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ECONOMIC ANALYSIS OF DEFORESTATION IMPACT ON THE YIELD OF AGRICULTURAL CULTURES IN UKRAINE

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Abstract

The role of forests in shaping sustainable use of nature is crucial. One of the main factors in regulating the effects of global warming is the positive impact of forest plantations in the formation of climatic conditions on adjacent agricultural land. The main purpose of our study was to investigate the impact of deforestation on crop yields in Ukraine on the basis of the correlation method, and to outline the economic consequences of such interaction. Deforestation leads to a deterioration of the microclimatic conditions of agricultural production, farmers have to increase the rate of fertilizer application, to solve the problem of optimizing the water regime of the soil, which ultimately has the effect of increasing the cost of growing crops. Based on the calculations, it was proved that crop yields increase with decreasing forest cover (R = 0.58 – 0.61), the reason for this being an increase in fertilizer application volumes (R = 0.72).

Key words: *analysis, deforestation, forest land, correlation coefficient. agricultural cultures*

INTRODUCTION

The role of forests in shaping sustainable use of nature is crucial. One of the main factors in regulating the effects of global warming is the positive impact of forest plantations in the formation of climatic conditions on adjacent agricultural land. Most effectively, forests affect the temperature, wind, precipitation and sunshine of large areas, as noted S. H. Sinitsyn, A. A. Molchanov, B. I. Hroshev, L. B. Zdanevych, L. T. Krushev, A. V. Malynovs′kyy, I. S. Matyuk, V. M. Pavlovo, E. S. Pavlovs′kyy, N. V. Khramov, M. H. Chervonyy, V. I. Yunov [11, p. 17 – 18]. Forest plantations offset temperature fluctuations, significantly reducing their maximum and minimum values. Also, by shading trees near agricultural land, the temperature of the soil surface decreases during the period of maximum insolation in the summer. Due to this "preserving" effect of the forest on the surrounding land, the heat loss during the night period is reduced, which in turn prevents the occurrence of frosts. According to scientists, the temperature at the soil surface near the forest lands decreases by 2 - 2.5 times in relation to the temperature regime in open fields.

Due to the fact that forests influence the formation of a favorable temperature regime for crops, collective of scientists S. E. Scott, S. A. Monks, D. V. Spreklen, S. R. Arnold, P. M. Forster, A. Rap and others [10], on a global scale, there was a direct correlation between an increase in the amount of deforestation and a decrease in crop yields.

At the same time, the destruction of large tracts of forests that regulate the climatic conditions and the water regime of the vast pools, as noted H. I. Vorobyov, K. D. Mukhamedshyn, L. M. Devyatkyn [15, p. 6], breaks the ecological balance established for millions of years, which in turn leads to the perpetual devastation of floods, mudslides, water erosion processes, dust storms, droughts or wetlands, depending on the specific climatic conditions and nature of the tree vegetation.

That is why the main task of our research is to establish a mathematical link between

deforestation and crop yields in the context of Ukraine's food security.

MATERIALS AND METHODS

The main purpose of our study was to investigate the impact of deforestation on crop yields in Ukraine on the basis of the correlation method, and to outline the economic consequences of such interaction. [4, 7]. According to the State Statistics Service of Ukraine, we have determined the productivity of agricultural crops for the period 2001 – 2017 [12] (Table 1).

Table 1. The dynamics of crop yields in Ukraine

Years	Crop yields, centners per 1 ha of harvested area				
	Cereal and leguminous crops (X_1)	Factory sugar beet (X_2)	Sunflower (X_3)	Potato (X_4)	Vegetable crops (X_5)
2001	27.3	189.0	12.0	104.0	124.0
2002	18.2	201.0	11.2	116.0	139.0
2003	28.3	238.0	8.9	133.0	149.0
2004	26.0	248.0	12.8	128.0	157.0
2005	24.1	285.0	13.6	133.0	171.0
2006	21.8	294.0	12.2	131.0	152.0
2007	34.6	356.0	15.3	139.0	174.0
2008	29.8	315.0	15.2	139.0	183.0
2009	26.9	279.0	15.0	132.0	174.0
2010	37.0	363.0	18.4	168.0	195.0
2011	31.2	411.0	16.5	161.0	199.0
2012	39.9	399.0	21.7	160.0	200.0
2013	43.7	477.0	19.4	176.0	208.0
2014	41.1	436.0	21.6	161.0	206.0
2015	46.1	482.0	22.4	166.0	211.0
2016	42.5	475.0	20.2	168.0	208.0
2017	47.4	509.0	23.0	171.0	214.0

Source: generated by the authors on the basis of data from [12].

Table 2. Results of correlation analysis between yield and decrease of wood cover according to the data Forest Global Watch in Ukraine (R)

	Loss of wood cover in Ukraine - Forest Global Watch (Y)	Crop yields				
		Cereal and leguminous crops (X_1)	Factory sugar beet (X_2)	Sunflower (X_3)	Potato (X_4)	Vegetable crops (X_5)
Y		**0.58**	**0.64**	**0.56**	**0.57**	**0.61**
X_1			0.91	0.91	0.87	0.86
X_2				0.92	0.94	0.95
X_3					0.86	0.92
X_4						0.96

Source: own calculations on the basis of data from [3, 12].

Using the correlation method of economic and mathematical analysis, we compared data of the dynamics of crop yields with the loss of wood cover in Ukraine determined by the data Forest Global Watch (Y – performance indicator) (Table 2).

In this table there are calculated the correlation coefficients between the resultant indicator (loss of wood cover) and the factors that depend on it (crop yield).

RESULTS AND DISCUSSIONS

The results of the calculations indicate a direct correlation between the resultant index (Y) and the determinants ($X_1 – X_5$) – crop yields. That is, with increasing losses of the tree cover increases the yield, although scientific developments of scientists, regarding the dependence of the yield of agricultural crops on the forested territory indicate the opposite [2].

The reasons for this are the increase in the rates of application of mineral fertilizers, due to changes in the microclimatic conditions of cultivation of crops due to deforestation, scientific substantiation of such statements is given in the relevant scientific works [1, 5, 6, 8, 9, 13].

In particular, due to the change of water, temperature and air conditions in adjacent agricultural land, the efficiency of fertilizer application is always higher than in open areas. [8].

Taking into account research of I. P. Mamchenkov [8, p. 13], namely, that when fertilizers are applied the conditions of plant growth are improved, however, the doses of their application must correspond to the fertility of the soil and the soil moisture reserves. Often, when overgrowth under the influence of high temperatures and lack of moisture in the soil dramatically reduces the yield and oilseeds.

The effect of mineral fertilizers on crop yields depends on soil moisture and heat - lack of moisture in the root layer causes an increase in the concentration of soil solution, resulting in mineral fertilizers becoming ineffective or

even negatively affect the yield, according to M. M. Myloserdova [8].

Thus, with a decrease in wind speed, uniform distribution of snow in the fields and a significant reduction of runoff of meltwater in protected forest plantations during the growing season, a special microclimate is formed, which affects soil microorganisms that process mineral fertilizers into suitable fertilizers for suitable fertilizers [14]. Therefore, the introduction of mineral fertilizers into the soil in fields protected by forest plantations significantly increases the crop yield, as opposed to the application of fertilizers in open areas, which confirms the results of research O. V. Albensky [1], M. M. Miloserdov [8], V. I. Koptev [6], A. A. Lyshenko [6], V. O. Kargov [5], E. S. Pavlovsky [9, p. 78] and others.

Instead, we have made the appropriate mathematical calculations that confirm the actual dependence of the increase in rates of application of mineral fertilizers as the area of losses of wood cover in Ukraine determined by the data Forest Global Watch (R = 0,72) (Table 3).

Table 3. The calculation of the dependence between the reduction of wood cover and the volume of mineral fertilizers in Ukraine

Year	**Loss of wood cover in Ukraine according to Forest Global Watch, thousand hectares**	**The total amount of mineral fertilizers made in Ukraine, 1,000 tons N, P_2O_5 and K_2O**
2017	87.7	2,028.1
2016	110.0	1,728.9
2015	49.8	1,415.0
2014	47.9	1,471.7
2013	38.4	1,493.8
2012	56.2	1,346.6
2011	60.8	1,266.9
2010	52.7	1,064.2
2009	48.8	889.6
2008	55.0	1,068.5
2007	64.9	899.8
2006	42.7	702.0
2005	37.0	560.5
2004	50.1	521.2
2003	39.4	381.6
2002	27.6	401.7
2001	29.2	403.9
Correlation coefficient calculation (R)		
	Loss of wood cover in Ukraine according to Forest Global Watch, thousand hectares	The total amount of mineral fertilizers made in Ukraine, 1,000 tons N, P_2O_5 and K_2O
Loss of wood cover in Ukraine according to Forest Global Watch, thousand hectares	1.00	
The total amount of mineral fertilizers made in Ukraine, 1,000 tons N, P_2O_5 and K_2O	**0.72**	1.00

Source: own calculations on the basis of data from [3, 12, 14].

Due to the fact that the loss of wood cover increases the volume of fertilizer application we have developed a corresponding regression equation, the coefficient of determination of which is 0.52 (formula 1):

$$Y = 105.89 + 17.64x \quad (1)$$

Y = volume of fertilizer application for crop cultivation;

X = the area of loss of wood cover is determined by data Forest Global Watch.

Such circumstances directly affect the increase in average prices of agricultural products sold by agricultural enterprises, for consumers as evidenced by the calculation data presented in Tables 4 and 5.

Table 4. Data matrix of wood cover reduction in Ukraine according to Forest Global Watch data and average prices of agricultural products (2001 – 2017)

Loss of wood cover in Ukraine according to Forest Global Watch, thousand hectares	Average prices of sold agricultural products by agricultural enterprises, UAH / ton								
	Cereal and leguminous crops, UAH / ton	Oilseeds, UAH / t	Factory sugar beet, UAH / ton	Potatoes, UAH / ton	Vegetable crops, UAH / ton	Fruits and berries, UAH / ton	Farm animals (live weight), UAH / ton	Milk, UAH / ton	Eggs, UAH per thousand
Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
29.2	381.3	779.6	139.1	449.8	748.9	575.8	4,175.5	603.7	210.0
27.6	312.5	850.3	128.1	555.8	864.8	509.6	3,644.0	541.0	168.1
39.4	535.1	873.7	140.3	623.3	1,012.7	434.0	3,480.7	696.9	193.2
50.1	453.1	1,153.4	135.7	530.4	1,225.0	740.1	5,092.7	835.3	238.3
37.0	417.8	981.5	177.0	685.2	1,462.1	987.8	6,909.9	1,126.9	251.8
42.7	515.2	1,007.5	186.0	1,070.3	1,547.4	1,446.1	6,307.7	1,070.2	192.7
64.9	833.5	1,866.8	157.6	1,032.0	1,995.4	1,528.4	6,466.5	1,660.6	274.4
55.0	778.6	1,734.6	218.9	1,154.3	2,059.9	1,877.4	10,184.3	2,065.1	377.4
48.8	799.0	2,086.2	409.9	1,298.6	1,790.0	1,892.4	10,362.9	1,888.8	403.9
52.7	1,120.9	2,942.6	478.5	2,131.0	2,551.6	2,419.8	10,797.1	2,938.7	470.6
60.8	1,374.2	3,312.0	516.0	2,032.8	2,139.1	3,175.9	11,967.2	3,041.6	521.5
56.2	1,547.1	3,584.0	426.8	1,139.6	1,956.6	2,707.1	13,456.9	2,662.2	627.0
38.4	1,299.8	3,087.5	397.8	1,860.9	2,354.0	3,010.8	12,901.3	3,364.0	656.7
47.9	1,801.4	4,062.8	494.2	2,173.6	2,514.3	2,429.1	15,736.9	3,588.4	782.4
49.8	2,912.1	7,531.5	788.6	2,436.3	3,903.4	5,894.5	21,966.2	4,347.3	1,333.2
110.0	3,414.0	8,656.1	848.6	2,631.8	3,924.2	5,863.8	22,468.0	5,461.8	1,108.7
87.7	3,771.6	9,132.0	825.3	3,296.3	4,136.1	8,766.6	31,838.4	7,234.0	1,145.9

Source: generated by the authors on the basis of data from [3, 13].

Table 5. Calculation of the mathematical dependence between the reduction of wood cover in Ukraine and the average prices of agricultural products (correlation coefficients)

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Y		0.78	0.78	0.72	0.69	0.76	0.74	0.74	0.76	0.63
X_1			1.00	0.95	0.91	0.95	0.97	0.97	0.97	0.96
X_2				0.96	0.91	0.96	0.97	0.97	0.96	0.96
X_3					0.94	0.94	0.93	0.94	0.94	0.95
X_4						0.94	0.92	0.93	0.96	0.89
X_5							0.94	0.95	0.95	0.94
X_6								0.98	0.97	0.92
X_7									0.99	0.94
X_8										0.92

Source: own calculations on the basis of data from [3, 13].

In fact, we have found that the loss of wood cover in Ukraine affects the increase in average prices of agricultural products sold by agricultural enterprises, correlation coefficients vary from 0.63 to 0.78 on the respective crops.

CONCLUSIONS

Thus, according to the results of our study, the direct impact of forest lands on crop yields can be argued.

Deforestation leads to a deterioration of the microclimatic conditions of agricultural production, farmers have to increase the rate of fertilizer application, to solve the problem of optimizing the water regime of the soil, which ultimately has the effect of increasing the cost of growing crops.

Based on the calculations, it was proved that crop yields increase with decreasing forest cover (R = 0.58 – 0.61), the reason for this being an increase in fertilizer application volumes (R = 0.72).

The proposed regression model depending on the volume of mineral fertilizers for growing crops on the area of tree cover losses - according to Forest Global Watch, will be useful for agricultural professionals. The application of this model will allow us to predict the likely additional costs of growing crops in the event of deforestation in the region.

Such additional costs affect the health of agricultural products. Therefore, on the basis of economic and mathematical analysis, we have determined that deforestation ultimately affects the increase in average prices of agricultural products (R = 0.63 – 0.78), which is a negative economic factor for the population.

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