The Main Results of Agroforestry Amelioration and Desertification Control in the Northern Caspian Semidesert Area in Russia

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Desertification control and soil conservation and reclamation are the urgent ecological problems in the Caspian region of Russia.

The detailed and integrated fifty-year-long biogeocenotic investigations have been conducted at the Djanybek Research Station of Institute of Forest Science RAS with special attention to afforestation under arid climatic conditions, changes in soils caused by agroforestry amelioration and to the experience of the desertification control and silvicultural amelioration of croplands.

The Northern Caspian Region is characterized by dry continental climate. Mean annual precipitation is 298 mm, and almost one half of it (136 mm) falls during the warm period (April-September), when the monthly evaporation reaches 900 mm—1000 mm and the maximum day temperature is above 40℃. Dry winds are observed for about 80 days per year. The stable snow cover persists from November till March, and the average depth of snow is 10 cm.

The area is a closed plain almost lacking in drainage with large mesodepressions and pronounced microrelief. The plain is composed of thick slightly saline Khvalyn heavy loams. Ground water table occurs at the depth of 5 m—6 m. The thickness of capillary fringe is 3 m. The area is noted by comlexity of soil cover and vegetation caused by microrelief. Two main kinds of ecotops can be obviously recognized, which differ greatly in main characteristics limiting the plant growth: mineralization of ground waters, and soil salinity. The first kind is represented by solonchakous solonetzes and ligth-chesnut soils occupied the microhills and their slopes respectively, under these soils ground water being highly mineralized. The second kind of ecotops is represented by non-saline meadow-chesnut soils with the lenses of fresh ground water below formed in microdepressions.

Salt-affected solonetzes and light chesnut soils occupy 75% of the whole area with the exeption of large mesodepressions. Salt-affected soils cannot be used for afforestation and cultivation without preliminary amelioration.

The system of agroforestry amelioration of soils of solonetz complexes was elaborated at the Djanybek Station. At first some desalinization and dealcalinization of soils is achieved by deep plowing, which destroys the solonetzic horizon, involves gypsum from the first subsolonetzic horizon into the plow layer and causes the increase in the water permeability of the topsoil. Further desalinization of these soils occurs due to additional moistening caused by snow accumulation with the system of one-row strips of elm (Ulmus pumila L). A specific profile of agro-transformed solonetzes with a homogeneous plow layer and a “salt-eluvial” (desalinized) horizon begins to form. The soils having no analogues in nature are formed as a result of long-term anthropogenic influence. The predominance of eluvial-salt elementary soil-forming process is the main trend in their development.

Together with the removal of easily soluble salts from the upper soil horizons, additional moistening results in the increase in moisture supply to both trees in the strips and crops cultivated between them. Cereals and perennial herbs can be grown on ameliorated lands**.** Their productivity is by 2—2.5 times higher, in average, as compared to that on non-afforested fields.

The necessary conditions for existence of shelterbelts are the large feeding area of trees and the possibility of snow accumulation. When these requirements are satisfied elm strips are able to work up to their age of 50 years at least.

On ameliorated soils of solonetzic complex the best growth and the highest tolerance was recorded for steppe xerophytes. 13 species have been proved to be the most tolerant and long-living (barberry, June berry, lilac, cotoneaster, ash tree, and others). 21 species may be sowed directly into microlows. Small areas of soils in solonetzic complexes are favorable for the introduced plants: their root systems may use moisture not only from the solonetzes but also from the adjacent not afforested depressions.

Much more favourable conditions for afforestation take place in the mesodepressions where it is possible to use the wider set of tree species. More than 200 species of trees and shrubs from different continents and geographical zones have been tested in the mesodepressions on the meadow-chesnut soils, where underground water is weakly mineralized and available to plants.

Many introduced trees are well adapted to severe semidesert climatic conditions. They grow well and quickly, begin to produce fruits at young age, and have abundant natural regeneration.

The best growth and stability were found for trees typical for broad-leaved forests on steep slopes and valley forests of the forest-steppe zone, and flood-plain forests. They include mesophytes and mesoxerophytes: ouk, birch, lime, pear tree, maple, mountain ash, and hazel nut. 96 forest species may be recommanded for planting in mesodepressions.

Table List of species for afforestation in semidesert of Northern Ciscaspian lowland

In mesodepressions		On soils solonetz complex
Acer negundo L.	Gleditsia triacanthos L.	Amelanchier spicata (Lam.) C. Koch
Acer platanoides L.	Malus silvestris (L.) Mill.	Berberis vulgaris L.
Acer saccharinum L.	Padus avium Mill.	Caragana arborescens Lam.
Amelanchier spicata (Lam.) C. Koch	Populus alba L.	Cotinus coggygria Scop.
Berberis vulgaris L.	Pyrus communis L.	Cotoneaster lucidus Schlecht.
Betula pendula Roth	Quercus robur L.	Elaeagnus oxycarpa Schlecht.
Caragana arborescens Lam.	Rhamnus cathartica L.	Fraxinus pennsylvanica Marsh.
Catalpa bignonioides Walt.	Robinia pseudacacia L.	Lonicera tatarica L.
Corylus avellana L.	Salix caspica Pall.	Prunus spinosa L.
Cotoneaster lucidus Schlecht.	Sorbus aucuparia L.	Ribes aureum Pursh.
Crataegus monogyna Jacq.	Spiraea hypericifolia L.	Rosa sp.
Crataegus submollis Sarg.	Syringa vulgaris L.	Schepherdia argentea (Pursh) Nutt.
Fraxinus excelsior L.	Tilia cordata Mill.	Syringa vulgaris L.
Fraxinus pennsylvanica Marsh.	Ulmus laevis Pall.	Tamarix ramosissima Ledeb.
		Ulmus pumila L.

Complex biogeocenoses are developed in some mesodepressions. Common oak (Quercus robur L.) is the main species here. Its plantations were created by acorn sowing and planting of seedlings from various geographical places. Planting was performed by different ways (in rows and holes) at mixing with various tree species (ash, elm, June berry, maple, pear tree, apple tree), using different agrotechnical and forestry measures. In the period of intensive growth (up to the age of 25 years—30 years), these trees formed dense one- or two-layer forests without grass layer with an average height of 7 m—13 m, mean diameter of 6 cm—13 cm, and total wood store of 77 m ^{3}/ha—163 m ^{3}/ha. Such great ranges in taxation characteristics are explained by different competition intensity between trees with respect to their amount, which depends on natural dying and cutting of trees. At present (when trees are about 50 years old), mean height of oak trees is 12 m—16 m at mean diameter of 15 cm—19 cm. Nevertheless, in recent years, some trees have died. Density of such forests decreases, but steppe vegetation is not regenerated. Other plants (mainly bushes) penetrate into forest communities, forming natural undergrowth canopy.

Dense undergrowth and thick ground litter are generated under oak canopy. Esculent mushrooms emerge and herbaceous species (Convallaria majalis L., Corydalis bulbosa (L.) DC., Scilla siberica Haw.) are introduced from forest-steppe oak stands. Depleted, but typical forest-fauna of dendrophilous insects, for example, bark beetles (Zeuzera pyrina L.) and soil invertebrates is created spontaneously. Earthworms (Eisenia nordenskioldi (Eisen)) are successfully acclimatized. Nesting of several bird species (Oriolus

oriolus L., Parus coeruleus L., Columba palumbus L., Falco tinnunculus L., F. Vespertinus L.) whith are not peculiar to semidesert is noticed. Typical forest mammals, hedgehods (Erinaceus europaeus L.) and mice (Apodemus uralensis Pall.) appear. There are multi-component self-regulating biogeocenoses.

Tree grove in depressions is a type of landscape most adapted to severe conditions of semidesert of the North Caspian region. In recent years, its concept has been elaborated at the Djanybek Station, and the first effoerts to develop this specific landscape, which includes the best features of forest and grass ecosystem, have been made. The proposed land -scape model includes a combination of small tree-and0bush plantations on meadow chesnut soils in mesodepressions (forest groves) wich grass vegetation on solonetzes and light chesnut soils. The possibility of creation and advantages of such landscape structure are manifested by natural Spirea communities in the Caspian region, as well as by the preserved artificial groves of State Shelter Belt, which were initially planted as dense multirow belt 60 m wide.

Forest groves provide considerable additional moistening (more than 200 mm) of the adjacent area at the expense of snow accumulation. This result is amelioration of solonetzes, on which more mesophytic south-steppe plant communities with higher projective cover, species diversity, and better floristic composition are developed. Biological productivity of this landscape is 2—2.5 times higher that of virgin soils.

The priposed stable and self-regulating system will tolerate removal of considerable amount of plant mass at grazing and haying, and tree communities will have high buffer capability to grazing. This “pastoral” landscape will be of high ecological capacity and value for cattle.

Scientific works of the Djanybek Station include comprehensive investigations of functioning of natural and artificial ecosystems of Caspian lowland and are of great importance for solving practical problems such as the increase in productivity of semidesert lands, improvement of agricultural systems, creation of landscapes favorable for life and work of people in semidesert, and ecological monitoring of the changing natural environment. These works are getting to be still more important as related to the problem of the rise of groundwater level in the region.

The results obtained are very important for predicting the behavior of plants upon the global climate warming and menace of desertification.

References

Biogeocoenotic Bases for the Development of North Caspian Semidesert. 1974, Moscow. 360 p. (in Russian)

Rode A., Polsky M. 1961. Soils of Djanybek Experimental Station: Morphology, Texture, Chemical and Physical Properties. Trudy Dokutch. Soil Inst. vol. **56**, pp. 1-214, (in Russian)

Senkevich N., Oloviannikova I. 1996. Introduction of woody plants in Northern Caspian Semidesert. Moscow. 180 p. (in Russian)

Vomperskii S., Oloviannikova I. , Bazykina G., Sapanov M., Sizemskaya M. 2000. The main results of biogeocenotic investigations and application of agroforestry practices in the Northern Caspian Semidesert. Eurasian soil science. vol. **33**, N 11. pp. 1305-1317.