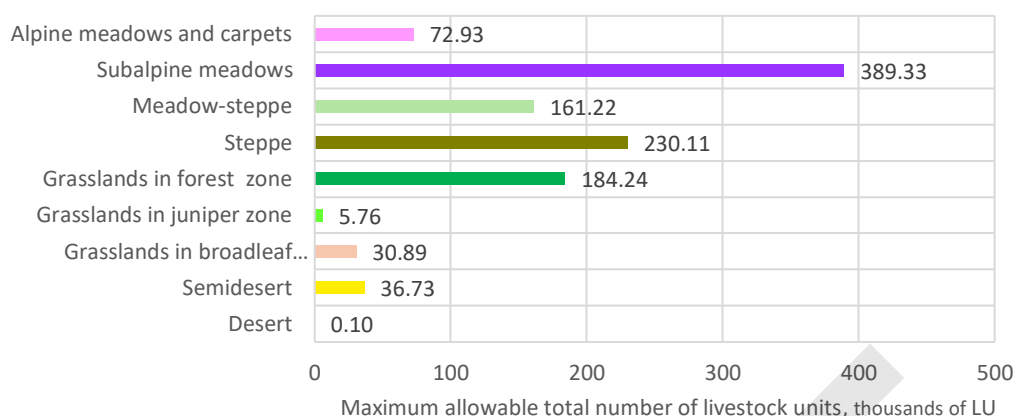


Figure 32A-2. Total carrying capacity of non-woody areas: maximum allowable total number of livestock units in different vegetation zones

Changes in land cover recorded by ESRI from 2017 to 2023 led to a reduction in non-woody areas across all zones except broadleaf woodlands, and to a corresponding decrease in the volume of ES provided. The greatest reduction in non-woody area occurred in the meadow-steppe and steppe zones (Figure 32A-3 a), with the allowable livestock numbers decreasing by 152,000 and 95,000 LU, respectively (Figure 32A-3 b).

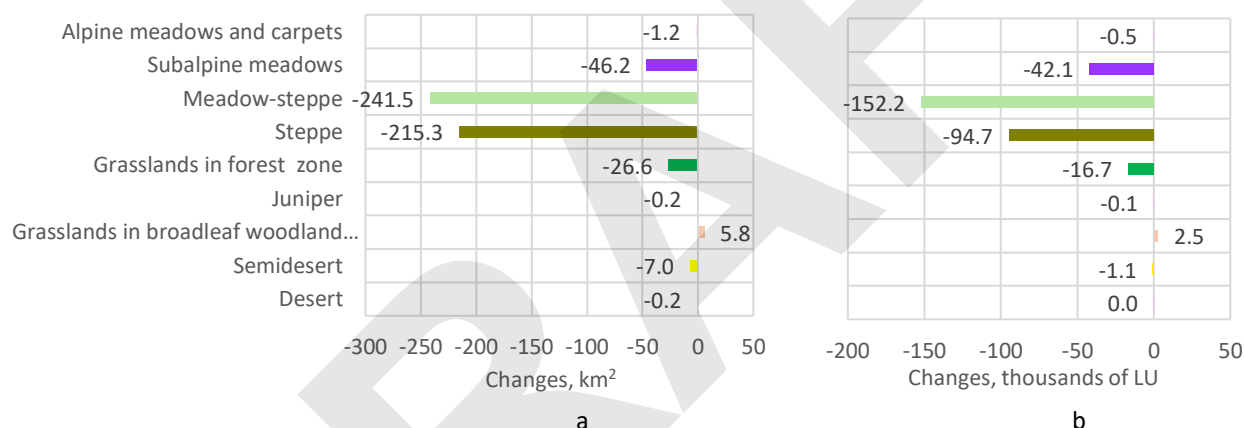


Figure 32A-3. Changes in the provided ES from 2017 to 2023: a) Changes in non-woody natural area; b) Changes in the maximum allowable total number of livestock units.

Provided ES at marz level

The largest volume of the ES is provided by non-woody areas in marzes Gegharkunik, Lori, and Syunik, with total stocking capacities ranging from 180,000 to 205,000 LU. In Gegharkunik marz, subalpine grasslands have the largest total carrying capacity; in Lori and Syunik marzes, they likewise account for about half of the total capacity. In Lori, Syunik, and Tavush marzes, grasslands within the forest zone constitute a substantial share of the total capacity. The lowest capacity of 7,000 LU is observed in the semi-desert of Armavir marz (Figure 32A-4).

Changes in land cover recorded by ESRI from 2017 to 2023 led to the greatest reduction of non-woody areas in Shirak marz, reducing their total capacity by 114,000 LU. A noticeable reduction in carrying capacity—by tens of thousands of LU —also occurred in marzes Aragatsotn, Gegharkunik, Lori, and Syunik. Across all marzes, the decline in capacity was driven primarily by the reduction in the area of steppe and meadow-steppe (Figure 32A-5).

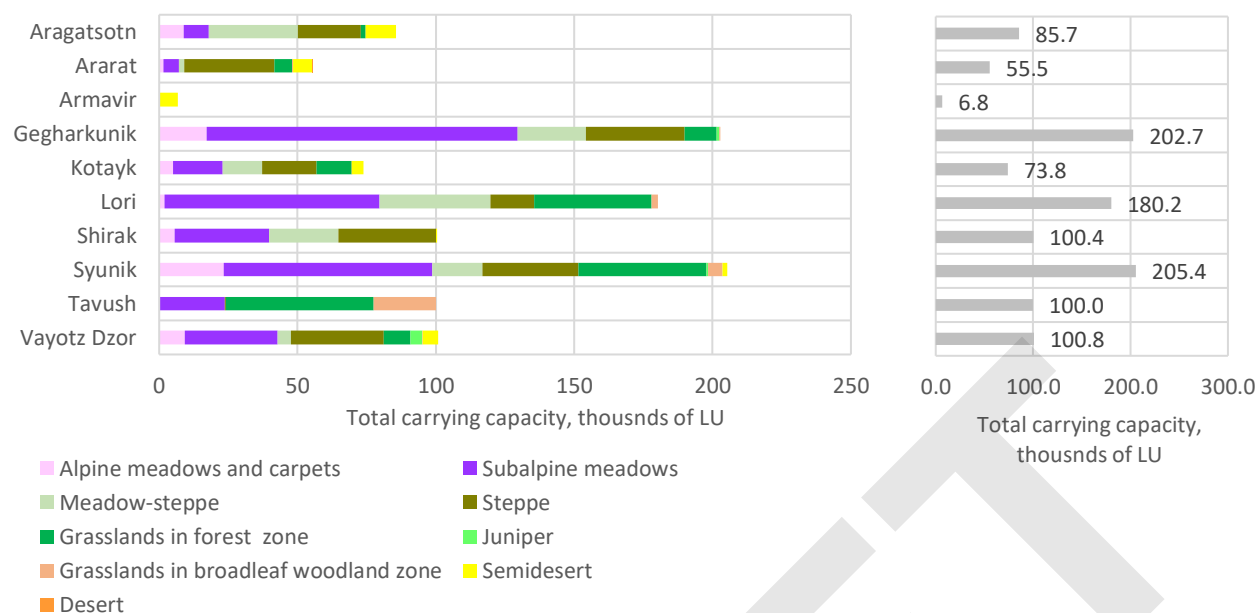


Figure 32A-4. Total carrying capacity of non-woody areas across marzes

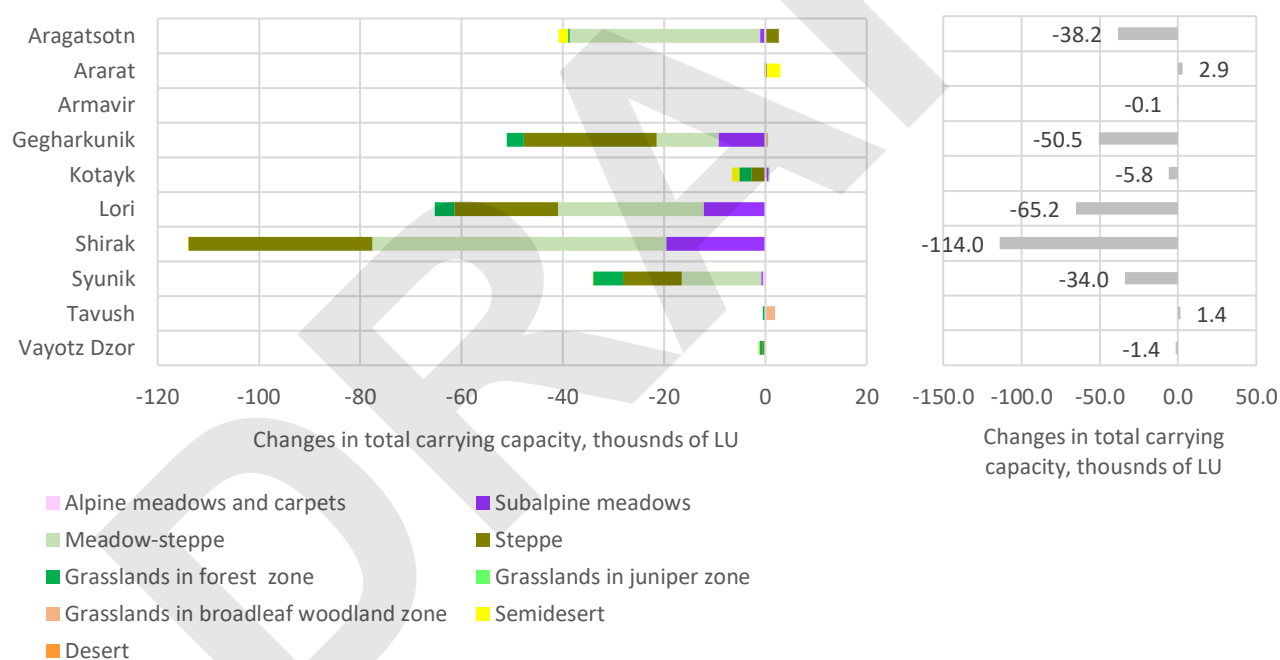


Figure 32A-5. Changes in total stocking capacity of non-woody natural areas across marzes

Table 32A-1. Non-woody natural area across vegetation zones and marzes, km²

	Aragats- otn	Ararat	Arma- vir	Geghar- kunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayotz Dzor	Total
Alpine meadows and carpets	202.5	37.1	0.0	390.9	113.6	44.0	126.1	530.4	0.3	212.4	1657.4
Subalpine meadows	100.1	61.0	0.0	1234.4	196.5	853.7	375.3	828.7	260.1	368.6	4278.4
Meadow-steppe	509.7	29.9	0.0	393.5	228.1	637.9	397.0	286.6	0.0	76.5	2559.1
Steppe	516.4	738.3	0.0	809.5	443.7	356.4	804.8	789.4	11.6	759.7	5229.8
Grasslands in forest zone	26.8	102.8	0.0	183.5	203.3	672.5	0.0	734.7	846.9	154.0	2924.5
Grasslands in juniper zone	0.0	0.0	0.0	20.0	0.0	0.0	0.0	13.3	0.0	97.6	130.9
Grasslands in broadleaf woodlands	0.0	6.9	0.0	7.7	1.2	53.4	0.0	119.3	510.2	3.4	702.1
Semidesert	742.3	470.3	455.4	0.0	278.7	0.0	17.1	115.6	0.0	369.2	2448.7
Desert	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9
Total	2097.8	1453.2	455.4	3039.5	1465.2	2617.8	1720.4	3418.0	1629.1	2041.4	19937.8

Table 32A-2. Changes in non-woody area from 2017 to 2023 across vegetation zones and marzes, km²

	Aragats- otn	Ararat	Arma- vir	Geghar- kunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayotz Dzor	Total
Alpine meadows and carpets	-0.3	-0.1	0.0	-0.1	0.6	0.0	0.0	-1.2	0.0	-0.1	-1.2
Subalpine meadows	-0.9	0.0	0.0	-10.2	0.5	-13.4	-21.6	-0.3	-0.1	-0.2	-46.2
Meadow-steppe	-59.8	0.0	0.0	-19.3	0.2	-45.6	-92.1	-25.0	0.0	0.0	-241.5
Steppe	6.1	0.6	0.0	-59.7	-6.2	-46.5	-82.6	-26.1	0.0	-0.8	-215.3
Grasslands in forest zone	-0.3	0.0	0.0	-5.3	-3.8	-6.1	0.0	-9.4	-0.6	-1.0	-26.6
Grasslands in juniper zone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	-0.3	-0.2
Grasslands in broadleaf woodlands	0.0	0.0	0.0	1.3	0.0	0.1	0.0	0.1	4.3	-0.1	5.8
Semidesert	-13.1	17.8	-0.9	0.0	-9.6	0.0	-0.1	-0.6	0.0	-0.5	-7.0
Desert	0.0	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
Total	-68.4	18.1	-0.9	-93.2	-18.4	-111.6	-196.4	-62.5	3.6	-2.8	-532.5

Table 32A-3. Total stocking capacity of non-woody areas across vegetation zones and marzes, maximum allowable number of livestock units, thousands of LU

	Aragats- otn	Ararat	Arma- vir	Geghar- kunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayotz Dzor	Total
Alpine meadows and carpets	8.91	1.63	0.00	17.20	5.00	1.94	5.55	23.34	0.01	9.35	72.93
Subalpine meadows	9.11	5.55	0.00	112.33	17.88	77.69	34.16	75.41	23.66	33.54	389.33
Meadow-steppe	32.11	1.88	0.00	24.79	14.37	40.19	25.01	18.06	0.00	4.82	161.22
Steppe	22.72	32.49	0.00	35.62	19.52	15.68	35.41	34.73	0.51	33.43	230.11
Grasslands in forest zone	1.69	6.48	0.00	11.56	12.81	42.36	0.00	46.29	53.36	9.70	184.24
Grasslands in juniper zone	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.59	0.00	4.30	5.76
Grasslands in broadleaf woodlands	0.00	0.30	0.00	0.34	0.05	2.35	0.00	5.25	22.45	0.15	30.89
Semidesert	11.13	7.05	6.83	0.00	4.18	0.00	0.26	1.73	0.00	5.54	36.73
Desert	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Total	85.68	55.49	6.83	202.72	73.82	180.20	100.38	205.40	99.99	100.81	

Table 32A-4. Changes in total stocking capacity of non-woody areas from 2017 to 2023 across vegetation zones and marzes, maximum allowable number of livestock units, thousands of LU

	Aragats- otn	Ararat	Arma- vir	Geghar- kunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayotz Dzor	Total
Alpine meadows and carpets	-0.14	-0.03	0.00	-0.04	0.26	0.00	0.00	-0.54	0.00	-0.03	-0.5
Subalpine meadows	-0.86	0.00	0.00	-9.26	0.41	-12.24	-19.62	-0.29	-0.08	-0.15	-42.1
Meadow-steppe	-37.69	0.02	0.00	-12.16	0.14	-28.70	-58.02	-15.73	0.00	-0.01	-152.2
Steppe	2.68	0.27	0.00	-26.27	-2.74	-20.48	-36.35	-11.50	0.00	-0.34	-94.7
Grasslands in forest zone	-0.21	-0.02	0.00	-3.34	-2.42	-3.85	0.00	-5.91	-0.39	-0.61	-16.7
Grasslands in juniper zone	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00	-0.12	-0.1
Grasslands in broadleaf woodlands	0.00	0.00	0.00	0.59	0.00	0.04	0.00	0.06	1.87	-0.03	2.5
Semidesert	-1.96	2.67	-0.13	0.00	-1.44	0.00	-0.01	-0.09	0.00	-0.08	-1.1
Desert	0.00	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Total	-38.2	2.9	-0.1	-50.5	-5.8	-65.2	-114.0	-34.0	1.4	-1.4	-304.9

Supply-use ES balance

Grasslands provide forage in summer and, as hay, in winter, comprising 65–70% of total feed demand (Tovmasyan, 2020). However, an IFC/World Bank report (IFC, 2017) notes that silage and compound feeds are not widely used in Armenia, and in practice the share of concentrates is generally below the recommended 30–35%. For sheep and goats, the share of concentrates is generally lower than for cattle. For the preliminary assessment, we assumed that grasslands provide 70% of the diet for cattle and 80% of the diet for sheep and goats. We also assumed an average livestock unit (LU) coefficient of 0.75 for all the cattle of different age and 0.14 for all sheep and goats of different age (Tovmasyan, 2015). Total number of LU adjusted for diet shares is shown in the Table 32A-5.

When comparing the supplied and used ES, it is important to note that not all grassland area is designated for pastures. In Armstat's regional statistics we did not find direct data on pasture and hayfield area by marz, so we derived it as the difference between total agricultural land area and arable land area (row 1 in Table 32A-6). Another source of data on pasture area could be the land-cover class areas (Statistical..., 2023), specifically, the area of meadows (row 2 in Table 32A-6).

Since we do not have a pasture map, we do not know their distribution across vegetation zones. Therefore, we had to use the average value of stocking capacity across all vegetation zones in each marz (row 6 in Table 32A-6). The stocking capacity of the pasture area C_p (row 7 in Table 32A-6), was computed as $C_p = C_g(S_p/S_g)$, where C_g is grazing capacity of all non-woody natural area (row 6 in Table 32A-6), S_p is the area of pastures (row 1 in Table 32A-6), and S_g is the area of non-woody natural area derived from ESRI data (row 3 in Table 32A-6). The grazing capacity of meadows was calculated in a similar manner as $C_m = C_g(S_m/S_g)$, where S_m is the area of meadows (row 2 in Table 32A-6). The share of grazing capacity used for the area of pastures and hayfields derived from regional ArmStat statistics was calculated as $U_p = (N/C_p) \cdot 100$, where N is number of LU based on ArmStat data from the Table 32A-5. The share of grazing capacity used for the area of meadows derived from land cover ArmStat statistics was calculated as $U_m = (N/C_m) \cdot 100$.

Table 32A-5. Livestock numbers in 2023, thousands

	Cattle			Sheep and goats			Total number of LU adjusted for diet shares
	Armstat data	LU	LU adjusted for the 70% diet share	Armstat data	LU	LU adjusted for the 80% diet share	
Aragatsotn Region	57.7	43.3	30.3	92.3	12.9	10.3	40.6
Ararat Region	38.1	28.6	20.0	106.0	14.8	11.9	31.9
Armavir Region	53.0	39.8	27.8	141.4	19.8	15.8	43.7
Gegharkunik Region	81.5	61.1	42.8	99.1	13.9	11.1	53.9
Kotayk Region	45.1	33.8	23.7	38.5	5.4	4.3	28.0
Lori Region	70.8	53.1	37.2	31.1	4.4	3.5	40.7
Shirak Region	70.1	52.6	36.8	73.7	10.3	8.3	45.1
Syunik Region	37.0	27.8	19.4	78.5	11.0	8.8	28.2
Tavush Region	29.1	21.8	15.3	18.4	2.6	2.1	17.3
Vayots Dzor Region	16.0	12.0	8.4	16.9	2.4	1.9	10.3

Table 32A-6. Total carrying capacity of pastures and meadows, and the share used, by marz

		Aragatsotn	Ararat	Armavir	Gegharkunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayots Dzor	Armavir+ Aragatsotn
1	Area of pastures, thousands of ha, S_p	164.5	131.9	57.1	263.7	117.1	208.9	132.8	262.1	85.2	173.6	221.6
2	Area of meadows, thousands of ha, S_m	163.3	99.3	29.3	238.1	102.8	200.4	144.4	194.8	82.7	114.8	0.3
3	Non-woody natural area (ESRI, 2023), thousands of ha, S_g	209.8	145.3	45.5	303.9	146.5	261.8	172	341.8	162.9	204.1	255.3
4	Share of pasture area in total non-woody area, S_p/S_g	0.8	0.9	1.3	0.9	0.8	0.8	0.8	0.8	0.5	0.9	0.9
5	Share of meadow area in total non-woody area, S_m/S_g	0.8	0.7	0.6	0.8	0.7	0.8	0.8	0.6	0.5	0.6	0.8
6	Capacity of non-woody natural area, thousands of LU, C_g	85.7	55.5	6.8	202.7	73.8	180.2	100.4	205.4	100	100.8	92.5
7	Capacity of pastures, thousands of LU, C_p	67.2	50.4	8.6	175.9	59	143.8	77.5	157.5	52.3	85.8	80.3
8	Capacity of meadows, thousands of LU, C_m	66.7	37.9	4.4	158.8	51.8	137.9	84.3	117	50.8	56.7	69.8
9	Number of LU based on ArmStat data, 2023, N	40.6	31.9	43.7	53.9	28	40.7	45.1	28.2	17.3	10.3	84.3
10	Share of pasture capacity used, %, U_p	60.5	63.3	509.5	30.6	47.4	28.3	58.1	17.9	33.2	12	105
11	Share of meadow capacity used, %, U_m	60.9	84.1	994.1	33.9	54.1	29.5	53.5	24.1	34.2	18.2	120.8

According to these calculations, in all marzes except Armavir the livestock numbers do not exceed the grazing capacity of pastures/meadows, ranging from 84% in Ararat to 12% in Vayots Dzor (Figure 32A-6). In Armavir marz, the livestock numbers are 5–10 times higher than the grazing capacity. This figure may be explained by livestock registered in Armavir being grazed on areas classified as arable land, kept under stall-feeding/zero-grazing, or grazed on pastures in the neighboring Aragatsotn marz. However, even if all livestock from Armavir and Aragatsotn were evenly distributed across both marzes, their combined herd size would exceed the combined grazing capacity of the two marzes (the last column in Table 32A-6).

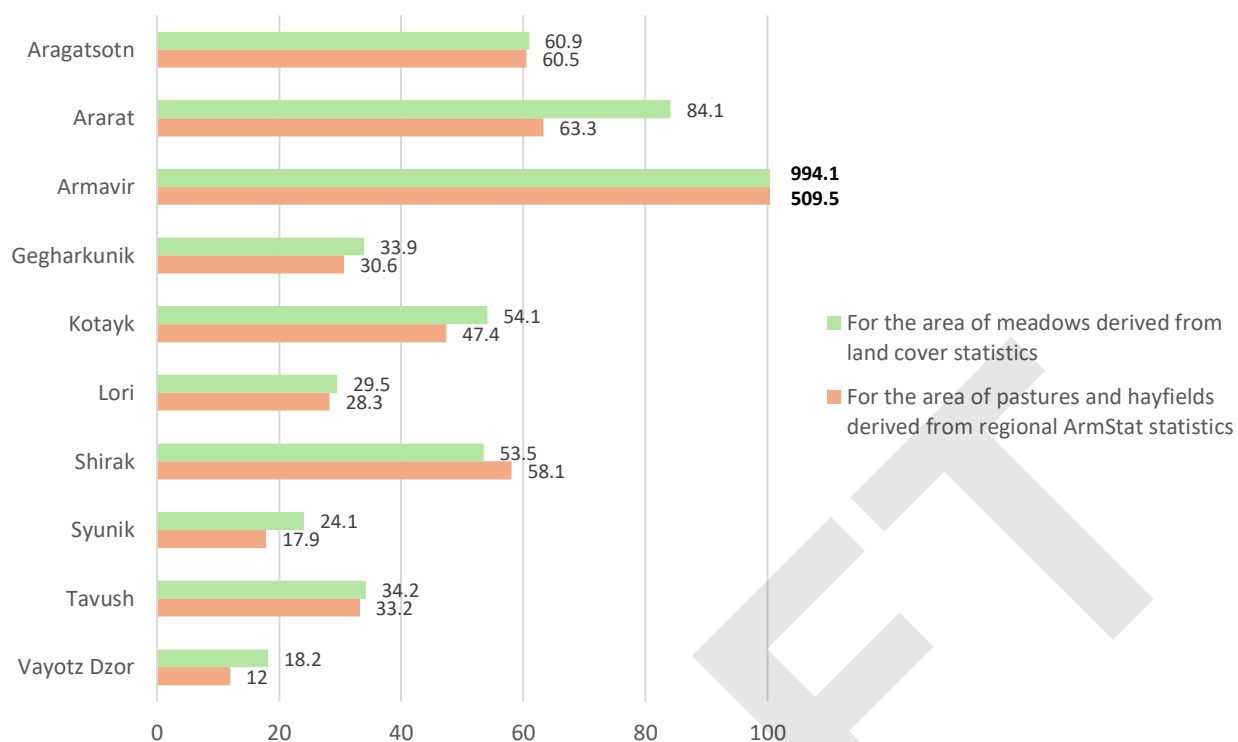


Figure 32A-6. Share of carrying capacity of pastures and meadows used, %.

In the above ES assessment, we do not take into account the degree of pasture degradation, which greatly reduces the amount of ES provided. For example, according to Tovmasyan (2020), the permissible grazing rate on degraded pastures at risk of erosion is reduced by 60% compared to pastures in good condition. Grazing should be prohibited altogether on severely degraded pastures with a high risk of erosion. Thus, the above estimate represents an upper bound that must be reduced to account for the degree of pasture degradation.

The map of the degree of pasture degradation in Armenia was not available to us; therefore, for a preliminary assessment we used a map of degraded lands from Armenian report for UNCCD (Government..., 2023) (Figure 32A-7 a), assuming that no grazing takes place in the areas identified there as degraded. The share of degraded non-woody natural areas by marz was determined after excluding croplands, built-up areas, and tree cover from this map (Figure 32A-7 b).

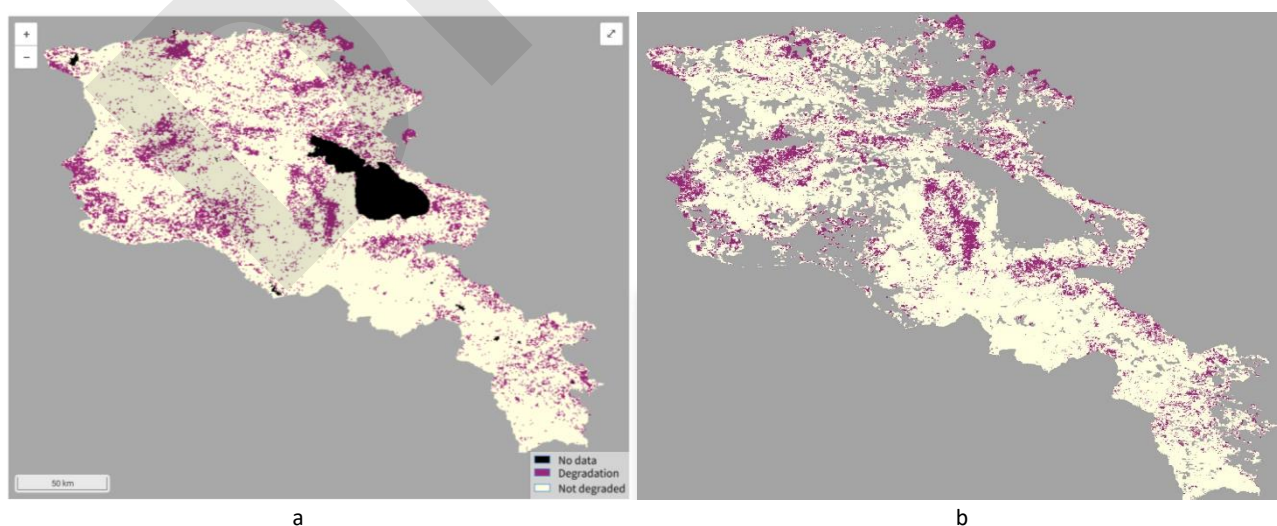


Figure 32A-7. The map of land degradation from UNCCD report (a) and the map used for this assessment with croplands, built-up areas, and tree cover excluded (b)

After subtracting from the total carrying capacity a portion equal to the share of degraded land in each marz, capacity utilization in all marzes—except Armavir—did not exceed 100%, ranging from 92% in Ararat to 12% in Vayots Dzor (Table 32A-7; Figure 32A-8). In Armavir marz, the livestock numbers are 7–14 times higher than the total carrying capacity.

Table 32A-7. Total carrying capacity of pastures and meadows, and the share used, by marz, excluding degraded land

	Aragats- otn	Ararat	Arma- vir	Geghar- kunik	Kotayk	Lori	Shirak	Syunik	Tavush	Vayotz Dzor
The share of non-degraded non-woody natural areas, %	81.8	91.2	69.7	74.2	81.7	83.7	79.7	89.4	59.4	95.7
Capacity of non-degraded pastures, thousands of LU	55.0	45.9	6.0	130.4	48.2	120.3	61.8	140.8	31.1	82.1
Capacity of non-degraded meadows, thousands of LU	54.6	34.6	3.1	117.7	42.3	115.4	67.1	104.6	30.2	54.3
Number of LU based on ArmStat data, 2023	40.6	31.9	43.7	53.9	28.0	40.7	45.1	28.2	17.3	10.3
Share of pasture capacity used, %	73.9	69.4	731.2	41.3	58.1	33.8	73.0	20.0	55.8	12.5
Share of meadow capacity used, %	74.5	92.2	1426.7	45.8	66.2	35.2	67.1	27.0	57.5	19.0

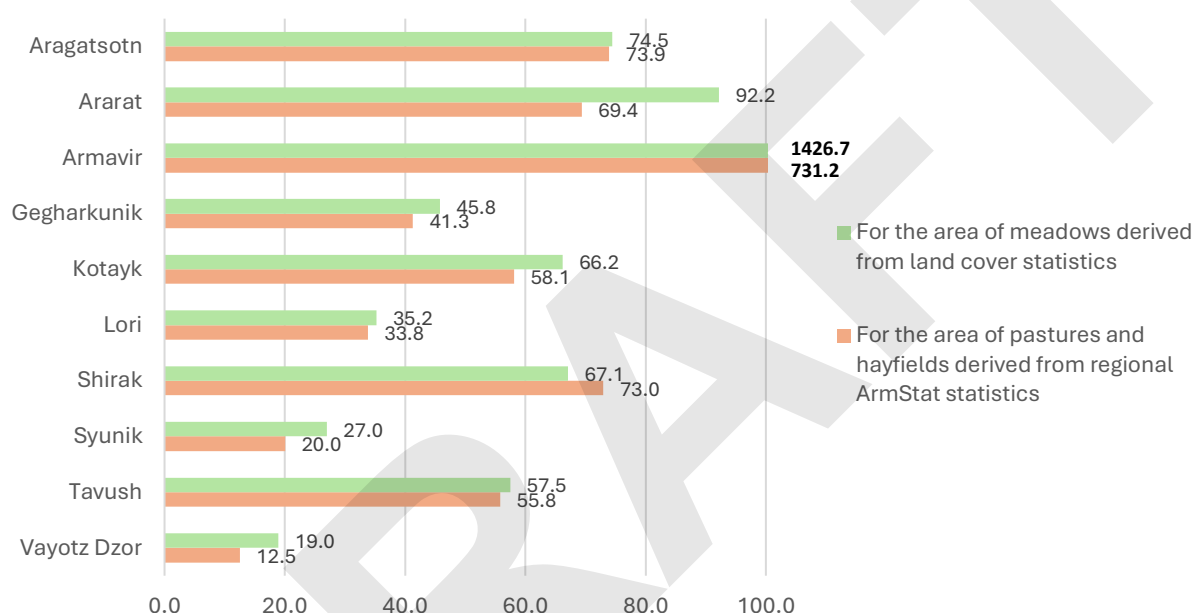


Figure 32A-8. Share of carrying capacity of pastures and meadows used, %, excluding degraded land.

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3.2.B. Wild plants used by humans

In this section we assess three types of benefits to people from the use of wild plants: culinary species, medicinal species, and the production of nectar by wild plants for subsequent honey production. The assessments of the provided ES are given in points based on the known number of species in the corresponding plant groups. In the future, these assessments should be refined using data on productivity and permissible levels of plant harvesting from the wild.

Edible and culinary plants

The wild flora of Armenia includes around 3,800 species of vascular plants, which accounts for more than half of the entire flora of the Caucasus. Among this botanical richness, many plant species have been used as food by the local population since ancient times. For this study, we selected species that are widely used both across Armenia and in specific regions. In the vast majority of cases, these plants are collected from natural ecosystems for personal use in households. They are more rarely sold at markets in small quantities, and large-scale commercial harvesting is practically absent.

Our review includes 75 species used as vegetables (in fresh or home-cooked form), 27 species of fruit, berry, and nut-bearing plants (used fresh, or in the form of juices, compotes, etc.), 9 species of aromatic herbs typically used as flavoring for dishes or beverages, 5 species used in alcoholic beverage production, and 17 species used in the preparation of non-alcoholic drinks. These species are found in various altitudinal zones and natural ecosystems (Figure 32B-1, Table 32B-1). The highest number of edible plant species is found in forest and steppe ecosystems, primarily within the mid-mountain belt. Slightly fewer species grow in broadleaf woodlands, meadow-steppes, and subalpine meadows. Edible plants are virtually absent in desert ecosystems and are very scarce in the alpine zone. Figure 32B-2 shows the uneven spatial distribution of species richness of culinary and edible plants.

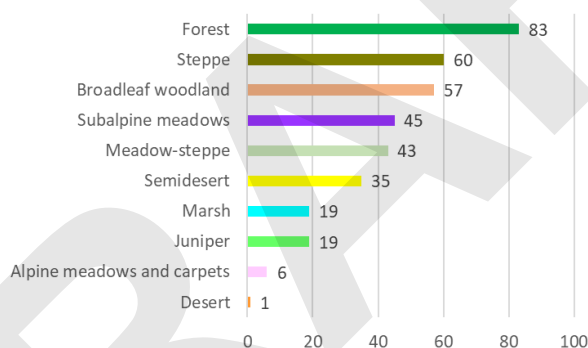


Figure 32B-1. The number of edible plant species characteristic for different types of natural vegetation

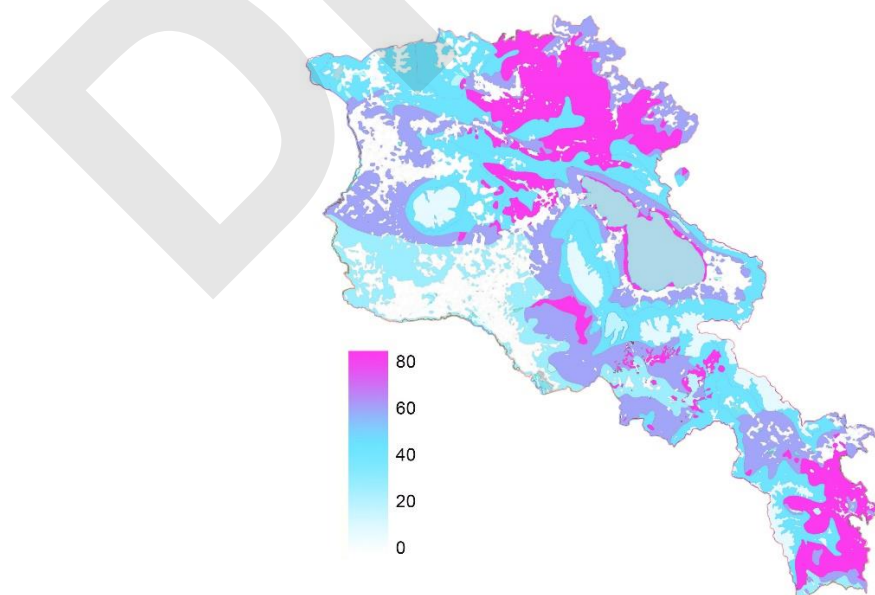


Figure 32B-2. Map of the ES provided by natural vegetation, assessed by the total number of edible plant species

Table 32B-1. The number of edible plant species characteristic for different types of natural vegetation

Vegetation zone	Vegetable	Fruit-berry and nuts	Spicy plants	Used in alcohol drinks	Used in non-alcohol drinks	Total
Alpine meadows/carpets	5	-	1	-	-	6
Broadleaf woodland	28	13	4	2	10	57
Desert	1	-	-	-	-	1
Forest	38	25	3	5	12	83
Juniper	12	1	4	-	2	19
Marsh	13	2	1	-	3	19
Meadow-steppe	27	5	3	-	8	43
Semidesert	28	2	3	-	2	35
Steppe	41	5	5	1	8	60
Subalpine meadows	27	7	2	1	8	45

Most edible plants are common in Armenia (taking into account the distribution of different ecosystems across the various regions of the country). The only species included in the Red Data Book of Plants of Armenia is *Gundelia hajastana* (listed in the Red Book as *Gundelia rosea*). This species was widely used as a food plant in the Kotayk Province (where its main range is located) until the 1950s. It was then largely forgotten and is now rarely gathered or used.

Edible plants in Armenia are collected primarily by the local rural population for personal use and in very small quantities for sale at urban markets. At the current level of use, wild populations of most species remain stable. Only a few species are collected in relatively large quantities for export. For example, several years ago, licorice (*Glycyrrhiza glabra*) was harvested for export to Georgia for the production of non-alcoholic beverages; however, even in that case, it was collected from abandoned agricultural fields where it was naturally spreading intensively.

Nevertheless, if large-scale commercial harvesting were to begin, many species could face the risk of overexploitation. Unfortunately, while some studies on wild plant resources were conducted during the Soviet period, in the past 30 years such research has been almost entirely lacking, and there are no available data on the current or potentially usable reserves of these plants.

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Medicinal plants of Armenia

Armenia is home to a very large number of medicinal plant species. Only a small number of them are included in the official pharmacopoeia, while the vast majority are used in traditional medicine. The medicinal properties of plants native to Armenia have been known since ancient times. As early as the Middle Ages, Armenian scholars wrote specialized treatises on medicinal plants (Harutyunyan, 1990). During the Soviet period, the Institute of Fine Organic Chemistry of the Armenian Academy of Sciences had a department dedicated specifically to studying the medicinal properties of wild plants in Armenia. Today, people mostly rely on pharmaceutical industry products, but at the same time, there is a growing trend toward the use of natural products, including medicinal plants.

From the vast diversity of medicinal plants in Armenia, we selected 155 species for analysis — those that are most widespread and most commonly used in traditional medicine. These species are found across various elevation zones and natural ecosystems (Figure 32B-3, Table 32B-2). The highest number of medicinal plant species is concentrated in the middle and upper mountain belts, primarily in forests, steppes, meadow-steppes, open woodlands, and subalpine meadows. Figure 32B-4 shows the uneven spatial distribution of species richness of culinary and edible plants.

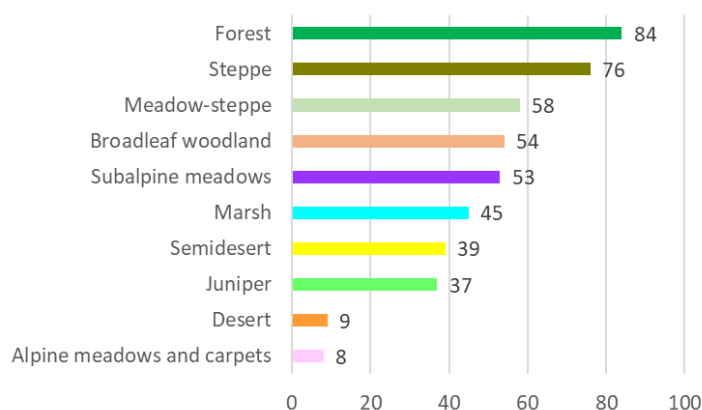


Figure 32B-3. The number of medicinal plant species characteristic for different types of natural vegetation

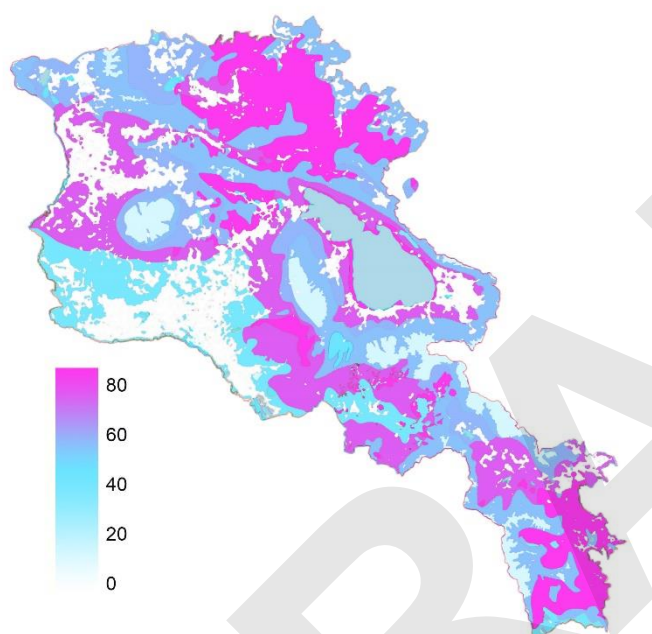


Figure 32B-4. Map of the ES provided by natural vegetation, assessed by the total number of medicinal plant species

Table 32B-2. The number of medicinal plant species characteristic for different types of natural vegetation

Type of vegetation	Species number
Alpine meadows and carpets	8
Broadleaf woodland	54
Desert	9
Forest	84
Juniper	37
Marsh	45
Meadow-steppe	58
Semidesert	39
Steppe	76
Subalpine meadows	53

Most populations of medicinal plants are found throughout Armenia within their respective natural ecosystems. They are generally abundant, and the current level of harvesting does not pose a threat of overexploitation. However, a number of species are rare and included in the Red Data Book of Plants of Armenia (Tamanyan et al., 2010) (Table 32B-3). Most of the species presented in our study are either not used at all today or are used in minimal quantities for personal household needs. Only a very small amount is sold in markets or on the streets of cities. Unfortunately, no research is currently being conducted in Armenia to assess the wild reserves of medicinal plants or the potential for their sustainable use.

Table 32B-3. Medicinal plants included in the Red Data Book of Plants of Armenia

Species	Category in the Red Book	Comments
<i>Acorus calamus</i>	Endangered (EN)	Grows only in Armavir and Ararat marzes
<i>Atropa bella-donna</i>	Vulnerable (VU)	-
<i>Calendula persica</i>	Endangered (EN)	Grows only in Sjuniq marz
<i>Cocciganthe flos-cuculi</i>	Critically Endangered (CR)	Only one population is known in Lori marz
<i>Cyclamen vernum</i>	Vulnerable (VU)	Grows only in the North of Tavush marz
<i>Halostachys belangeriana</i>	Endangered (EN)	Has small area of occurrence, grows on salt bodies (solonchaks) in Armavir and Ararat marzes
<i>Menyanthes trifoliata</i>	Vulnerable (VU)	Usually size of populations is very small
<i>Nuphar lutea</i>	Critically Endangered (CR)	Very rare species, only one population is known in the North of Shirak marz
<i>Nymphaea alba</i>	Endangered	Rare species, the main area of distribution lies in Lori marz
<i>Paeonia tenuifolia</i>	Critically Endangered (CR)	Very rare species, only one small population is known in Sjuniq marz
<i>Potentilla erecta</i>	Critically Endangered (CR)	Only a few small populations are known in the North of Armenia
<i>Sphaerophysa salsula</i>	Vulnerable (VU)	Rare species, only one population was known, but in the last years some new small populations were found in Ararat marz

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Nectar production by natural vegetation

In the strict narrow sense, the ES of wild honey production refers specifically to honey collected from wild bees. However, this practice is currently rare in Armenia. Most honey in Armenia is produced through conventional beekeeping using domesticated honeybees (*Apis mellifera*). Even so, much of this honey is still derived from natural vegetation. In this case, natural ecosystems produce nectar, which is then processed into honey by domesticated bees. At this stage, for a preliminary assessment of the potential supply of the ES, we used the number of honey plant species across different types of natural vegetation in Armenia. Clearly, this estimate should be refined in the future using data on the abundance and productivity of honey plants. The used ES can be considered as honey production for human consumption. However, since we do not have such statistical data, the used ES was not assessed.

Honey plants are those that produce large amounts of nectar and/or pollen. According to A.A. Grossheim (1952), all honey plants can be divided into two groups: primary and secondary. Primary honey plants are those that produce significant quantities of nectar and pollen accessible to bees and are, in most cases, characterized by a long flowering period. A limited flowering period is not always a disadvantage for honey plants. For example, plants that bloom in early spring—although for a relatively short time—are important seasonal sources of nectar. Secondary honey plants are of lesser value but still contribute to the overall nectar potential of an area. Their presence in the vegetation increases the usefulness of the land from the perspective of beekeeping.

In Armenia, nearly half of all flowering plant species—over 1,400 species—are considered honey plants, either primary or secondary (Muradyan, 2019). We analyzed only primary honey plants, as their abundance and diversity largely determine the value of ecosystems in terms of the ecosystem service of wild honey provision. When assessing the importance of plant species for this ES, in addition to the flowering period, it is also necessary to consider their representation across various ecosystems, elevation zones, and ecological amplitude. The broader and more widespread these characteristics are, the more valuable the species is as a honey plant.

We identified 238 species of primary honey flowering plants from 47 families and 117 genera. These species are distributed very unevenly across the main vegetation types of Armenia (Figure 32B-5, Table 32B-4).

The great diversity of honey plants is found in the mid-mountain zone—from the middle to subalpine mountain belts (steppe, meadow steppe, and subalpine zones)—where natural ecosystems occupy the largest areas. However, the relatively low number of honey plant species in the alpine belt should not be underestimated: almost all of them are

dominant species in alpine meadows and cover the largest areas there. Moreover, their mass flowering occurs in the second half of summer, when most honey plants in the lower belts have already finished blooming. Semi-deserts should also be considered valuable honey-producing ecosystems, despite the relatively low number of melliferous plant species. This is because their flowering period occurs mainly in spring—when ecosystems at higher elevations have not yet begun to bloom. It should also be noted that the main fruit orchards, which are among the most important honey resources, are located in this zone. However, our analysis does not include cultivated plants. For desert zone, we identified only two honey plant species. Given the very limited area of true deserts in Armenia, their value as honey-producing ecosystems is minimal. Marsh ecosystems, represented by waterlogged habitats along the shores of water bodies, also have low value as honey-producing areas. Forest ecosystems are mainly characterized by spring-flowering and wind-pollinated species, which produce large amounts of pollen. Figure 32B-6 shows the uneven spatial distribution of species richness of culinary and edible plants.

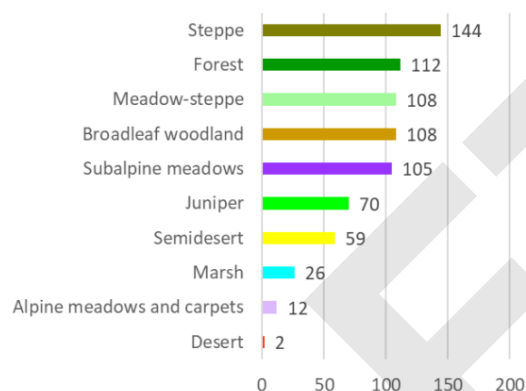


Figure 32B-5. Number of honey plant species in the main vegetation types

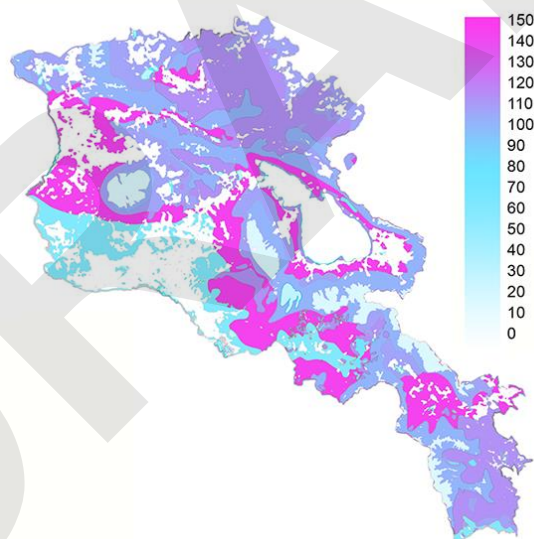


Figure 32B-6. Map of the ES provided by natural vegetation, assessed by the number of honey plant species

Table 32B-4. Number of honey plant species in the main vegetation types

Vegetation type	Number of honey plant species
Alpine meadows and carpets	12
Broadleaf woodland	108
Desert	2
Forest	112
Juniper	70
Marsh	26
Meadow-steppe	108
Semidesert	59
Steppe	144
Subalpine meadows	105

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Aggregate assessment of the ES provided by human-used plants

The total ES was calculated by adding together the scores for the three plant groups: culinary, medicinal, and honey plants. The scores were normalized within each group (to the maximum value) and expressed as percentages (Table 32B-5). Overall, ES is provided to the greatest extent by forest and steppe ecosystems, and to the least extent by desert and alpine ecosystems (Figures 32B-7, 32B-8). This pattern is very similar across all three plant groups.

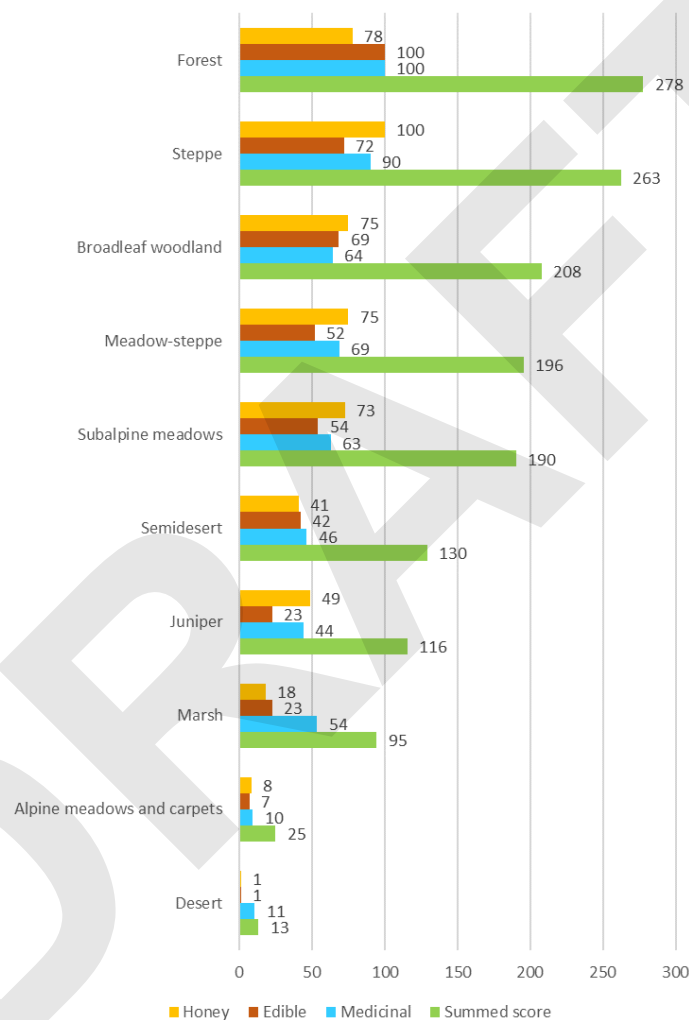


Figure 32B-7. ES scores across vegetation zones

Table 32B-5. Species number and score (normalized to the maximum value, %) of three groups of human-used plants in vegetation zones of Armenia

Type of vegetation	Medicinal plants		Edible plants		Honey plants		Total	
	Species number	Score	Species number	Score	Species number	Score	Species number	Summed score
Alpine meadows and carpets	8	10	6	7	12	8	26	25
Broadleaf woodland	54	64	57	69	108	75	219	208
Desert	9	11	1	1	2	1	12	13
Forest	84	100	83	100	112	78	279	278
Juniper	37	44	19	23	70	49	126	116

Marsh	45	54	19	23	26	18	90	95
Meadow-steppe	58	69	43	52	108	75	209	196
Semi-desert	39	46	35	42	59	41	133	130
Steppe	76	90	60	72	144	100	280	263
Subalpine meadows	53	63	45	54	105	73	203	190

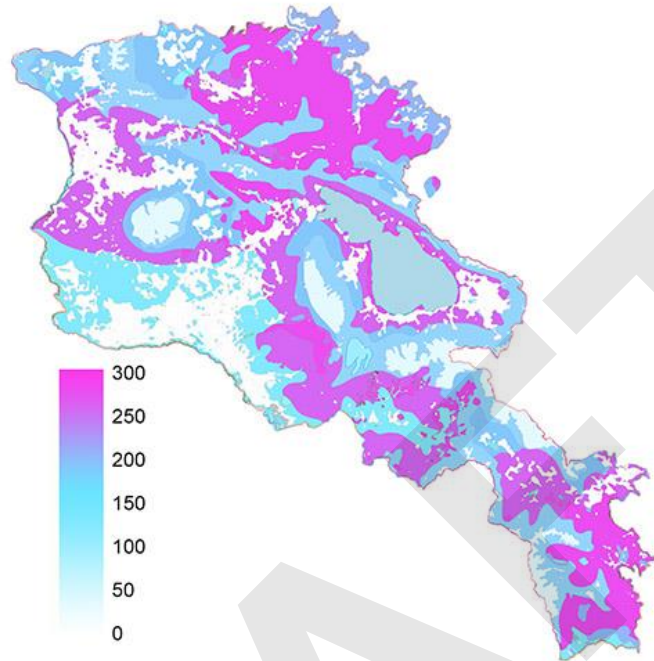


Figure 32B-8. The map of ES summed score in vegetation zones

The volume of ES provision by ecosystems within marzes was assessed by multiplying the total scores of vegetation types (Table 32B-5) by the area of each vegetation zone in each marz (Section 2.3.D). The largest ES volume is provided in marzes that have extensive areas of forest and steppe zones (Syunik, Lori, Tavush). The high ES value in the Gegharkunik marz is due to the large area of subalpine meadows, which, along with forests and steppes, also host a considerable number of useful plant species. The lowest level of ES provision is observed in Armavir marz due to the small area of remaining natural ecosystems which are almost entirely semi-deserts with a relatively low number of useful plant species (Figure 32B-9). Figure 32B-10 shows the share of ES provision contributed by different vegetation types in various marzes. In Tavush marz, the overwhelming majority of the ES is provided by forests and woodlands, while in Shirak and Aragatsotn marzes it is delivered mainly by typical and meadow steppes.

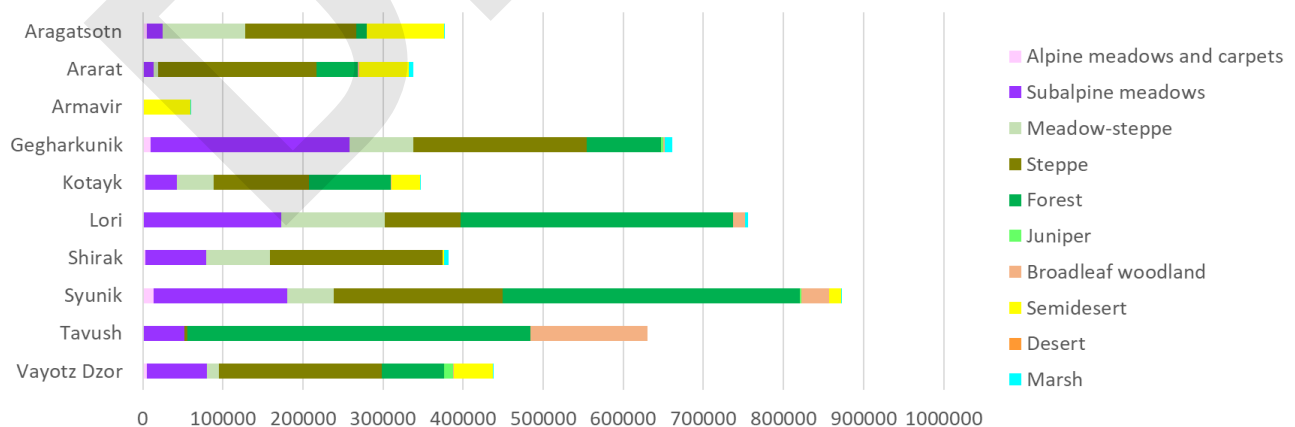


Figure 32B-9. ES provision by ecosystems within marzes (summed scores)

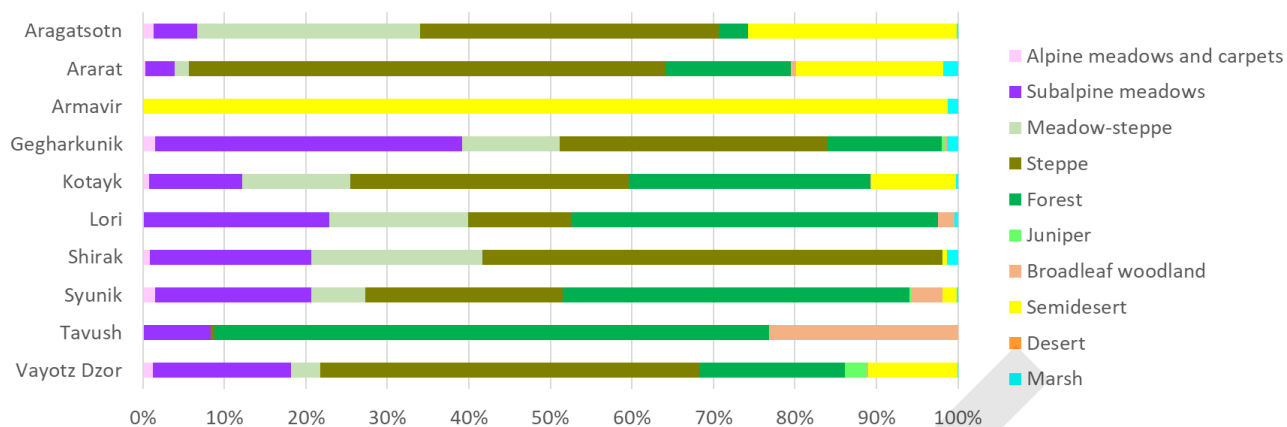


Figure 32B-10. The share of ES provided by different vegetation types within marzes (%)

According to the applied scoring method for assessing ES provided by different vegetation types, the changes in ES across marzes differ from changes in the area of various vegetation types (Section 2.3.D) being multiplied by their corresponding total ES scores (Figure 32B-11).

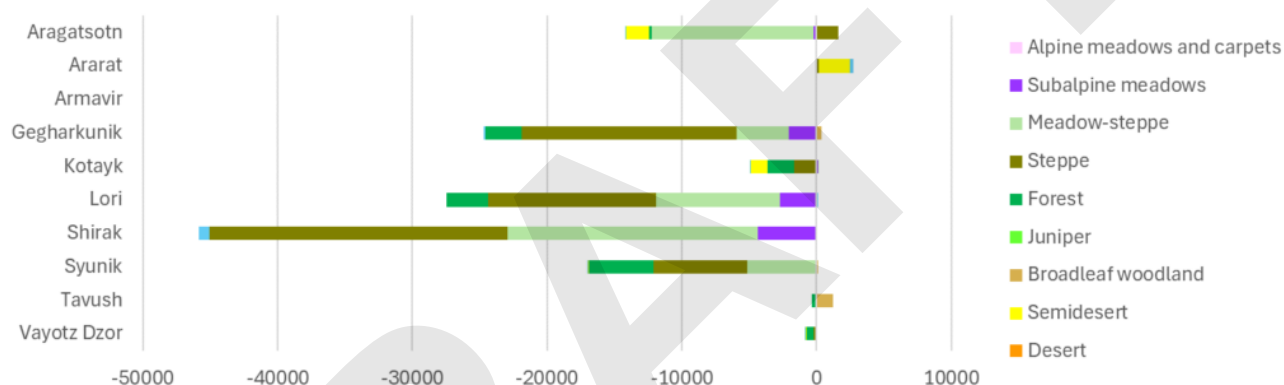


Figure 32B-11. Changes in ES provision by ecosystems within marzes (summed scores)