Phytocenoses with *Tilia cordata* Mill. at some areas of the south of the Tyumen region

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Abstract. Within the south of the Tyumen region, linden forests are represented by various phytocenoses (Tiletum urtico – diplaziosum, Tiletum diplaziosum, Tiletum pariso – caricosum, Tiletum struthiopteriosum, Tiletum athyriosum, Tiletum paeoniosum, Tiletum oxalidosum, Tiletum microcaricosum, Tiletum microherbosum, Tiletum graminosum, Tiletum gymnocarpiosum, Tiletum cirsiosum, Tiletum brachipodiosum, Tiletum lycopodiosum, Tiletum linnaeo – microcaricosum). Lime forests are distributed along the banks of the Irtysh and Tobol rivers and on the slopes of the shores of lakes of southern exposure. The bonitet of *Tilia cordata* Mill., the studied phytocenoses, varies from class I to V, which is determined by the degree of soil moisture, and is an edificator of phytocenoses. Unique phytocenoses with participation of *Tilia cordata* Mill. identified near the village of Setovo (Tobolsk district, Tyumen region). This community is relict.

1 Introduction

Of particular importance for ecology and related areas of scientific knowledge, as well as forestry production is the study of ecological and biological features of *Tilia cordata* Mill. Linden heart-shaped (arboreal form of natural origin) *Tilia cordata* Mill. The family is Tiliaceae – Tiliaceae. The order Malvotsvetnye – Malvales. Category and status: 3 - a rare species. Deciduous tree up to 30 m high. The bark is dark gray, the annual shoots are reddish brown. Leaves petiolate, rounded heart-shaped, saw-toothed along the edge, pointed, 3-9 cm long. Inflorescence of semi-umbrellas, uniting 2-4 flowers. Bracts oblong, pale green, rounded at the top, one-quarter fused with a common peduncle. The flowers are fragrant, the petals are yellowish-white. The fruit is a one- or two-seeded, thin-walled nut [1-3].

Grows in drained watershed areas, on manes in dark, light coniferous and mixed forests. Rarely forms pure stands. Linden (*Tilia cordata* Mill.) prefers fertile, loamy, moderately moist soils. A relic of broad-leaved forests. Blossoms in July, bears fruit in August-September. Honey plant, decorative, ornamental plant [4-6].

The area of forests with a predominance of linden in the composition of forest stands in the Tyumen region is about 11000 ha. Occurs in Aromashevsky, Vagaysky, Vikulovsky,

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Nizhnetavdinsky, Sorokinsky, Tobolsky, Tyumensky, Uvatsky, Yurginsky, Yarkovsky districts, Zavodoukovsky urban district [7-11].

2 Material and methods

In order to select geobotanical test sites and describe the vegetation, the author followed the common phytosociological methods and approaches that are widely used in geobotanical studies. In accordance with the geobotanical research methodology, the description of ground vegetation communities was used as the main method at the field stage of the study.

The abundance of species was estimated visually according to the Drude scale (a system of visual score-based estimates) [11, 12].

3 Results

The first block is linden forests located along the banks of the Tobol River (near the Stove station and the village of Elan, Tyumen region). Eight kilometers to the south are described: Tiletum urtico – diplaziosum, Tiletum diplaziosum, Tiletum pariso – caricosum, Tiletum struthiopteriosum, Tiletum athyriosum, Tiletum paeoniosum.

Tiletum urtico – diplaziosum. The total projective cover is 100%. Crown density 0.8. The association is four-layered. The first layer (1.2 – 0.9 m) features sparse vegetation and is represented by *Urtica sondenii* (Simmons) Avrorin ex Geltman (soc), *Conioselinum tataricum* Hoffm. (sp), *Struthiopteris filicastrum* All. (sp), *Lilium cordifolium* Thunb. (sp), *Milium effusum* L. (sp). The second layer (0.8 – 0.6 m) includes such species as *Diplazium sibiricum* (Turcz. ex Kunze) Sa. Kurata (cop_1), *Aegopodium podagraria* L. (sp), *Paeonia anomala* L. (sp), etc.

In the third layer (0.6 – 0.3 m), *Paris quadrifolia* L. (sp), *Equisetum sylvaticum* L. (sp), *Pulmonaria mollis* Wulfen ex Hornem grow. (sp), *Carex macroura* Meinsh. (sp), etc.

The composition of plants of the fourth tier (0.20 m and below) is the poorest: *Stellaria bungeana* Fenzl (sp), *Stellaria holostea* L. (sp), *Viola mirabilis* L. (sp), etc. It should be noted that this community is one of the typical ones for lime forests. This is confirmed by the abundance of mesotrophic, many of which are nemoral species. In addition, the vertical structure corresponds to the development of broadleaf forest communities.

The set of corresponding species according to ecological cells in the community indicates the most complete use of the action of ecological factors.

Tiletum diplaziosum. The total projective cover is 80%. Crown density 0.9. The diameter of the *Tilia cordata* Mill. trunk at chest level is 30 cm, and the height is about 18 m. The association is four-layered. If we compare the communities of Tiletum urtico – diplaziosum and Tiletum diplaziosum, then the composition of herbaceous satellite species is poorer in the latter. The first layer (0.9 – 0.7 m) of Tiletum diplaziosum was formed by *Diplazium sibiricum* (cop_1), *Milium effusum* (sp), *Aconitum septentrionale* Koelle (sp). *Equisetum sylvaticum* (sp), *Aegopodium podagraria* (sp) and others were noted in the second layer (0.7 – 0.5 m). The third layer (0.6 – 0.3 m) consists of Paris quadrifolia (sp), Dryopteris carthusiana (Vill.) H.P. Fuchs (sp), etc. In the fourth tier, within 0.20 m and below, *Stellaria bungeana* (sp), *Oxalis acetosella* L. (sp), *Maianthemum bifolium* (L.) F.W. Schmidt (sp.). The growth of *Oxalis acetosella* is not typical for lime forest. This fact can be explained as the heritage of fir forests, on the site of which these lime forests were formed. One tree, *Abies sibirica* Ledeb, has been noted near this community.

The replacement of fir forests by linden forests confirms another one by the community of Tiletum oxalidosum. Tthe stand formula is 10L. Crown density 0.9. The total projective

cover is 80%. Trunk diameter of *Tilia cordata* Mill. at chest level 0.25 m. The association is four-layered.

In the first layer (1.0 – 0.8 m) grow *Dryopteris carthusiana* (sp), *Milium effusum* (sp). The second layer (0.7 – 0.5 m) includes *Aegopodium podagraria* (sp), *Equisetum sylvaticum* (sp), etc. In the third tier (0.5 – 0.3 m) *Paris quadrifolia* (sp) and others were noted.

The relationship of this association with fir forests is shown by plants of the fourth tier (0.2 m and below). First of all, these are plants: *Oxalis acetosella* L. (cop_1), *Maianthemum bifolium* (sp), *Trientalis europaea* L. (sp). The fourth layer contains *Stellaria holostea* (sp).

A special place in the formation of lime forest communities in the south of the Tyumen region is occupied by sedges: Carex macroura and Carex arnellii H. Christ.

The community dominated by *Carex macroura* is considered zonal, and with the inclusion of *Carex arnellii*, they are rare. As an example, the Tiletum pariso – caricosum community. The stand formula is 10L. The total projective cover is 100%. Crown density 0,8. The trunk diameter of *Tilia cordata* Mill. at chest level is 0.2 m. The association is four-layered. In the first tier, one can note *Milium effusum* (sp). The second layer (0.7 – 0.5 m) includes Lathyrus vernus (L.) Bernh. (sp), Aegopodium podagraria (sp), etc. In the third tier (0.5 – 0.3 m), *Paris quadrifolia* (cop_1) is abundant. In the fourth tier (0.3 – 0.2 m) also grows *Carex macroura* (cop_1). It also includes *Stellaria bungeana* (gr). Visually, this community is perceived as two-level: a level at 0.50 m of *Paris quadrifolia* and a second level at 0.30 m consists of *Carex macroura*.

The same visual picture is typical for Tiletum equiseto – caricosum with horizontal levels from Equisetum sylvaticum (0.60 m) and *Carex macroura* (0.30 m).

Relationships of a different order are characteristic of *Carex macroura* and ferns: *Dryopteris carthusiana*, *Athyrium filix-femina* (L.) Roth, *Pteridium aquilinum* (L.) Kuhn, *Diplazium sibiricum*.

Ferns have a large "leaf" surface area. Accordingly, they shade the plants located below the tiers, because ferns form in communities mainly the first layer (0.9 – 0.7 m). The abundance of *Carex macroura* in the fern community decreases, the plants themselves become oppressed (narrow-leaved). Example, Tiletum struthiopteriosum.

The fern *Tiletum struthiopteriosum* is often found in lime forests in the vicinity of Setovo village, along with *Tiletum athyriosum.* The total projective cover is 80%. Tthe stand formula is 10L. Crown density 0.6. The trunk diameter of *Tilia cordata* Mill. at chest level is 0.20 m. The community is three-tiered. In the first tier (0.90 – 0.80 m) *Urtica sondenii* (sp), *Athyrium filix-femina* (cop_1) were found. In the second layer (0.7 – 0.5 m) *Aegopodium podagraria* (sp), *Actaea spicata* L. (un) grow. In the third tier (0.40 and below), *Pulmonaria mollis* (sp), *Carex macroura* (sp), *Stellaria holostea* (sp) and others were noted.

A distinctive feature of the lime forests in the vicinity of the village of Setovo is the abundance of *Paeonia anomala* in the lime forests. *Tiletum paeoniosum* should be included not only in the regional "Green Book", but also in the Russian.

Tiletum paeoniosum. The stand formula is 10L. Crown density 0.8. The trunk diameter of *Tilia cordata* at chest level is 0.30 m. The total projective cover is 100%. The association is four-layered. The first tier includes *Thalictrum macrophyllum* V.V. Boczantz. (sp), *Pteridium aquilinum* (sp). The second layer (0.80 – 0.60 m) consists of abundant *Paeonia anomala* (cop_1), *Equisetum sylvaticum* (sp), *Aegopodium podagraria* (sp), *Lathyrus vernus* (sp) and others. In the third layer (0.60 – 0.30 m) *Actaea spicata* (sp), *Carex arnellii* (cop_1) grow. In the fourth layer, *Stellaria bungeana* (sp), *Viola mirabilis* L. (sp) and others are common.

Identified Tiletum paeoniosum is close in species composition to Populetum paeoniosum, also noted in the vicinity of Setovo settlement. Tthe stand formula is 10O.

Crown density 0.8. The total projective cover is 100%. The diameter of the aspen trunks is 15 cm. Of the shrubs, *Lonicera xylosteum* L. (un) was noted. There are four layers of grass cover in Populetum paeoniosum. In the first layer (1.50 – 0.90 m) *Aconitum septentrionale* (sp), *Thalictrum macrophyllum* (sp), *Parasenecio hastatus* (L.) H. Koyama (sp) were noted. Plants of the second tier (0.90 – 0.70) *Epipactis helleborine* (L.) Crantz (sp), *Paeonia anomala* (soc), *Urtica galeopsifolia* Wierzb. ex Opiz (sp), *Pleurospermum uralense* Hoffm. (cop_1), (sp). The species composition of plants of the third tier (0.6 – 0.4 m) is less rich and is represented mainly by *Aegopodium podagraria* (sp). In the fourth tier (0.4 m and below), *Carex macroura* (sp) was found. The influence of shading causes her oppression. Also in the fourth layer, *Stellaria bungeana* (sp), *Stellaria holostea* (sp), and *Veronica chamaedrys* L. (sp) were recorded.

As noted above, *Struthiopteris filicastrum* is often found in the lime forests near Setovo settlement, forming Tiletum struthiopteriosum in places. Tiletum struthiopteriosum. Tthe stand formula is 10L. Crown density 0.6. The total projective cover is 100%. The trunk diameter of *Tilia cordata* Mill. is 0.4 m. The association is four-layered. In the first layer (1.0 – 0.9 m) *Struthiopteris filicastrum* (cop_1) is abundant. In addition to the fern, *Milium effusum* L. (sp), *Aconitum septentrionale* (sp), *Urtica sondenii* (sp), and *Thalictrum macrophyllum* (sp) were noted in the first layer. In the second layer (0.9 – 0.7 m) *Paeonia anomala* (un), *Aegopodium podagraria* (sp) grow. In the third tier (0.5 – 0.2 m), *Lathyrus vernus* (sp), *Pulmonaria mollis* (sp) were noted. The fourth layer (0.2 m and below) was formed by *Stellaria bungeana* (sp), *Stellaria holostea* (sp).

Characterized lime forests of Setovo village grow on the slope of the root bank of the Tobol River. The Pleistocene age is confirmed by the find of *Juncus stygius* L., whose range is currently shifted to the north by hundreds of kilometers. The distribution of lime forests on the slopes depends on the increase in soil moisture when descending the slope of the coast to the floodplain of the Tobol. Three stripes of linden forests can be distinguished along the slope. The first lane (top of the slope) - Tiletum caricosum; the second lane (middle of the slope) - Tiletum equisetosum and Tiletum paeoniosum; the third lane (close to the bottom of the slope) - Tiletum urtico - diplaziosum.

The second block of studied lime forests in the vicinity of Abaevskaya station (Yarkovsky district, Tyumen region). Lipnyaks near Setovo village spread along the slope towards the mesotrophic birch-willow bog. The following change of plant communities occurs along the slope to the swamp: Tiletum microcaricosum → Tiletum microherbosum → Tiletum graminosum → Tiletum gymnocarpiosum → Tiletum cirsiosum. There is a change of bonitet *Tilia cordata* Mill. from I (Tiletum microcaricosum) to V (Tiletum cirsiosum).

Tiletum microcaricosum. Tthe stand formula is 10L. Crown density 0.9. The total projective cover is 80%. The trunk diameter of *Tilia cordata* Mill. at a height of 1.5 m is 0.4 m. A feature of this community is the joint growth of three types of sedges: *Carex macroura*, *Carex rhizina* Blytt ex Lindblom, *Carex digitata* L. *Elymus sibiricus* L. (sp), *Elymus caninus* (L.) L. (sp) have been noted here. The first layer (1.1 – 0.8 m) was formed by *Calamagrostis phragmitoides* Hartm. (sp), *Pteridium aquilinum* (sp), *Thalictrum macrophyllum* (un). The second layer (0.6 – 0.4 m) consists of *Brachypodium pinnatum* (L.) Beauv. (sp), *Equisetum sylvaticum* (sp). In the third tier (0.4 – 0.3 m) *Paris quadrifolia* (sp) grows. *Carex digitata* (cop_1), as well as *Carex macroura* (sp), *Carex rhizina* (sp) are abundant here. *Viola mirabilis* (sp), *Maianthemum bifolium* (sp), *Rubus saxatilis* L. (sp) are found in the fourth layer.

Tiletum microherbosum. The total projective cover is 60%. Tthe stand formula is 10L. Crown density 0.9. The trunk diameter of *Tilia cordata* Mill. is 0.4 m. The association is four-layered. In the first layer (1.0 – 0.9 m) *Calamagrostis phragmitoides* (sp), *Thalictrum macrophyllum* (sp) were noted. The second layer (0.9 – 0.5 m) is represented by

Brachypodium pinnatum (cop$_1$). In the third layer (0.5 – 0.3 m) there are *Equisetum sylvaticum* (sp), *Paris quadrifolia* (cop$_1$) less often *Aegopodium podagraria* (sp), *Actaea erythrocarpa* (sp), *Melica nutans* L. (sp). The fourth layer (0.3 m and below) includes *Carex macroura* (sp), *Carex digitata* (sp), *Viola mirabilis* (sp), *Maianthemum bifolium* (sp), *Pyrola chlorantha* Sw. (un).

Tiletum brachipodiosum includes a number of species characteristic of birch forests. Tthe stand formula is 10L. Crown density 0.7. The total projective cover is 90%. The trunk diameter of *Tilia cordata* Mill. at the level of 1.5 m from the soil surface is 0.3 m. The grass cover of the community is five-tiered. In the first layer (1.2 – 0.9 m) grow, *Thalictrum macrophyllum* (sp), *Pteridium aquilinum* (sp), *Calamagrostis phragmitoides* (sp). The second tier includes plants with a height of 0.8 to 0.5 m: *Actaea erythrocarpa* (sp), *Equisetum sylvaticum* (sp), *Melica nutans* (sp). In the third tier, (0.5 m) *Brachypodium pinnatum* (cop1), *Aegopodium podagraria* (sp) were noted. The fourth layer (0.4 – 0.2 m) consists of *Carex macroura* (sp), *Carex digitata* (sp), *Stellaria holostea* (sp). In the fifth tier (0.2 m and below), low-growing plants are represented: *Maianthemum bifolium* (sp), *Viola mirabilis* (sp), *Moehringia lateriflora* (L.) Fenzl (sp), etc.

Tiletum gymnocarpiosum occupies a special place in the ecological series of linden forests near Abaevskaya station. The econiche of this linden forest is a transitional strip between a swampy spruce forest and a slope occupied by Tiletum brachypodiosum. Bonitet *Tilia cordata* Mill. in this association IV – V. Tthe stand formula is 10L. Crown density 0.7. The total projective cover is 100%. The diameter of *Tilia cordata* Mill. trunks at the level of 1.5 m from the soil surface is 0.15 – 0.20 m. The grass cover of the community is five-tiered. The first layer (1.2 – 0.8 m) was created by *Cirsium heterophyllum* (L.) Hill (sp), *Athyrium filix-femina* (un), *Dryopteris carthusiana* (sp), *Milium effusum* (sp). In the second layer (0.8 – 0.6 m), a hybrid of *Actaea spicata* x *Actaea erythrocarpa* (sp), *Galium boreale* L. (sp) grows. The third layer (0.6 – 0.4 m) consists of *Lathyrus vernus* (sp), *Equisetum sylvaticum* (sp), *Paris quadrifolia* (sp) and others. Visually, this community is distinguished by *Gymnocarpium dryopteris* (L.) Newman (cop$_1$) phoning in the fourth layer (0.3 – 0.2 m). *Rubus saxatilis* (sp), *Viola mirabilis* (sp) are noted here. *Viola selkirkii* Pursh ex Goldie (sp) belongs to the next, fifth layer (0.2 m and below), where *Circaea alpina* L. (sp), *Stellaria bungeana* (sp) and others also grow.

Lime forests, occupying a certain niche in the system of woody phytocenoses, often penetrate into the econiches of other tree communities while retaining the features of the previous community. An example is Tiletum lycopodiosum formed in small areas within pine forests - blueberries and cowberry pine forests (vicinity of the village of Komaritsa, Yarkovsky district). Tthe stand formula is 10L. Crown density 0.8. The total projective cover is 100%. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.2 m. The association is four-layered. The first layer (1.0 – 0.9 m) was formed by *Calamagrostis arundinacea* (sp). In the second layer (0.5 – 0.4 m), *Aegopodium podagraria* (sp), *Lathyrus vernus* (sp) grows. The third layer (0.4 – 0.3 m) includes *Vaccinium vitis-idaea* L. (sp), *Vaccinium myrtillus* L. (sp), *Potentilla erecta* (L.) Raeusch. (sp), *Rubus saxatilis* (sp). The fourth tier is formed by *Lycopodium annotinum* L.

Lipnyaks, near the village of Baikalova (Tobolsk district, Tyumen region) reflect the relationship with birch forests, aspen forests and spruce forests. Here linden forests are represented by sedge, vorontsovy, kochedyzhnikovy.

Tiletum cirsiosum. Tthe stand formula is 10L. Crown density 0.7. The total projective cover is 80%. *Tilia cordata* Mill. I boniteta. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.4 m. The grass cover of the community is five-tiered. The first layer (1.1 – 0.9 m) is represented by *Thalictrum macrophyllum* (sp), *Crepis sibirica* L. (sp). *Serratula coronata* L. (sp), *Equisetum hyemale* L. (cop1), *Scrophularia nodosa* L. (sp), *Poa remota Forselles* (cop$_1$) grow in the second layer (0.8 – 0.6 m). The third layer (0.6 – 0.3

m) consists of *Geranium sylvaticum* L. (sp). *Lathyrus vernus* (sp), *Brachypodium pinnatum* (sp), *Galium boreale* L. (sp), *Actaea spicata* (sp). In the fourth tier (0.2 and below), *Carex digitata* (sp), *Carex rhizina* (sp), *Stellaria holostea* (sp), *Viola mirabilis* (cop_1) were identified.

Down the slope grows Tiletum actaesiosum. Tthe stand formula is 10L. Crown density 0.9. The total projective cover is 70%. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.4 m. The association is four-layered. In the fourth layer, (*Calamagrostis arundinacea* (sp), *Milium effusum* (sp), and others are noted. In the second layer (0.8 – 0.5 m) *Melica nutans* (sp), *Brachypodium pinnatum* (sp), etc. The third layer is represented by *Actaea spicata* (sp). *Carex digitata* (sp) enters together with *Viola mirabilis* (sp) as part of the fourth tier (0.3 m and below).

Tiletum athyriosum is formed at the base of the slopes. Tthe stand formula is 10L. Crown density 0.7. The total projective cover is 100%. Bonitet *Tilia cordata* Mill. III. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.15 – 0.20 m. In the first tier, *Cirsium oleraceum* (L.) Scop. (sp), *Carduus acanthoides* L. (sp). The second layer (0.9 – 0.7 m) is mainly *Athyrium filix-femina* (cop_2), *Milium effusum* (sp), *Elymus sibiricus* (sp). *Equisetum hyemale* (sp), *Aegopodium podagraria* (sp), *Equisetum sylvaticum* (sp), *Pulmonaria mollis* (sp) is found in the third tier (0.6 – 0.4 m). The fourth tier (0.3 and below) includes *Carex digitata* (sp), *Glechoma hederacea* L. (sp).

The variety of linden forests near the village of Baikalovo is manifested in the order of moisture from linden forests with mesohygraphites. At the same time, other woody phytocenoses (birch, spruce, aspen forests) are saturated with *Tilia cordata* Mill. to varying degrees, the trees of which differ in the degree of oppression in different phytocenoses.

Betuletum microherbosum. The dominant is *Betula pubescens* Ehrh. Tthe stand formula is 10B. Crown density 0.5. The total projective cover is 100%. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.3 m. The first layer (1.8 – 0.9 m) was formed by *Filipendula ulmaria* (L.) Maxim. (cop_1), *Cirsium oleraceum* (sp), *Cirsium palustre* (L.) Scop. (sp). The second layer (0.8 – 0.6 m) includes *Equisetum fluviatile* L. (sp), *Thelypteris palustris* Schott (sp). It should be noted the significant height of *Thelypteris palustris* - up to 0.9 m. Among the plants of the third tier, *Anemonidium dichotomum* (L.) Holub (sp), *Poa remota* Forselles (sp), *Melica nutans* L. (sp) stand out.

Betuletum polypodioso – varioherbosum. *Tilia cordata* Mill. is included in the second (arboreal layer, in a small amount). Tthe stand formula is 10B. Crown density 0.8. The total projective cover is 100%. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.3 m. *Tilia cordata* Mill. occurs singly. The first layer (1.5 – 1.0 m) includes *Cirsium oleraceum* (sp), *Cirsium palustre* (sp). The second layer (0.9 – 0.6 m) consists of *Glyceria lithuanica* (Gorski) Gorski (sp), *Poa remota* (cop1), *Equisetum palustre* L. (sp), *Carex diandra* (sp). The third tier (0.6 – 0.4 m) includes *Athyrium filix-femina* (sp), *Dryopteris carthusiana* (sp), *Carex elongata* L. (sp). In the fourth layer (0.5 – 0.2 m) there are *Dryopteris cristata* (L.) A. Gray (cop_1), *Gymnocarpium dryopteris* (L.) Newman (sp), as well as *Epilobium palustre* L. (sp), *Lycopus europaeus* L. (sp) and a number of small sedges: *Carex disperma* Dewey (sp), *Carex tenuiflora* Wahlenb. (sp).

Tilia cordata Mill. is even more oppressed. in Betuletum thelypteriosum and Betuletum equisetosum. Bonitet of Betula pubescens III. Tthe stand formula is 10B. Crown density 0.7. The total projective cover is 100%. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.2 m. *Tilia cordata* Mill. occurs singly. The association is four-layered. *Filipendula ulmaria* (sp), *Cirsium palustre* (sp) grow in the first tier within 1.3 – 1.0 m. In the second layer (0.9 – 0.7 m), *Equisetum fluviatile* (sp), *Thelypteris palustris* (cop_1) are common. In the third layer (0.5 – 0.4 m), *Comarum palustre* L. (sp), *Solanum dulcamara* L. (un), *Lycopus europaeus* L. (sp), *Epilobium palustre* L. (sp) grow. *Tilia*

cordata Mill. found on the near-trunk elevations of the dominant - *Betula pubescens* 1.8 - 2.5 m high.

In Betuletum equisetosum, with the same dominant, the subdominant *Betula pubescens* changes. It is represented in Betuletum fluviatile - equisetosum. Bonitet of Betula pubescens III. Tthe stand formula is 10B. Crown density 0.7. The total projective cover is 90 %. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.2 m. *Tilia cordata* Mill. occurs singly. The association is four-layered. The first layer includes *Filipendula ulmaria* (sp), *Kadenia salina* (Turcz.) Lavrova & V.N. Tikhom. (sp). *Equisetum fluviatile* (cop_1) is abundant in the second layer, *Cicuta* (sp) is occasionally found. In the third layer (0.6 – 0.4 m), *Comarum palustre* (sp) grows. The fourth layer contains *Dryopteris cristata* (sp), *Menyanthes trifoliata* L. (sp).

Tiletum linnaeo - microcaricosum - a transitional association from lime forests to moss Pinetum microcaricosum, developed on the border of Tiletum (near the village of Baikalovo, Tyumen region). The association is four-layered. Dominant *Tilia cordata* Mill. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.15 m. Bonitet III. Tthe stand formula is 10B. Crown density 0.7. The total projective cover is 70 %. *Thalictrum macrophyllum* (sp) grows in the first layer of grass cover. In the second layer (0.9 – 0.7 m) *Cypripedium macranthos* Sw. (sp), *Milium effusum* (sp). The third layer (0.6 – 0.4 m) is weakly expressed and is represented by single plants *Pulmonaria mollis* and *Dryopteris carthusiana*. Most of the grass layer species of this association belong to the fourth layer (0.3 m and below): *Orthilia obtusata* (Turcz.) H. Hara (sp), *Moneses uniflora* (L.) A. Gray (sp), *Pyrola rotundifolia* L. (sp), *Linnaea borealis* (cop_1), *Carex digitata* (sp), *Carex rhizina* (sp), *Viola mirabilis* (sp), *Rubus arcticus* L. (sp), *Rubus saxatilis* (sp), *Carex tenuiflora* (un).

Spruce forests border with lime forests growing on the slopes, where *Tilia cordata* Mill. occurs singly, boniteta IV. Tthe stand formula is 10E. Crown density 0.6. The total projective cover is 50 %. The diameter of the trunks at the level of 1.5 m from the soil surface is 0.5 m. The association is four-layered. In the first layer, *Poa remota* (cop_1), *Elymus sibiricus* (sp) grows. In the second layer (0.6 - 0.4 m), *Aegopodium podagraria* (sp), *Actaea spicata* (un) were noted. In the third layer (0.4 – 0.3 m), *Carex digitata* (cop_1), *Paris quadrifolia* (sp), *Pulmonaria mollis* (sp), *Pyrola rotundifolia* (sp) grow. The fourth layer is represented by *Circaea alpina* L. (sp).

Sometimes lime forests occupy insignificant areas in the complex of forest communities, for example, near the village of Karachino (Tobolsk district, Tyumen region). In the center is a swamp with oppressed *Betula pubescens* trees. In the direction of movement to the slopes (20 - 30 m), which limits this tract with a swamp, the next change of communities occurs.

Betuletum salicetosum. Tthe stand formula is 10B. Crown density 0.7. The total projective cover is 100 %. Phytocenosis four-tiered: tree-shrub layer (*Betula fruticosa* Pall., *Salix myrsinifolia* Salisb., *Salix rosmarinifolia* L.) → herbaceous tier → layer of mosses. The herbaceous layer is divided into sublayers: A (Eriophorum, Rumex), B (*Petasites frigidus* (L.) Fr., C (Comarum), D (Pyroleae). A distinctive feature of this association is the abundance of *Carex dioica* L in places. This species usually grows scattered.

4 Conclusion

Tilia cordata Mill. in the south of the Tyumen region (Tobolsk, Vagai, Yarkovsky districts) it acts as a cenose generator.

Compared to other plants of the broad-leaved complex, *Tilia cordata* Mill. less demanding on heat, is an important stabilizing element in ecosystems as a soil-improving breed, grows well and multiplies in difficult environmental conditions.

The grass cover in phytocenoses usually includes four or five layers. Faithful companions of lime forests are (*Actaea spicata* L., *Stellaria holostea* L., *Carex macroura* Meinsh., *Carex arnellii* H., *Viola mirabilis* L., *Paris quadrifolia* L., *Aegopodium podagraria* L.). The optimal places for their growth are the slopes of the southern exposure.

Lime forests often represent the stage of replacement of fir forests, which is confirmed by the growth of a number of true species of fir forests in lime forests (*Oxalis acetosella* L., *Maianthemum bifolium* (L.), *Trientalis europaea* L.).

In the course of the research, replacements of pine and birch forests with phytocenoses of linden forests were noted.

A special place in the system of phytocenoses is occupied by the peony lime forest Tiletum paeoniosum with the subdominant *Paeonia anomala* L. These phytocenoses are relic.

References

1. N. I. Naumenko, Rare and endangered plants of the forest-steppe Trans-Urals (Kurgan University, Kurgan, 1994)
2. P. V. Kulikov, Identifier of vascular plants of the Chelyabinsk region (UrB RAS, Ekaterinburg, 2010)
3. L. V. Shumilova, Botanical geography of Siberia (Publishing house of Tomsk University, Tomsk, 1962)
4. J. R. Milligan, R. A. Krebs, K. M. Tarun, International Journal of Plant Sciences **169(5)** (2008)
5. J. M. Arenas, A. Escudero, I. Mola, M. A. Casado, Applied Vegetation Science **20(4)** (2017)
6. D. Jewitt, P. S. Goodman, B. F. N. Erasmus, T. G. O'Connor, T. F. Witkowski, Environmental Management **59(5)** (2017)
7. N. I. Naumenko, Flora and vegetation of the southern Zuraliy (Kurgan University, Kurgan, 2004)
8. A. Bykov, *Ecological dictionary* (Science, Alma-Ata, 1983)
9. J.Jakobsson, Oecologia **175** (**1**) (2014)
10. A. Mottaeva, L. Kopteva, *Problems of competitiveness of industries in ensuring the economic security of Russia*, in E3S Web of Conferences **284**, 11014 (2021) https://doi.org/10.1051/e3sconf/202128411014
11. A. Nyangarika et al., Frontiers in Environmental Science **10** (2022) https://doi.org/10.3389/fenvs.2022.1031343
12. S. K. Cherepanov, Vascular plants of the USSR (Science, Leningrad, 1981)