Bioresource potential of forest lands as the source of honey yield in steppe area of the river Don

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Abstract. Successful development of beekeeping, the increased number of beehives and apiaries, as well as high yields of honey and wax are possible only thanks to good and sustainable bee forage. The task of the study was to determine exactly species diversity of melliferous flora in different phytocenosis, to define honey productivity of plant formations in steppe zone of the river Don, bioresource potential and honey supply in different vegetative communities on forest fund lands, to develop the complex of measures, directed to rational and effective use of natural melliferous plants of forest lands. Species composition of nectar bearing vegetation on forest fund lands according to forest and non-forest categories is determined. The northwestern part of the region is the richest one, there are more than 1200 plant species, and many of them are melliferous. The southeastern part is poorer in flora. As a result it is defined that there is a huge bioresource forest potential for honey yield in Rostov region. Approximate honey supply on forest fund lands is not less than 6468 tons and the number of beehives is about 54 thousand. One of the most perspective species for bee breeding is black locust (Robinia pseudoacacia).

1. Introduction
Beekeeping is an important branch of agriculture and there are good perspectives for development when forests are used according to Article 38 of Forest Codex of Russian Federation. Successful development of beekeeping, enhancement of number of beehives and apiaries together with high honey yields are possible only if there is good and sustainable bee forage [1].

Non-wood forest products (NWFPs) are products of «biological origin other than wood derived from forests, other wooded land and trees outside forests» including a wide range products from trees, understory plants, fungi or animals. These products are collected from forests and agroforestry. Usually forest honey, pollen and propolis are of high quality because no agricultural activities are carried out in forests [2].

Detailed study of melliferous flora is of great importance as it is the only natural bee forage resource. [3].
Sustainable development of bee breeding and forestry in modern conditions is based on wide usage of biological and ecological potential of plants and their system formations – biocommunity. An important role in implementing this task play questions of studying and exploitation of melliferous resources. Hundreds of valuable melliferous plants grow in Rostov region, but plant resources are studied insufficiently and it influences negatively the development of bee breeding and its productivity.

Significant part of potential melliferous resources produced by melliferous lands in the Russian Federation belong to different categories of forest lands where multiple species of melliferous plants grow everywhere [4]. Authentic data about floral composition of melliferous vegetation, quantitative indices of nectar store, plentitude and areal location of melliferous resources in different plant communities are necessary to plan forest areas, projected and forecasted calculations, forest taxation and arrangement of ecological monitoring.

Distribution of forested areas according to main forest species is taken into account. Bees and forest trees are closely interrelated in the forest ecosystems and adjacent agricultural lands. Bees sustain forests and agricultural crops by pollinating flowering plants and crops [5]. They not only help to increase yield of seeds/fruits but also provide human with bee products. Land transformation including previous deforestation and intensive cultivation has affected insect populations and their adaptation to the new environment conditions [6].

Honey yield conditions and melliferous resources are changing over the time and rarely to the better. Successful preservation of biodiversity as a condition of conserving sustainability of ecosystems and biosphere in whole is possible only on the basis of comprehensive studying of its species and populations.

Providing new measures in nature conservation improves conditions for well-functioning whole ecosystem [7]. The nectar and pollen productivity in honey plants varies across different geographical areas depending on the type of vegetation, length of blooming period, and climate conditions. Nectar-producing trees such as *Aesculus hippocastanum* L., *Acer negundo* L. and *Acer platanoides* L., are planted in parks, green areas of Lithuanian cities, homesteads as well as near roadsides [8].

Beekeeping is closely related to cropping and animal breeding. Bees are pollinators of entomophilous plants that influence productivity of berry and fruit plants, and contributeto regeneration of natural flora of forest resources.

Anthropic factors impact biological objects, first of all wild growing resource plants that are exposed to different stress factors among which human economic activity is of special importance. Lack of normative base of nectar productivity leads to decreased attention of forestry to apiaries which use forest lands as a resource basis and it is reflected in huge losses marketable honey.

The aim of this study is to define bioresource potential on the basis of complex evaluation of nectar bearing vegetation of forest land directed to efficient use of bee forage in steppe zone of the river Don.

2. Methods and materials

Evaluation of melliferous resources was done with the help of route, geobotanic and stationary research studies and use of taxation descriptions of forest farms of the region and maps of farms.

To determine honey productivity of forest lands the amount of melliferous trees and shrubs on the experimental areas was registered.

Founded areas of melliferous plants were multiplied on honey productivity of this or that melliferous plant determined by ourselves or accepted by N P Smaragdova [9].

To simplify calculations, using taxation descriptions, honey productivity of a stand was defined by its composition and that of understory by frequency coefficient taken from normative tables.

Honey productivity was calculated according to the formula

$$M = m \cdot \frac{L}{10}$$
where, \( m \) - is honey productivity per ha with 100% share in a stand, kg; \( L \) - is share of melliferous trees in a stand.

Registration of honey yield with pointing the corresponding melliferous plant was done according to indices of check beehives on apiaries of a studied area.

Honey productivity (\( M \)) of melliferous lands on one hectare of territory was defined on the basis of that 100 parts of honey contain 80 parts of sugar and 20 parts of water, i.e. sugar productivity (\( X_c \)) of a certain melliferous plant on one hectare was multiplied on 1,25 and magnitude of potential honey production per unit of area (kg/ha) was calculated according to the formula [10]:

\[
M = 1.25X_c
\]  

(1)

Bioresource potential (\( B_{rp} \)) of forests for honey yield of the area was defined with regard of distribution of forest area and forest strips to species. Areas of melliferous lands (\( S_i \)) were consistently multiplied on their sugar productivity (\( X_{ci} \)). Obtained figures were summed up and forest bioresource potential for honey yield was calculated according to the formula [11]

\[
B_{rp} = S_1X_{c1} + S_2X_{c2} + S_3X_{c3} + \ldots + S_nX_{cn}
\]  

(2)

where, \( S_1, S_2, S_3, \ldots, S_n \) are areas (ha) of growing of separate forest species (melliferous);

\( X_{c1}, X_{c2}, X_{c3}, \ldots, X_{cn} \) is sugar productivity (kg/ha) of separate forest species.

While calculating honey store and honey yield of the region (district) it was regarded that bees usually collect only a part of nectar emitted by plants – from 1/3 to 1/3. Forest bioresource potential cannot be entirely used because of:

a) a part of nectar is collected by other insects;

b) bees cannot visit all melliferous plants and flowers;

c) unfavourable weather conditions.

Calculation of honey store (\( P \)) or honey yield was done according to the formula [11]

\[
P = 0.625B_{rp}
\]  

(3)

where, 0.625 is a coefficient regarding conversion of sugar to honey (honey from nectar of main nectar bearing plants contains about 80% of sugar) if ½ of forest bioresource potential is used for honey yield (\( 0.5 \times 1.25B_{rp} \)).

Potential honey supplies of melliferous lands represented by forest plantations was defined out of actual areas of stands given by Department of Forestry of Rostov region as well as average normative honey productivity of one hectare of these melliferous of plants.

Assignment of beehive number (\( N \)) required for honey yield if ½ of forest bioresource potential is used was calculated, taking into account the need for honey of a bee family per year which in average is 90 kg and 30 kg, provisional getting of marketable honey in the sum of 120 kg, according to the formula

\[
N = 0.625B_{rp}/120.
\]

3. Results and Discussion

Rostov region gets a lot of warmth thanks to its location in the south. Duration of sun shining is 2000-2200 hours per year. Frost-free period is from 160-170 days in the north and up to 180-190 days in the south of the region. It gets warm rapidly in spring. Climate of the region is favourable for beekeeping.

For beekeeping development in Rostov region vegetation on forest fund lands is of great importance. According to registered data area of forest lands of the region was 344.6 thousand hectares on 01.01.2012 and 222.8 thousand hectares are forested areas (Report about the state and land use, 2013).

Natural forests of Rostov region occupy 47.2% of forested area, the most part of which is represented by Common oak with mixture of other species: elm, lime, birch, aspen, maple and others. Main forested areas are oak groves (36%), coniferous forests (34%), black locust (9%) and other species (willow, ash, elm, poplar) are 21% in the whole.
However, many plant species of these phytocenosis are fine nectar and pollen bearing plants valuable for beekeeping [11].

As a result of study of biological resources melliferous, flora is registered and species composition of nectar bearing vegetation of forest lands according to categories such as forest and non-forest lands (farmlands, meadows, roads, farm yards, haylands) was defined, and significant forest potential for intensive beekeeping development of the region was determined.

Floral composition diversity of forest ecosystems was taken into account while assessing forest melliferous resource.

Species composition of melliferous vegetation of sandy terrace forests (46 types) is different depending on moisture conditions. Birch and aspen separated forest stands develop on loose sands of average humidity mainly in the northern part. On loose and very humid sands separated forest stands consist of pollen plants and European alder. Arboreal melliferous plants such as oak (Quercus), elm (Ulmus), poplar (Populus), willow (Salix), Tatar maple (Acer tataricum) and pear (Pyrus communis) are spread here. Understory is represented by such melliferous plants as spindle tree (Euonymus verrucosus), walwort (Sambucus nigra), dyeweed (Genista tinctoria), common buckthorn (Rhamnus cathartica), cranberry tree (Viburnum opulus), alder blackthorn (Frangula alnus), dogberry (Cornus sanguinea), blackthorn (Prunus stepposa), European bird cherry (Padus avium), dog rose (Rosa canina), amorpha (Amorpha fruticosa).

The most valuable herbs that produce continuous honey yield are locoweed (Astragalus glycyphylllos), ground ivy (Glechoma hederacea), willow-wort (Lysimachia nummularia and L. vulgaris), clump speedwell (Veronica longifolia), snakeweed (Bistorta officinalis), pale-flowered vetch (Vicia pisiformis), herb bennet (Geum urbanum), blackberry (Rubus caestus), Gipsywort (Lycopus europaeus), dropwort (Filipendula vulgaris), swallowwort (Vincetoxicum scandens), knitback (Symphytum officinale), bedstraw (Galium phorcarpum), woundwort (Stachys recta).

Ravine forest study was done according to groups of the main species: oak forests, maple forests and elm forests that play role in practical beekeeping.

Ravine oak forests have the most honey productivity (426.4 kg/ha) on light banks, occupying medium and bottom parts of gully banks, where the most favourable growth conditions are, i.e. soil moisture and temperature regimen is optimal. The main honey yield is produced by understory melliferous plants of maple (188.6 kg/ha) in ravine oak stands on shadow banks. There are no melliferous plants in herb cover.

Honey productivity of 73.0 kg/ha is supplied by margin brushwood of aglet, blackthorn, dog-rose and steppe cherry.

Thus, shrub and herb vegetation also produces some amount of nectar (blackberry, starwort), and can provide maintaining honey yield in flower period, but does not play the main role.

Studies carried out in ravine oak woods in the steppe part of the river Don show the natural increase of growth and development of many melliferous plants from such forest type group as ravine oak wood to that on the light banks. Forest types with good moisture and light intensity are more productive.

The most part of Tatar maple is observed in the best moisture conditions in ravine oak stands on shallow slopes. It must be considered that Tatar maple is inferior in honey productivity to common maple. Maple forests of ravine oak stands (369.1 kg/ha) take the first place according to calculations. Differences in honey productivity of maple stands in various forest types are not significant.

An important role in honey yield plays blackthorn of average density in undergrowth, but in ravine oak groves on light banks frequency coefficient of this melliferous representative is 40% and on shadow banks it is 65% because of favourable moisture conditions. Honey productivity of the observed shrub formation ranges from 20 kg/ha on shade banks to 45 kg/ha on light banks with the best light intensity conditions that influence growth and flowering intensity of blackthorn.

We defined honey productivity of shrub formations of blackthorn on light banks as 18.7 kg/ha and on shade banks as 13.6 kg/ha depending on frequency coefficient and honey productivity on different
elements of landscapes with peculiar forest vegetative conditions. Melliferous herbs are found in ground vegetative cover. They are ground ivy, different types of pale flowered vetch and herb bennet.

Thus, maple stands are valuable lands for beekeeping. Thanks to maple in arboreal level this formation is the source of plenty honey yield.

Elm stands with low level honey productivity (106.4 – 203.3 kg/ha) are also valuable lands for beekeeping.

Elm is characterized by the most honey productivity in stand composition of ravine oak groves (60-80%) on shade banks with indices of 32.2 kg/ha. Availability of common maple in stand composition of elm groves improves total indices of honey productivity of vegetative formation on a slope which is 203.3 kg/ha.

Melliferous plants of undergrowth are characterized by significant honey productivity of 46.2 kg/ha on light banks. Herb vegetation under canopy and on margins of a stand is characterized by species composition, frequency coefficient and sugar productivity. Elm stands have maximum indices of honey productivity on light banks where common yarrow (25 kg/ha) and steppe Sage (100 kg/ha) are predominant.

Arboreal level of this formation is the source of significant honey yield in early spring in the period when bee family becomes stronger thanks to availability of elm.

Figure 1 shows the dynamics of honey productivity of ravine forests.

**Figure 1.** Honey productivity of ravine forests.

Shrub formations as a part of ravine vegetation are widely spread in all areas of ravine forests. Blackthorn, ground cherry, almond, pea tree, meadow sweet, aglet and black maple grows can be pointed out among these formations.

Their productivity in creases if there are gulches, gullies, streams, marshes on their territory and if there are many margins, clearings, old cuts and the flower period of main melliferous plants is long.

Willow groves on the banks of bottomlands of flood plain forests are the most productive (156.6 kg/ha), they provide keeping honey yield in early spring.

In flood plain elm groves the main honey yield is produced by elm and common willow, and in understory by common blackthorn, alder blackthorn and cranberry tree (35.3 kg/ha). Blackberry, bedstraw and vetch are characterized by honey productivity (30.3 kg/ha) in ground vegetation cover [12].

Shrub formations of willow (*Salix triandra, S. purpurea, S. acutifolia, S. caspica, S. cinerea*), black maple and blackthorn are dominant in flood plains.

Willows provide bees with early honey yield. Willow brushwood supplies bees with keeping honey yield during the year with less favourable weather.
Willows often produce marketable honey with proper beekeeping practices in steppe area of the river Don. Nectar productivity of shrub willow reaches 20-50 kg/ha [13]. In the process of study it was defined that willows flower plenty and every year during 1.5-2 months, changing each other. The total area of forests at the age of hundred years ranges from 1842 to 5542 hectares, and that of “young” forests from 62 to 2,682 hectares. Even-aged crops prevail on forestsed lands occupying from 75 to 92%, they were primarily created by seeding or planting in open steppe conditions.

In a dry sedge oak stand the most productive are pure plantings of field maple (10 MC) with a honey productivity of 1,059 kg/ha. Oak and maple plantings with a field maple (487.8 kg/ha) in composition, nut and lime (326 kg/ha), oak and lime in the undergrowth with Tatar maple (3,064 kg/ha), lime and ash are characterized by a considerable honey productivity (421.6 kg/ha). In a fresh bishop's weed and sedge oak stands the high honey productivity is noted in the underbrush with Tatar maple and in a live ground cover with bishop's weed, snake-grass, ground ivy and lungwort(603.4 kg/ha). It is a little more than in drier conditions. Honey productivity of stands of oak, Bosnian maple, fine-leaved lime and apricot, with dense underbrush of Tatar maple in the considered forest type is 239.8 kg/ha.

Plantings of very dry sedge and cereals in oak stands are characterized by the smallest productivity. In these conditions three-thorned acacia plantations with apricot in composition are of high honey productivity (214.3 kg/ha), as well as elm plantings (130.5-165.7 kg/ha) in the understory with Tatar honeysuckle of dense and rare density.

To determine the bioresource potential and honey supplies data on species composition of melliferous plants, an area of their distribution and the indication of honey productivity were used.

It is established that on lands of forest fund black locust (table 1) is one of the most perspective species for beekeeping not only by the occupied area (20,144 hectares), but also by the largest bioresource potential (8,165 t) among melliferous plants. Thanks to intensive measures such as planting of forest crops and creation of protective environment forming stands, the area of black locust plantations on forest fund lands of Rostov region constantly increases from 13,3 thousand hectares in 1980, 17.7 thousand hectares in 1990 up to 18,8 thousand hectares in 2000 [14].

**Table 1.** Bioresource potential of forests for honey yield and a provisional number of beehives for the development of beekeeping in the forest land of the Rostov region.

| Melliferous resources                  | Areas, ha | Bioresource potential of forests, kg | Honey supply | Number of beehives |
|----------------------------------------|-----------|-------------------------------------|--------------|--------------------|
| Oak (Quercus robur L.)                 | 62793     | 400961.44                           | 250600.9     | 2089               |
| Maple (Acer)                           | 3904.3    | 802671.888                          | 501669.9     | 4180               |
| Elm (Ulmus)                            | 14299.6   | 417972.96                           | 261233.1     | 2177               |
| Black locust (Robinia pseudoacacia L.) | 20144.4   | 8165291                             | 5103307     | 42529              |
| Lime fine-leaved (Tilia cordata L.)    | 157.5     | 88200                               | 55125        | 459                |
| Common willows (Salix alba L.)         | 4390.2    | 379281.6                            | 237051       | 1976               |
| Honey locust (Gleditschia triacanthos L.) | 311.5   | 26478.4                             | 16549        | 138                |
| Apricot (Armeniaca), pear (Pyrus), apple tree (Malus), cherry (Primus) et al. | 669.8 | 38835.2 | 24272 | 204 |


Golden currants (*Ribes aureum* *Purch.*). black thorn (*Prunus spinosa* L.). yellow acacia (*Caragana arborescens* Lam.). honeysuckle (*Lonicera*). amorpha (*Amorpha fruticosa* L.) et al.

| In total | 107214.7 | 10348458.9 | 6467787 | 100.36 | 53901 |

According to the latest available data of the statistical report of the Department of Forestry the area of plantings of black locust on 01.01. 2009 constituted 18.2 thousand hectares. The main plantings of this species are concentrated in the centre and east areas of the region. In plantings of black locust middle-aged forest stands and young growths prevail.

Maples (802 t), elms (418 t) and willows (379 t) also have high bioresource potential. Three-thorned acacia (26.5 t) and fruit types (38.8 t) have the smallest bioresource potential among tree species.

Thus, melliferous lands of forests of the researched region have a great bioresource potential – 10348 tons.

Data about blossom terms of melliferous plants [14], honey productivity and bioresource potential of the woods were used for development of the melliferous conveyor from evenly (consistently) blossoming forest melliferous plants.

On schemes of the melliferous conveyors made for honey yield areas it is seen that the periods of blossom of the main melliferous plants often overlap each other, it gives the chance to create the flower conveyor and, in case of its proper organization and rational use, to provide availability of sustainable honey yield in conditions of the researched region.

Thus, the flower and nectar bearing conveyor in the researched region consists of consistently blossoming melliferous plants. Duration of blossoming of melliferous plants in the conditions of the steppe area of the river Don constitutes from 20 to 60 days that provides filling of the honey yield free period, and also creates the main productive honey yield. The obtained data also allow make schedules of movements of apiaries for pollination of forest plants and more complete use of bioresource potential of the forests for honey yield.

Wood and shrubby melliferous vegetation grows generally in forest stands, and also ravine, flood plain and sandy terrace woods. Among them are maple (*Bosnian, Tatar, field*), lime, black locust, pear, bird cherry, apple-tree, apricot, willow, and also Tatar maple, dogwood, aglet, hawthorn, Tatar honeysuckle, Siberian acacia, amorpha, cranberry, alder buckthorn, silver berry, snowberry, steppe cherry.

In age composition of forest communities on the forested area the share of young growths (black locust - 39%, maple – 25%, elm - 16% of the total area of prevailing tree and shrub species) and the share of middle-aged trees (maple - 39%, elm - 36%, black locust - 29%) has increased. The areas occupied by theriopening, mature and over maturetrees was reduced.

The approximate honey supply on forestlands of Rostov region constitutes at least 6.5 million tons, quantity of bee families for the development of beekeeping is about 54 thousand.

Having data about distribution of melliferous plants in various communities, features and terms of their blossoming and nectar emission under various weather conditions it is possible to make the schedule of movement of an apiary for more complete use of honey yield.

**4. Conclusion**

Bee forage base in the woods of Rostov region needs improvement. The main measures for honey productivity increase of forest lands are meliorative actions, with use of silvicultural and forestry methods and techniques, as well as irrigation. Considering terms of blossoming of forest melliferous plants, they should be planted while creating forest plantations of different function (forest cultures, protective forest strips, forest parks, planting of greenery). On forest margins and grassy glades it is
necessary to seed melliferous herb plants: clover, alfalfa, desert bluebell, sweet clover, cock’s head, coriander, bird’s foot, sunflower, vetch and others. Plantings of bushes such as willow, maple, snowberry, privets, amorpha, serviceberry, honeysuckle and others also can be suitable for beekeeping.

When forming forest stands of nectar bearing plants (black locust, lime, three-thorned acacia, maple, sophora, chestnut, pear, etc.) by clean cuttings, the increase in phytomass which determines biological productivity of phytocenosis in general is provided. Optimal density of black locust at the age of 30 years is 850-900 trunks on 1 hectare.

Irrigation of forest lands in the period of atmospheric drought considerably enhances nectar emission and honey productivity of melliferous plant species and lands [15]. The map of zoning of the honey collection will allow to trace the dynamics of the bioresource potential of honey collection geographically. Monitoring of honey collection conditions by areas of honey collection will help to plan in time for the migrations of the apiary or to design and implement measures aimed at eliminating non-collecting periods in the region’s medical collection.

Complex usage of forest fund lands as nectar bearing base of beekeeping, can give significant increase of forest fund and will provide forestry development with powerful accumulations in the southern region of the European territory of the Russian Federation.

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