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Ravine denudation on hollow downslopes

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The purpose. To study state and dynamics of development of gullens upon hollow nets of slope lands in land-use of modern agricultural facilities. **Methods.** Geomorphologic analysis of maps and geodetic methods of erosion-hydrological researches on hollows. **Results.** Factors influencing the loss of land on thalweg of hollows are determined and mathematical-and-statistical model of gully erosion which determines a layer of ravine denudations is elaborated**. Conclusions.** They consider that the layer of ravine denudation most objectively characterizes parameters of ablation on the upper parts of hydrographic network.

Key words: *gullen, hollow, scour, downslope, erosion, accumulation.*

Contemporary erosion new formations (rain canals and gullies) in majority of events succeed elements of the ancient hydrographical network. In the first place ephemeral gullies or soil scours are begun in runoff concentration places, on the upper chains of hydrographical network – coombs or hollows [1, 2]. At the same time coombs form outlet ditches network on the slope lands and fulfill very important role for runoff distribution in fact. Nowadays the most of the coombs slopes are under the continual agricultural loading, therefore a threat of gully creation arises. For results of some investigators gully creation on a thalweg of a depression begins, when a rain canal will get the depth of a plough layer [3]. Big territories of Ukraine expose to gully erosion. Every year an area of eroded lands is being increased for 80 thousands ha. It does mean, that every year a coombs network is transformed into gullies of 4 thousands km [5].

Investigation purpose - research of a condition and dynamic of gully development on the coombs network of the modern agricultural enterprises territory slope lands in conditions of North steppe on the west part of the Ukraine.

Materials and methods. Process of gullies creation on coombs slopes is very difficult, therefore its study needs different methods of erosion and hydrological investigations with field and stationary survey, cartography material and cosmic prints analysis with the help GIS technology. Coombs watersheds on lands of agricultural enterprises were taken for the investments objects. There were surveys for snow melting runoff [6] and washed out and an accumulation of the soil, fulfilled along the thalweg [7, 8]. Morphometric indexes and an area under the different agricultural crops were measured on every watershed (table. 1). Process of gully denudation is long term one, therefore a study of its development was carried out by topographic and geodesy methods [9]. Cartography analysis of change in coombs relief was carried out on the base of algebraic summation its surface, corresponded to different periods of time [10].

Investigations results show that a direction of erosion and accumulation process on the coombs except hydrological indices of a runoff is stipulated by morphometric indices and agrotechnical loading degree. Acceleration and retardation of erosion processes depends on the soil surface. Until the soil on slopes is not cultivated, coombs discharge runoff safely. Watercourse surface there achieves some balance. However with intensive soil cultivation, concentrated runoff creates a rain channel on the hollow bottom to a cultivation depth, which is filled by soil particles, ploughed from adjoining slopes. Leveling process on rain channels pretend to prepare the soil particles from adjacent slopes for carrying-out in the next runoff passing. To coombs thus adjoins the rain channels net. Through them a runoff from adjoining slopes moves to coombs thalweg. Rain channels net supplements loading on a comb bottom, what can create conditions for gullies creation. Calculations of quantity indices of the soil losses on the watersheds gave possibility to obtain mathematical and statistical model of gully erosion. It has the next image:

$$Y = [0{,}052 \cdot h_c^{0.79}] \cdot [0{,}54 \cdot e^{0.017 \cdot b}][0{,}0007 \cdot \ell + 0{,}38] \cdot [0{,}82 \cdot e^{0.0015 \cdot \alpha}] \cdot [0{,}59 \cdot k_e + 0{,}70]\ [1{,}04 \cdot k_\rho + 1{,}23];$$

$$R = 0{,}87 \pm 0{,}13; \qquad \partial e \qquad (29)$$

Y – layer of gully denudation, mm

h_c – layer of a snow melting runoff, mm

b - basis of erosion, m

ℓ - length of runoff line along the thalweg, m

α – azimuth of runoff line along the thalweg, degree

k_e – coefficient of erosion danger [11]

k_ρ – coefficient of a hollow bottom stability (relation of a soil mass, accumulated in the bottom of a hollow to the mass, removed outside a watershed).

Required indicator of the model is the layer of gully denudation. This value was obtained as a removed soil volume, modified to the whole hollow area. That indicator depend from runoff layer, as the main runoff creating factor, the basis of erosion, runoff lines length, which increase the layer of gully denudation (fig. 1). Influence of a slope exposition we expressed through the azimuth of the line of runoff. Results shows, that as a whole, with a passage from the slopes of the North exposition to slopes of the South exposition gully denudation soils loss increases. Coefficient of erosion danger describes the soil susceptibility to erosion under different agrotechnical loading. This is a value, reciprocal one to a coefficient of the soil conservation effect [11]. Hollow bottom stability coefficient shows hollow bottom security from the outwash. It can be specified at design of runoff dispersers on a hollow. For the model a calculating nomogram was constructed (fig. 2). The model gives possibility to define a layer of the gully denudation on coombs, but there comes into existence a question about acceptable soil losses from the gully erosion. Nowadays nobody gave well-defined answer to the question in fact. For the territory of the European part of Russia a gully threat scale was composed, it includes four gradations: dangerous, moderately dangerous, a little dangerous and insignificantly dangerous. Maximum gullies density for gradation “a little dangerous” is 0.5 km/km^2. From the data of V.D. Ivanov and E.B. Kuznetsova [13] corrugated slopes have the biggest risk of a line erosion development, therefore they represent an estimation of gully creation threat as a slopes corrugation in three gradations: weak, middle and strong. I.P. Kovalchuk [14] in his investigations in conditions of the West “Podillya” picked out four erosion dangerous regions, which need fulfillment of protection from a gully erosion measures. Immediately density of gullies network there varies from 0.7 to 1.7 km/km^2 with the line increase approximately from 0.5 to 10.8 m/km^2. Thereby majority of investigators estimate a degree of gully erosion development by indices of line

Table 1. Indices of gully denudation on coombs

Watershed number	Investigations year	Area, ha	Length along the thalweg, m	Basis of erosion, m	Runoff line azimuth, degree.	Agrotechnical background	Erosion threat coefficient of agrotechnical background	Stability bottom coefficient	Runoff layer from a watershed, mm	Gully denudation layer, mm
Experimental farm of Soils and agrochemistry Institute after O.N.Sokolovskiy object “Stukalova gully”										
1	2004	13.60	930	45	175.5	W.w, plowing	0.70	0.12	27.00	1.15
2	2004	22.73	1040	43.7	168.0	W.w, plowing	0.68	0.22	21.00	0.89
3	2004	14.54	790	44.0	173.5	W.w, plowing	0.65	0.33	36.42	0.81
4	2004	12.31	850	35.0	165.0	W.w, plowing	0.77	0.04	15.73	0.63
5	2004	8.36	480	31.2	160.0	W.w	0.40	0.15	18.09	0.43
1	2006	13.60	930	45	175.5	P.gr., plowing	0.31	0.37	35.0	0.82
2	2006	22.73	1040	43.7	168.0	P.gr., plowing	0.31	0.22	3.00	0.15
3	2006	14.54	790	44.0	173.5	P.gr., plowing	0.25	0.21	21.00	0.50
4	2006	12.31	850	35.0	165.0	P.gr.	0.10	0.30	2.00	0.06
Experimental field “Selectionist”										
1	2010	13.69	639	25.0	24.0	W.w, plowing	0.39	0.29	4.00	0.11
2	2010	22.29	994	40.0	20.5	plowing	0.65	0.23	8.83	0.20
3	2010	3.02	308	12.5	18.5	plowing	0.60	0.18	1.20	0.08

Comment: W.w. – Winter wheat, – P.gr – perennial grasses.

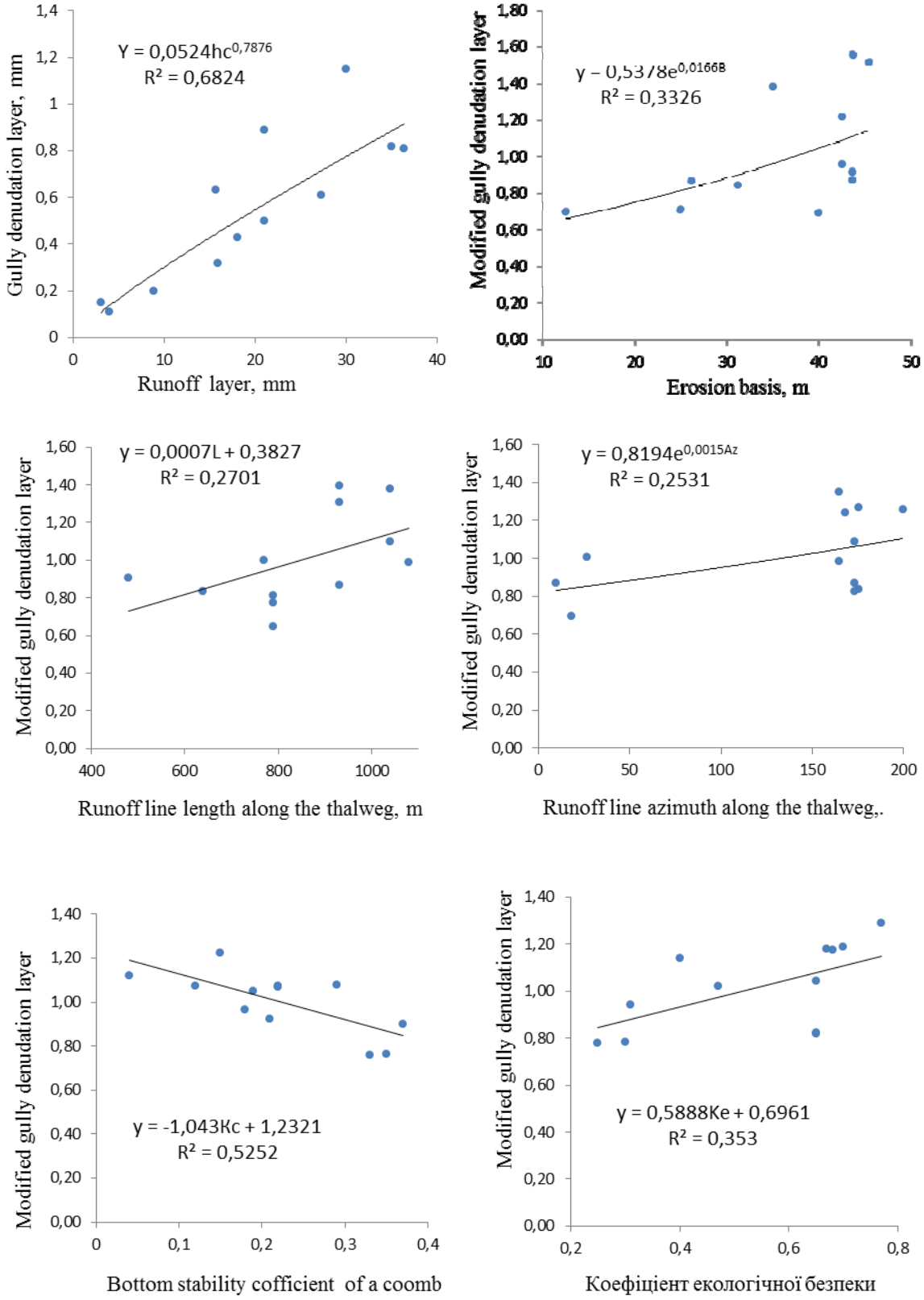

Fig. 1 Different factors influence on the gully denudation layer

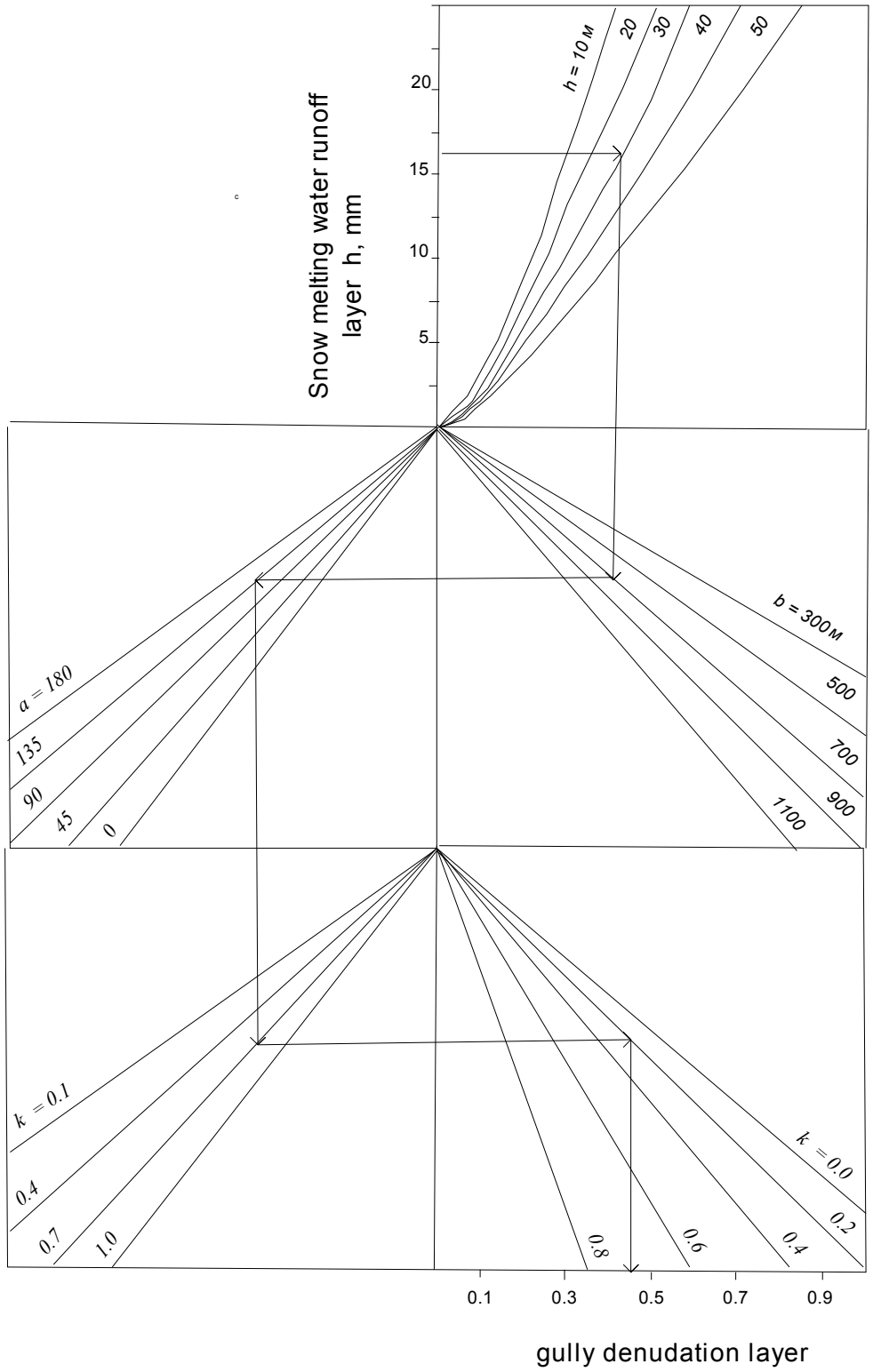

Fig. 2 Calculation nomogram of gully denudation layer definition

⟶ key for gully denudation definition

increase of gullies or its density in agrolandscapes. For our opinion, gully denudation volume must be equal to an acceptable soil outwash volume from its watershed. According to the recommended standards [11] for acceptable soil outwash from snow melting water we consider 2 t/ha. In average, this value equal 0.2 mm layer. By increasing of this rate the outwash, concentrated along thalweg will create an accretion, which will be transformed in a gully progressively.

Conclusions

Investigations results allowed establish main influence factors on the soil outwash on upper parts of a hydrographical network and develop gully erosion model on the level of agrofirms. The model could be used for gully denudation layer definition. We consider, the obtained index most objectively characterizes indices of soil outwash on coombs and allows more optimally define soil conservation measures composition.

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