NATURAL AFFORESTATION OF AGRICULTURAL LAND IN UKRAINE

Mykola Malashevskyi[1], Olena Malashevska[2], Olena Kishchak[3], Yuriy Kishchak[3]
[1]Land Management Institute of the National Academy of Agrarian Sciences of Ukraine, Ukraine;
[2]National University of Life and Environmental Sciences of Ukraine, Ukraine;
[3]Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine, Ukraine
mykola.malashevskyi@gmail.com, olenamalashevska@gmail.com, cherry0308@ukr.net, fruitechdept@gmail.com

Abstract. The issue of agriculture on naturally afforested land is in the focus of the study. The analysis of the change of preconditions for agricultural activities on the naturally afforested land masses is the aim of the research. Evaluation of the forest cover and changed spatial characteristics of such land masses is the basis for decision making at land management. The forest cover development analysis in the timespan of 20 years was carried out. Due to partial agricultural land mass afforestation, it is impossible to cultivate some areas of agricultural land; the configuration of land plots is altered, interspersed areas, broken boundaries, and cutting in are developed. Such an alteration of spatial characteristics of agricultural land masses leads to impaired effectiveness of agriculture. The main ways of resolving the issue of naturally afforested agricultural land have been examined. Keeping the natural forest cover is predefined by the legislation of Ukraine, however, it was established, that the decision on transferring the naturally afforested land to forest fund needs to be addressed additionally. Three topics are examined: forest cover, i.e. features of the young forest; determination of the area subject to alteration of the designated use; the influence of the altered spatial characteristics on the effectiveness of agriculture, i.e. the length of furrows, no-load runs and turns due to broken boundaries, interspersions, etc. The method can be introduced into multifunctional land consolidation projects. It was approbated in Chernihiv Region, Ukraine. The method allows to develop the agricultural and forest land masses of optimal configuration, and facilitate the decision making on the practicability of transferring the naturally afforested land plots to forest land with the least possible inconvenience for cultivation of agricultural land masses.

Keywords: land management, agricultural land, natural afforestation, abandoned land.

Introduction

Natural afforestation is one of the issues of agricultural land; the management of such land should consider the sustainable development of territories, especially with the global environmental change [1]. The naturally afforested land masses are actually agricultural land, however, it is impossible to conduct agricultural activities on such land without rehabilitation. This issue is typical for Ukraine, its resolving facilitates the food security and nature conservation [2].

It is reasonable to single out a number of trends of exploring such territories. First of all, natural afforestation of agricultural land leads to loss of crops and increased costs of cultivation [3]. Due to partial agricultural land mass afforestation, it is impossible to cultivate some areas of agricultural land; the configuration of land plots is altered, interspersed areas, broken boundaries, and cutting in are developed. Such an alteration of spatial characteristics of agricultural land masses leads to impaired effectiveness of agriculture.

On the other hand, naturally afforested land could be considered over the course of nature rehabilitation after logging [4]. In this context, it is reasonable to pay attention to the issue of increasing the cropland at the expense of forests [5]. Often, the precondition for afforestation is abandonment of agricultural land [6; 7] or improper cultivation.

The main ways of resolving the issue of naturally afforested agricultural land are the following: clearance (logging), providing the status of forest (alteration of designated use by landowners), and reallotment over the course of land consolidation [2].

The issue of the identification of naturally afforested agricultural land is one of the most important [8; 9]. According to the legislation of Ukraine, a land plot is considered a naturally afforested one, if the landowner (manager of state and communal land) considers it to be a naturally afforested land plot, and these data is registered in the State Land Cadastre [10]. It is predefined that such a land plot should have the area of more than 5000 m^2 and be partially or fully covered with forest cover, which developed in a natural way [10]. Keeping the natural afforestation is predefined by the legislation of Ukraine, however, the legislation in effect is not enough to substantiate the transition of naturally afforested agricultural land to forest land.

The working hypothesis is, to increase the effectiveness of the management of naturally afforested agricultural land technical data should be defined, which can allow to evaluate the practicability of transition of the naturally afforested agricultural land to forest land. It is suggested to address the characteristics of young forest, as well as the alteration of spatial characteristics of agricultural land masses as the result of transfer of parts of agricultural land masses to naturally afforested forest land.

The analysis of the change of preconditions for agricultural activities on the naturally afforested land masses is the aim of the research.

Materials and methods

Natural afforestation in Ukraine is mostly due to that the land bordering on forest, afforested ravines or forest belts were not cultivated for a protracted period of time (Fig.1). This situation is typical for the period of land relations reforming [2; 11].

Fig. 1. **Retrospective analysis of agricultural land afforestation, Chernihiv Region, Ukraine Source: created by the authors using the Google Earth Pro 7.3.4 software**

As we can see from Fig.1, land masses I-III were subject to afforestation to a different extent. To identify a land plot as a naturally afforested one, it is suggested to examine three constituents: forest cover, i.e. features of the young forest; determination of the area subject to alteration of the designated use; the influence of the altered spatial characteristics on the effectiveness of agriculture, i.e. the length of furrows, no-load runs and turns due to broken boundaries, interspersions, etc. It is not enough to state the existence of natural afforestation for the formation of sustainable forest and agricultural land tenure, it is necessary to ensure the optimal spatial characteristics of land plots as the result of reallotment.

According to the determination of forest [12], it is suggested to consider a land plot to be afforested, when it is covered with wood and shrub vegetation, and the top branches of young trees evenly cover at least 40 per cent of the land plot.

The study focuses on that, the natural afforestation of agricultural land leads to impossibility to use the land, and to the alteration of its spatial characteristics.

Results and discussion

A number of factors may be used for the analysis of spatial characteristics. The dependence of the machinery productivity from the furrow length is characterized by the furrow use coefficient K_{fu} and no-load run percentage fx [13]:

$$K_{\text{fu}} = \frac{Lp}{Lp + Lx}, \tag{1}$$

$$fx = \frac{Lp \times 100}{Lp + Lx}, \tag{2}$$

where Lp – furrow length, m;
Lx – length of no-load runs for one work run, m.

Losses on no-load turns and runs (V_L) can be calculated from the working length of the furrow (L) (Fig. 2).

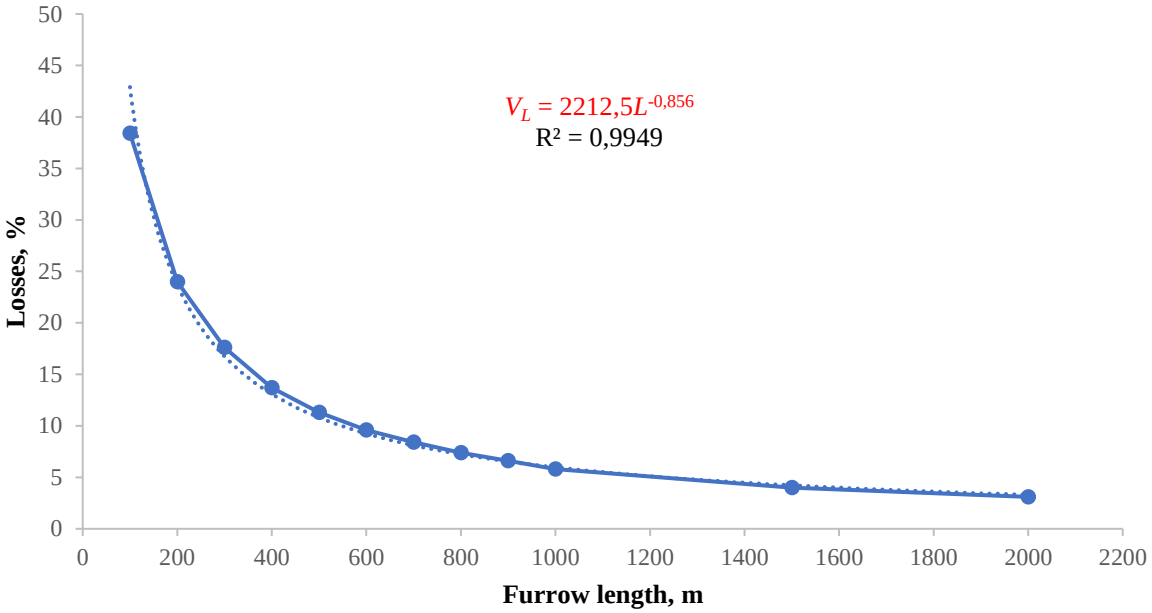

Fig. 2. **Correspondence of losses on no-load runs and turns from the furrow length**

For land plots with form other than rectangular, the length of furrow is defined by formula:

$$L_p = \frac{S}{W}, \tag{3}$$

where S – field area, m^2;
W – calculated conditional field width:

$$W = \frac{3H + c + d}{5}, \tag{4}$$

where H – height of the land plot geometric figure, m;
c, d – length of tapered sides of trapezoid (for land plots of irregular shape – lengths of lines, not parallel to the cultivation direction).

In general case:

$$L_p = \frac{5S}{3H + c + d}. \tag{5}$$

Idle turn losses depend on the furrow length, as well as the agricultural machinery type and the ratio of work in direct and transverse directions.

When there is no parallel and perpendicular sides, residual triangles are developed, which are either not cultivated, or improperly cultivated, which leads to impaired productivity. The calculation of residual triangles (Fig. 3) depending on the least furrow length and the angle, opposite to the direction, can be calculated by formula:

$$S_t = \frac{L^2 ctg\alpha}{2}, \tag{6}$$

where S_t – residual triangle area, m^2;
L – least furrow length at cultivation, m;
α – angle, opposite to the cultivation direction.

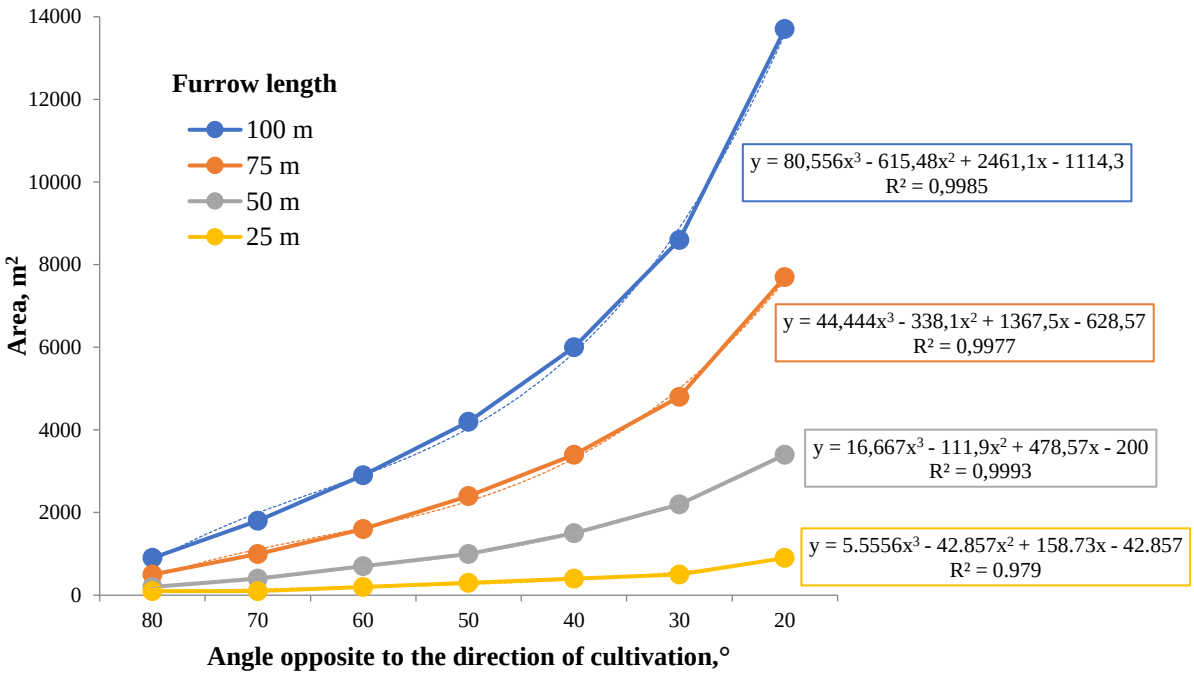

Fig. 3. **Residual triangle area depending on the angle opposite to the direction of cultivation**

Then losses on impaired cultivation of residual triangles are calculated by formula:

$$V_t = S_t V_{cr} Y , \quad (7)$$

where V_t – cost of the impaired residual triangles, UAH;
S_t – area of residual triangle, m^2;
V_{cr} – crop selling price, UAH·centner^{-1};
Y – crop yield, centner·m^{-2}.

The analysis allows to characterize the selected agricultural land masses (Fig. 1) at the formation of natural afforestation (Table 1).

Table 1

Spatial characteristics of the selected land masses before and after afforestation

Characteristics		Land mass		
		I	II	III
Afforestation, %	2003	0.17	6.17	0.03
	2023	91.25	33.68	4.73
	Change, %	+ 91.08	+ 27.51	+ 4.70
Arable land area, m^2	2003	701,446.15	1,520,512.76	651,775.86
	2023	450,44.00	1,074,288.76	578,297.02
	Change, %	-93.58	-29.35	-11.27
Mean furrow length, m	2003	1397.28	1510.25	744.01
	2023	513.94	1114.93	618.99
	Change, m	-883.34	-395.32	-125.02
Residual triangle area, m^2	2003	298.70	485.39	336.04
	2023	126.62	938.77	350.26
	Change, m^2	-172.08	+ 453.38	+ 14.22

Based on the selected factors, it is reasonable to transfer the land mass I to forest land fully, for masses II and III – transfer of parts of land mass with the area of 446,224 m^2 and 73,479 m^2 respectively is reasonable.

The results may be used for the substantiation of land reallotment aiming at the formation of sustainable land tenure in Ukraine [14], they uphold the studies on the impact of land plot configuration and placement on the effectiveness of economic activities [15]. The presented criteria may be used to supplement the methods of afforested land identification [8], and for multifunctional land consolidation [16].

Conclusions

The study corroborates the significant impact of natural afforestation on agricultural activities. At the management of naturally afforested agricultural land, it is suggested to analyse three main constituents: forest cover, i.e. features of the young forest; determination of the area subject to alteration of the designated use; the influence of the altered spatial characteristics on the effectiveness of agriculture, i.e. the length of furrow, no-load runs and turns due to broken boundaries, interspersions, etc.

It is reasonable to use the factors, singled out in the study, for the formation of agricultural and forest land masses of optimal configuration, and at the decision making on the practicability of transferring the naturally afforested land plots to forest land with the least impact on agricultural land cultivation.

Author contributions

Conceptualization, M.M. and O.M.; methodology, M.M. and O.M.; software, M.M.; validation, M.M. and O.K.; formal analysis, O.M. and J.K.; investigation, M.M., O.M., O.K.and Y.K.; data curation, O.M.; writing – original draft preparation O.M. and Y.K..; writing – review and editing, M.M. and O.K.; visualization, M.M. and O.M.; project administration, M.M. All authors have read and agreed to the published version of the manuscript.

References

[1] Talukdar S., Eibek K. U., Akhter S., Ziaul S., Islam A., Mallick J. Modeling fragmentation probability of land-use and land-cover using the bagging, random forest and random subspace in the Teesta River Basin, Bangladesh. Ecological Indicators, vol. 125, 2021, pp. 1-16.

[2] Malashevskyi M., Kishchak O., Malashevska O., Kishchak, Y. Land Consolidation and Its Effects on Afforested Agricultural Land: A Case Study of Ukraine. Sustainability, vol. 17(4), 2025, pp. 1517. DOI: 10.3390/su17041517

[3] Gniadek J., Pijanowski J.M., Śmigielski M. Impact of the forest succession on efficiency of the arable land production. Journal of Water and Land Development, vol. 34, 2017, pp. 131-138. DOI: 10.1515/jwld-2017-0046

[4] Ustaoglu E., Collier M.J. Farmland abandonment in Europe: An overview of drivers, consequences, and assessment of the sustainability implications. Environmental Reviews, vol. 26, 2018, pp. 396-416.

[5] Garay C. Permissive Regulations and Forest Protection. Studies in Comparative International Development, vol. 59, 2024, pp. 313-352.

[6] Cukor J., Vacek Zd., Linda R., Sharma R., Vacek,S. Afforested farmland vs. forestland: Effects of bark stripping by Cervus elaphus and climate on production potential and structure of Picea abies forests. PLOS ONE, vol. 14(8), 2019, e0221082. DOI: 10.1371/journal.pone.0221082

[7] Queiroz C., Beilin R., Folke C., Lindborg R. Farmland abandonment: Threat or opportunity for biodiversity conservation? A global review. Frontiers in Ecology and the Environment, vol. 12, 2014, pp. 288-296.

[8] Janus J., Bożek P., Mitka B., Taszakowski J., Doroż A. Long-term forest cover and height changes on abandoned agricultural land: An assessment based on historical stereometric images and airborne laser scanning data. Ecological Indicators, vol. 120, 2021. DOI: 10.1016/j.ecolind.2020.106904

[9] Łukaszewicz J., Krajewski S. Reconstruction of forest areas on post−agricultural land in selected forest districts of State Forests in Poland based on archival maps. Sylwan, vol. 166, 2023, pp. 777-795.

[10] The Land Code of Ukraine. [online] [07.02.2025]. Available at: https://zakon.rada.gov.ua/laws/show/2768-14?lang = en#Text

[11] Malashevskyi M., Palamar A., Malanchuk M., Bugaienko O. The possibilities of sustainable land use formation in Ukraine. Geodesy and Cartography, vol. 46(2), 2020, pp. 83-88.
[12] Закон України «Про Державний земельний кадастр» (The Law of Ukraine "On the State Land Cadastre"). (In Ukrainian). [online] [01.02.2025]. Available at: https://zakon.rada.gov.ua/laws/show/en/3613-17?lang = uk#Text
[13] Методичні рекомендації щодо розроблення проектів землеустрою, що забезпечують еколого-економічне обґрунтування сівозміни та впорядкування угідь (Methodological recommendations for the development of land management projects that provide ecological and economic justification for crop rotation and land improvement). (In Ukrainian). [online] [01.02.2025]. Available at: https://zakon.rada.gov.ua/rada/show/v0396821-13#Text
[14] Malashevskyi M., Malashevska O. The aims and trends of the sustainable land tenure formation in Ukraine: The spatial aspect. Geodesy and Cartography, vol. 47(3), 2021, pp. 131-138.
[15] Ptacek M., Frick F., Stetter C., Wimmer S., Pahl H., Sauer J. 'ShapeCostTUM': A calculation tool for field geometry dependent cultivation and transport costs. Computers and Electronics in Agriculture, vol. 225, 2024. DOI: 10.1016/j.compag.2024.109254.
[16] Liu Y., Dai L., Long H. Theories and practices of comprehensive land consolidation in promoting multifunctional land use. Habitat International, vol. 142, 2023, 102964. DOI: 10.1016/j.habitatint.2023.102964.