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CHANGES IN THE PRODUCTIVITY OF PLANT COMMUNITIES IN THE COURSE OF SUCCESSIONS ON RIVER ALLUVIUM

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It is customary for successions of plant communities to be mainly characterized by indices of changes in their floristic composition and structure. Only recently have criteria of productivity changes also been drawn in for these purposes (Miroshnichenko and Togyzaev, 1972; Bulatova and Gorchakovskii, 1974; Perino and Risser, 1972; Golley, 1974; Mellinger and McNaughton, 1975).

One of our previous publications (Gorchakovskii and Peshkova, 1970) described general regularities governing the formation of herbaceous plant communities at the initial stages in overgrowth of young alluvium in the valley of the Ural River on the southern edge of the steppe zone. Overgrowth of alluvium here is accomplished via two successional series, viz., a halomesophytic series, which is associated with sand–clay–fine sand alluvium, and a psammoxerophytic series, which is associated with sand alluvium. The halomesophytic series includes two stages, viz., hygromesophyte–mixed grass groupings and Crypsis overgrowths (in which Crypsis alopecuroides is the dominant), whereas the psammoxerophytic series includes three stages, viz., hygromesophyte–mixed grass groupings, Crypsis–Corispermum overgrowths (in which Corispermum marschalli is the dominant and Crypsis alopecuroides a codominant), and Agriophyllum–Corispermum overgrowths (in which Corispermum marschalli is the dominant and Agriophyllum arenarium a codominant). These loosely closed herbaceous communities exist for a short time (12-20 years) and are then replaced by flood-plain willow associations (Salix alba ass.) and flood-plain poplar associations (Populus nigra ass.).

It was interesting to trace how the productivity of herbaceous plant communities changes in the course of successions on river alluvium. For this purpose, special investigations were conducted on the middle course of the Ural River near the settlement of Kushum (51° N lat.) in the first decade of September of 1974 during the period of mass fruit bearing and maximal biomass storage of the plants. In five plant communities representing different stages of successions of two development series (halomesophytic and psammoxerophytic), 9-10 record-keeping plots (48 in all) measuring 1 m^2 each were set up to determine the stock of overground and underground biomass. The size and number of the plots were experimentally selected so that the statistical error of determining the stock of overground biomass did not exceed 20%, while that of determining the stock of underground biomass did not exceed 25-28%.

The values of overground and underground biomass of the dominant species were broken down according to species. The biomass of other herbaceous plants was reckoned totally, but likewise with division into overground and underground components. The biomass of seedlings and advance growth of Salix alba and Populus nigra was not taken into account, since these plants are cenotically foreign to the investigated herbaceous communities and only anticipate the transition to subsequent successional stages. Weighing of biomass was conducted in the air-dry state on commercial (overground part) and analytical (underground part) scales.

Table 1 presents results of estimating stock and structure of the biomass of plants in herbaceous plant communities of river alluvium.

In the first stage of the halomesophytic series, more than half of the total biomass stock falls on Chenopodium rubrum, while a fourth falls on Crypsis alopecuroides. The role of other components is relatively slight (16% of the total biomass stock). The stock of overground biomass is nine times greater than that of underground biomass. An especially high ratio of overground to underground mass (21:1) is characteristic of Crypsis.

The total biomass stock decreases significantly (from 92 to 48 g/m^2) with transition to the second stage of this series. This transition is accompanied by the development of monodominance: The share of participation of Chenopodium rubrum decreases significantly, and Crypsis takes on nearly undivided supremacy (92% of the total mass). The ratio of overground to underground mass here increases to 15:1, which is associated with the predominance of Crypsis.

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TABLE 1. Stock of Biomass of Plants in the Air-Dry State and Structure of the Biomass of Herbaceous Communities at Different Successional Stages

Successional series	Successional stages	Main components of communities	Biomass, g/m²			Ratio of overground to underground biomass
			overground	underground	total	
Halomesophytic	I	*Chenopodium rubrum* . .	49 (59)*	6 (67)	55 (60)	8:1
		Crypsis alopecuroides . .	21 (25)	1 (11)	22 (24)	21:1
		Other species	13 (16)	2 (22)	15 (16)	6:1
		In all	83 (100)	9 (100)	92 (100)	9:1
	II	*Crypsis alopecuroides* . .	42 (93)	2 (67)	44 (92)	21:1
		Other species	3 (7)	1 (33)	4 (8)	3:1
		In all	45 (100)	3 (100)	48 (100)	15:1
Psammoxerophytic	I	*Crypsis alopecuroides* . .	39 (40)	2 (20)	41 (38)	19:1
		Chenopodium rubrum . .	14 (15)	3 (30)	17 (16)	5:1
		Other species	44 (45)	5 (50)	49 (46)	9:1
		In all	97 (100)	10 (100)	107 (100)	10:1
	II	*Crypsis alopecuroides* . .	44 (33)	3 (25)	47 (33)	15:1
		Corispermum marschalli	42 (32)	2 (17)	44 (30)	21:1
		Other species	46 (35)	7 (58)	53 (37)	7:1
		In all	132 (100)	12 (100)	144 (100)	11:1
	III	*Corispermum marschalli* *Agriophyllum arenarium*	34 (83)	4 (80)	38 (83)	8:1
		Other species	7 (17)	1 (20)	8 (17)	7:1
		In all	41 (100)	5 (100)	46 (100)	8:1

*The number in parentheses indicates % of the total stock in each stage

In comparison with the analogous stage of the halomesophytic series, the first stage of the psammexerophytic series is characterized by a slightly greater biomass stock (107 g/m²). The composition of components is more variegated here. Crypsis plays the part of the main dominant (38% of the total biomass), while Chenopodium rubrum occupies the position of a codominant (16% of the total biomass). The total shock of the two dominant species in this community is lower than at the initial stage of the halomesophytic series, whereas the participation of other species is higher. In connection with the predominance of Crypsis, the ratio of overground to underground mass is fairly high (10:1) in this community.

The total biomass stock increases to 144 g/m² with transition to the second stage. Participation of the dominant species (Crypsis alopecuroides and Corispermum marschalli) in composition of the biomass is nearly equal (33 and 30%, respectively). The other species account for 37% of the biomass. The underground organs of Crypsis are better developed in communities at this stage (the ratio of overground to underground mass comprises 15:1) than in the preceding stage. The total ratio (for all components) of overground to underground biomass remains approximately the same as during the first stage.

In the third stage, supremacy passes to Corispermum marschalli, which comprises 83% of the total biomass. In connection with the fact that ground water in communities at this stage is found at a greater depth, the root system in Corispermum here is more extensively developed (the ratio of overground to underground mass being equal to 8:1, whereas it is equal to 21:1 during the second stage). Participation of the codominant Agriophyllum arenarium and a few other species comprises 17% of the total biomass. The total ratio (for all species) of overground to underground mass is equal to 8:1. The total biomass stock in the third stage is significantly lower (46 g /m²) than in the second stage.

It is impossible to ignore the considerable predominance of overground mass over underground mass in Crypsis alopecuroides and Corispermum marschalli. Crypsis is an annual grass whose underground part is weakly developed, consisting of the fiber of slender roots situated in the uppermost horizon of the soil. Corispermum marschalli is an annual of the family Chenopodiaceae with a tap root, from which several fine ramifications pass off. There are reports indicating that the overground phytomass is considerably greater than the underground phytomass in many cultivated annuals (Evdokimova and Grishina, 1971). In cereal crops, the ratio of overground to underground phytomass at the greatest theoretically possible productivity is equal to 10:1 (Bazilevich and Rodin, 1971), whereas it attains a value of up to 8:1 in normal winter wheat plantings (Cox and Wright, 1975). In a flood plain of the Vakhsh River in Tadzhikistan, the ratio of overground to underground phytomass attains 15:1 in the grass Imperata cylindrica (in a Populus diversifolia–Imperata cylindrica association) (Stanyukovich, 1971).

Investigation of the productivity of flood-plain meadows in the middle source of the Ural River (Ageleuev, 1968; Ageleuev and Shuinshaliev, 1973) indicated that the total biomass stock (underground and overground parts) comprises 2250-2650 g/m^2 and 1200 g/m^2 in different types of Agropyron meadows. Thus, productivity of the herbaceous plant communities that we studied (which characterize the initial stages of successions) is 10-50 times lower than that of flood-plain meadows.

Successions of primary plant communities on young river alluvium are accompanied and in some measure determined by development and deepening of the river channel, lowering of the ground water level, and (in the psammoxerophytic stage) increase in mobility of the substrate (wind erosion). The water supply available to the plants deteriorates in proportion to successions of plant communities. In the halomesophytic series, decrease in the productivity of communities and increase in the ratio of overground to underground mass (in connection with the fact that the position of dominant is occupied by Crypsis, whose weakly developed superficial root system is adapted to the capture of rain water and condensing moisture) are observed in the course of successions. In the psammoxerophytic series, the productivity of communities in the course of successions increases at first, but then decreases; the ratio of overground to underground biomass decreases, since the plants develop deeper and more powerful root systems in connection with lowering or the ground water level. In proportion to lowering of the ground water level, herbaceous communities are replaced at the next successional stages by communities of woody plants (Salix alba, Populus nigra, etc.), whose roots are capable of extracting moisture from deeper horizons and better able to hold the mobile substrate.

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