4. ЗАХИСТ ЛІСІВ І МИСЛИВСЬКЕ ГОСПОДАРСТВО

**Forestry Academy of Sciences
of Ukraine**

UDC 630.4

GIS-based prediction of the foliage browsing insects' outbreaks in the pine stands of the SE "Kreminske FHE"

V.L. Meshkova[1], O.I. Borysenko[2]

To improve the detection and prevention of foliage browsing insects' outbreaks it is very important to reveal the forest plots, which are the most favorable for these pests.

The aim of this research was to predict using GIS technologies the spatial dynamics of foliage browsing insects' outbreaks in the pine stands of the State Enterprise "Kreminske FHE" (Luhansk region).

Forest inventory databases of Production Association "Ukrderzhlisproekt" were analyzed for the SE "Kreminske FHE" as of 2001 and 2011. Rating of forest plots preferences for common pine sawfly (Diprion pini L.) and European pine sawfly (Neodiprion sertifer Geoffr.) considered the type of forest site conditions, age of stand, density of stocking, and the part of pine in the stand composition. If forest plot bordered with clear-cut, then 1 point was added to the general score of the threat.

It was shown, that the area with high threat of European pine sawfly and common pine sawfly outbreaks for 2001–2011 increased in the forest fund of the SE "Kreminske FHE" by 702.8 and 2004.2 hectares respectively. The part of foci area made up 27.5 and 32 % from forest fund area, 42.5 % and 49.5 % from pine stands area for European pine sawfly and common pine sawfly respectively.

The areas of pine sawflies foci increased mainly in result of decrease the stocking density of pine stands and increase the number of plots which border with clear-cuts.

The survey for pine sawflies is recommended to carry out first of all in the plots with high threat of foci appearance.

Key words: *foliage browsing insects, common pine sawfly (Diprion pini L.), European pine sawfly (Neodiprion sertifer Geoffr.), forest inventory, insect preferences to forest plots, risk assessment, density of stocking, forest site conditions, land category of neighboring plots, GIS-based risk rating of forest insect outbreak.*

[1] *Valentyna L. Meshkova* – full member of Forestry Academy of Sciences of Ukraine, Doctor habil. (agricultural sciences), professor, Ukrainian Research Institute of Forestry & Forest Melioration named after G. M. Vysotsky. Pushkinska str., 86, Kharkiv, 61024, Ukraine. Tel.: +38(097)371-94-58. E-mail: Valentynameshkova@gmail.com

[2] *Oleksandr I. Borysenko* – researcher, Ukrainian Research Institute of Forestry & Forest Melioration named after G. M. Vysotsky. Pushkinska str., 86, Kharkiv, 61024, Ukraine. Tel.: +38-066-888-83-49. E-mail: xalekter@gmail.com

Introduction. Mass propagation of foliage browsing insects (outbreaks) is one of the most important causes of forest weakening (Behmer et al., 2012, Branco et al., 2016, Isaev et al., 2015, Kollberg et al., 2013, Liebhold et al., 2008, Morin & Liebhold, 2015). Much attention was devoted to revealing the regularities of spatial & temporal population dynamics of such pests (Allstadt et al., 2013, Berggren et al., 2009, Bjorkman et al., 2011, Peltonen et al., 2002, Pimental et al., 2017) as well as their outbreaks prediction, especially under climate change (Haynes et al., 2012, 2014, Logan et al., 2003, Neuvonen & Viiri, 2017). It was shown that outbreaks of foliage browsing insects develop synchronously in different regions and forest plots (Haynes et al., 2013, Liebhold et al., 2004), first of all in the regions and plots, where ecological conditions are little favorable for forest (Meshkova & Kolienkina, 2016, Nevalainen et al., 2015).

To improve the detection and prevention of outbreaks development it is very important to know precisely the plots, which are the most favorable for foliage browsing insects. Methodical approach for evaluation of individual plots preferences for the most spread foliage browsing insects was developed by Meshkova (2009) and tested in Kharkiv (Meshkova, 2006a, 2006b), Kherson, Luhansk (Meshkova & Kolienkina, 2016) and Zhytomyr regions of Ukraine (Andreieva, 2009).

According to this approach, a rating of forest plots preferences for the main species of foliage browsing insects was carried out considering the type of forest site conditions, age of stand, density of stocking, and the part of pine in the stand composition. Then total score of points and threat risk is calculated for each forest plot taking into account forest inventory database. The plots with maximal threat of foliage browsing insects' outbreaks are recommended for high priority field inspection, and total area of such plots in the forest stand corresponds to the potential area of certain pest focus in the years of its outbreak.

In different countries GIS-approach is widely used for evaluation of forest damage by different causes, including insects, together with remote sensing and aerial survey (Bone et al., 2013, Rullan-Silva et al., 2013, Senf et al., 2017).

The maps of forest stands are plotted and connected with geographic coordinates and forest inventory database in Ukrainian Research Institute of Forestry & Forest Melioration (URIFFM). Additional fields can be attached with characteristics of certain insect pests' preferences, abundance, and forest damage by wind, fire etc. (Polupan et al., 2011). Such approach gives the possibility not only to reveal the foci, but also to predict the trends in their development in time and space (Grodzki, 2005, Meshkova, 2006a, 2006b). However, the possibility of change the land category of neighboring plots was not taken into account. It is known (Meshkova, 2009), that the risk of foliage browsing insects outbreaks increases, if forested neighboring plots are converted to clear-cuts, burnt area, roads or another categories of the lands, which are not covered with forest. Influence of land category change on spread of foliage browsing insects' foci can be taken in to account with the help of

GIS applications. A similar approach was developed for assessment the level of fire threat (Polupan et al., 2011) and gave the possibility to build respective thematic maps, to obtain the lists of forest plots with high fire risk and respective area, to plan the necessary preventive measures, as well as to improve the algorithm for optimal mobility of vehicles in the case of forest fires.

The using of GIS approaches gives the possibility also to improve the prediction of foliage browsing insects spread for the cases of change the forest age, species composition or stocking density (Meshkova & Kolienkina, 2016).

The State Enterprise "Kreminske Forest & Hunting Economy" (SE "Kreminske FHE", Luhansk region) was selected as model object, because of high severity, frequency and duration of foliage browsing insects outbreaks there, which strengthens by climate aridity (annual precipitation 492 mm per year, annual air temperature 8 °C) and high anthropogenic loading (Meshkova & Kolienkina, 2016).

At the beginning of XXI century the area of foliage browsing insects foci and outbreak duration increased, and intervals between outbreaks decreased, particularly from 12 to 7 years for common pine sawfly (Diprion pini L.) and from 7 to 5 years for European pine sawfly (Neodiprion sertifer Geoffr.) (Meshkova & Kolienkina, 2016).

The aim of this research was to predict using GIS technologies the spatial dynamics of foliage browsing insects' outbreaks in the pine stands of the State Enterprise "Kreminske FHE".

Objects and methods. Forest inventory Databases of Production Association "Ukrderzhlisproekt" were analyzed for the SE "Kreminske FHE" as of 2001 and 2011. These databases were converted into Access and Excel tables using applications developed in URIFFM.

The foci of two foliage browsing insects of pine stands – common pine sawfly (Diprion pini L.) and European pine sawfly (Neodiprion sertifer Geoffr.) were analyzed as the most spread forest pests in the region (Meshkova & Kolienkina, 2016).

The threat of pine sawflies spread in the pine forests of SE "Kreminske FHE" was evaluated using approach of Meshkova (2009). According to it each plot in the database was scored by the type of forest site condition, part of pine (Pinus sylvestris L.) in the forest composition, stand age, density of stocking, and then total score and threat level were evaluated. For all plots with the absence of pine the threat was evaluated as "0 points".

In the second scenario of evaluation the threat of pine sawflies spread, the neighboring plots were taken into account. Using QGIS 2.18, the spatial query was formed with the fulfillment of the predicates of neighborhood, affiliation and adjoining. So if forest plot bordered with clear-cut, then 1 point was added to the general score of the threat.

Thus total area with the threat of pine sawflies outbreaks was evaluated for forest fund of the SE "Kreminske FHE" by three levels: low, moderate and high. Thematic maps on common pine sawfly and European pine sawfly foci distribution were built using QGIS 2.18 for

the whole territory of forest fund. Here we show only the maps for Serebryanske forestry by the variants:

– as of 2001 without considering land category of neighboring plots;

– as of 2001 with considering the land category of neighboring plots;

– as of 2011 without considering land category of neighboring plots;

– as of 2011 with considering the land category of neighboring plots.

Results and discussion. Data analysis shows that the area of forest stands in the SE "Kreminske FHE" increased from 41401.5 hectares in 2001 to 41503.8 hectares in 2011. The area of pine stands increased from 26340.4 to 26827.8 hectares, and the part of pine

stands in forest fund increased from 63.6 to 64.6 % (Table 1). According to this, the area of stands available for pine sawflies outbreaks increased.

The area of stands with high threat for European pine sawfly outbreak increased from 10701.7 hectares in 2001 to 11404.5 hectares in 2011 (by 702.8 hectares), and that for common pine sawfly increased from 11266.5 hectares in 2001 to 13270.7 hectares in 2011 (by 2004.2 hectares). The part of European pine sawfly foci area from forest fund area increased for this period from 25.8 to 27.5 %, and the part of common pine sawfly foci area – from 27.2 to 32 %. The part of European pine sawfly foci area from pine stands area increased from 40.6 to 42.5 %, and the part of common pine sawfly foci area – from 42.8 to 49.5 % (see Table 1).

Table 1

Predicted area with the highest threat of spread the pine sawflies outbreaks in SE "Kreminske FHE"

Indices	Foci area (hectares) or its part (%)			
	European pine sawfly		Common pine sawfly	
	evaluated by forest inventory of:			
	2001	2011	2001	2011
Area of forest fund, hectares	41401.5	41503.8	41401.5	41503.8
Area of pine stands, hectares	26340.4	26827.8	26340.4	26827.8
Area of foci, hectares				
– without considering the land category of neighboring plots	10701.7	11404.5	11266.5	13270.7
– with considering the land category of neighboring plots	11029.4	11571.9	11508.8	13533.9
Part from forest fund area, %				
– without considering the land category of neighboring plots	25.8	27.5	27.2	32.0
– with considering the land category of neighboring plots	26.6	27.9	27.8	32.6
Part from pine stands area, %				
– without considering the land category of neighboring plots	40.6	42.5	42.8	49.5
– with considering the land category of neighboring plots	41.9	43.1	43.7	50.4

More intensive growth of common pine sawfly foci area, than European pine sawfly foci area, is explained by greater photophilia of the first species. It prefers the plots with lower relative density of stocking. Therefore if we consider only the change of relative density of stocking, we can calculate, that the area with the high threat of outbreaks increased for 2001–2011 from 853.5 to 2576 ha, and its part from all predicted foci area (with low, moderate and high threat) increased from 3.2 to 9.6 % (Fig. 1).

The change of land category of neighboring plots also contributes to the growth of pine sawfly foci area. So with considering the land category of neighboring plots in 2001 the area of European pine sawfly and common pine sawfly foci was by 327.7 and 242.3 hectares larger respectively, than without considering the land category of neighboring plots. In 2011 respective difference was 167.4 and 263.2 hectares for European pine sawfly and common pine sawfly foci respectively (see Table 1).

For 2001–2011 the area of pine stands with high threat of European pine sawfly and common pine sawfly foci, evaluated considering land category of neighboring plots, increased by 542.5 and 2025.1 hectares respectively (see Table 1).

The trend of growth the pine sawflies foci in connection with decrease of stocking density of stands and increase of number of plots, which border with clear-cuts, was supported also for individual forestries of SE "Kreminske FHE", particularly for Serebryanske forestry (Fig. 2–4).
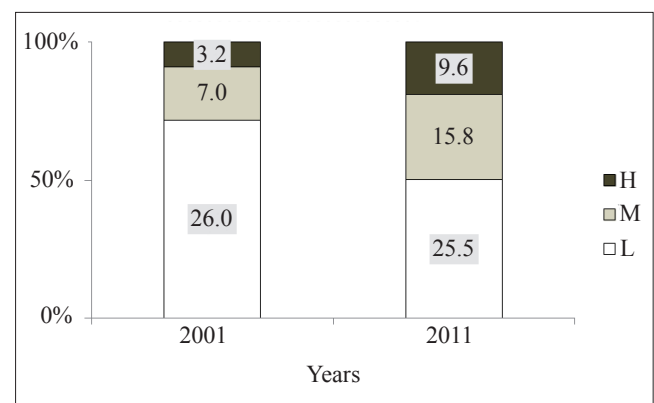

Fig. 1. Distribution of pine sawflies foci area in SE "Kreminske FHE" by threat level with considering the change of stocking density for 2001–2011 (H – high threat: M – moderate threat; L – low threat)

The area of pine stands in Serebryanske forestry with high threat of European pine sawfly foci, evaluated by 2011 database, exceeded 209 and 261.1 hectares such area evaluated by 2001 database, and for common sawfly by 416.5 and 448.9 hectares in the cases without considering neighboring plots and with such considering.

It is necessary to carry out the survey and assessment of pine sawflies first of all in these plots. Considering these data gives the possibility to reduce the costs both on forest inspection and on forest treatment with insecticides.
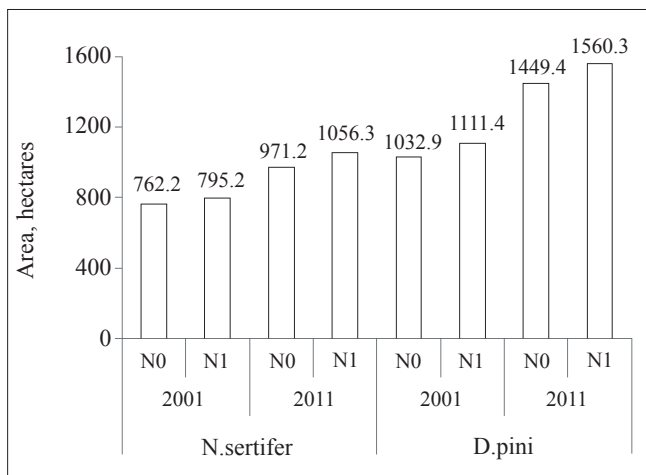

Fig. 2. Area of European pine sawfly and common pine sawfly foci in Serebryanske forestry of SE "Kreminske FHE", evaluated by forest inventory databases for 2001 and 2011 without considering the land category of neighboring plots (N0) and with considering the land category of neighboring plots (N1)

Fig. 3. Distribution of predicted European pine sawfly foci area in Serebryanske forestry of SE "Kreminske FHE" (upper row – as of 2001, lower row – as of 2011; in every row left map is built without considering the land category of neighboring plots; right map is built with considering the land category of neighboring plots)

Due to greater photophilia of common pine sawfly it is more sensitive not only to decrease of stocking density, but also to appearance of clear-cuts in the neighboring plots (Meshkova, 2009).

As the area of pine stands in Serebryanske forestry was 2627.5 and 2688.1 hectares in 2001 and 2011, the part of area with the highest threat of European pine sawfly foci from pine stands area increased from 30.3 to 39.3 %, and the part of area with the highest threat of common pine sawfly foci from pine stands area increased from 42.3 to 58 %.

Obtained data show, that total treatment of all pine forests with insecticides is inexpedient, because potential area of European pine sawfly foci cannot exceed 39.3 % of pine stands area, and such area for common pine sawfly cannot exceed 58 % of pine stands area.

Fig. 4. Distribution of predicted common pine sawfly foci area in Serebryanske forestry of SE "Kreminske FHE" (upper row – as of 2001, lower row – as of 2011; in every row left map is built without considering land category of neighboring plots; right map is built with considering the land category of neighboring plots)

Considering these data gives the possibility to reduce the costs on insecticide treatment and negative influence of forest ecosystem.

Conclusions. Rating of forest plots by preferences for foliage browsing insects show, that in the forest fund of the SE "Kreminske FHE" the area with high threat of European pine sawfly and common pine sawfly outbreaks for 2001–2011 increased by 702.8 and 2004.2 hectares respectively.

The part of foci area made up 27.5 and 32 % from forest fund area, 42.5 % and 49.5 % from pine stands area for European pine sawfly and common pine sawfly respectively.

The areas of pine sawflies foci increased mainly in result of decrease the stocking density of pine stands and increase the number of plots which border with clear-cuts.

On example of Serebryanske forestry it was evaluated, that the area of pine stands with high threat of European pine sawfly outbreak increased for 2001–2011 by 209 and 261.1 hectares, and such area for common pine sawfly by 416.5 and 448.9 hectares respectively in the cases without considering neighboring plots and with their considering.

The survey for pine sawflies must be first of all carried out in the plots with high threat of foci appearance.

Refereces

Allstadt, A. J., Haynes, K. J., Liebhold, A. M., & Johnson, D. M. (2013). Long-term shifts in the cyclicity of outbreaks of a forest-defoliating insect. *Oecologia*, *172* (1), 141-151.

Andreieva, O. Ju. (2009). Prediction of pine sawflies outbreaks in the forests of Central Polissya. *Scientific Bulletin of National University of Life and Environmental Sciences of Ukraine, Series "Agronomy"*, *132*, 135-141 (in Ukrainian).

Behmer, S. T., Joern, A., Abbott, K. C., Shlichta, J. G., Smilanich, A. M., Lind, E. M., ... & Liebhold, A. M. (2012). *Insect Outbreaks Revisited*. USA, Ca: John Wiley & Sons.

Berggren, Å., Björkman, C., Bylund, H., & Ayres, M. P. (2009). The distribution and abundance of animal populations in a climate of uncertainty. *Oikos*, *118* (8), 1121-1126.

Björkman, C., Berggren, Å., & Bylund, H. (2011). Causes behind insect folivory patterns in latitudinal gradients. *Journal of Ecology*, *99* (2), 367-369.

Bone, C., Wulder, M. A., White, J. C., Robertson, C., & Nelson, T. A. (2013). A GIS-based risk rating of forest insect outbreaks using aerial overview surveys and the local Moran's I statistic. *Applied Geography*, *40*, 161-170.

Branco, M., Battisti, A., & Mendel, Z. (2016). Foliage feeding invasive insects: defoliators and gall makers. In *Insects and Diseases of Mediterranean Forest Systems* (pp. 211-238). Springer International Publishing.

Grodzki, W. (2005). *GIS and databases in the forest protection in Central Europe, Krakow, Poland, 35-27 November 2004*. Instytut Badawczy Leśnictwa (Forest Research Institute).

Haynes, K. J., Allstadt, A. J., & Klimetzek, D. (2014). Forest defoliator outbreaks under climate change: effects on the frequency and severity of outbreaks of five pine insect pests. *Global change biology*, *20* (6), 2004-2018.

Haynes, K. J., Bjørnstad, O. N., Allstadt, A. J., & Liebhold, A. M. (2013, February). Geographical variation in the spatial synchrony of a forest-defoliating insect: isolation of environmental and spatial drivers. In *Proc. R. Soc. B* (Vol. 280, No. 1753, p. 20122373). The Royal Society.

Haynes, K. J., Liebhold, A. M., & Johnson, D. M. (2012). Elevational gradient in the cyclicity of a forest-defoliating insect. *Population ecology*, *54* (2), 239-250.

Isaev, A. S, Palnikova, E. N, Suhovolsky, V. G., & Tarasova, O. V. (2015). *Dynamics of forest phyllophagous insects: models and forecasts*. Moscow: Association of Scientific Publications KMK (In Russian).

Kollberg, I., Bylund, H., Schmidt, A., Gershenzon, J., & Bjoerkman, C. (2013). Multiple effects of temperature, photoperiod and food quality on the performance of a pine sawfly. *Ecological entomology*, *38* (2), 201-208.

Liebhold, A. M., & Tobin, P. C. (2008). Population ecology of insect invasions and their management. *Annu. Rev. Entomol.*, *53*, 387-408.

Liebhold, A., Koenig, W. D., & Bjørnstad, O. N. (2004). Spatial synchrony in population dynamics. *Annu. Rev. Ecol. Evol. Syst.*, *35*, 467-490.

Logan, J. A.; Regniere, J,; Powell, J. A. (2003) Assessing the impacts of global warming on forest pest dynamics. *Front Ecol Environ*, *1*, 130-137.

Meshkova, V. (2006a). Foliage browsing insects risk assessment using forest inventory information. *Proc. of the IUFRO Symposium WP7*, *3*, 11-14.

Meshkova, V. (2006b). Rating of forest plots preferences for foliage browsing insects. In Oszako, T., & Woodward, S. (Eds.). *Possible limitation of decline phenomena in broadleaved stands*. Forest Research Institute. Warsaw: IBL (pp. 125 – 134).

Meshkova, V. L. (2009). *Seasonal development of foliage browsing insects*. Kharkov: Novoe slovo (In Russian).

Meshkova, V. L., Kolienkina, M. S. (2016). *Mass propagations of pine sawflies in the stands of Luhansk region:* Kharkiv: Planeta Print (in Ukrainian).

Morin, R. S., & Liebhold, A. M. (2015). Invasive forest defoliator contributes to the impending downward trend of oak dominance in eastern North America. *Forestry*, *89* (3), 284-289.

Neuvonen, S., & Viiri, H. (2017). Changing climate and outbreaks of forest pest insects in a cold northern country, Finland. In *The Interconnected Arctic–UArctic Congress 2016* (pp. 49-59). Springer International Publishing.

Nevalainen, S., Sirkiä, S., Peltoniemi, M., & Neuvonen, S. (2015). Vulnerability to pine sawfly damage decreases with site fertility but the opposite is true with Scleroderris canker damage; results from Finnish ICP Forests and NFI data. *Annals of forest science*, *72* (7), 909-917.

Peltonen, M., Liebhold, A. M., Bjørnstad, O. N., & Williams, D. W. (2002). Spatial synchrony in forest insect outbreaks: roles of regional stochasticity and dispersal. *Ecology*, *83* (11), 3120-3129.

Pimentel, C. S., Ferreira, C., Santos, M., & Calvão, T. (2017). Spatial patterns at host and forest stand scale and population regulation of the pine processionary moth *Thaumetopoea pityocampa*. *Agricultural and Forest Entomology*, *19* (2), 200-209.

Polupan, A. V., Bogomolov, V. V., Ostapchik, O. V., Borisenko, O. I. (2011) Methodology of forest plots allocation into fire risk classes for fire control using GIS // Collection of scientific works. 10th International Practical Conference. "Modern Information Technologies for Management of Environmental Safety, Nature Use, Emergency Measures", September 5-9, 2011. Kyiv-Kharkiv-Crimea. "VIK Print", 168-171 (in Ukrainian).

Rullan-Silva, C. D., Olthoff, A. E., de la Mata, J. D., & Pajares-Alonso, J. A. (2013). Remote monitoring of forest insect defoliation-A Review. *Forest Systems*, *22* (3), 377-391.

Senf, C., Seidl, R., & Hostert, P. (2017). Remote sensing of forest insect disturbances: Current state and future directions. *International Journal of Applied Earth Observation and Geoinformation, 60*, 49-60.

Базоване на ГІС-технології прогнозування спалахів комах-хвоєгризів у соснових насадженнях ДП «Кремінське ЛГ»

В.Л. Мєшкова[1], О.І. Борисенко[2]

Для вдосконалення виявлення та запобігання розвитку спалахів масового розмноження комах-хвоєгризів дуже важливо точно знати перелік виділів, які найпринадніші для цих шкідників. Таку можливість надає бальне оцінювання преференцій цих комах стосовно типу лісорослинних умов і деяких характеристик насаджень. Хоча відомо, що ризик розвитку спалаху зростає, якщо сусідні лісові виділи стають зрубами, згарищами або іншими не вкритими лісом землями, водночас зміни категорії земель сусідніх виділів під час визначення таких преференцій комах-хвоєгризів досі не було враховано через трудомісткість такого аналізу.

Метою цього дослідження було прогнозування з використанням ГІС-технологій просторової динаміки осередків комах-хвоєгризів у соснових насадженнях ДП «Кремінське ЛГ» (Луганська область).

Під час виконання дослідження використано бази даних ВО «Укрдержліспроект» стосовно ДП «Кремінське ЛГ» станом на 2001 та 2011 рр. Принадність виділів розраховували стосовно найпоширеніших у регіоні звичайного соснового пильщика (*Diprion pini* L.) та рудого соснового пильщика (*Neodiprion sertifer* Geoffr.). До бальної оцінки насаджень кожного виділу включали тип лісорослинних умов, вік деревостану, відносну повноту та частку сосни у його складі. Якщо виділ межував зі зрубом, до оцінки загрози спалаху додавали один бал.

Загрозу поширення осередків соснових пильщиків у лісовому фонді ДП «Кремінське ЛГ» оцінили за трьома рівнями – низький, помірний і високий. Відповідні тематичні карти з використанням QGIS 2.18 побудовано для всієї території лісгоспу, а в статті наведено, як приклад, карти стосовно Серебрянського лісництва за варіантами: станом на 2001 та 2011 рр. без урахування та з урахуванням категорії земель сусідніх виділів.

Оцінювання насаджень за принадністю для комах-хвоєгризів свідчить, що у лісовому фонді ДП «Кремінське ЛГ» площа з високою загрозою виникнення спалахів рудого соснового пильщика та звичайного соснового пильщика за 2001–2011 рр. зросла на 702,8 та 2004,2 га відповідно. Частка площі осередків рудого соснового пильщика та звичайного соснового пильщика становила 27,5 і 32 % від площі лісового фонду, 42,5 і 49,5 % відповідно від площі соснових насаджень.

Площі осередків соснових пильщиків збільшилися переважно внаслідок зменшення відносної повноти насаджень і збільшення кількості виділів, які межують зі зрубами.

На прикладі Серебрянського лісництва визначено, що площа соснових насаджень із високою загрозою поширення осередків рудого соснового пильщика зросла за 2001–2011 рр. на 209 і 261,1 га, а звичайного соснового пильщика – на 416,5 і 448,9 га за розрахунками без урахуванням сусідніх виділів та з їхнім урахуванням відповідно.

Нагляд за сосновим пильщиками потрібно насамперед здійснювати у виділах із високою загрозою виникнення осередків.

Ключові слова: комахи-хвоєгризи, звичайний сосновий пильщик (*Diprion pini* L.), рудий сосновий пильщик (*Neodiprion sertifer* Geoffr.), лісовпорядкування, преференції комах стосовно виділів лісу, оцінювання ризику, повнота деревостану, лісорослинні умови, категорія земель сусідніх виділів, базоване на ГІС-технології оцінювання ризику спалахів лісових комах

Основанное на ГИС-технологии прогнозирование вспышек хвоелистогрызущих насекомых в сосновых насаждениях ГП «Кременское ЛХ»

В.Л. Мешкова[1], А.И. Борисенко[2]

Для обнаружения и предотвращения развития вспышек хвоелистогрызущих насекомых важно знать перечень наиболее привлекательных для них выделов. Такую возможность дает балльная оценка преференций насекомых относительно типа лесорастительных условий и некоторых характе-

[1] *Мєшкова Валентина Львівна* – дійсний член Лісівничої академії наук України, доктор сільськогосподарських наук, професор, Український науково-дослідний інститут лісового господарства та агролісомеліорації ім. Г. М. Висоцького, вул. Пушкінська, 86, Харків, 61024, Україна. Тел.: +38(097)371-94-58. E-mail: Valentynameshkova@gmail.com

[2] *Борисенко Олександр Ігорович* – науковий співробітник, Український науково-дослідний інститут лісового господарства та агролісомеліорації ім. Г. М. Висоцького, вул. Пушкінська, 86, Харків, 61024, Україна. Тел.: +38-066-888-83-49. E-mail: xalekter@gmail.com

[1] *Мешкова Валентина Львовна* – действительный член Лесной академии наук Украины, доктор сельскохозяйственных наук, профессор, Украинский научно-исследовательский институт лесного хозяйства и агролесомелиорации им. Г. Н. Высоцкого, ул. Пушкинская, 86, Харьков, 61024, Украина. Тел.: +38(097)371-94-58. E-mail: Valentynameshkova@gmail.com

[2] *Борисенко Александр Игоревич* – научный сотрудник, Украинский научно-исследовательский институт лесного хозяйства и агролесомелиорации им. Г. Н. Высоцкого, ул. Пушкинская, 86, Харьков, 61024, Украина.. Тел.: +38-066-888-83-49. E-mail: xalekter@gmail.com

ристик насаждений. Хотя известно, что риск развития вспышки возрастает, если соседние лесные выделы становятся вырубками, горельниками или другими не покрытыми лесом землями, однако изменения категории земель соседних выделов при определении таких преференций хвоелистогрызущих насекомых ранее не принимали во внимание, в связи с трудоемкостью такого анализа.

Целью данного исследования было прогнозирование с использованием ГИС-технологий пространственной динамики очагов хвоелистогрызущих насекомых в сосновых насаждениях ГП «Кременское ЛХ» (Луганская область).

При выполнении исследований использованы базы данных ПО «Укргослеспроект» относительно ГП «Кременское ЛХ» по состоянию на 2001 и 2011 гг. Привлекательность выделов оценивали относительно наиболее распространенных в регионе обыкновенного соснового пилильщика (*Diprion pini* L.) и рыжего соснового пилильщика (*Neodiprion sertifer* Geoffr.).

В балльную оценку каждого выдела включали тип лесорастительных условий, возраст древостоя, относительную полноту и долевое участие сосны в составе насаждений. Если выдел граничил с вырубкой, к оценке угрозы вспышки добавляли один балл. Угрозу распространения очагов сосновых пилильщиков в лесном фонде ГП «Кременское ЛХ» оценили по трем уровням – низкий, умеренный и высокий. Тематические карты построены с использованием QGIS 2.18 для лесхоза. В статье приведены карты Серебрянского лесничества по состоянию на 2001 и 2011 гг. без учета и с учетом категории земель соседних выделов.

Оценка насаждений по привлекательности для хвоегрызущих насекомых показывает, что в лесном фонде ГП «Кременское ЛХ» площадь с высокой угрозой возникновения очагов рыжего и обыкновенного соснового пилильщика за 2001–2011 гг. возросла на 702,8 и 2004,2 га соответственно. Доля площади очагов рыжего и обыкновенного соснового пилильщика составила 27,5 и 32 % от площади лесного фонда, 42,5 и 49,5 % соответственно от площади сосновых насаждений. Площади очагов сосновых пилильщиков возросли в основном в результате уменьшения относительной полноты насаждений и увеличения количества выделов, граничащих с вырубками.

На примере Серебрянского лесничества рассчитано, что площадь сосновых насаждений с высокой угрозой распространения очагов рыжего соснового пилильщика возросла за 2001–2011 гг. на 209 и 261,1 га, а обыкновенного соснового пилильщика – на 416,5 и 448,9 га по расчетам с учетом и без учета соседних выделов соответственно.

Надзор за сосновыми пилильщиками следует в первую очередь осуществлять в выделах с высокой угрозой возникновения очагов.

Ключевые слова: хвоегрызущие насекомые, обыкновенный сосновый пилильщик (*Diprion pini* L.), рыжий сосновый пилильщик (*Neodiprion sertifer* Geoffr.), лесоустройство, преференции насекомых относительно выделов леса, оценка риска, полнота древостоя, лесорастительные условия, категория земель соседних выделов, основанная на ГИС-технологии оценка риска вспышек лесных насекомых