ISSN 0096-7807

Vol. 14, No. 5, September-October, 1983

May, 1984

SJECAH 14(5) 235-300 (1983)

THE SOVIET JOURNAL OF

ECOLOGY

ЭКОЛОГИЯ/ÉKOLOGIYA

TRANSLATED FROM RUSSIAN

CONSULTANTS BUREAU, NEW YORK

GRAZING DEGRADATION OF FLOODPLAIN MEADOWS AND ITS ASSESSMENT FROM THE PROPORTION OF SYNANTHROPIC SPECIES

P. L. Gorchakovskii and A. V. Abramchuk

UDC 581.524.33

Variations in the floristic composition, structure, and productivity of floodplain meadows were analyzed on the basis of three stages of grazing degradation with particular attention to the position of synanthropic species in grass stand structure. The possibility of using the index of proportion of synanthropic species in assessing meadow community degradation is substantiated.

Degradation of plant communities by man's activity is part of the more general process of synanthropization of the Earth's plant cover (Falinski, 1971; Gorchakovskii, 1979). Anthropogenic degradation is accompanied by undesirable consequences such as simplification of floristic composition and structure of plant communities, decrease in their diversity, disturbance in stability, and decline in productivity. Information on mechanisms governing anthropogenic degradation of plant communities is necessary for developing scientific foundations for the rational use of the plant cover, which would maintain the productivity and stability of plant communities at a rather high level.

Meadow vegetation has been subjected rather severely to anthropogenic transformations in the temperate zone of the northern hemisphere. Long-term inappropriate exploitation in many regions and habitats resulted in the degradation of grass stands and a decrease in their agricultural value. With excessive anthropogenic loads, changes in grass stands in some areas became irreversible, plant communities degenerated, and almost barren anthropogenic wastelands were formed in the place of meadows that had had a specific agricultural value.

For this reason, the organization of a work force for monitoring the state of meadowlands has become highly significant. The purpose of monitoring is to indicate at the appropiate time all plant communities in which degradation has reached a critical level. Prompt measures to alter the use of grasslands and meadows should be instituted on the basis of such indications.

Monitoring activity should be based on appropriate and reliable methods for evaluating the state of plant communities and the extent of their anthropogenic degradation. At present such methods are still inadequately elaborated. E. Hadač (1978) used the index of the proportion of ruderal species in the flora of a region in Czechoslovakia to assess the effect of human activity on the natural plant cover. In our previous work (Abramchuk and Gorchakovskii, 1980), we used the index of the proportion of synanthropic species in dry-valley meadows in the Transural forest steppes (number of synanthropic species in a certain association and their abundance according to Drude's scale) to assess the degradation of these meadows. We define the term *synanthropic plants* rather broadly and include both native and alien species that have entered phytocenoses disturbed by man or increase in abundance with greater anthropogenic loads. Three stages of meadow degradation were defined. A small number (1-7) of synanthropic species with a very low abundance (sol.) enter the grass stand in the first stage; in the second stage the number of synanthropic species increases (to 7-23) with one of these acting as the codominant (abundance is sp.-cop.$_1$). The third stage is characterized by the general decline in floristic composition and, accordingly, a slight decrease in the number of synanthropic species (7-11), but one of these becomes the dominant species (abundance of cop.$_2$-cop.$_3$). Convergence of meadow communities occurs during degradation (their diversity is reduced to several associations with predominance of *Deschampsia caepitosa, Trifolium repens,* and *Potentilla anserina*), and yield declines.

Nevertheless, Drude's abundance scale is not accurate enough, and the intrusion of subjectivity into assessments is not precluded with its use. Continuing our studies on this

Institute of Plant and Animal Ecology, Ural Scientific Center, Academy of Sciences of the USSR. Translated from Ékologiya, No. 5, pp. 3-10, September-October, 1983. Original article submitted June 3, 1983.

0096-7807/83/1405-0235$07.50

topic, we attempted to find more objective criteria for assessing meadow community degradation. For this purpose, we used the index of the proportion of synanthropic species in the aboveground phytomass, in addition to their numbers and abundance.

The investigations were performed within the southern taiga subzone of the Transural peneplain in the valley of the Ambarka River, a tributary of the Neiva River (Tura River basin), in the Prigorodnyi Raion of Nizhni Tagil. The bed of the Ambarka River has a poorly developed floodplain, which can be divided into low, middle, and high regions. The low areas of the floodplain are flooded annually for to 20 days, and the middle and high areas for up to 10-12 days, but not each year.

The studied floodplain meadow communities are in the vicinity of the village of Yuzhakovo (Yuzhakovo state farm) and have been used for a long time for grazing cattle. The level of their degradation increases with nearness to the settlement. A series of sampling areas was established for the study. Seven associations reflecting different levels of grazing degradation of several original types were defined and described. To describe each association, we established 8-10 sampling areas, 10 × 10 m, and 10 plots within each area to quantitate aboveground mass and five plots to quantitate underground mass. Determinations of aboveground phytomass were made at the time of greatest grass stand development (end of July to beginning of August) using hay from the grass stand on 0.5 × 1 m plots. Mown grass was separated into agrobotanical groups (grasses, legumes, forbs), and dominants and codominants were singled out. The phytomass of synanthropic species was determined separately. In addition, we obtained samples of aboveground phytomass for chemical analysis. To determine underground phytomass reserves, we took 25 × 25 cm core samples. Underground plant parts were washed and dried. Both aboveground and underground phytomass were weighed in an air-dry state. The data were analyzed by methods used in mathematical statistics. Statistical error did not exceed 10% in quantitations of aboveground phytomass reserves, and 15-20% for underground phytomass.

The original types of floodplain meadow communities had not been preserved in the study region. All meadows associated with alluvial loamy, meadow soils were to some extent subjected to anthropogenic degradation with cattle grazing acting as the major factor. In the first stage of degradation, the major cenosis-forming species, typical for natural floodplain meadows, still retain the position of dominants; their vitality is rather high, and they are capable of regeneration by seed. With the transition to stage 2, these species lose their dominant position, their vitality declines, and synanthropic species more resistant to grazing enter the community. In the third stage, synanthropic species become totally dominant.

Meadow communities in the first stage are represented by three basic associations (see Scheme). One of these, meadow fescue (*Festuca pratensis* association), occupies the higher and drier areas (high floodplain), and the others, meadow geranium (*Geranium pratense* association) and giant bent grass (*Agrostis gigantea* association) are found in relatively low and extremely wet areas (middle and low floodplain).

In the second stage of degradation, a yarrow–white clover association (*Trifolium repens* + *Achillea millefolium* association) forms in higher areas of the floodplain in place of the meadow fescue association. Only a silverweed cinquefoil–white clover association (*T. repens* + *Potentilla anserina* association) forms in middle and low floodplain in the place of the two associations, meadow geranium and giant bent grass. As the soil becomes compacted and its aeration deteriorates, earlier differences in ecotopes disappear, and this results in convergence.

In the third stage of degradation, a yarrow association (*A. millefolium* association), replacing the yarrow–white clover association, forms in higher areas of the floodplain, and silverweed cinquefoil (*P. anserina* association), replacing silverweed cinquefoil–white clover, in lower areas.

TABLE 1. Floristic Composition of Meadow Communities

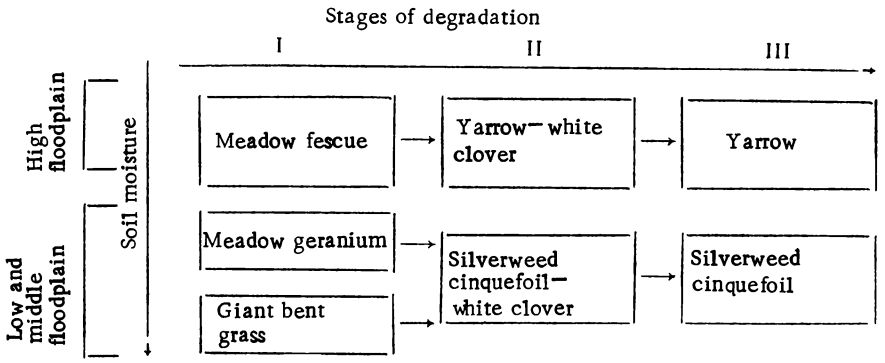
Paragraph No.	Plant	Stage I			Stage II		Stage III	
		meadow fescue	meadow geranium	giant bent grass	yarrow—white clover	silverweed cinquefoil—white clover	yarrow	silverweed cinquefoil
	Grasses							
1	*Festuca pratensis* . .	cop.$_2$	sp.	sp.	sol.-sp.	sol.	sol.	sol.
2	*Poa pratensis* . . .	cop.$_1$	sp.-cop.$_1$	sp.	cop.$_1$	sp.	sol.-sp.	sol.
3	**Elytrigia repens* . .	sp.	sol.-sp.	sp.-cop.$_1$	sp.	sp.	sol.-sp.	sp.
4	*Festuca rubra*	sp.	sol.-sp.	sp.	sp.-cop.$_1$	sol.-sp.	sol.	sol.
5	*Phleum pratense* . . .	sp.-cop.$_1$	sp.	sp.	sol.-sp.	sol.-sp.	sol.	—
6	*Agrostis gigantea* . .	sol.-sp.	—	cop.$_2$	sol.-sp.	sol.-sp.	sol.	—
7	**Deschampsia caespitosa*	—	sol.-sp.	sol.-sp.	sol.-sp.	sp.	sol.-sp.	sp.
8	*Agrostis tenuis* . . .	sol.	sol.-sp.	sol.	sp.	—	—	—
9	*Alopecurus pratensis* .	sol.	sol.	sol.-sp.	—	—	—	—
10	*Bromopsis inermis* . .	sol.-sp.	sol.-sp.	—	—	—	—	—
11	*Dactylis glomerata* .	sol.	sol.	—	—	—	—	—
	Total grasses	10	10	9	8	7	7	5
	Legumes							
12	**Trifolium repens* . .	sol.	sol.	sol.-sp.	cop.$_2$	cop.$_2$	sp.	sp.
13	*T. pratense*	sol.-sp.	sol.-sp.	sol.-sp.	sol.	sol.	sol.	—
14	*Vicia cracca*	sol.	sol.-sp.	sol.	sol.	sol.-sp.	sol.	—
15	*Trifolium medium* . .	sol.-sp.	sol.	sol.	sol.	—	—	—
16	*Lathyrus pratensis* .	sol.	—	sol.	sol.	—	—	—
17	*Vicia sepium* . . .	sol.	sol.	—	sol.	—	—	—
18	*Astragalus danicus* . .	sol.	sol.	—	—	—	—	—
	Total legumes	7	6	5	6	3	3	1
	Forbs							
19	**Achillea millefolium*	sol.	sp.	sol.	cop.$_1$	sp.	cop.$_{2-3}$	sp.
20	**Carum carvi*	sol.	sol.-sp.	sol.-sp.	sp.	sol.-sp.	cop.$_1$	sp.-cop.$_1$
21	*Glechoma hederacea* .	sol.	sol.	sol.	sol.	sol.-sp.	sol.	sol.-sp.
22	**Potentilla anserina* .	—	sol.-sp.	—	sp.-cop.$_1$	cop.$_1$	sp.	cop.$_3$
23	**Leontodon autumnalis*	—	—	sol.	sp.	sol.-sp.	sp.	sol.-sp.
24	*Leucanthemum vulgare*	sol.-sp.	sol.-sp.	sol.	sol.	sol.	—	—
25	**Taraxacum officinale* .	sol.	sol.-sp.	—	sp.	sol.	sol.-sp.	—
26	*Pimpinella saxifraga* .	sol.-sp.	sp.	sol.	sol.	—	sp.	—
27	*Stellaria graminea* .	sol.	sol.	sol.	sol.	sol.	—	—
28	*Viola canina* . . .	sol.	sol.	sol.	sol.	sol.	—	—
29	*Geranium pratense* .	sol.	cop.$_{2-3}$	sol.	—	sol.	—	—
30	*Galium boreale* . .	sol.-sp.	sp.	sol.	sol.	—	—	—
31	**Plantago major* . .	—	—	—	sol.-sp.	sp.	sol.	sol.-sp.
32	**P. media* .	sol.	sol.	—	sol.	sp.	—	—
33	*Galium mollugo* . .	—	sol.	sol.	sol.	sol.	—	—

TABLE 1 (continued)

Paragraph No.	Plant	Stage I			Stage II		Stage II	
		meadow fescue	meadow geranium	giant bent grass	yarrow–white clover	silver weed cinque-foil–white clover	yarrow	silver-weed cinquefoil
34	*Prunella vulgaris* .	—	sol.	sol.	sol.	sol.	—	—
35	*Ranunculus acer* . . .	sol.	—	sol.	sol.	sol.	—	—
36	*Thalictrum minus* . .	sol.	sol.	sol.	—	sol.	—	—
37	*Veronica chamaedrys*	sol.	sol.	sol.	—	sol.	—	—
38	*Agrimonia pilosa* . .	sol.	—	sol.	sol.	—	—	—
39	**Artemisia vulgaris* .	sol.	—	sol.	—	—	—	—
40	*Centaurea phrygia* . .	sol.	sol.	sol.	—	—	—	—
41	*Equisetum pratense* .	sol.	sol.	sol.	—	—	—	—
42	*Lythrum salicaria* . .	—	sol.	sol.	—	sol.	—	—
43	*Potentilla argentea* .	sol.	—	—	sol.	—	sol.	—
44	*P. goldbachii* . . .	sol.	—	sol.	—	sol.	—	—
45	*Ranunculus repens* . .	sol.	—	sol.	—	sol.	—	—
46	*Sanguisorba officinalis* .	sol.	sol.	sol.	—	—	—	—
47	*Solidago virgaurea* .	sol.	—	sol.	sol.	—	—	—
48	*Heracleum sibiricum* .	sol.	sol.	sol.	—	—	—	—
49	**Odontites serotina* .	—	—	—	—	sol.-sp.	—	sp.
50	**Polygonum aviculare* .	—	—	—	—	—	—	sp.
51	**Artemisia absinthium*	—	sol.	—	—	—	sol.	—
52	*Geranium collinum* .	sol.	sol.	—	—	—	—	—
53	**Euphrasia tatarica* . .	—	—	—	—	—	sol.	sol.
54	**Mentha arvensis* . .	—	—	—	—	sol.	—	sol.
55	*Melandrium album* . .	sol.	—	sol.	—	—	—	—
56	**Rumex confertus* . .	—	—	—	—	sol.-sp.	—	sol.
57	*Tanacetum vulgare* . .	sol.	sol.	—	—	—	—	—
58	*Triglochin palustre* .	—	sol.	sol.	—	—	—	—
59	**Alchemilla leiophylla*	—	sol.	—	sol.	—	—	—
60	*Betonica officinalis* . .	sol.	—	—	—	—	—	—
61	**Bidens tripartita* . .	—	—	—	—	—	—	sol.
62	*Centaurea scabiosa* .	sol.	—	—	—	—	—	—
63	**Linaria vulgaris* .	—	—	—	—	—	sol.	—
64	**Rumex acetosella* . .	—		—	—	—	sol.	—
	Total forbs	29	26	27	20	23	13	12
	Total number species	46	42	41	34	33	23	18
	Including synanthropic species	7	9	7	11	13	13	14
	% of synanthropic species in relation to total floristic composition	15,2	21,4	17,1	32,4	39,39	56,5	77,8

*Synanthropic species.

Grazing Degradation of Floodplain Meadows



A relatively broad floristic range is typical for meadow associations in the first stage of degradation (Table 1). Their grass stand included 41 to 46 species. Common meadow grasses (*F. pratensis, A. gigantea*) or certain forbs (*G. pratense*) predominate. The group of grasses is represented by 9-10 species, legumes by 5-7 species and forbs by 26-29 species. The 7-9 synanthropic species represent a minor addition, and their abundance does not exceed a rating of sol. or sp.

In the second stage of degradation, the total number of species in individual associations declines to 33-34, and of grasses to 7-8. The number of legume species in certain association declines to three, and remains approximately unchanged in others; there are fewer forbs (20-23 species). There are a greater number of synanthropic species in this stage (11-13) than in the previous stage; some grazing-resistant species (*T. repens*) become dominant, and others (*P. anserina, A. millefolium*) codominant.

In the third stage of degradation, the overall species composition of meadow associations is even lower (18-23 species), and the proportion of grasses and legumes declines (in abundance and in some associations in number of species); the number of synanthropic plants remains unchanged or increases slightly (to 13-14), but their proportion with respect to total species composition increases considerably, to 78%. Synanthropic species have the dominant position in relation to abundance in meadow communities in the third stage of degradation.

Among communities in the first stage of degradation, highest overall phytomass reserves (1025 g/m^2) were noted in the meadow fescue association, which cover higher areas of the floodplain; somewhat lower reserves (851 g/m^2) were found in the meadow geranium association which covers the middle area of the floodplain, and even lower reserves (641 g/m^2) were found in the giant bent grass association, typical for the lowest areas (Table 2). A decrease in

TABLE 2. Changes in the Productivity of Meadow Communities with Degradation

Stage of degradation	Association	Phytomass reserves, g/m^2 of air-dry matter			Ratio of aboveground to underground phytomass reserves
		aboveground	underground	total (aboveground and underground)	
I	Meadow fescue	263	762	1025	1 : 2,9
	Meadow geranium	343	508	851	1 : 1,5
	Giant bent grass	208	433	641	1 : 2,1
	Average for stage	271	568	839	1 : 2,1
II	Yarrow–white clover	168	434	602	1 : 2,6
	Silverweed cinquefoil–white clover	158	347	505	1 : 2,2
	Average for stage	163	390	553	1 : 2,4
III	Yarrow	172	408	580	1 : 2,4
	Silverweed cinquefoil	193	293	486	1 : 1,5
	Yarrow	182	350	532	1 : 1,9

TABLE 3. Alteration of the Relation of Agrobotanical Groups and Proportion of Synanthropic Species in the Aboveground Phytomass (air-dry matter) of Meadow Associations

Agrobotanical groups	Stage I						Stage II				Stage III			
	giant bent grass		meadow geranium		meadow fescue		yarrow–white clover		silverweed cinquefoil–white clover		yarrow		silverweed cinquefoil	
	g/m²	%	g/m²	%	g/m²	%	g/m²	%	g/m²	%	g/m²	%	g/m²	%
Grasses	158	60,1	113	32,9	122	58,6	46	27,4	39	24,7	30	17,4	32	16,6
	15	5,7	—	—	12	5,8	17	10,1	8	5,1	17	9,9	24	12,4
Legumes	17	6,5	—	—	12	5,8	57	33,9	40	25,3	3	1,7	7	3,6
	—	—			—	—	57	33,9	35	22,1	3	1,7	7	3,6
Forbs	88	33,4	230	67,1	74	35,6	65	38,7	79	50,0	139	80,9	154	79,8
	16	6,1	45	13,1	17	8,1	13	7,8	34	21,5	123	71,5	137	71,0
Total	263	100	343	100	208	100	168	100	158	100	172	100	193	100
Synanthropic species	31	11,8	45	13,1	29	13,9	87	51,8	77	48,7	143	83,1	168	87,0

Note. Aboveground phytomass is given above the line, and the phytomass of synanthropic species below the line.

total phytomass reserves along the ecological series of increasing soil moisture is explained by the fact that root systems of plants in wetter areas of the floodplain are less developed and underground phytomass serves are reduced accordingly. With degradation, total phytomass reserves (aboveground and underground) decline to 505-602 g/m² in the second stage and to 486-580 g/m² in the third. This is primarily due to the decrease in underground phytomass reserves (from 433-762 g/m² in the first stage to 293-408 g/m² in the third) as a result of soil compaction and reduced soil aeration. The detrimental effect of grazing on formation of root systems in meadow plants was noted by N. S. Konyushkov (1930).

According to literature data (Matveeva, 1974), the ratio of aboveground to underground phytomass varies from 1:1 to 1:10 for different meadow communities. There are indications (Rabotnov, 1974) that with an increase in soil moisture, reduced drainage, and increased acidity, the mass of underground organs increases, which is apparently caused by the accumulation of dead roots in the soil. Nevertheless, in certain cases, as Rabotnov notes, a decline and then an increase in underground organ reserves are observed with transition from drier to wetter meadows. Moreover, there are data (Shalyt, 1950) indicating that conditions unfavorable for root system development in meadow plants are created with fluctuation in groundwater level, particularly during its periodic rise almost to the soil surface.

Our findings demonstrated that the ratio of aboveground to underground mass varies from 1:1.5 to 1:2.9 in communities of floodplain meadows in the first stage of degradation. The somewhat higher reserves of underground mass in comparison with aboveground mass are explained by the fact that these communities in floodplain meadows have a rather adequate supply of water. Water moves through the soil here, and for this reason, plant root systems do not experience an oxygen deficiency; dead underground fragments of plants decay rather rapidly. The minor differences in the ratios of aboveground to underground mass for individual associations are explained not so much by differences in moisture supply as by the different morphobiological features of dominant species.

The role of grasses in the formation of aboveground phytomass declines with the transition from the first to second stage of degradation, and that of legumes increases. *T. repens*, which is resistant of moderate grazing, becomes the dominant species (Table 3). In the third stage, the proportion of legumes declines considerably, and the increase in the contribution of forbs to the composition of aboveground phytomass is especially evident. Nevertheless, the steady increase in the proportion of synanthropic species in the aboveground phytomass is most demonstrative (11.8-13.9% in stage I, 48.7-51.8% in stage II, and 83.1-87.0% in stage III).

CONCLUSIONS

1. In the course of grazing degradation of floodplain meadows, their floristic composition, structure, productivity, and proportion of synantropic species change considerably. It is feasible to differentiate three stages of degradation corresponding to moderate, high, and excessive grazing.

The floristic composition of meadow communities (41-46 species in stage I, 33-34 in stage II, and 18-23 in stage III) declines with degradation; the number of synanthropic species increases (from 7-9 to 13-13), as well as indices of their abundance and the percentage of synanthropic species with respect to total species composition (from 15 to 78%).

2. In addition to these changes, there is a decline in meadow communities in total phytomass reserves and role of grasses, and then of legumes as well, in the aboveground phytomass; valuable fodder grasses are replaced by poorly consumed plants of little value. In the first stage, synanthropic species represent an insignificant addition; they are encountered as solitary or scattered plants, forming not more than 10-15% of the aboveground phytomass; in the second stage, they begin to dominate the grass stand and comprise about 50% of the aboveground phytomass; in the third stage, they become absolutely dominant (80-90% of aboveground phytomass).

3. To assess the level of grazing degradation of meadow communities and to place them in a specific stage of degradation, it is feasible to use indices of the proportion of synanthropic species: a) number of synanthropic species in individual associations; b) their percentage with respect to total species composition; c) abundance of synanthropic species; and d) the percentage of their phytomass with respect to total aboveground phytomass.

LITERATURE CITED

Abramchuk, A. V., and Gorchakovskii, P. L., "Formation and anthropogenic degradation of meadow plant communities in the Transural forest steppe," Ékologiya, No. 1, 22-34 (1980).

Falinski, J. B., "Synanthropization of plant cover. II. Synanthropic flora and vegetation of towns connected with their natural condition, history and function," in: Mater. Zakl. Fitosoc. Stos. Uniw. Warszawskiego, Vol. 2, (1971), pp. 21-37.

Gorchakovskii, P. L., "Tendencies of anthropogenic changes in the Earth's plant cover," Bot. Zh., 64, No. 12, 1697-1714 (1979).

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

Konyushkov, N. S., "Effect of grazing on the plant cover in a meadow," Byull. Inst. Lugov Pastbishch im. V. R. Vil'yamsa, No. 5 (1930).

Matveeva, E. P., "Biological productivity of meadows in the USSR," Rast. Resur., No. 4, 473-489 (1974).

Rabotnov, T. A. Study of Meadows [in Russian], Izd. Mosk. Gos. Univ., Moscow (1974), 384 pp.

Shalyt, M. S., "Underground parts of certain meadow, steppe, and desert plants and phytocenoses," Tr. Biol. Inst., Akad. Nauk SSSR, Geobot., No. 6, 205-435 (1950).