ISSN 0096-7807

Vol. 11, No. 1, January-February, 1980

September, 1980

SJECAH 11(1) 1-70 (1980)

THE SOVIET JOURNAL OF

ECOLOGY

ЭКОЛОГИЯ/ÉKOLOGIYA

TRANSLATED FROM RUSSIAN

CONSULTANTS BUREAU, NEW YORK

FORMATION AND ANTHROPOGENIC DEGRADATION OF MEADOW PLANT COMMUNITIES IN THE TRANS-URAL FOREST—STEPPE REGION

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UDC 581.526.4;581.524.34

Exemplified by the trans-Ural forest—steppe region, the change in the vegetation cover under the effect of anthropogenic factors are traced and regularities of the formation and subsequent degradation of meadow plant communities are established. The degree of anthropogenic degradation of meadows is assessed with consideration of the share of participation of synanthropic species in their composition.

Meadows have been subjected to considerable anthropogenic changes. They were and remain objects of intense economic use. It is necessary to establish the origin of meadows and regularities of their anthropogenic transformation in order to substantiate measures for the rational use of forage lands. In this article the general regularities of the change in vegetation under the effect of man, leading to the formation and subsequent degradation of meadow plant communities, are characterized on the basis of investigations conducted in one of the regions of intense agricultural development — the trans-Ural forest—steppe region. Special attention is devoted to the convergence of meadow communities during anthropogenic degradation and changes intheir structure, composition, and share of participation of synanthropic species in them.

REGION AND METHOD OF INVESTIGATION

The investigations were conducted in the eastern part of the Sverdlovsk district (Irbit, Kamyshlov, and Kamensk regions). According to the physiographic regionalization (Prokaev, 1976) this region is located in the forest—steppe area of the West Siberian plain, in the Tura—Miass province of the trans-Ural sloping plain, in the northern forest—steppe subprovince. V. I. Baranov (1927) assigns this territory to the Irbit—Chelyabinsk region of the northern forest—steppe of the eastern slopes of the Urals and to the Kamyshlov—Shadrinsk region of the cis-Ural northern forest—steppe. The same characterization of the zone to which the region belongs is given in the "Geobotanical Map of the USSR" (1954) at a scale of 1:4,000,000. Unlike this, the authors of the map "Vegetation of the West Siberian Plain" (1976) at a scale of 1:1,500,000 assign it to the taiga zone, to the Tobol—Tura district of the subtaiga subzone. This interpretation is wrong, since widespread here are chernozem soils, which are foreign to the taiga, steppe and forest—steppe elements compose a considerable share in the flora of vascular plants, and here and there areas of steppe meadows untouched by plowing, halophilic plant communities, and even fragments of meadow steppes, that have become lost among fields and birch groves, have been preserved.

At the start of the investigations a line-plot survey of the territory was made to reveal the general regularities of the distribution of vegetation. The geobotanical description of the plant communities was made at 850 main sample plots measuring 10×10 m. At each main plot the complete floristic composition of the communities was recorded and the share of synanthropic species was noted. The aboveground phytomass was determined by taking cuts on 30 calculation areas measuring 1/16 m^2 or on 10 areas measuring 1/2 m^2 laid out within each main sample plot. This enabled us to obtain results with a statistical error not exceeding 10-15%. The stages of degradation of the meadow communities were established by comparing series of plots with the originally homogeneous vegetation but subjected in different degrees to the pressure of anthropogenic factors (cattle grazing, haymaking, etc.), special attention being devoted to compaction of the soil, change in the composition and

Institute of Plant and Animal Ecology, Ural Scientific Center, Academy of Sciences of the USSR. Translated from Ékologiya, No. 1, pp. 22-34, January-February, 1980. Original article submitted October 23, 1979.

0096-7807/80/1101-0011$07.50

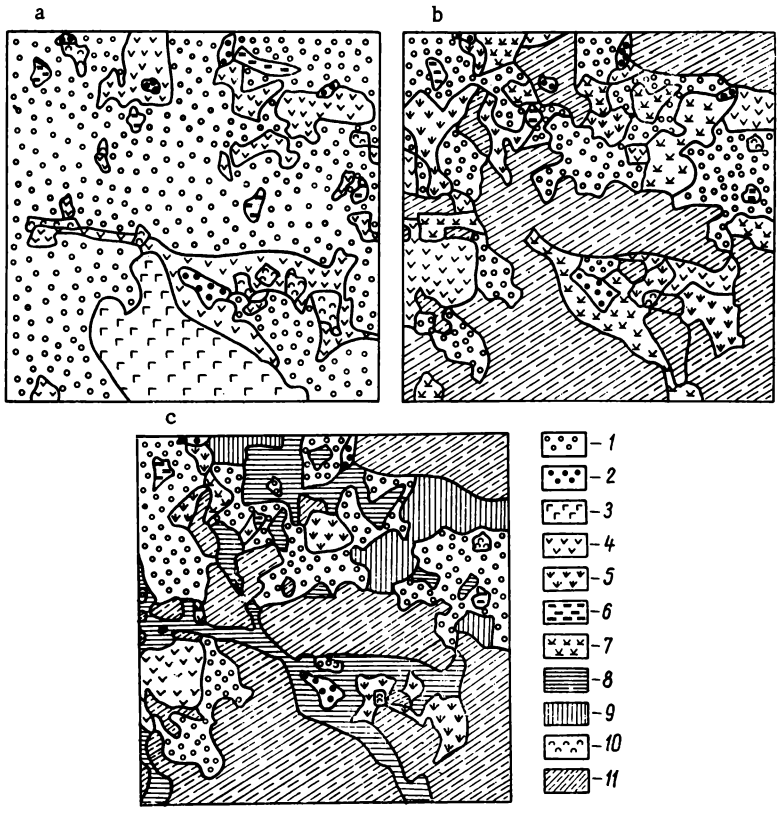


Fig. 1. Change in the vegetation cover of the key tract of the trans-Ural forest—steppe region. Vegetation: a) reconstructed; b) actual; c) transformed (prediction); 1) small-leaved forests; 2) uremas; 3) meadow speppes; 4) steppe meadows; 5) peaty meadows; 6) same, halophilic variant; 7) true meadows; 8) semi-cultural meadows; 9) cultivated meadows; 10) lowmoor bogs; 11) plowland.

structure of the plant communities, and introduction of synanthropic species. To establish trends in the change of vegetation under the effect of man and to substantiate the prediction of the transformation of vegetation on the basis of planned meadow-improvement measures, a series of geobotanic maps was compiled for three key tracts. Maps of preagricultural and actual (current) vegetation and a predictive map of the transformed vegetation were compiled for each key tract. Forest-management data, topographic and soil maps, and aerial photographs were used for compiling these maps.

TRENDS IN THE CHANGE OF STRUCTURE OF THE VEGETATION COVER

The character and direction of the main changes in the vegetation cover of the trans-Ural forest—steppe region under the effect of anthropogenic factors are illustrated by the series of geobotanic maps for the "Galkinskii" key tract (Kamyshlov region of the Sverdlovsk district). The area of the key tract is 2300 ha. The originals of the maps were compiled at a scale of 1:10,000; reduced generalized schemes compiled on the basis of these maps are given in the article (see Fig. 1). The map of the reconstructed (preagricultural) vegetation (see Fig. 1b) shows the structure of the vegetation cover in the period preceding agricultural development of this territory (end of the 17th century). At that time birch (*Betula pendula, Betula pubescens*) and partly aspen (*Populus tremula*) forests predominated in the trans-Ural forest—steppe region, having occupied 70.7% of the area; furthermore, uremas [riverine deciduous forest strips] of *Salix* spp. and *Padus racemosa* (1.5%) were widespread in river valleys and closed shallow depressions. Even then primary meadows existed here — steppe meadows and the halophilic variant of peaty meadows; the share of their participation was 16%. Bulrush—reed lowmoor bogs (2%) were distributed in the closed basins. Thus

TABLE 1. Classification of Meadows of the Trans-Ural Forest—Steppe Region

Meadow formation classes	Subclasses of formations of meadows	Groups of formations of meadows	Formations	Associations
Steppe meadows	Grass	Shortgrass	Narrow-leaved meadowgrass	Narrow-leaved meadowgrass—fescue (*Poa angustifolia*+*Festuca valesiaca* ssp. *sulcata*)
			Crested hair grass	Crested hairgrass—fescue (*Koeleria cristata* + *Festuca valesiaca* ssp. *sulcata*)
			Purple-stem cat's-tail	Purple-stem cat's-tail—fescue (*Phleum phleoides*+*Festuca valesiaca* ssp. *sulcata*) Purple-stem cat's-tail—narrow-leaved meadowgrass (*Phleum phleoides*+*Poa angustifolia*)
	Forb-grass	Midherb-shortgrass	Midherb-purple-stem cat's-tail	Purple-stem cat's-tail—libanotis (*Phleum phleoides*+*Libanotis sibirica*) Purple-stem cat's-tail—dropwort (*Phleum phleoides*+*Filipendula hexapetala*)
			Midherb-narrow-leaved meadowgrass	Narrow-leaved meadowgrass—burnet saxifrage (*Poa angustifolia*+*Pimpinalla saxifraga*) Narrow-leaved meadowgrass—yellow bedstraw—strawberry (*Poa angustifolia*+*Galium verum*+*Fragaria viridis*)
		Shortherb-shortgrass	Shortherb-narrow-leaved meadowgrass	Narrow-leaved meadowgrass—hoary plantain *angustifolia*+*Plantago media*) Narrow-leaved meadowgrass—strawberry *angustifolia*+*Fragaria viridis*)
	Grass-forb	Shortgrass-midherb	Shortgrass-mountain clover	Mountain clover—narrow-leaved meadowgrass (*Trifolium montanum*+*Poa angustifolia*). Mountain clover—purple-stem cat's-tail (*Trifolium montanum*+*Phleum phleoides*)
			Shortgrass-dropwort	Dropwort—purple-stem cat's-tail (*Filipendula hexapetala*+*Phleum phleoides*)
			Shortgrass-yellow bedstraw	Yellow bedstraw—purple-stem cat's-tail (*Galium verum*+*Phleum phleoides*)
		Shortgrass-shortherb	Shortgrass-strawberry	Strawberry—narrow-leaved meadowgrass (*Fragaria viridis*+*Poa angustifolia*)
True meadows	Grass	Tallgrass	Meadow fescue	Meadow fescue—bluegrass (*Festuca pratensis*+*Poa pratensis*) Meadow fescue—tufted hair grass (*Festuca pratensis*+*Deschampsia caespitosa*)
			Timothy	Timothy—awnless brome (*Phleum pratense*+*Zerna inermis*)
			Meadow foxtail	Meadow foxtail (*Alopecurus pratensis*)
		Shortgrass	Bluegrass	Bluegrass (*Poa pratensis*) Bluegrass—tufted hair grass (*Poa pratensis*+*Deschampsia caespitosa*)
			Red fescue	Red fescue (*Festuca rubra*)
			Common bent	Common bent (*Agrostis vulgaris*)
	Forb-grass	Midherb-tallgrass	Midherb-meadow fescue	Meadow fescue—slimtop meadow rue (*Festuca pratensis*+*Thalictrum simplex*) Meadow fescue—oxeye daisy (*Festuca pratensis*+*Leucanthemum vulgare*)
		Shortherb-shortgrass	Shortherb-meadow fescue	Bluegrass—silverweed (*Poa pratensis*+*Potentilla anserina*) Bluegrass—hoary plantain (*Poa pratensis*+*Plantago media*)
			Shortherb-red fescue	Red fescue—white clover (*Festuca rubra*+*Trifolium repens*)

Classes of formations of meadows	Subclasses of formations of meadows	Groups of formations of meadows	Formations	Associations
True meadows	Grass-forb	Tallgrass-midherb	Tallgrass-globeflower	Tufted hairgrass-common globeflower (*Trollius europaeus+Deschampsia caespitosa*)
			Tallgrass-ladys-mantle	Common lady's-mantle-tufted hair grass (*Alchemilla vulgaris+Deschampsia caespitosa*)
		Shortgrass-shortherb	Shortgrass-white clover	White clover-bluegrass (*Trifolium repens+Poa pratensis*)
			Shortgrass-plantain	Hoary plantain-bluegrass (*Plantago media+Poa pratensis*)
			Shortgrass-dandelion	Red fescue-dandelion (*Taraxacum officinale+Festuca rubra*)
			Shortgrass-hawkbit	Common bent-autumn hawbit (*Leontodon autumnalis+Agrostis vulgaris*)
	Forb	Midherb	Globeflower	Common globeflower-water avens (*Trollius europaeus+Geum rivale*)
			Snakeweed	Snakeweed-water avens (*Polygonum bistorta+Geum rivale*)
			Oxeye daisy	Oxeye daisy-burnet saxifrage (*Leucanthemum vulgare+Pimpinella saxifraga*)
		Shortgrass	Silverweed	Silverweed (*Potentilla anserina*)
Peaty meadows	Steppe meadows	Tallgrass	Tufted hair grass	Tufted hair grass-meadow fescue (*Deschampsia caespitosa+Festuca pratensis*) Tufted hair grass-timothy (*Deschampsia caespitosa+Phleum pratense*) Tufted hair grass-bluegrass (*Deschampsia caespitosa+Poa pratensis*) Tufted hair grass-red fescue (*Deschampsia caespitosa+Festuca rubra*)
	Grass	Tallherb-tallgrass	Tallgrass-tufted hair grass	Tufted hair grass-queen of the meadow (*Deschampsia caespitosa+Filipendula ulmaria*)
		Midherb-tallgrass	Midherb-tufted hair grass	Tufted hair grass-snakeweed (*Deschampsia caespitosa+Polugonum bistorta*) Tufted hair grass-caraway (*Deschampsia caespitosa+Carum carvi*)
	Grass	Shortherb-tallgrass (halophilic (variant)	Shortherb-tufted hair grass	Tufted hair grass-silverweed with stemless thistle (*Deschampsia caespitosa+Potentilla anserina +Cirsium esculentum*)
	Grass-forb	Tallgrass-tallherb	Tallgrass-queen of the meadow	Queen of the meadow-meadow foxtail (*Filipendula ulmaria+Alopecurus pratensis*)
	Sedge-grass	Tallsedge-tallgrass	Tallsedge-tufted hair grass	Tufted hair grass-tufted sedge (*Deschampsia caespitosa+Carex caespitosa*)
			Tallsedge-purple reed bent	Purple reed bent-tufted sedge (*Calamagrostis purpurea+Carex caespitosa*)
	Grass-sedge	Tallgrass-tallsedge	Tallgrass-tufted sedge	Tufted sedge-purple reed bent (*Carex caespitosa+Calamagrostis purpurea*) Purple reed bent-tufted sedge-tufted hair grass (*Calamagrostis purpurea+Carex caespitosa+Deschampsia caespitosa*)

a vegetation cover characteristic for the northern forest—steppe existed in the region of investigations in the preagricultural period.

Later, with agricultural development of the territory, as the map of actual vegetation (Fig. 1b) shows, a considerable part of the forests were felled and the forest coverage decreased to 24.3%. The decrease in forest coverage occurred mainly as a result of deforestation and partly under the effect of forest fires. All meadow steppes, steppe meadows, and forest lands were transformed into plowland, and the remaining territory began to be used for cattle grazing and haymaking. To prevent reforestation of the haylands and pastures, their clearing of brush and regrowth of trees was widely practiced. In the key tract the uremas were not touched by cuttings and were preserved in a little-changed form, though in certain regions a part of them was cleared and these lands began to be used as haylands. In the key tract plowland presently accounts for 45.4% of the area. In the investigated regions of the trans-Ural forest—steppe region plant growing plays the leading role, but animal husbandry, mainly cattle raising, is also widespread. A considerable part of the land is under pasture and hay (28.5% of the area). Long-term grazing and haymaking had a substantial effect on the character of the current vegetation cover. Part of the lowmoor bogs retained their original appearance (0.3% of the area), and the remaining swamplands after conducting drainage works were transformed into haylands.

The predictive map (see Fig. 1c) shows the probable character of vegetation which should be formed provided optimization of the use of natural resources as a result of implementing planned measures on the rational use of the vegetation cover and increase of its productivity. In working out the norms of the use of natural resources we proceeded from the need to maintain the forest coverage of the territory at about the current level (24.3%). However, conversion of part of the territory covered by birch forests of quality class IV (on chernozem—meadow soils) to forage lands is envisaged. Conversely, it is considered advisable to eliminate certain low-productivity pastures in open woodland from the forage land fund and by natural regeneration to convert them to the category of forests. The share of lands allocated for plowlands is also preserved at the former level (45.4%).

Since uremas and bogs perform an important hydrological role in the region of investigations, it is considered advisable to keep them approximately within the current limits (respectively 1.4 and 0.3% of the area). Substantial changes in the total area of forage lands is not planned, and in the key tract 28.6% of the territory is allocated to their share. However, the relationship of the categories of plant communities differing in degree of their anthropogenic transformation and productivity will change considerably. Ecosystems and plant communities can be divided into the following categories depending on the degree of man's impact on their composition and structure (Westhoff, 1952); natural, quasi-natural, semicultural, and cultural.

Actually, natural plant communities no longer remained in the trans-Ural forest—steppe region. Meadow communities affected by grazing and haymaking belong to the category of quasi-natural. Meadow communities which were natural in their origin but into the composition of which cultivated components — herb species more valuable in a forage respect — were introduced by undersowing (so-called surface improvement) belong to semicultural. Cultural meadow communities are represented by sown meadows created as a result of radical improvement with complete elimination of the natural herbage that existed here earlier. At present the entire meadow vegetation on the "Galkinskii" key tract is represented by quasi-natural communities; in other places, along with quasi-natural, there are also seminatural communities, which account for up to 10-15% of the area.

It is planned to implement the complex of measures aimed at improving meadows and increasing their productivity during the next 5-10 years. It is assumed that after conducting the planned amelioration works from 50 to 70% (66% in the "Galkinskii" key tract) of the forage lands will be represented by semicultural and cultural communities. As a result of surface improvement semicultural communities will form at the place of quasi-cultural, and the yield will increase by a factor of 2-2.5. An increase of yield by a factor of 3-5 is expected after conducting radical improvement works. On the whole for all key tracts with preservation of approximately the former area of forage lands the average yield (usable part of the aboveground phytomass) will increase from 9.9 to 24.5 centners/ha (by a factor of 2.5).

An increasing replacement of quasi-natural meadows by semicultural and cultural is observed of late everywhere in the trans-Ural forest—steppe region. However, this process

should be limited to a certain scope, since the complete elimination of quasi-natural meadows would involve an irretrievable loss of genetic resources of the aboriginal meadow flora. To preserve the gene pool of meadow flora it is necessary that the quasi-natural meadows account for at least 30% of the area of all forage lands.

PHYTOCOENOTIC SPECTRUM OF MEADOW COMMUNITIES AND SOME OF THEIR CHARACTERISTICS

An idea about the diversity of meadow communities in the trans-Ural forest—steppe region is obtained from their classification (see Table 1) developed on the basis of A. P. Shennikov's classification principles (1938) with the use of a number of additional criteria (determinants, differential species, and indices of the vitality of individual species). Meadows are divided into three classes of formations: steppe, true, and peaty. Each class of formations, in turn, is divided into subclasses. Thus, in the class of formations of true meadows are distinguished subclasses of grass, forb—grass, grass—forb, and forb meadows. At the next step of the classification the subclasses of formations are divided into groups of formations. For example, in the subclass of forb—grass meadows are distinguished midherb—tallgrass and shortherb—shortgrass meadows. In all, 12 subclasses, 20 groups of formations, 37 formations, and 51 associations of meadows are distinguished.

Flora of the meadows of the trans-Ural forest-steppe region contains 297 species of vascular plants. They belong to 45 families, 181 genera. The bulk is composed of mesophytes (136 species, or 45.9%), then follow mesoxerophytes (36 species, 12.1%), xeromesophytes (35 species, 11.8%), hygrophytes (33 species, 11.1%), mesohygrophytes (24 species, 8%), hygromesophytes (22 species, 7.4%), and, finally, xerophytes (11 species, 3.7%). The spectrum of the ecological groups reflects the zonal location of the region of investigations, as well as the flatland character of its relief with pronounced waterlogging.

It is interesting to analyze the relation of ecological groups of plants in different classes of formations. Xerophytes are associated only with the steppe meadows and hygrophytes only with peaty meadows. Mesohygrophytes are found only on peaty and true meadows, but are absent on steppe meadows. Mesoxerophytes grow on steppe and partly on true meadows, but are absent on peaty. Mesophytes have a broader range, they are found in all classes of formations, but are most numerous on true meadows. Xeromesophytes and hygromesophytes also have a broad range, but predominate in number of species in classes of formations corresponding more to their ecology (the former on steppe meadows and the latter on peaty meadows).

Characterizing the spectrum of the cenotic groups of plants, we need note that on the whole meadow species proper predominate in all meadow categories (96 species, 32.4%), and rather numerous are bog (51 species, 17.2%), synanthropic (46 species, 15.5%), forest (40 species, 13.5%), and forest—steppe (34 species, 11.4%). The number of steppe (15 species, 5%) and solonchak (15 species, 5%) is comparatively small.

A considerable share (46 species, 15.5%) in the composition of the meadow flora of the region of investigations belongs to synanthropic plants associated with man. This is explained by the long and intense human impact on the natural vegetation cover. Of the number of synanthropic species, 15 belong to the group of pascual, 14 to segetal, 14 to ruderal, and 3 to pyrogenic.

One cannot but note that the assignment of a particular plant species to the category of synanthropic is to some extent arbitrary, since one and the same aboriginal species within the boundaries of the same geobotanic region can figure in the composition of both natural and man-altered plant communities. Furthermore, in one part of its range it can figure as a component of natural communities and in another part as a component of synanthropic communities. Despite these difficulties, in each geobotanic region a group of synanthropic plant species can be singled out. We assign to synanthropic both local plant species and extraregional species actively taking roots in the composition of the natural plant communities in connection with man's interference in their life and holding out in them so long as the anthropogenic pressures remain.

ORIGIN AND STAGES OF ANTHROPOGENIC DEGRADATION OF MEADOWS

A large part of the meadow communities of the trans-Ural forest—steppe region has a secondary origin: they arose at the site of other types of plant communities (forests and

uremas). The exceptions are the steppe meadows, which belong to the category of primary, having formed naturally and having existed in this region before the start of agricultural development of the territory.

The formation of meadows and their subsequent degradation occurred under the effect of such factors as deforestation, forest fires, clearing of bushes, grazing, and haymaking.

Compared to certain other types of vegetation (forests, bogs), the meadows in the trans-Ural forest—steppe region have been subjected to more intense anthropogenic effects. At the same time, meadow plant communities have a high anthropotolerance, they are able to withstand long and intense anthropogenic pressures to a greater degree than forests and bogs.

The alteration of the vegetation cover under the effect of anthropogenic factors has come to be called synanthropization (Falinski, 1972). Recently the problem of synanthropization of the vegetation cover has been attracting the attention of botanists in both the USSR and especially abroad (Gorchakovskii and Peshkova, 1975). Investigations of this problem are being carried out intensely in Poland, Czechoslovakia, West Germany, England, USA, and other countries.

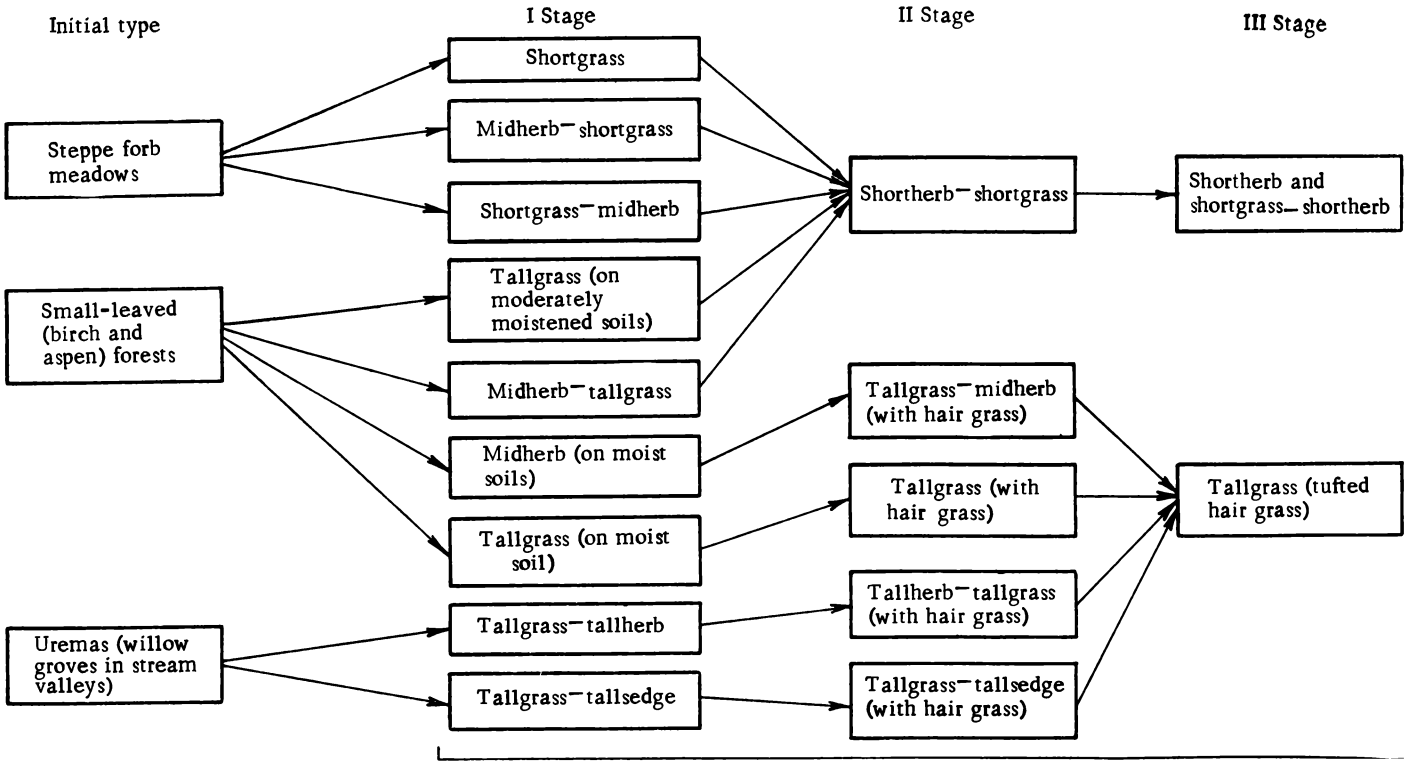
Synanthropization of vegetation is accompanied by impoverishment of the floristic composition of plant communities, replacement of aboriginal species by extraregional, stenotopic species by eurytopic, endemic species by cosmopolitan, simplication of the structure of the communities, replacement of primary plant communities by secondary, natural communities by synanthropic, decrease of the spatial ecological diversity of the vegetation cover, and decrease of its stability and productivity (Gorchakovskii, 1979). Attempts have already been made to use the relationship between adventicous plant species and aboriginal species as an indicator of the intensity of human activity in a particular region (Hadac, 1978). It seems to use that such a criterion as the share of participation of synanthropic species (number of species, abundance) in the composition of meadow communities is more convenient for assessing the degree of their anthropogenic degradation. For this purpose a special scale is proposed which permits assigning a particular plant community to one of three categories differing in degree of anthropogenic degradation: I, weak; II, moderate, III, strong.

The initial change in the vegetation cover involves the formation of meadow communities that are in the I stage of anthropogenic degradation. They are characterized by a negligible participation of synanthropic plant species (from 1 to 7 species with an abundance not greater than sol.* and in rare cases one of the species reaches abundance sp.). With intensification of the pressure of anthropogenic factors more substantial changes occur in the composition and structure of the meadow communities (II stage of degradation). Some synanthropic plant species (*Deschampsia caespitosa, Plantago media, Potentilla anserina*) at this stage figure in the role of codominants (abundance sp.—cop.$_1$), the number of synanthropic species reaches 7-23. Meadow communities that experienced the longest and strongest effect of anthropogenic factors belong to the III stage of degradation. In the composition of such communities one of the synanthropic species already occupies the position of dominant (abundance cop.$_2$—cop.$_3$). The overall species composition of the communities at this stage is impoverished, the number of synanthropic species is lower (7-11) than in the preceding stage.

Our investigations showed that in the trans-Ural forest—steppe region the formation and anthropogenic degradation of meadows occur on the base of three initial types of plant communities — steppe meadows, small-leaved forests, and uremas. The successions of plant communities of the trans-Ural forest—steppe region under the effect of anthropogenic factors are shown in the following schematic diagram.

Succession on a Base of Steppe Forb Meadows. Differentiation of the plant communities originating from the initial type of steppe forb meadows occurs in the I stage of degradation. This differentiation is partly due to differences in the relief, but mainly in the character and intensity of economic use of the lands. In the case of grazing shortgrass meadows are formed, in the composition of which the share of participation of xerophytes (*Festuca valesiaca* ssp. *sulcata*) and mesoxerophytes (*Poa angustifolia*), which displace the forbs, increases slightly. In the case of haymaking use midherb—shortgrass and shortgrass—

*Translator's note: The Drude abundance scale (1890) is used: sol. = solitarius; sp. = sparsus; cop. = copiosus, which was divided by V. V. Alexin (1929) into cop.$_1$, cop.$_2$, and cop.$_3$; soc. = socialis.



midherb meadows are formed (with dominance of *Filipendula hexapetala, Libanotis sibirica, Galium verum, Phleum phleoides, P. angustifolia*), and as a consequence of the ability of grasses to reproduce vegetatively their share of participation in the composition of the herbage increases in many cases.

In the II stage of degradation shortgrasses still retain the position of dominants, but in the species composition there occur certain changes (*P. pheloides*, which cannot stand up to grazing, disappears, and the role of *P. angustifolia, F. valesiaca* ssp. *sulcata*, and *Festuca rubra*, which are more resistant to grazing, increases). Simultaneously with this the midherbs (*Galium verum, F. hexapetala*, etc.) are replaced by shortherbs (*Plantago media, Taraxacum officinalis*, etc.). At the III stage of degradation the shortherbs acquire a dominant position. As degradation progresses the xerophytes and mesoxerophytes that had been a part of the initial steppe forb meadows disappear from the composition of the herbage and are replaced by mesophytes.

Successions on a Base of Small-Leaved Forests. At the site of small-leaved (birch and aspen) forests, after felling and clearing of shrubs, diverse categories of true meadows are formed: midherb, midherb-tallgrass, and tallgrass (I stage of degradation). Their herbage is composed mainly of meadow—forest and meadow mesophytes (*Briza media, Alopecurus pratensis, Dactylis glomerata, Festuca pratensis, Trollius europaeus, Polygonum bistorata*), and the admixture of synathropic species (*D. caespitosa, Plantago major, P. anserina*) is negligible. At the II stage of degradation the midherb meadows on moist soils (with dominance of *Geum rivale* and *T. europaeus*) are transformed to tallgrass—midherb meadows with hair grass, and the tallgrass meadows on moist soils (with dominance of *A. pratensis*) are transformed to tallgrass in whose composition the role of tufted hair grass (*D. caespitosa*) increases considerably. The midherb—tallgrass (meadow fescue—oxeye daisy, meadow fescue—slimtop meadow rue) and tallgrass (timothy—awnless brome, meadow fescue—bluegrass, etc.) meadows are replaced by shortherb—shortgrass (bluegrass—silverweed, bluegrass—hoary plantain, red fescue—white clover) meadows. In this case the midherbs (*Leucanthemum vulgare, Thalictrum simplex, Sanguisorba officinalis*) are replaced by shortherbs (*P. media, P. anserina*), and tallgrasses (*Phleum pratense, F. pratensis, Zerna inermis*) by shortgrasses (*Festuca rubra, Poa pratensis, Agrostis vulgaris*) more resistant to grazing. At the III stage of degradation the shortherbs (*P. media, P. anserina, Trifolium repens*) in meadow communities associated with moderately moistened soils become the dominant component, and the

shortgrasses (*P. pratensis, F. rubra*) become codominants. On wet soils tufted hair grass passes to absolute dominance.

Successions on the Base of Uremas. After felling trees and clearing the shrubs tallgrass—tallherb meadows (with a predominance of *Filipendula ulmaria* and *Alopecurus pratensis*) form at the site of the initial type of uremas (willow groves in valleys of rivers and streams) at the I stage of degradation on more elevated and drained places, and tallgrass—tallsedge (*Carex caespitosa, Calamagrostis purpurea*) meadows in the lower, wetter places. Further degradation (II stage) on the elevated places is accompanied by transition to the dominance of grasses (*A. pratensis*) and the appearance of tufted hair grass in the herbage, whereupon tallgrasses move to the background. In low places under the effect of grazing the soil is compacted still more, the position of tufted sedge weakens, and the role of tufted hair grass, which readily reproduces vegetatively, increases. In this case a tallgrass—tallsedge (with hair grass) meadow forms. With longer intense economic use (III stage) tufted hair grass everywhere becomes the leading component of meadow communities.

A. P. Shennikov (1929) indicated long ago that meadow plant communities differing in soil conditions and character of the vegetation cover gradually converge in their characters under the effect of intense pastural use and ultimately become practically indistinguishable. He called this phenomenon convergence of plant communities.

In the case being considered convergence of plant communities is expressed quite distinctly. During anthropogenic degradation the former diversity of communities substantially declines and at the III stage is reduced to shortherb, shortgrass—shortherb , and tallgrass meadows with dominance of tufted hair grass. Communities originating from both steppe meadows and small-leaved forests on moderately moistened soils, with their mesophilic herbage from time immemorial, become practically indistinguishable. The differences between communities originating from small-leaved forests on moist soils and from uremas are obliterated in exactly the same way.

The most general trends of the change in the composition of the leading components of the herbage of meadow communities during their degradation reduce to the following. On moderately moistened soils grasses and forbs are displaced by shortherbs, which are most resistant to trampling. In this case mesophilization of the primary steppe meadows and their transition to the category of true meadows occur. The shortherb and shortgrass—shortherb meadows form both at the site of steppe and true meadows associated with more drained places. On moister soils intense grazing entails compaction, deterioration of aeration, and depletion of soils. This process is accompanied by dispersal and transition to the dominance of tufted hair grass, which K. N. Igoshina (1964) noted in her time. Secondary communities with dominance of tufted hair grass belong to the class of formations of peaty meadows. However, they form not only at the site of tallgrass—tallherb peaty meadows but also at the site of certain categories of true meadows on moist soils — midherb and tallgrass meadows. The passage of some true meadows during degradation to the category of peaty meadows is explained by the fact that intense grazing causes compaction of the soil, deterioration of its aeration, and this hinders the decomposition of dead plant material and promotes the formation of a peat layer in the soil.

Anthropogenic degradation of meadow vegetation leading to the formation of shortherb and shortgrass—shortherb meadows is accompanied by impoverishment of the floristic composition and decrease of productivity. Thus, for example, 78 species with a yield of 16-18 centners/ha was noted in the meadow fescue—slimtop meadow rue association (I stage) and 32 species with a yield of 3-4 centners/ha in the silverweed (III stage). In the queen of the meadow—meadow foxtail association there were 67 species with a yield of 24-25 centners/ha, whereas in the tufted hair grass—bluegrass association (III stage) there were 43 species with a yield of 8-9 centners/ha. Along with a decrease in productivity the forage value of the herbage depreciates. As degradation progresses the species composition of the meadow communities becomes simpler, synanthropic species occupy the position of dominants (*D. caespitosa, P. anserina, Polygonum aviculare, Leontodon autumnalis*).

An analysis of the preceding data shows that during anthropogenic degradation (primarily under the effect of grazing and haymaking) there occur simplification of the ecological and phytocoenotic diversity of meadows, impoverishment of the species composition and convergence of the plant communities that earlier differed in character of biotopes and composition of dominant species, and a decrease of productivity. At the same time communities little

resistant to anthropogenic effects are succeeded by communities that can withstand considerable anthropogenic pressures (i.e., are more anthropotolerant). However, a considerable increase of the pressure of anthropogenic factors compared to the actual can entail complete destruction of meadow communities and the appearance in their place of waste land with sparse ruderal vegetation.

CONCLUSIONS

1. The anthropogenic transformation of the vegetation cover of the trans-Ural forest—steppe region led to the disappearance of the natural meadow communities and appearance of quasi-natural communities in their place. A trend toward a replacement of the quasi-natural meadows by semicultural and cultural is presently observed. However, a part of the quasi-natural meadows (at least 30% of the area of forage lands) should be preserved to avoid loss of the gene pool of the aboriginal meadow flora.

2. The share of participation of synanthropic plant species in the composition of meadow communities can serve as a criterion of the degree of their anthropogenic degradation. In connection with this three stages of degradation of meadows should be distinguished: I, weak (introduction into the community of several synanthropic species with negligible abundance); II, moderate (introduction of a large number of species, of which one performs the role of codominant); III, strong (impoverishment of the floristic composition, decrease in the number of synanthropic species, emergence of one of them to the position of dominant).

3. The formation and anthropogenic degradation of meadows in the trans-Ural forest—steppe region occur on the base of three initial types of plant communities: steppe meadows, small-leaved forests, and uremas. At the I stage of anthropogenic degradation the meadow communities are still characterized by a large ecological and phytocoenotic diversity and richness of the floristic composition. Later, thediversity of the communities substantially declines, their composition and structure become simpler, and at the III stage as a result of convergence only shortherb (*Potentilla anserina*), shortgrass—shortherb (*Trifolium repens + Poa pratensis*), and tufted hair grass (*Deschampsia caespitosa*) tallgrass meadows remain. Mezophilization of the primary steppe meadows occurs during anthropogenic degradation, and part of the true meadows pass into the category of peaty. Meadow communities at the III stage of degradation have a low productivity but have a high anthropotolerance.

LITERATURE CITED

Baranov, V. I., Vegetation of the Chernozem Belt of Western Siberia (Experience in Botanic—Geographic Surveying and Regionalization) [in Russian], Izd. Za. Sib. Otd. Russkogo Geograf. Obshch., Omsk (1927), p. 162.

Falinski, J. B., "Synantropization of plant cover," in: II. Synanthropic Flora and Vegetation of Towns Connected with Their Natural Condition, History, and Function. Mater. Zakl. Fitosoc. Stos. U. W. Warszawa—Bialowieza, Vol. 27 (1971).

Geobotanical Map of the USSR. Scale 1:4,000,000 [in Russian], Izd. Akad. Nauk SSSR, Moscow—Leningrad (1954).

Gorchakovskii, P. L., "Trends of anthropogenic changes in the world's vegetation," Bot. Zh., 64, No. 12, 1697-1713 (1979).

Gorchakovskii, P. L., and Peshkova, N. V., "Problem of synanthropization of the natural vegetation cover and its elucidation in works of Polish botanists," Bot. Zh., 60, No. 1, 118-128 (1975).

Hadac, E., "Ruderal vegetation of the Broumov basin as an indicator of human activities in this region," Acta Bot. Slovaca, A. 3, s. 431-434 (1978).

Igoshina, K. N., "Vegetation of the Urals (outline)," Tr. Bot. Inst. Akad. Nauk SSSR, Ser. III (Geobotany), No. 16, 6-229, Nauka, Moscow—Leningrad (1964).

Prokaev, V. I., Physiographic Regionalization of the Sverdlovsk District [in Russian], Sverdlovskii Pedagog. Inst., Sverdlovsk (1976), p. 136.

Shennikov, A. P., "Convergence of plant associations," in: Outlines on Phytosociology and Phytogeography [in Russian], Novaya Derevnya, Leningrad (1929), pp. 101-119.

Shennikov, A. P., "Meadow vegetation of the USSR," in: Vegetation of the USSR [in Russian], Vol. 1, Izd. Akad. Nauk SSSR, Moscow—Leningrad (1938), pp. 427-674.

Vegetation of the West Siberian Plain [in Russian], Izd. GUGK, Moscow (1976).

Westhoff, V., De beteklnis van naturgebieden voor wetenschap en praktijk. Brochure Concuctcil. Natuur-en Landschapsbescherming. Amsterdam (1952).