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ANALYSIS OF SYNERGIES BETWEEN THE VEGETATION COVER AND THE INTENSITY OF OUTWASH IN MOUNTAIN CONDITIONS

Abstract. The case study of the most degraded catch land of the Southern macroslope of the Crimean mountains by the method of ecological profiling the growth of anthropogenic (man-induced) transformation of vegetation cover depending on the intensity of outwash and cleveness of slope is shown.

Key words: *outwash, vegetational cover, ecological factors.*

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АНАЛІЗ ВЗАЄМОЗВ'ЯЗКУ РОСЛИННОГО ПОКРИВУ ТА ІНТЕНСИВНОСТІ ВОДНОЇ ЕРОЗІЇ В ГІРСЬКИХ УМОВАХ

Анотація. Однією з основних причин трансформації структури рослинного покриву, зниження його стійкості та ємності в гірських умовах є розвиток водної ерозії. Дослідження взаємозв'язку «рослинний покрив-водна ерозія» ускладнене низкою причин: геоморфологічна будова водозборів є дуже мозаїчною; площа підземних водозборів не співпадають з площею поверхневих за наявності карстових сполучень різних водозбірних басейнів; гірським екосистемам характерні локальні опади; більшість рік та водотоків є зрегульованими. Реакція рослинного покриву на ерозійні явища залежить також від типу, інтенсивності та тривалості впливу процесу, що може бути виявлено перш за все на фітоценотичному рівні. Завдяки унікальним природним умовам, межуванню з Чорним морем, пересіченню кількох природних зон найбагатшим на біорізноманіття регіоном України є Південний макросхил Кримських гір. В Кримських горах ерозійно-небезпечний поверхневий стік формується під взаємозалежним впливом великої кількості екологічних чинників абіотичного, біотичного та антропогенного походження.

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В роботі представлено аналіз взаємозв'язку стану рослинного покриву та інтенсивності водної ерозії за синергетичних засад на прикладі найбільш еродованого водозбору Кримських гір. Встановлено, що стан рослинного покриву відображає інтегральний ефект взаємодії екзо- та ендогенних екологічних чинників. Досліджені середньовікові дубові ліси є низькопродуктивними, сильно ослабленими внаслідок природних умов та певного зниження природної стійкості і продуктивності у процесі 4–5 генерацій природного поновлення. Їхній стан погіршується по мірі зниження від верхньої до нижньої, прибережної частини водозбору залежно від збільшення крутизни нахилу поверхні понад 20^0. Найчутливішим індикатором інтенсивності прояву водної ерозії є трав'яний ярус. Ерозійно-деградовані ділянки є досить бідними, найбільш репрезентативними є представники родини *Poaceae*, *Caryophyllaceae*, *Asteraceae.* Встановлено, що за градієнтом ерозійної деградації поступово збільшується кількість криптофітів та терофітів. Особливістю є повна відсутність на сильно ерозійно-деградованих ділянках фанерофітів. Аналіз спектру життєвих форм рослинного покриву та типу будови пагона свідчить про наявність своєрідних морфологічних пристосувань та адаптацій рослин до постійно змінених ґрунтових умов. За екологічною стратегією встановлено збільшення частки експлерентів по мірі зростання ерозійної дигресії ґрунту.

Оцінка екологічних параметрів середовища існування видів показала, що за дії різної інтенсивності впливу водної ерозії на рослинний покрив лімітуючими екологічними чинниками є вологість та загальний сольовий режим ґрунту, при цьому характерним є поступове збільшення по мірі дигресії ґрунту кількості видів з широкою екологічною амплітудою (мезовалентні, геміевроивалентні, евривалентні). Виявлені закономірності свідчать про ерозійне та антропогенне подальше підсилення деградації цих лісових екосистем, що, в свою чергу, спричиняє зниження гідрологічної ролі лісів у водозборі, зростання інтенсивності водної ерозії ґрунту та збільшення небезпеки прояву екологічних загроз для населення, природних екосистем, суміжних земельних угідь і комунікацій.

Ключові слова: *водна ерозія, рослинний покрив, екологічні чинники.*

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АНАЛИЗ ВЗАИМОСВЯЗИ РАСТИТЕЛЬНОГО ПОКРОВА И ИНТЕНСИВНОСТИ ВОДНОЙ ЭРОЗИИ В ГОРНЫХ УСЛОВИЯХ

Аннотация. Одной из основных причин трансформации структуры растительного покрова, снижения его устойчивости и емкости является развитие водной эрозии в горных условиях. Благодаря уникальным природным условиям, пересечению нескольких природных зон самым богатым на биоразнообразие регионом Украины является Южный макросклон Крымских гор, в котором эрозионно-опасный поверхностный сток формируется под влиянием абиотических, биотических и антропогенных экологических факторов.

В роботе установлено, что исследованные средневековые дубовые леса являются низкопродуктивными, сильно ослабленными вследствие природных условий, снижения устойчивости и производительности в процессе 4–5 генераций естественного возобновления. Их состояние ухудшается по мере снижения от верхней до нижней, прибрежной части водосбора в зависимости от увеличения крутизны наклона поверхности более 20°. На эрозионно-деградированных участках наиболее репрезентативными представителями являются семейства *Poaceae, Caryophyllaceae, Asteraceae.* Установлено: увеличение количества криптофитов, терофитов и эксплерентов; полное отсутствие на деградированных участках фанерофитов. Проведенные анализы спектра жизненных форм и типа строения побега свидетельствуют о наличии своеобразных морфологических приспособлений, адаптаций растений к постоянно изменяющимся почвенным условиям. Лимитирующими экологическими факторами являются влажность и общий солевой режим почвы, характерным есть постепенное увеличение по мере дигрессии почвы количества видов с широкой экологической амплитудой (мезовалентные, гемиэвриивалентные, эвривалентные).

Ключевые слова: *водная эрозия, растительный покров, экологические факторы.*

INTRODUCTON

The Southern macroslope of the Crimean Mountains is the richest in biodiversity among the regions of Ukraine owing to unique environmental conditions, adjoining Black Sea and junction of several natural zones (Davydova, 1991; Bokov, 2009).

At the same time mountain terrain of the region are under a mighty anthropogenic influence that limits normal development of vegetation cover. As the studies testify, the underregulated anthropogenic induction has caused significant disturbance of environmental balance of catchments' ecosystems of the Southern macroslope of the Crimean mountains, increase in number, frequency and intensity of manifestations of negative ecological factors. Expansion of outwash is one of the main reasons of transformation of vegetation structure, decrease in its resistibility and capacity there. The studies of «vegetation cover-outwash» links is complicated by the following reasons: the geomorphologic structure and vegetation of catchments are rather mosaic; the area of subsurface catchments does not coincide with the area of the surface ones due to presence of karstic communications between different catchments; locally encouraged precipitation which is organic to mountain ecosystems; most rivers and water flows are regulated ones (Gorshenin, 1994; Klyukin, 2007; Wells, 2001). In the Crimean mountains the erosion hazardous run-off is being formed under the interdependent influence of a great number of ecological factors of abiotic, biotic and anthropogenic origin, among which a great role is played by the sylvan by regulating the distribution of atmospheric precipitation in time and space. The reaction of vegetation cover upon erosive phenomena depends on the type, intensity and duration of the process exposition, that can be detected both at the coenotic level – intermediate observation of the parameters of the entire coen, and at populational level, subject to control over the entirety of the coen (Egas, 2004; DeWitt,1998).

So, the aim of study was the analysis of dependence between the state of vegetation cover and the intensity of outwash at experimental plots of the Southern Coast of the Crimea.

MATERIAL AND METHODS

Depending on the anthropogenic transformation gradient at different elevations and different slope steepness in the upper, middle and lower parts of Andus river catchment in accordance to the principles of comparative ecology the ecological profile consisting of three experimental plots (EP) was founded (Tab. 1). EP1 is at the distance of 1 km off the highland plateau of Karabi-Yaila massif mass (800 m asle) in a slightly eroded zone, EP2 – on a medium eroded slope, EP3 – on a riparian heavily eroded slope that protrudes to the coastal communications line. For each stand, forest mensuration parameters were determined: weighted average diameter (D_{ave}) and height (H_{ave}), age (A), mean tree basal area (G), total number of trees (N), stand density (P), growth class (B), stand of timber (M).

Table 1

Characteristic of oak stands

№ EP	Altitude above sea-level, m	Steepness of slope α, degree	H, m	D, cm	A, years	G, m²/acr.	N, us./ acr.	P	B	M, m ³/acr.
1	400	12°	5,8	13,4	65	12,31	833	0,9	IV	160
2	200	24°	3,7	8,8	65	3,59	581	0,5	V	110
3	175	35°	3,3	7,9	60	1,14	202	0,2	V^b	90

At the EPs field studies of structural-functional elements of phytocoenosis (stand, staddle, underwood and vegetational cover) were conducted by common forestry and geobotanical methods (Anuchin, 1977; Tsiganov, 1983; Vorobev, 1967). The plants' named were identified by S. Cherepanov (Cherepanov, 1995). To appraise the diversity of species was used the scale of J. Braun-Blanquet (Braun-Blanquet, 1964). The systematic structure of the herbage was given consideration; life-forms were considered by Ch. Raunkiaer (Raunkiaer, 1934); the structure of above-ground bines, types of ecological strategies by L. Ramenskiy (Ramenskiy, 1938). The appraisal of ecological environmental attributes was made under scales of D. Tsiganov (1983): 1) climatic: thermo-climatic scale (Tm), climate continentality (Kn), ombroclimatic scale (Om), cryoclimatic scale (Cr); 2) soil: moisture (Hd), humidification frequency (Fh), nitrogen value of soils (Nt), salt regime (Tr) and acidity of soils (Rc). In order to determine the quantitative appraisal of usage of each factor under the method of L. Zhukova (2010) based on the graduations of scales by D. Tsiganov (1983), the ecological valence of each species was specified. The area of EPs was calculated with the account of steepness of the slope. The phytosanitary state of trees was appraised in accordance with the Phytosanitary Forest Regulation in Ukraine (1995). The stand state index was calculated as sum of gains in the index of trees' state for the number of trees in a certain category, divided by total quantity of examined trees. Stand with index value from the interval 1–1,5 (I) are considered healthy, the weakened ones (II) – 1,51–2,50, heavily weakened (III) – 2,51–3,50, the wilting ones (IV) – 3,51–4,50, recently dead (V) – 4,51–5,50, old dead stands (VI) – 5,51–6,50. In order to avoid the influence of irregular intensity of sylvicultural practice upon the index of stand state, for each category of states the weighted average Kraft class (WAKC) was calculated as the sum of gains of number of trees of each Kraft class to its index (I–V), divided by total number of certain category of state. For this purpose the trees of each category were subdivided into 5 more groups according to Kraft classes. Classes V^a and V^b were united into class V, since the trees of these categories were rarely found in the studied plant plots. The WAKC depicts the localization of damage zone in the tree stratum: the closer the WAKC is to Kraft class I, the higher is the degree of damage, since this evidences that the most persistent trees are influenced by negative ecological factors. The degree of damage of a territory was determined under N. Gorshenin (1994), A. Klyukin (2007).

RESULTS

The Andus river springs at the Southern slope of Karabi-Yaila massif mass in the central part of the Southern coast of the Crimea. The soils are arenose, in the upper stream adjacent there are limy chumps and break stone. Under the clay loams there is a red clayey soil thick layer. The catching is covered with dry oak and hornbeam forests of predominantly two types – very dry and dry hornbeam and oak subors. Most frequently are formed the stands of natural origin of the 4th- 5th generations with dominating of *Quércus robur* L. and *Carpinus betulus* L. In the underwood dominating are *Crataegus pojarkovae* Kossych., *Carpinus orientalis* Mill., *Rosa canina* L. It is discovered, that the main type of soil erosion on slopes over 20^o in the catchment is outwash, and erosive manifestations begin in the zone of partially degraded forests where the canopy closure is below 0.6. Only at its Eastern edge, where the slope is 30^o steep, the herbage and soil are damaged, in spots reaching the loose subsurface rock. At the same time, under a tight canopy cover the typical forest vegetation is well preserved, and there are no signs of erosion. More degraded EP2 has rather lower parameters. Stand consists of fragments, comprised of patches of vegetative renewal of *Quercus petraea* Liebl., each of 6–15 plants which differ by development and state. Erosive formations are developing, they are partially covered with turf, but in some places on cleve elements of mesorelief the rock comes to the surface (Tab. 2). Only in the places, where biogroups of *Q. petraea* Liebl*.,* are developing the growth of erosive formations has suspended. Even worse are the corresponding figures at EP3. All detected erosion gullies in the lower part of catchment are active. The erosion rate under majority of criteria at EP3 is twice higher. The ecological profile clearly shows the gradient of catchment area erosive degrading increase depending on growth of cleveness of slope. It conforms to known data on increase of potential energy of erosive processes down the slope under the influence of increase of speed and mass of direct runoff. Sylvipathological survey of the profile's vegetation has not discovered fireplaces, pests and deceases.

Table 2

Characteristic of gullies at the ecoprofile

Characteristic of ravines, transformation of EP	EP2	EP 3
Number of gullies on experimental plots, pcs.	4	2
Average depth, m	3,8±0,2	7,5±0,4
Average width, m	2,6±0,1	4,3±0,2
Average distance between the gullies, m	15,2±0,8	25,5±1,3
Average ravines length within the experimental plot, m	58,4±2,9	120, 3±6,0
Average volume of erosional forms m³/acr.	963,9±48,2	3341,7±167,1
Dissection degree of area gullies, m/acr.	7,4±0,4	2,8±0,1
Degree of transformation	middle, IV stadium	intense, II stadium

The analysis of the stand structure testifies that the biggest number of very weakened and dyeing trees was detected in EP3. The number of weakened trees decreases: 23,6 %, 13,4 %, and 7,3 %. At the same time it is noted that at EP1 and EP2 this category is represented predominantly by trees of III Kraft class, compared to the EP3 having weakened trees by 81 % consist plants of II Kraft class. Even codominants' development is more depressives at EP3. The medium eroded EP2 contains 19,1 % of wilting trees, the highly eroded one – 15,1 %. But at the last EP3 also 4 % of codominant trees are in this category (WAKC=3,0). At the same time at EP1 and EP2 the drying out pattern is close to the natural mortality: $WAKC_{EP1}$=3,4; $WAKC_{EP2}$=3,5, that is accordingly 40 % and 50 % are the trees of IV category. The representatives of V category also are represented richer on EP2 and EP3. It evidences higher intensity of stand wilt at EP2 and EP3 (Tab. 3).

Table 3

Phytosanitary structure of oak stands at the ecoprofile

№	Category												Index
	I		II		III		IV		V		VI		
	WAKC	%	WAKC	%	WAKC	%	WAKC	%	WAKC	%	WAKC	%	
1	–	–	2,9	23,6	3,0	65,5	3,4	8,0	5,0	0,5	6,1	2,4	3,11
2	–	–	3,0	13,4	3,3	64,9	3,5	19,1	4,1	1,9	5,0	0,6	3,35
3	1,0	0,31	2,2	7,3	3,2	75,7	3,0	15,1	5,0	1,4	–	–	3,12

Reaction of herb stratum upon appropriate changes of edapho-lithogenous basis is indicative. The herb stratum of the most erosion degraded MP3 is rather poor, the representatives of families *Poaceae* (46,2 %), *Caryophyllaceae* (23,1 %) та *Asteraceae* (15,4 %) which are present on all the elements of gullies. For the medium zone the most widely spread are also families *Poaceae*, *Caryophyllaceae* та *Asteraceae*. Only in the places, where biogroups of *Q. petraea* Liebl. are developed, start to appear species of other families, namely *Fabaceae, Rubiaceae, Brassicaceae* etc. Such domination of *Poaceae*, *Caryophyllaceae* and *Asteraceae* is associated with erosive formations, where the most active are processes of deformation and creep. The most florist saturation (27 species) and range of families (11) is detected in the control plot, which is typical for this forest type. Within the framework of study of interrelation between «outwash-vegetation cover» distribution of plants by life-forms system is important. Hemicryptophytes (56,3 %) dominate in phytocoenosis with mild erosive degradation, cryptophytes (21,9 %) and phanerophytes (15,6 %) are spread there. With the gradient of erosive degradation the quantity of cryptophytes and therophytes increases gradually. Maximal quantity of therophytes is characteristic for EP3 – 38,5 % (with the account of minimal species saturation) (Tab. 4).

An interesting peculiarity is complete absence of phanerophytes on highly erosion degraded plots, which is explained with a weak mechanism of adaptation of phanerophytes' generative organs to strong anthropogenic loads. So, the range of vegetation life-forms of the ecoprofile testifies the presence of original morphological fit and adaptation of plants to permanently changing soil environment.

Table 4

Biological spectrum at the ecoprofile

Life-form	EP1, %	EP2, %	EP3, %
Phanerophytes	15,6	9,1	–
Chamephytes	3,1	13,2	15,3
Hemicryptophytes	56,3	36,8	23,1
Cryptophytes	21,9	27,3	38,5
Therophytes	3,1	13,6	23,1

One of features characterizing the conditions of a habitat is the built-up of plants' surface shoots. By this criterion there is quantitative domination of species with non-rosellate pattern of surface shoot formation in the regional flora (Golubev, 1989). On medium (63,0 %) and slightly (53,9 %) eroded plots a significant place is occupied also by species with non-rosellate type. The number of species with semi-rosellate built-up of surface shoot increases by growth of erosive degrading of soils from 25,9 % (EP1) to 35,8 % (EP3). Maximal quantity of species with rosellate type is characteristic for EP3 – 16,6 %. It is explained by morphological peculiarities of adaptation of plants to dynamic soil conditions. By co-relation of ecologic & coenotical strategies of plants the increase of share of explerents by increase of soil erosive digression is detected at the ecoprofile. Thus, the number of explerents at EP2 and EP3 is almost the same (52,3–52,4 %), but at a slightly damaged plot the number of explerents comprises one-fifth (22,3 %) of total number of species. In this case the biggest quantity of violents (43,1 %) and patients (34,6 %) is naturally determined.

It is known that each organism is characterized with ecological amplitude – the range of indicator values allowing it to exist. Analysis of ecological scales that characterize climatic factors showed that the biggest number of broad valence fractions is detected at medium and heavily damaged territories. On slightly damaged territory there were not detected any species which are eurybiontic towards climatic factors. Studying the interrelation «outwash-vegetation cover» revealed that more actual appears to be the distribution of valence fractions relevant to soil factors, especially moisture and salt relations in the soil (Figs. 1, 2). As against climatic factors moisture and salt relations in the soil have narrower values ranges.

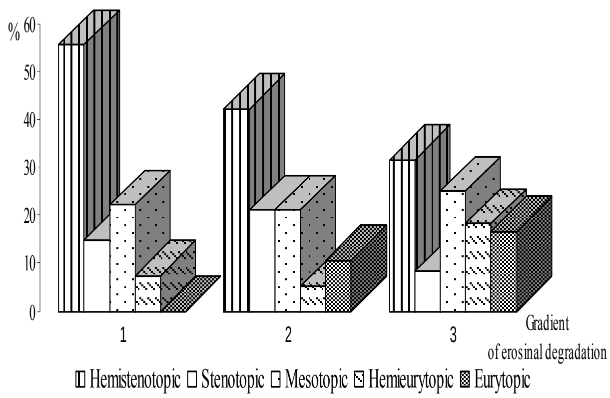

Fig. 1. **Soil moisture**

The appraisal of ecological parameters of the environment where the species exist by soil moisture testifies that stenotopic and hemistenotopic species on the slightly eroded plot comprise 70,37 %, on the medium one – 63,42 %, the heavily eroded one – 40,0 % (Fig. 1).

Such distribution of valence fractions testifies that confirmed are theoretical and experimental data on the fact that species with the least tolerance index take dominating position in constant or slightly changes habitats (Parsons, 1994). And vice versa, the increase in number of eurybiontic species by the transformation gradient testifies evidences the amplitude of eurybionts' reaction to the set moisture regime resulting from the influence of water erosion (0 %, 10,5 %, 16,7 %). Upon study of habitat conditions within the ecoprofile with common salt regime it is detected: irrespective of the level of transformation of surface soil the hemistenovalence fraction prevails in all experimental plots; the number of eurybionts increases by digression growth; almost similar on the ecoprofile is the distribution of mezovalence species (Fig. 2).

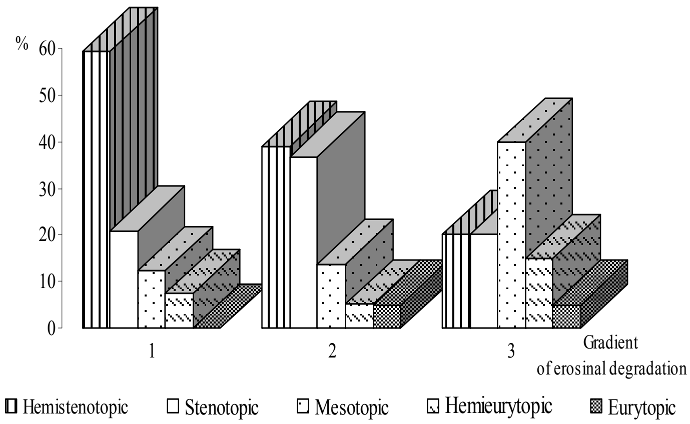

Fig. 2. **Salt regime**

In general, the appraisal of habitat conditions under common salt regime and moisture of the soil has the same trends connected with prevailing of species that have broad amplitude of fluctuations in relation to relevant edaphic factors on more degraded territories. How such dynamics of ecological parameters can be explained? We believe that the increase of stenobionts' share depending of soil moisture can occur in the result of extortion of eurybiontic species from the vegetative community through this factor, secondly – the increase of share of stenobiontic, new species which are more adapted to rich habitats. The fact that among forest species there is no adaptation to fluctuations of moisture changes may in such groups result from absence of inter-specific and intra-specific competition under this parameter following relatively steady environment conditions, that arise through depositing of moisture under the cover of layered tree vegetation and developed ground litter layer and humic layer. All this provides for stationary relatively steady conditions by soil moisture without sharp fluctuations as this inevitably happens in erosion degraded soils where a closed multilayer shoot is absent.

CONCLUSION

The analysis of vegetation cover depicts the integral effect of inter-action of exogenous and endogenous ecological factors. The anthropogenic factors shall be referred to determinant exogenous factors. The secondary ones, which are currently gaining development, are the endogenous factors of inter-specific and intra-specific competition between forest species and non-forest ones, which fill the ecological niche that has become free. The studied middle-aged oak forests are low-productive and heavily weakened. Their state is degenerating as going down from the upper to the lower parts of the catchment depending on increase of cleveness of surface on slopes. The most sensible indicator of outwash manifestations' intensity is the herbage. Most representative are the members of

Poaceae, *Caryophyllaceae and Asteraceae.* It is found that: depending on the gradient of erosion degrading the quantity of cryptophytes and therophytes is gradually increasing; complete absence of phanerophytes on heavily erosion degraded plots. The range of vegetation life-forms evidences the presence of specific morphological accommodations and adaptations of plants. By ecological strategy the increase of share of explerents by increase of soil erosive digression is detected. Subject to varied intensity of outwash influence upon the vegetation the soil moisture and salt relations are the limiting ecological factors, provided that gradual decrease of mezovalence, hemieuryvalence and euryvalence species is characteristic. The revealed regularities evidence the erosive and anthropogenic further growth of degrading of these forest ecosystems, that causes decrease in hydrological role of forests in the catchment and increase in intensity of soil erosion.

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