ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1992 z. 398, 155-161

# INFLUENCE OF SOIL UTILIZATION ON THE CHANGES IN SOIL PROPERTIES AND EVOLUTION

*S. Uziak, Z. Klimowicz*

Department of Soil Science, Maria Curie-Skłodowska University,
Akademicka 19, 20-033 Lublin, Poland

A b s t r a c t. The studies were conducted in various parts of the Lublin Upland on the soils formed from loess and loess-like formations as well as from limestone. The greatest and the quickest changes in the soil cover and typology are caused by erosion resulting from the changes of forest soils into cultivated soils. Several cycles of soil development in the undulating terrain are presented in relation to the intensity of erosion, mother rock, and original soil. Forest soils are not prone to undergo transformations. Cultivation going on for several hundreds years causes slow changes, mainly in some of the chemical soil properties (e.g., in the fractional humus contents, soil reaction, the contents of available K and P). A probable soil cover that existed 500-600 years ago, and the cover expected in several hundreds years have also been presented.

## INTRODUCTION

Only Schroeder's paper [10] deals with the changes of soil properties under the influence of many-year, differentiated cultivation (forest, agricultural). The few works that are available concern only relatively short periods of time [1,2,4,6,7,9]. Whereas many other papers deal with the influence of terrain relief and cultivation on erosion and their influence on the soil properties [3,5,8,11,12].

Hence the present study has been undertaken in order to establish changes in the properties of the chosen soils and to determine the rate and direction that the soil transformation take, i.e., evolution of the soil under the influence of many-year, differentiated cultivation on undulating terrain. A further task that has been undertaken was an attempt towards the reconstruction of the former soil cover at the chosen sites and determination of the expected most probable soil cover in a chosen period of time.

## TERRAIN AND METHODS

The present study was conducted at 10 chosen sites in the Wyżyna Lubelska (Lublin Upland) on the soils formed from loess and loess-like formations and lime rocks. The chosen soils represented the soils typical for that region, i.e., grey-brown podzolic soils, brown soils, chernozems, and rendzinas.

At each of the study sites, cultivated soils with differentiated but known cultivation periods, and, for the sake of comparison, nearby forest soils were studied. From the cultivated soils the following were chosen: soils cultivated for 40-50 yrs, for 70-100 yrs, 150-200 yrs, about 300 yrs, 400 yrs, and 500 yrs, as well as 550-600 yrs. The history of the land cultivation was recovered from various maps, and from the archives. Because of the considerable deforestation of the Lublin Upland and because of the changes in the soil cover resulting from water erosion as well as the lack of suitable maps the choice posed many problems.

The method of soil levelling section was chosen because of the configuration of the terrain and water erosion. It should be clearly stressed that in the topographically differentiated terrain it is difficult to differentiate between the influence of the period of agricultural utilization and the influence of erosion on the changes of soil characteristics in practice. A few sections were made at each of the chosen sites (of the cultivated soils) and one section of the forest soil cover. A total of 58 section were made in different regions.

Samples for laboratory studies were taken from a number of profiles; they complemented field investigations. Laboratory studies were conducted according to methods commonly used in Polish laboratories.

The results of laboratory studies were presented in tables and graphs. They take into consideration time periods of agricultural utilization of the studied soils and terrain inclinations. To present the tendencies and directions of soil transformations mean values were calculated, and generalized pictures were drawn.

The actual image of the soil cover at the studied sites was worked out on the basis of sections and accessory soil pits. It also presented probable soil cover that existed 500-600 yrs ago, and the cover expected in several hundred years.

In the present work, in which the results of a 5-year long study period are presented only a few graphs and figures are enclosed (Figs 1-5) to illustrate the results. A more comprehensive presentation of the results can be found in another paper that is being prepared for publication at the moment.

## RESULTS AND CONCLUSIONS

The results of the study on the changes in the soil properties under the influence of many-year, differentiated utilization conducted in the period 1986-1990 in the Lublin Upland on the soils originating from loess and loess-like formations as well as lime rocks may be generally summarized in the following way.

1. Soil cover under forest is typologically little differentiated. It was also like that 500-600 years ago.

2. The changes in the character of soil utilization, i.e., forest soils into agriculturally used soils, caused water erosion and in turn considerable changes in the soil cover, and what follows, typology, especially in the first years (up to 50 years).

3. Transformations of the cultivated soils (under the influence of erosion) depend on the intensity of erosion, the type of mother rock and original soil. Some transformation cycles may be distinguished. For example grey-brown podzolic loess soils may be transformed into brown soils (artificial), into deluvial soils or even into soils at the initial stage of development; grey-brown podzolic loess-like soils on limestone change into brown soils (artificial), rendzinas and into deluvial soils; degraded chernozems are transformed into brown soils, pararendzinas, and deluvial soils.

4. The influence of the many-year agricultural use was relatively slow and concerned mainly chemical soil properties.

5. The soil cover expected in 500-600 years' time will be similar to the contemporary one. This may be concluded on the basis of the rate of changes taking place in the arable soil.

6. In case of forest soils the influence of the relief on the soil morphology and especially on the soil thickness $A_1$ is hardly visible. But it is very prominent in case of cultivated loess soils and loess-like formations. In rendzinas the above changes are much slower.

7. An intensive denudation of the surface soil layer, especially when the terrain inclination is above 18 %, takes place mainly in the first tens of years after cultivation has been started and it gets smaller in time. The thickness of the deluvial horizon increases most rapidly when the inclination is from 6

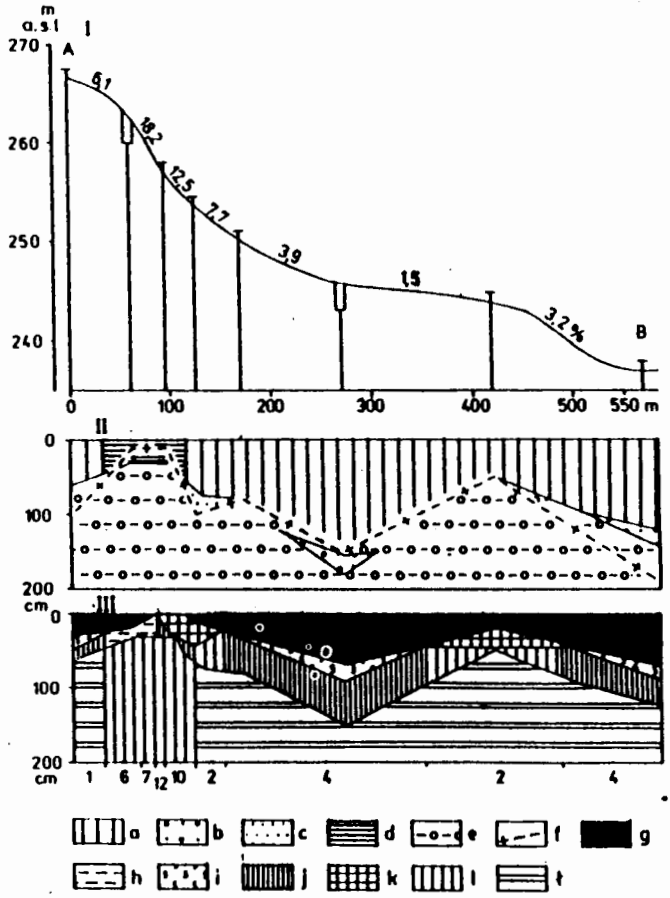


**Fig. 1.** Rudnik C(A-B) section. I - levelling section, II - geological section, III - pedological section; a- silt loam, b - loam, c - sand, d - clay, e - limestone, f - depth of decalcification, g - humus horizon $A_1$ and deluvial horizon $A_{de}$, h - transitional horizon $A_1C$, i - lessivage horizon $A_3$, j - transitional horizon BC, k - browned horizon (B), l - parent rock C, ł - underlying material D; 1, 6, 7...- soil units to enclosed maps in Fig.2.

to 12 %, then it gradually decreases (with the increase of inclination).

8. In the eroded soils denudation is selective in its character. It is different in silty soils than in rendzinas. In the former the contents of the silty fractions increase with the length of cultivation period (most intensive at the foot of the hill). Whereas the contents of fine fraction (<0.02 mm) and colloidal fractions decrease. In case of rendzinas the increase of the <0.02 mm particles and <0.002 mm particles (though to a lesser degree) is clearly most visible on the slope and then at the foot of the hill.

9. The contents of organic carbon in the soils under cultivation decreases significantly in relation to forest soils. Further changes-slight impoverishment of silty soil - take place mainly in the top layer. Actually, no changes occur on the slope (in the soils cultivated for more than 40 years). In case of the foot of the hill, a slight increase of the studied component was observed. In rendzinas, especially on the slope and at the hill foot, the contents of organic C increases with the cultivation period.

10. The content of humus stronger and permanently bound to the mineral part of the soil is the lowest in forest soils. In the soils cultivated for a short period of time (up to 50 yrs) its contents clearly increase,

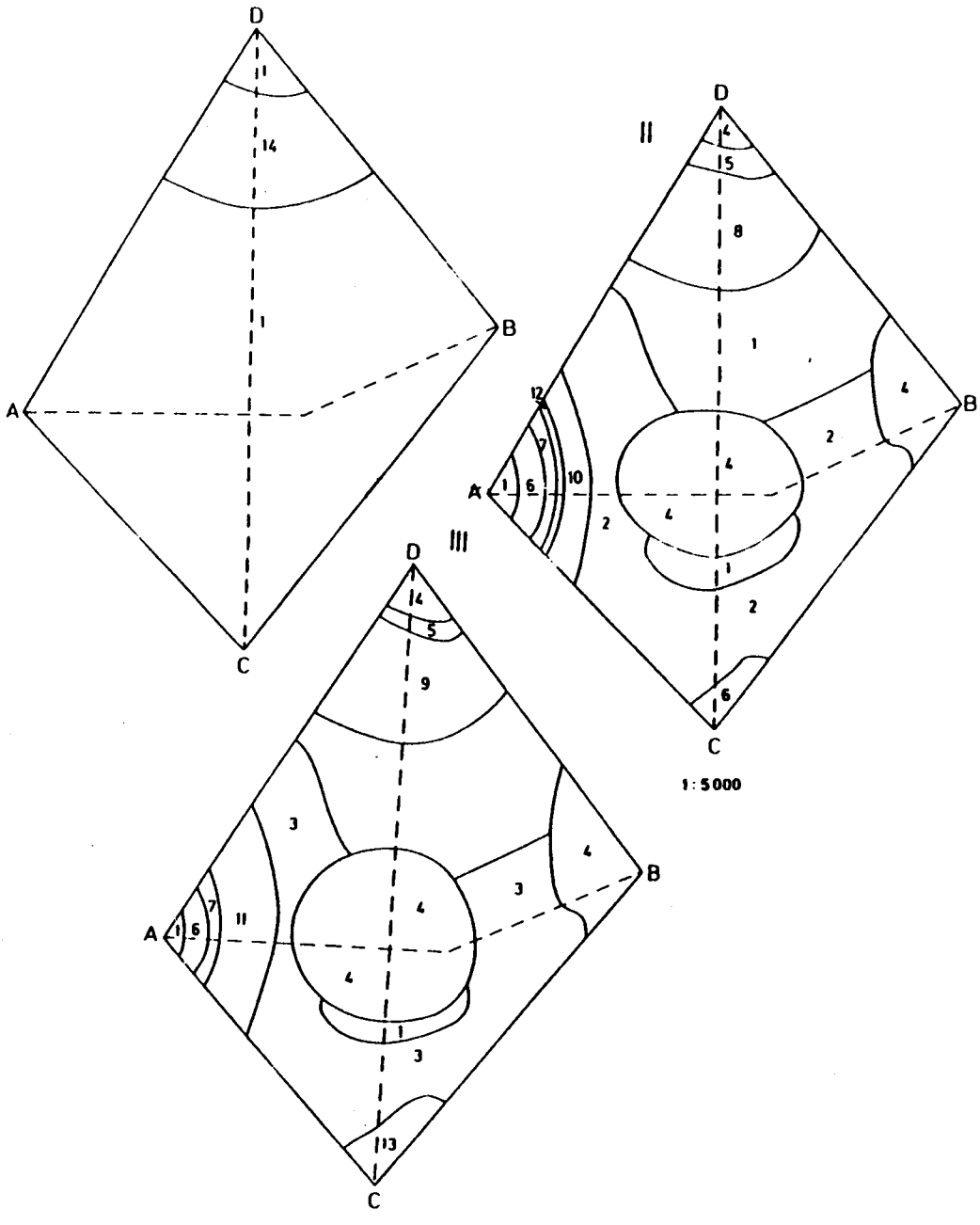


**Fig.2.** Soil cover of Rudnik object (C). I - probable 500 years ago, II - at present, III - expected in 500 years. Soils developed of loess-like formations: 1- grey-brown podzolic soils, 2- typical brown soils, 3- typical brown soils weekly eroded, 4- deluvial soils (grey-brown podzolic soils-continually accumulated), 5- soils of undefined typology. Soils developed of limestone: 6- typical rendzinas, 7- eroded rendzinas (typical to initial). 8- brown rendzinas, 9- eroded brown rendzinas (weekly or intensively), 10- brown rendzinas intensively eroded, 11- brown rendzinas intensively eroded and initial rendzinas, 12- initial rendzinas, 13- complex of typical and brown rendzinas. Soils developed of loess-like and limestone formations: 14- complex of brown soils and rendzinas.A-B,C-D- lines of sections.

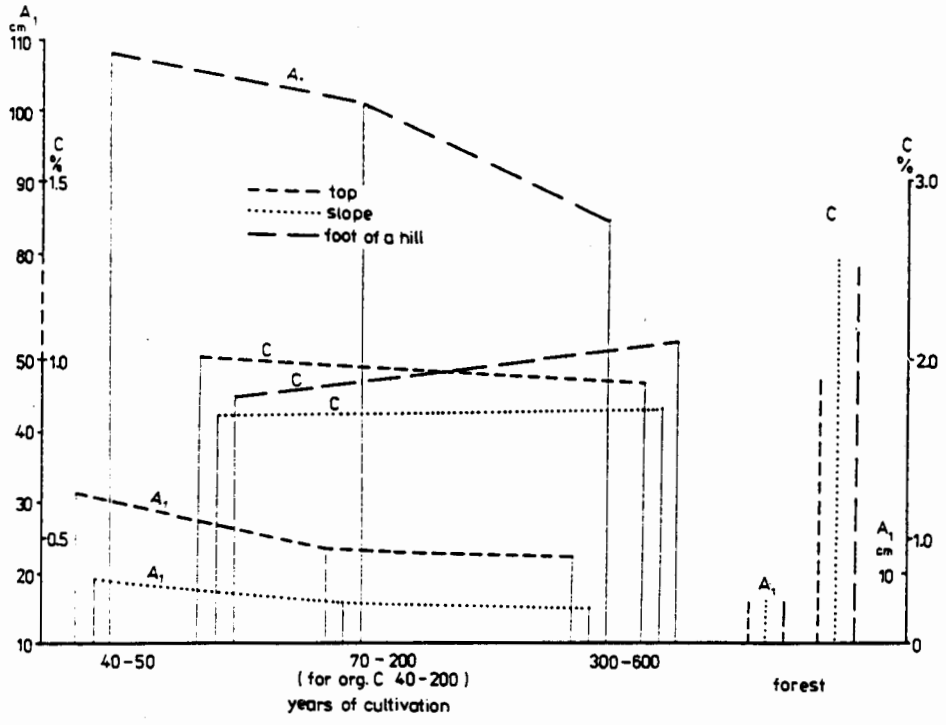


**Fig. 3.** Thickness of humus horizon (A1) and content of organic matter (C) in cultivated silty soils depending on the age of cultivation and the relief of terrain.

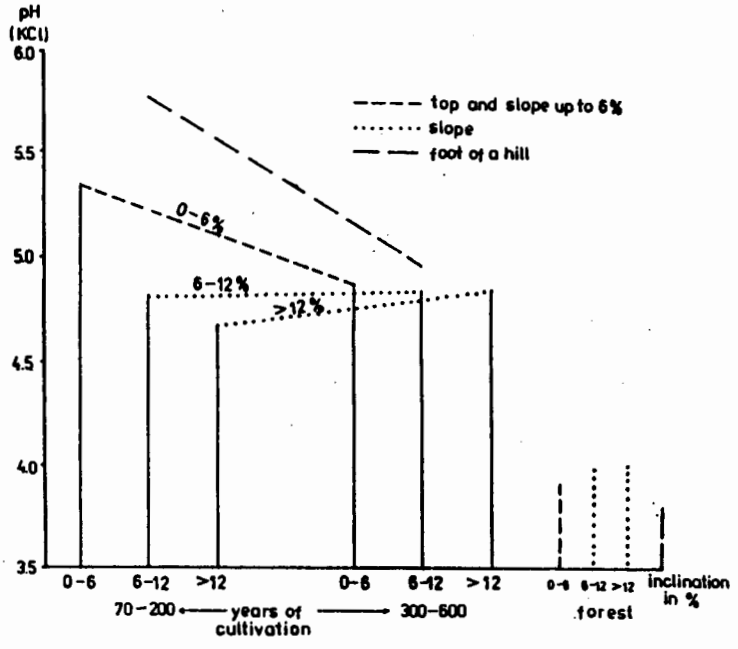


**Fig. 4.** Influence of cultivation age and slope inclination on silty soil reaction (pH KCl).

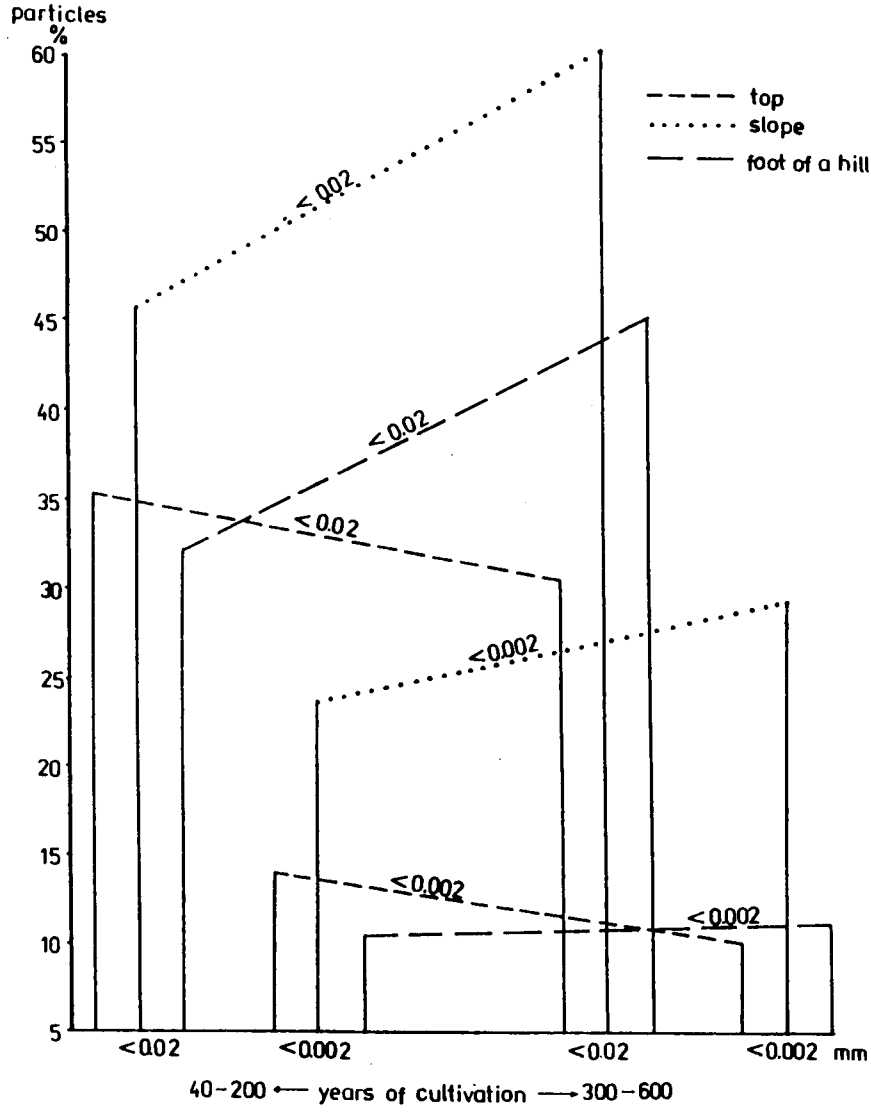


Fig. 5. Changes of content of particles <0.02 and <0.002 mm in rendzinas depending on the age of cultivation and relief of terrain.

whereas in the soils cultivated for a longer period of time the increase is slight.

11. The total amount of humic acids in cultivated soils is considerably higher than in forest soils. The contents of humic acids, usually high in the soils cultivated for less than 50 years, clearly decreases in favour of fulvic acids in the soils cultivated for longer periods of time.

12. The contents of total N follows a similar pattern to humus.

13. The mean pH value in the surface layers decreases in time, especially at the foot of the hill, and at the top. On the slopes with the inclination of 6-12 % it practically does not change with the cultivation time, but on the slopes where inclination is more than 12 %, it slightly increases (carbonates are closer to the surface as a result of erosion).

14. The longer the cultivation time the less available phosphorus remains in the

soils (in all the relief formations). The P contents correlate well with the contents of <0.02 mm particles.

15. The contents of available K increase in silty soils with the increasing cultivation time. It is especially true of the foot. Whereas, in the case of slopes with an inclination of more than 12 %, decreasing amounts of this component are observed. The increase in the amount of available potassium accompanies the increase in the contents of the silty fraction.

16. Though in practice it was not possible to distinguish the influence of many-year cultivation from the influence of erosion on the soil evolution in undulating terrain, it was nevertheless possible to establish the direction and rate of changes.

The agricultural utilization of soils practiced up to now has been leading to soil degradation in Poland. In the case of soils originating from silt formations, it means gradual acidification and decrease of the contents of available components, especially the contents of phosphorus.

## REFERENCES


1. **Bac S.**: Przyczynek do badań nad zmianą położenia powierzchni ornych gruntów lessowych. Rocz. Nauk Roln., 19, 463-499, 1928.
2. **Borowiec J.**: Wpływ wylesienia i użytkowania rolniczego na morfologię i właściwości czarnoziemu w terenie urzeźbionym. Ann.UMCS, s.E, 21, 83-103, 1967.
3. **Dobrzański B.**: Z badań wpływu erozji wodnej na ewolucję czarnoziemu. Wiad. IMUZ, 1, 4, 27-47, 1960.
4. **Van Doren D.U., Moldenhauer W.C., Triplett G.B.**: Influence of long-term tillage and crop rotation on water erosion. Soil Sci. Soc. Am. J., 48, 636-640, 1984.
5. **Gliński J.,Turski R.**: Rozwój procesów erozji gleb w zależności od sposobów zagospodarowania oraz uprawy mechanicznej i ich wpływ na kształtowanie pokrywy glebowej. Zesz. Probl. Post. Nauk Roln., 177, 47-71, 1976.
6. **Hlibowicki R.**: Przemieszczanie gleb i kształt pól uprawnych. Rocz. Nauk Rol., F, 71, 89-110, 1955.
7. **De Jong E., Kachanoski R.G.**: The importance of erosion in the carbon balance of prairie soils. Can. J. Soil Sci., 68, 111-119, 1988.
8. **Mazur Z., Pałys S.**: Wpływ erozji wodnej na morfologię i zmienność pokrywy glebowej terenów lessowych. Zesz. Probl. Post. Nauk Roln., 292, 21-37, 1985.
9. **Norton L.D.**: Erosion-sedimentation in a closed drainage basin in northwest Indiana. Soil Sci. Soc. Am. J., 50, 209-213, 1986.
10. **Schroeder D.**: Untersuchungen über Verwitterung und Bodenbildung an Lössprofilen. Habilitationsschrift, Hannover, 1954.
11. **Turski R.**: Substancja organiczna gleb terenów erodowanych. Rocz. Glebozn., 22, 19-57, 1971.
12. **Uziak S.**: Wpływ rzeźby terenu na typologiczne zróżnicowanie pokrywy glebowej w Karpatach fliszowych. Rocz. Glebozn., 20, 81-97, 1969.


## WPŁYW UŻYTKOWANIA GLEB NA ZMIANY ICH WŁAŚCIWOŚCI I EWOLUCJĘ

Badania przeprowadzono w różnych regionach Wyżyny Lubelskiej na glebach wytworzonych z lessów i utworów lessowatych oraz ze skał wapiennych. Największe i najszybsze zmiany w pokrywie glebowej i w typologii powoduje erozja w wyniku zamiany gleb leśnych na uprawne. Podano też kilka cyklów rozwojowych gleb w terenie falistym, zależnie od natężenia erozji, skały macierzystej i gleby wyjściowej. Gleby leśne są bardzo mało podatne na zmiany w czasie. Kilkusetletnia uprawa rolna wywołuje zmiany powolne, głównie niektórych właściwości chemicznych gleb (np. w składzie frakcjonarnym próchnicy, odczynie, zawartości przyswajalnego fosforu i potasu). Przedstawiono też prawdopodobną pokrywę glebową przed 500-600 laty a także przewidywaną za kilkaset lat.