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Resource potential of the medicinal plant *Achillea millefolium* L. in forest protected areas of the Western and Southern Altai ridges

In the article the results of field studies of the medicinal plant *Achillea millefolium* L. in forest protected areas of the Western and Southern Altai ridges were presented. The total study area covers 4 ranges of the Western Altai (Ivanovsk, Ulbinsk, Ubinsk, Listvyaga) and 3 ranges of the Southern Altai (Narymsk, Kurchumsk and South Altai Tarbagatai). The survey of *Achillea millefolium* raw material stocks and its ecological state were assessed using generally accepted methods, taking into account intensive harvesting of this plant in the region. In 2 ridges: Ubinsk (Ust-Kamenogorsk SI) and Ivanovsk (Pikhtovsk SI) we have revealed and taken into account that yarrow forms thickets on grass-grassy meadows and along forest edges. Useful properties and uses of *Achillea millefolium* has a wide range, this is evidenced by their chemical composition: isovalerian, fatty and salicylic acid, asparagine, sterol, phenol, bitter and tannins, alkaloid, flavonoid, glycoside, essential oil, terpenoid, steroid, sesquiterpene derivatives, resins, saponin. The survey of common yarrow showed that raw material should be harvested during flowering. In terms of exploitable reserve, it is noted that it varies in the range of 4.19–7.89 tons. Yarrow raw reserves in the Southern Altai are accounted for in 13 populations, in 4 pilot forest protection institutions: Zyryanovsk State Institution (4 populations); Bolshenarymsk State Institution (2 populations); Katon-Karagai (KK) SNNP (4 populations); Kurchumsk State Institution (3 populations). The exploitable stock in the Southern Altai varies in the range 4.95–118.31 tons. The stocks volume in the following pilot SIs are suitable for commercial harvesting: Bolshenarymsk SI, Katon-Karagai SNNP, Kurchum SI and Zyryanovsk SI.

Keywords: medicinal plants, Western and Southern Altai, biotopes, stocks of raw materials, stock volume.

Introduction

The history of human development is inextricably linked to the cognition of the surrounding world and the involvement of natural resources in economic use. The higher the level of development of the productive forces of society, the higher the rate of their development and diverse application.

The plant world in all its great diversity has long been widely used by man in his daily economic activities. Even at the dawn of its development man highlighted, studied and described the surrounding plants, their useful properties [1].

In the natural flora of Kazakhstan there are a significant number of useful plants widely used in the national economy. In addition to well-known environmental and anthropogenic factors, the thickets of such species are affected by the most destructive — the process of direct unregulated mass harvesting of raw materials.

Plant resources, which are an integral part of natural biological resources, under the influence of ecological and anthropogenic factors are now undergoing significant, sometimes irreparable transformations. As a result, entire plant complexes and communities are irretrievably disappearing.

At present, an important task in the study of plant resources is the balanced use and protection of the riches of natural flora, as well as the vegetation cover as a whole.

Intensive exploitation impairs the ability of the population to recover losses and leads to a rapid decline in the productivity of the land. To avoid this, the rules for harvesting medicinal raw materials should be strictly followed. Systematic disruption of vegetative and seed regeneration of plants as a result of immoderate, improper collection and annual continuous intensive exploitation of the same arrays violates not only the age structure of populations, but also leads to significant shifts in their numbers, the static equilibrium of the

number of components in the phytocenosis fluctuates, which itself can cause degradation of the plant community [2].

The natural flora of the Kazakhstan part of Altai is rich in floristic composition and natural reserves of some medicinal plants used in folk and traditional medicine. However, for rational use and preservation of natural thickets of useful plant species it is necessary to carry out full-fledged resource studies, on the basis of which the current state and norms of withdrawal from nature are determined annually.

Such studies as the current state of economically valuable, intensively exploited, rare and endangered species of medicinal plants on the territory of the studied region need to be supplemented. There is practically no scientific information on the ecological state of medicinal plants promising for harvesting. Taking into account the above-mentioned, the purpose of the research was to study the issues on assessment of resource potential and ecological safety of medicinal plants of the Kazakhstan part of Altai, available for procurers. One of such objects is *Achillea millefolium* L.

Achillea millefolium is a perennial plant with (5) 20–60 cm of height; rhizome is thin, creeping, branched; plant is pubescent with fine white hairs; stems are few or solitary, erect or ascending from the base, straight, less often slightly sinuous, simple or branched in the upper part with shortened olive branches in the axils of middle and upper stem leaves; leaves are lanceolate, oblong-lanceolate or almost linear, pinnately-stigmatous, twice or thrice pinnately dissected, with numerous segments widely spaced 1.5–10 mm apart, lower stem leaves and leaves of infertile shoots 10–35(40) cm length, 0.8–5 cm width, axis 1–2 mm wide, usually in upper part with single intermediate teeth between main segments, lobes and teeth lanceolate, rarely linear, 0.5–1.5 mm long, 0.3–0.4 mm wide, acuminate at the top into short cartilaginous acuminate; baskets are in numerous, compound shields, 2–15 cm in diameter.; wrappers oblong to almost ovate, 3–4(6) mm long, 2–4 mm wide; leaflets of the envelope are green, keeled with a projecting median vein, with a filmy border along the margin, often brownish colored; bracts ovate to oblong-elliptic, filmy, downy above, with scattered glands on the dorsum; tongues of marginal flowers white, pink or red (1) 2–4 mm long, 1.5–3(4.5) mm wide, almost rounded, 2–3 toothed at the apex, bend twice shorter than the length of the wrapper; tubular flowers up to 20 in number, with glands outside [3].

Chemical composition of *Achillea millefolium*: isovaleric acid, salicylic acid, asparagine, sterol, phenol [4] bitter substances, tannins, coumarin, alkaloid, essential oil, terpenoid [5] steroid, sesquiterpene derivatives [6], resin, saponin, coumarin [7], fatty acid, alkaloid, flavonoid, essential oil [8], glycoside [9].

Useful (pharmacological and other) properties and uses of *Achillea millefolium*: tonic, stimulant, aromatic, cold, flu, amenorrhoea remedy [10] anti-inflammatory [11, 12], stimulating bile flow [13], diuretic [14], analgesic [15], gastroprotective, antibacterial [16], antioxidant, antimicrobial [17], antiseptic, expectorant, retrogonic, antispasmodic, styptic, choloretic gastrointestinal [18], anti-ulcer [19], hepatoprotective, antispasmodic [20], hypotensive [21], anxiolytic [22], hypoglycaemic, hypolipidemic [23], antimutagenic [24] antitumour [25].

Experimental

Resource survey of the territory was carried out by the route-reconnaissance method [26] and in accordance with the generally accepted “Methodology for determining the reserves of medicinal plants” [27], as well as taking into account the methodological guidelines for the study of medicinal plant resources [28], [27], as well as taking into account the methodological guidelines for the study of medicinal plant resources [28]. Stocks of raw materials were counted in specific thickets using the method of counting sites or model specimens. Traditional geobotanical methods were used to describe plant communities with the participation of resource objects [29, 30].

The structure of cenopopulations of rare medicinal plants was studied according to the methods of T.A. Rabotnov [31] and O.V. Smirnova [32]. To find out the life cycle, the method of A.A. Uranov was applied [33]. When studying the ecological and biological features of the species in the field, the methodological guidelines developed by M.F. Golubev and E.F. Molchanov were applied.

The assessment of stocks of raw materials of common yarrow was carried out in forest protection areas within the following forestry farms and the National Park: Zyryanovsk State Forestry Department, Bolshenarymsk State Forestry Department, Katon-Karagai State Forestry Department, Kurchumsk State Forestry Department. The surveyed area covers 4 ridges of the Western Altai (Ivanovsk, Ulbinsk, Ubinsk, Listvyaga,) and 3 ridges of the Southern Altai (Narymsk, Kurchumsk and South Altai Tarbagatai) (Fig.).

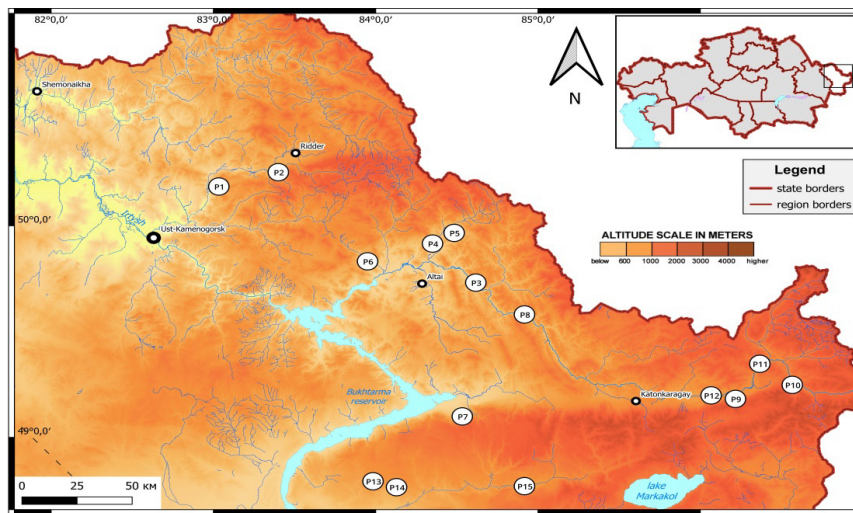


Figure. Map of *Achillea millefolium* population scheme in forest protected areas of the Western and Southern Altai ridges

Results and discussion

Common yarrow *Achillea millefolium* — herbaceous perennial plant of the family Asteraceae Bercht. Asteraceae Bercht. & J. Presl. It blooms in July-August and bears fruit in September-October. It grows in forest, forest-steppe and steppe zones, in meadows, steppe and meadow mountain slopes, on fallow lands, along field margins. The above-ground part is used as a raw material.

Stocks of common yarrow in the phase of blossoming — beginning of flowering were identified and accounted for 2 ridges: Ubinsk and Ivanovsk, where yarrow forms thickets on grass-grass meadows and on forest edges (Fig.).

On the territory of Ust-Kamenogorsk SI, Tarkhan forestry (P1) average yield of air-dry raw material of yarrow was 838.2 kg/ha. The exploitation reserve (ER) of air-dry aboveground phytomass of yarrow on the area of 5.0 ha was 4.19 tons (Table 1). Taking into account the duration of recovery of the species' stocks after harvesting of raw materials, the volume of possible annual harvesting (VPAH) should not exceed 0.83 tons of air-dry above-ground phytomass. The species is a part of grass-grass (*Dactylis glomerata*, *Achillea millefolium*, *Fragaria viridis*) communities on forest edges.

On the territory of Pikhtovsk SI, Kedrovsk forestry (P2), the average yield of air-dry yarrow raw material was 607.20 kg/ha. ER on the area of 13.0 ha was equal to 7.89 tons with VPAH not more than 1.57 tons. The species is a part of Yarrow-grass (*Dactylis glomerata*, *Achillea millefolium*, *Phleum pratense*) communities in extensive meadows.

Common yarrow *Achillea millefolium*: raw stocks of yarrow in the Southern Altai are accounted for in 13 populations, in 4 pilot forest protection institutions: Zyryanovsk State Institution (4 populations); Bolshenarymsk State Institution (2 populations); Katon-Karagay (KK) SNNP (4 populations); Kurchumsk State Institution (3 populations).

The survey was carried out during the flowering phase. The species is poorly eaten by livestock, and for this reason yarrow dominates in herbaceous communities in areas with heavy overgrazing.

In Zyryanovsk SI yarrow reserves were identified on the Ulbinsk ridges and in the Bkhtarminsk Mountains, on the territories of 4 forestries: Bykovskoy, Lesnopristansk, Stolboushinsk and Osinovsk. The species forms yarrow-timothy-leaved-clover, yarrow-hedge, yarrow, yarrow-chicory communities.

The main habitats of the species in the Zyryanovsk SI are flat meadows, lowlands, hayfields and old fallow lands. In Bykovsk forestry (P3), the ER of air-dried yarrow raw material on an area of 25.0 ha was 9.9 tons, with VPAH not exceeding 1.98 tons (Table 2). The species grows in yarrow-thymopheif-clover (*Phleum pratense*, *Trifolium pratense*, *Achillea millefolium*) communities in flat meadows.

In Lesnopristansk forestry (P4), the ER of yarrow on the area of 5.0 ha is 2.44 tons with the VPAH not exceeding 0.48 tons. The species is a part of yarrow-hedge (*Dactylis glomerata*, *Achillea millefolium*) communities in flat meadows.

Table 1

**Stocks of raw materials of the medicinal plant *Achillea millefolium*,
identified in the territories of the pilot forest protection organizations in Western Altai**

Population number	Location (ridge, forestry, quarter, thicket coordinates)	Price population, ecology	Area, ha		Air-dry stock density, kg/ha		Operating reserve of air-dry raw materials, tonnes		VPAH, air-dry raw materials	
			Total	Occupied species	Above-ground part	Under-ground part	Above-ground part	Under-ground part	Above-ground part	Under-ground part
Ust-Kamenogorsk										
P1	Ubinsk, Tarkhansk, 29, N 50,185835, E 83,034009		6	5	838.20	–	4.19	–	0.83	–
Pikhtovsk										
P2(66)	Ivanovsk, Kedrovsk, 01, N 50,257407, E 83,409735		15	13	607.20	–	7.89	–	1.57	–

Table 2

**Stocks of raw materials of the medicinal plant *Achillea millefolium*,
identified on the ridges of the Southern Altai Mountains**

Population number	Location (ridge, name of the State Unit of Forestry or SNNP, forestry, quarter, coordinates of the thicket)	Area, ha		Air-dry stock density, kg/ha (grass)	Operating stock of air-dry raw material, tons (grass)	SNNP, air-dry raw material, tons (grass)
		Total	Occupied species			
Zyryanovsk						
P3	Bukhtarma Mountains, Bykovsk, 70, N 49,74808, E 84,630533	25	20	495.00	9.90	1.98
P4	Ulbinsk, Lesnopristansk, 45, N 49,927754, E 84,36158	5	4	610.50	2.44	0.48
P5	Ulbinsk, Stolboushinsk, 116, N 49,973095, E 84,488364	30	25	445.50	100.23	20.04
P6	Ulbinsk, Osinovsk, 57, N 49,833838, E 83,955742	15	12	478.50	5.74	1.14
Bolshenarymsk						
P7	Narymsk, Koktereksk, 117, N 49,116321, E 84,548268	15	12	412.50	4.95	0.99
P8	Bukhtarma Mountains, Novo-Berezovsk, 11, N 49,584335, E 84,925789	16	13	396.00	5.14	1.02
Katon-Karagay SNNP						
P9	South Altai tarbagatai, Shyngystaysk, 23, N 49,195082, E 86,218586	20	17	402.6	6.84	1.36
P10	South Altai tarbagatai, Archatinsk, 46, N 49,264389, E 86,573621	23	19	429.00	8.15	1.63
P11	South Altai tarbagatai, Berelskoy, 51, N 49,352481, E 86,370288	28	23	891.00	20.49	4.09
P12	Listvyaga, Czernowinsk, 92, N 49,210689, E 86,072882	50	41	752.40	30.84	6.16
Kurchum						
P13	Kurchumsk, Cherdoyaksk, 48, N 48,814893, E 84,076826	15	12	478.50	5.74	1.14
P14	Kurchumsk, Cherdoyaksk, 53, N 48,788062, E 84,110417	8	6	491.70	2.95	0.59
P15	Kurchumsk, Pugachevsk, 143, N 48,768721, E 84,931526	15	12	514.80	6.17	1.23

In Stolboushinsk forestry (P5) on the area of 30.0 ha the ER of air-dry raw material was 100.23 tons with the VPAH not exceeding 20.04 tons. The species forms mono-dominant yarrow (*Achillea millefolium*) communities on flat meadows.

In Osinovsk forestry (P6) the ER on the area of 15.0 ha was 5.74 tons, with a VPAH of not more than 1.14 tons of air-dry aboveground phytomass. The species is a member of yarrow-chicory (*Cichorium intybus*, *Achillea millefolium*) communities on old deposits.

The total ER of yarrow raw material in the Zyryanovsk SI was 118.31 tons, with a total VPAH of no more than 23.64 tons of air-dry aboveground phytomass (Table 2).

Two populations of yarrow were identified in Bolshenarymsk State Unit on the Narymsk Ridge and Bukhtarma Mountains, in Kokterek and Novoberezovoi forestries. Raw material reserves were surveyed in yarrow (*Achillea millefolium*) and yarrow-tipchak (*Festuca valesiaca*, *Achillea millefolium*) communities on foothill terraces and on steppe slopes of foothills.

In Kokterek forestry yarrow thickets were found (P7) on the area of 15.0 ha, where ER of air-dry raw material was 4.95 tons, VPAH should not exceed 0.99 tons of dry raw material. In Novoberezovoi forestry (P8) yarrow reserves were identified on the area of 16.0 ha (ER — 5.14 tons, VPAH should not exceed 1.02 tons).

The total ER of yarrow raw material in Bolshenarymsk SI was 10.09 tonnes, with a total VPAH of not more than 2.01 tons of air-dry above-ground phytomass (Table 2).

In the Katon-Karagai SNNP, yarrow raw material reserves were identified on the South Altai Tarbagatai and Listvyaga ridges, in Shyngystay, Archatinsk, Berelsk and Chernivinsk forestry. In Shyngystay forestry (P9) yarrow thickets were found) on an area of 20.0 ha, where ER was 6.84 tons, with a total VPAH not exceeding 1.36 tons. In Archatinsk forestry (P10) the ER of milfoil on an area of 23.0 ha was 8.15 tons with a total VPAH not exceeding 1.63 tons. In Berelsk forestry (P11) on an area of 28.0 ha, the ER was 20.49 tons with a VPAH of 4.09 tons. In Chernovinsk forestry (P12) on an area of 50.0 ha, the ER was 30.84 tons with a VPAH not exceeding 6.16 tons.

The species is found in the national park in grass-grassy meadows, on steppe slopes of foothills and in intermountain hollows. Communities with yarrow participation are usually dominated by the following species: *Dactylis glomerata*, *Festuca valesiaca*, *Phleum pratense*, *Poa pratensis*, *Linaria vulgaris*.

The total ER of yarrow raw material for Katon-Karagai SNNP was 66.32 tons with a total VPAH of no more than 13.24 tons of air-dry aboveground phytomass.

Three populations of common yarrow on the Kurchumsk Ridge in Cherdoyaksk and Pugachevsk forestry were surveyed in Kurchumsk State Unit. Two populations of yarrow were identified in Cherdoyaksk forestry: in P13 on an area of 15.0 ha, where the ER was 5.74 tons with a VPAH not exceeding 1.14 tons, and in P14 on an area of 8.0 ha (ER — 2.95 tons, VPAH not exceeding 0.59 tons). In Pugachevsk forestry (P15) yarrow reserves are recorded on the area of 15.0 ha (ER — 6.17 tons, VPAH- 1.23 tons). The species forms yarrow-grass and yarrow-grass communities on foothill meadows and steppe slopes of hills.

Conclusion

As a result of field studies covering forest protected areas of four ridges of Western Altai (Ivanovsk, Ulbinsk, Ubinsk, Listvyaga) and three ridges of Southern Altai (Narymsk, Kurchumsk and South Altai Tarbagatai), the reserves of *Achillea millefolium* raw materials and its ecological state were assessed using generally accepted methods, taking into account intensive harvesting of this plant in the region.

Stocks of common yarrow were carried out in the phase of budding — the beginning of flowering. In 2 ridges: Ubinsk (Ust-Kamenogorsk SI) and Ivanovsk (Pikhtovsk SI) we have revealed and taken into account that yarrow forms thickets on grass-grassy meadows and on forest edges. The survey was conducted in the flowering phase. The exploitable stock showed that it varies in the range of 4.19–7.89 tons.

Yarrow raw reserves in the Southern Altai are accounted for in 13 populations, in 4 pilot forest protection institutions: Zyryanovsk State Institution (4 populations); Bolshenarymsk State Institution (2 populations); Katon-Karagai (KK) SNNP (4 populations); Kurchumsk State Institution (3 populations). The exploitable stock in the Southern Altai varies in the range 4.95–118.31 tons.

Yarrow stocks in the following pilot SIs are suitable for commercial harvesting: Bolshenarymsk SI (ER — 10.09 tons; VPAH — 2.01 tons), Katon-Karagai SNNP (ER — 66.32 tons, VPAH — 13.24 tons), Kurchumsk PA (ER — 14.86 tons, VPAH — 2.96 tons) and Zyryanovsk SI (ER — 118.31 tons, VPAH — 23.64 tons).

It is revealed that in order to restore raw material stocks, the volume of possible annual harvesting of raw materials should not exceed 30 % of the exploitable stock.

Thus, the raw material base of medicinal plant *Achillea millefolium* of East Kazakhstan region is able to meet the needs of the domestic pharmaceutical industry. Also, it meets the requirements of regulatory documents in the field of environmental safety, which allow us to recommend their use for economic purposes and harvesting in industrial quantities.

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Батыс және Оңтүстік Алтай жоталарының орман қорғау территорияларындағы *Achillea millefolium* L. дәрілік өсімдігінің ресурстық әлеуеті

Мақалада Батыс және Оңтүстік Алтай жоталарының орман қорғау аймақтарындағы *Achillea millefolium* L. дәрілік өсімдігінің далалық зерттеулерінің нәтижелері берілген. Негізгі зерттеу аймағы Батыс Алтайдың 4 жотасын (Ивановский, Үлбі, Убинский, Листвяга) және Оңтүстік Алтайдың 3 жотасын (Нарым, Күршім және Оңтүстік Алтайлық Тарбағатай) қамтиды. Жалпы қабылданған әдістермен *Achillea millefolium* шикізат қорын зерттеу және аймақтағы осы өсімдіктің қарқынды жиналуын ескере отырып, оның экологиялық жағдайы бағаланды. Екі жотада, яғни Убинский («Өскемен» ММ) және Ивановский («Пихта» ММ) жоталарының мыңжапырақ шөпті шалғындарында және ормандардың шеттерінде қалың бұталар түзетіні анықталып, есепке алынды. *Achillea millefolium* пайдалы қасиеттері мен қолданылуы кең ауқымға ие, яғни изовалерия, май және салицил қышқылдары, аспарагин, стерол, фенол, ащы және таниндер, алкалоид, флавоноид, гликозид, эфир майы, терпеноид, стероид, сесквитерпен туындылары, шайырлар, сапонин сияқты химиялық құрамымен дәлелденген. Кәдімгі мыңжапырақты зерттеу шикізатты жинау гүлдену кезінде жүргізілуі керек екенін көрсетті. Пайдалану қоры бойынша ол 4,19-7,89 т диапазонында өзгеретіні байқалды. Оңтүстік Алтайдағы мыңжапырақтың шикізат қоры 13 популяцияда, 4 пилоттық орман қорғау мекемесінде тіркелген, олар: «Зырян» ММ (4 популяция); «Үлкен Нарым» ММ (2 популяция); «Қатын Қарағай» (КК) МҰТП (4 популяция); «Күршім» ММ (3 популяция). Оңтүстік Алтайдағы пайдалану қоры 4,95-118,31 тонна аралығын құрайды. Мыңжапырақ қорларын өнеркәсіптік дайындауға мына пилоттық табиғатты қорғау мекемелері: «Үлкен Нарым» ММ, «Қатын Қарағай» МҰТП, «Күршім» ММ және «Зырян» ММ жарамды.

Кілт сөздер: дәрілік өсімдіктер, Батыс және Оңтүстік Алтай, биотоптар, шикізат қоры, дайындау көлемі.

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Ресурсный потенциал лекарственного растения *Achillea millefolium* L. на лесоохранных территориях хребтов Западного и Южного Алтая

В статье представлены результаты полевых исследований лекарственного растения *Achillea millefolium* L. на лесоохранных территориях хребтов Западного и Южного Алтая. Общая область исследования охватывает 4 хребта Западного Алтая (Ивановский, Ульбинский, Убинский, Листвяга) и 3 хребта Южного Алтая (Нарымский, Курчумский и Южно-Алтайский Тарбагатай). Общепринятыми методами были оценены запасы сырья *Achillea millefolium* и его экологическое состояние, учитывая интенсивную заготовку данного растения в регионе. В двух хребтах: Убинском (Усть-Каменогорское ГУ) и Ивановском (Пихтовское ГУ) нами выявлены и учтены, что тысячелистник образует заросли на разнотравно-злаковых лугах и по опушкам леса. Полезные свойства и применение *Achillea millefolium* имеет широкий спектр, об этом говорит их химический состав: изо-валериановая, жирные и салициловая кислота, аспарагин, стерол, фенол, горькие и дубильные вещества, алкалоид, флавоноид, гликозид, эфирное масло, терпеноиды, стероиды, производные сесквитерпены, смол, сапонин. Обследование тысячелистника обыкновенного показало, что заготовку сырья следует проводить во время цветения. По эксплуатационному запасу отмечается, что он варьирует в диапазоне 4,19–7,89 т. Сырьевые запасы тысячелистника на Южном Алтае учтены в 13-ти популяциях, в 4-х пилотных лесоохранных учреждениях: Зырянское ГУ (4 популяции); Большенарымское ГУ (2 популяции); Катон-Карагайский (КК) ГНПП (4 популяции); Курчумское ГУ (3 популяции). Эксплуатационный запас в Южном Алтае варьирует в диапазоне 4,95–118,31 т. Для промышленных заготовок пригодны запасы тысячелистника в следующих пилотных природоохранных учреждениях: «Большенарымское» ГУ, «Катон-Карагайский» ГНПП, «Курчумское» ГУ и «Зырянское» ГУ.

Ключевые слова: лекарственные растения, Западный и Южный Алтай, биотопы, запасы сырья, объем заготовок.

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