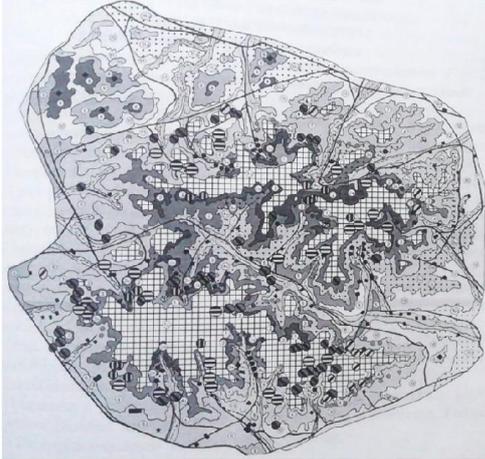


LARGE-SCALE MAPPING OF THE VEGETATION OF THE SEMIPALATINSK NUCLEAR TEST SITE AFTER UNDERGROUND NUCLEAR TESTS BASED ON THE USE OF SATELLITE IMAGES

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Within the framework of the "Ecological consequences of radioactive pollution consecutive to nuclear test performed between 1949 and 1989 in Semipalatinsk Region (Kazakhstan)" project, the vegetation of the experimental site (ETS) "Degelen" was mapped at 1:50,000 m. Vegetation mapping was carried out based on the use of satellite images (SI). SI - combined. Part of it was made by the ETM sensor from the Landsat satellite, the other part was made by the LISS sensor from the Ressoursessat satellite.

The SI shows the scale and degree of disturbance of the ecosystems of the "Degelen" ETS during the period of underground nuclear explosions.

Numerous light spots (from white to light gray) at the SI ETS "Degelen" are soil outcrops in areas not developed by plants. They are located in the southern, northern, northeastern parts of the low mountains and indicate a high level of disturbance of the ridges and slopes of the ridges.

This area is a granite lowland. During the period of nuclear testing, the crests of the main ridges and their side spurs collapsed under the repeated impact of shock waves. On the crests of the ridges, "split zones" appeared, and on their slopes - technogenic talus. The "split zones" are granite fragments of various sizes - from 0.1 to 3.0 m. Rare specimens of *Solanum dulcamara*, *Urtica urens*, *Setaria viridis*, *Artemisia frigida* are found only in rare depressions with small fragments. In depressions up to 0.7 m on fine earth, sparse groups were noted with a predominance of *Artemisia frigida*, *Festuca valesiaca*, *Agropyron cristata*. Technogenic scree consists of granite fragments 0.03-1.0 m in size. In the lower part of technogenic specimens, thickets of *Rosa spinosissima*, *R. laxa*, *Spiraea trilobata*, *Berberis sibirica*, *Ribes saxatile* are sometimes found.

On the periphery of the granite low mountains there are foothill plains and gentle plumes of hills. The foothill plains turn into soft ridges with separate domed hills. They smoothly merge with low-mountain ranges. On the tops and slopes of gently sloping hillocks, mixed herbs and shrubs (*Caragana pumila*, *C. frutex*, *Orostachys spinose*, *Sedum hybridum*) are common on stony outcrops. Grass-forb (*Gypsophila patrinii*, *Goniolimon speciosum*, *Festuca valesiaca*) cenoses are found in the woody areas. On the SI, they are highlighted in dark gray. Disturbed procenoses from *Festuca valesiaca*, *Veronica incana*, *Berteroa incana*, *Artemisia dracunculus* in these habitats are highlighted in white on the SI.

Shrub-wormwood-grass (*Stipa sareptana*, *Artemisia frigida*, *Caragana pumila*) cenoses are formed on the rubble chestnut soils of the slopes and trails of the gently sloping hillocks. On the SI, they are highlighted in gray. Disturbed procenoses dominated by *Festuca valesiaca*, *Artemisia austriaca*, *Caragana papposa* are highlighted in white.

Shrub-grass-forb (*Medicago falcate*, *Leymus ramosus*, *Spiraea hypericifolia*) cenoses are widespread on meadow-chestnut soils of depressions between hills. They are highlighted in SI in dark gray. Disturbed procenoses dominated by *Festuca valesiaca*, *Artemisia austriaca*, *Dodartia orientalis* are highlighted in SI in light gray.

On the SI, the valleys of large and small streams and natural meadows are clearly distinguished in black. In the course of contour survey of vegetation in the valleys of large streams on meadow soils, a number of cenoses were revealed: reeds (*Spartanium microcarpum*) → cattails (*Typha laxmanii*) → reeds (*Phragmites australis*) → grass-



forbs (*Thalictrum flavum*, *Potentilla virgate*, *Calamagrostis epigeios*, *Bromopsis inermis*) → forb-shrub (*Salix cinerea*, *Rosa glabricolia*, *Padus*, *Galium boreale*, *Angelica sylvestris*).

On the meadow soils of small streams, a number of cenoses were identified: hygrophytic forb (*Juncus gerardi*, *Butonus umbellatus*) → grass-forb (*Galatella biflora*, *Iris sibirica*, *Elytrigia repens*, *Leymus ramosus*) → chia (*Achnatherum splendens*) → chingil (*Halimodendron halodendron*).

On marsh, meadow and meadow-chestnut soils of natural meadows located in the northeastern part of the Degelen ETS, the following cenoses are formed: cattail-reed (*Phragmites australis*, *Thypha laxmannii*), forb-sedge (*Carex omskiana*, *Geranium divaricatum*), forb- cereals (*Alapecurus arundinaceus*, *Glycyrrhiza uralensis*, *Filipendula ulmaria*), willows (*Salix cinerea*, *S. viminalis*), hairy (*Leymus angustus*), forbs-bluegrass-fescue (*Festuca valesiaca*, *Poa angustifolia*, *Medicago falcata*).

At the ETS “Degelen” during the period of nuclear testing, 181 adits for underground explosions were built. Vegetation cover on adits near mouths is rarely partially disturbed (usually only its structure changes). More often, the vegetation dies completely due to the violation of the entire ecosystem: soils and underlying rocks. Restoration of vegetation depends on many factors: the location of a technogenic habitat in a certain altitudinal zone, the differentiation of the topography of the estuarine area, and the composition of the substrate. Single plants or sparse plant groups appear on these technogenic habitats. On SI, upon careful examination, adits can be distinguished as dark gray, gray and light gray spots.

At the mouth areas of adits located on the slopes of granite ridges, sparse plant groups are formed with the dominance of *Artemisia dracunculus*, *A. obtusifolia*, *Silene suffruticosum*, *Dianthus acicularis*, *Tumaria vaillantii*, *Chondrilla laticoronata*, *Atrophaxis frutescens*.

At the estuarine areas of adits located on the slopes of internal valleys, the species composition of procenoses is represented by *Artemisia sieversiana*, *A. dracunculus*, *Medicago falcate*, *Euphorbia humilis*, *Berteroa incana*, *Alyssum desertorum*.

On the estuarine sites located on the foothill plains, sparse plant groups are common with the dominance of *Thlaspi aevense*, *Isatis costata*, *Lactuca seriola*, *Ceratoides papposa*, *Goniolimon speciosum*, *Ceratocarpus arenarius*, *Artemisia vulgaris*.