SFI Sustainable Forestry Implementation

МІНІСТЕРСТВО ЕКОНОМІКИ, ДОВКІЛЛЯ ТА СІЛЬСЬКОГО ГОСПОДАРСТВА УКРАЇНИ

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Forest Policy Report **SFI/2025/18**

Analysis of forest growth and the state of the forest by analysing the target attributes for RS-Inventory 2023

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About the Project "Sustainable Forestry Implementation" (SFI)

The project "Promotion of multifunctional sustainable forest management planning and implementation in Ukraine" (SFI) is a project established within the framework of the Bilateral Cooperation Programme (BCP) of the Federal Ministry of Agriculture, Food and Regional Identity (BMLEH) with the Ministry of Economy, Environment and Agriculture of Ukraine (MEEA). It is a continuation of activities started in the forest sector within the German-Ukrainian Agriculture Policy Dialogue (APD) forestry component.

The Project is implemented based on an agreement between GFA Group, the general authorised executor of BMEL, and the State Forest Resources Agency of Ukraine (SFRA) since October 2021. On behalf of the GFA Group, the executing agencies - IAK Agrar Consulting GmbH and Unique land use GmbH and are in charge of the implementation jointly with the SFRA.

The project aims to support sustainable forest management in Ukraine and has a working focus on the results in the Forest Policy and National Forest Inventory.

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Content

Summary

The results of forest inventory based on remote sensing (RS-Inventory) have created a unique information base for analysing changes in forest structure. In total, the RS-Inventory of all forests in Ukraine revealed a forest area of approximately 11.2 million hectares, or approximately 18.6% of Ukraine's total area. The total timber stock may amount to 2.8 billion m3.

A detailed analysis of the RS-Inventory results for tree species groups, individual regions, ecozones, and the territory of Ukraine as a whole was conducted based on data from the website nfi.lisproekt.gov.ua/en. The analysis accounted for the specifics of the methodology used, as well as statistical estimates and errors.

For a comprehensive and critical analysis of the RS-Inventory results, data from scientific sources, forest mensuration reference books, and the reference book on the accounting of Ukraine's forest fund (as of 2011) were used.

The main challenge for analysing the RS-Inventory results is the combination of all errors and uncertainties associated with the interpretation of different types of land use, the creation of a forest mask, the mapping of coniferous and deciduous forests, assessing the area of specific tree species plantations on plains and in mountainous terrain, and calculating forest inventory indicators, their biomass and carbon stocks.

The analysis focused on primary indicators (area, tree species, timber stock) used to calculate derived indicators (e.g., biomass, carbon).

The overall change in the area of pine forests is characterised by the loss of 124,000 hectares, with the main losses occurring in middle-aged, mature, and overmature stands. The loss of pine forests may be due to the loss of pine forests as a result of hostilities (≈50,000 hectares), fires in 2020 (Chornobyl Exclusion Zone and Zhytomyr region (≈38,000 hectares) and Luhansk region (≈20,000 hectares)), typical forest use and reforestation, as well as the felling of natural forests in northern Ukraine and illegal amber mining. At the same time, an increase in the area of young pine stands has been identified, which may be due to the continued closure of self-seeded young pine stands in northern Ukraine. Despite simultaneous uprooting, these areas may show a positive balance.

Analysis of primary indicators

Forest stands area

Changes in age distribution

Changes in distribution of area of stands of Ukraine by age, ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Total
Pine	46 854	86 362	-48 008	-137 656	-67 452	-3 185	-925	-124 012
Spruce (Fir)	932	14 913	1 453	-13 209	-14 113	-8 336	3 076	-15 283
Oak	359	1 099	16 520	47 727	24 718	-1 656	-331	88 437
Beech	258	-1 548	5 997	5 361	-3 716	-4 479	1 423	3 295
Ash, Linden, Maple, Black locust	-4 121	-93 834	-80 318	39 022	-45	-6 121	-993	-146 411
Birch, Alder, Poplar	2 420	16 915	98 201	61 715	1 646	1 027	-50	181 875
Hornbeam	-304	-944	-3 848	2 887	3 650	1 323	14	2 779
All coniferous	**47 787**	**101 275**	**-46 554**	**-150 865**	**-81 566**	**-11 522**	**2 151**	**-139 295**
All deciduous	**-1 388**	**-78 312**	**36 552**	**156 714**	**26 254**	**-9 906**	**62**	**129 976**
All species	**46 398**	**22 963**	**-10 002**	**5 849**	**-55 312**	**-21 428**	**2 214**	**-9 318**

The decrease in the area of spruce forests (≈15 thousand hectares) aged 60+ years may be caused by the unsatisfactory sanitary condition of spruce monocultures due to the impact of bark beetle infestation and other agents of spruce stand drying.

The decrease in the area of the 'Ash, Linden, Maple, Black locust' species group (≈146 thousand hectares) may be due to the death (drying out) of ash plantations from the emerald ash borer, the disruption of protective plantations and field protection strips as a result of hostilities. However, this group of forest plantations comprises different species that rarely form pure stands, so there may be inaccuracies in interpreting and mapping tree species and different land cover types. There may be a particular impact on the misinterpretation of other deciduous species, particularly oak.

The increase in the area of Birch, Alder, Poplar forests (≈182 thousand hectares) may be due to an increase in the area of young self-seeded forests on abandoned agricultural fields, meadows and other lands and disturbed lands, as well as a change in the predominant species in middle-aged and mature stands due to sanitary felling as a result of forest damage by diseases, insects, fires and other factors. At the same time, shortcomings and difficulties in deciphering deciduous stands of different species composition could have played a key role.

It should be noted that during the study period, there was a clear decrease in the area of coniferous plantations (-139 thousand hectares) and an increase in deciduous plantations (+130 thousand hectares) were evident during the study period, which is generally explained by the loss of coniferous (or replacement with deciduous) stands as more sensitive to the intensification of the impact of abiotic and biotic agents of disturbance during combat operations and climate change.

The overall decrease of 9.3 thousand hectares in forest area may indicate a negative trend in total forest area. However, these data likely fall within the margin of uncertainty in the remote sensing of forest area. In simple terms, when using this method, this figure for forest loss may be insignificant, as remote sensing has clearly described shortcomings in the methodology.

During the period 2019-2023, the total forest area of Ukraine decreased by 9,318 hectares according to the table, which may be associated with the following main processes:

- destruction of forests as a result of hostilities in eastern and southern Ukraine;

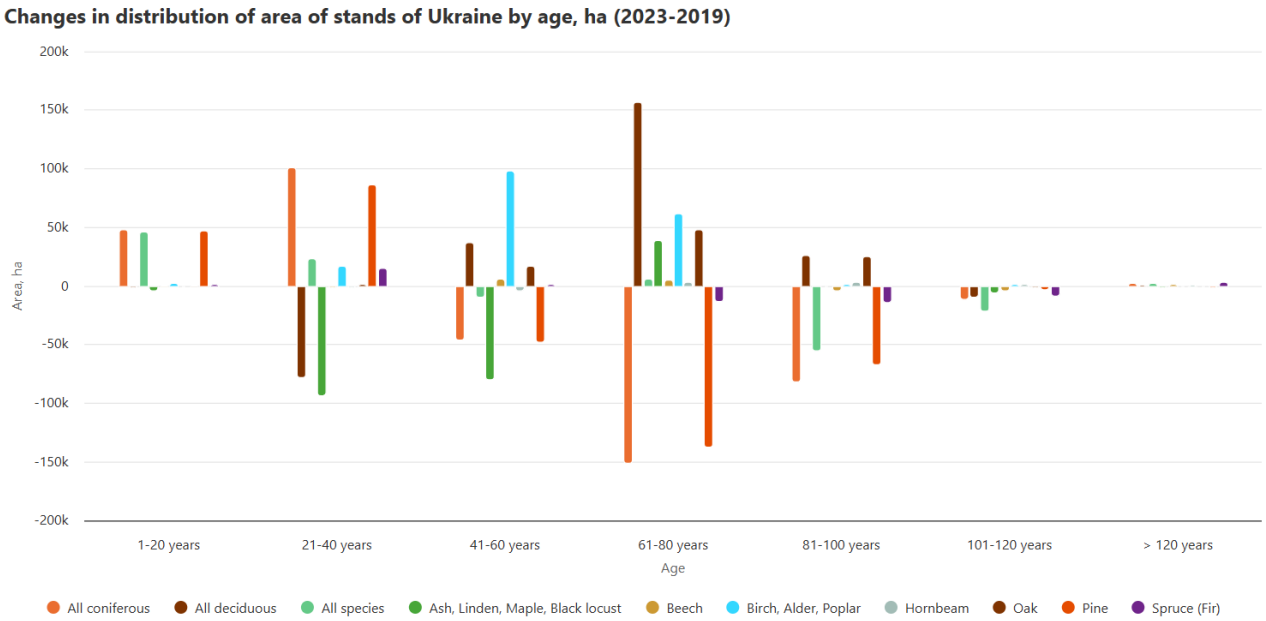
- felling of young trees on agricultural land;

- amber mining and other violations;

- acceptable errors in deciphering different types of landscapes.

The distribution by age groups (in particular, 20-year-olds) should be considered conditional and generalised, since the confusion matrix does not allow confirmation of the reliability of the data on the age distribution of tree stands.

Changes in forest area, as indicated by other indicators that closely correlate with age (DBH, height, growing stock), are fully consistent with trends in area change by age.



Changes in mean diameter classes

Changes in distribution of area of stands of Ukraine by diameter, ha (2023-2019)

Species	6-20 cm	21-40 cm	41-60 cm	> 60 cm	Total
Pine	106 021	-196 098	-31 208	-2 727	-124 012
Spruce (Fir)	15 501	-18 909	-11 878	2	-15 283
Oak	-2 481	85 353	5 100	465	88 437
Beech	-1 375	16 520	-11 840	-9	3 295
Ash, Linden, Maple, Black locust	-104 361	-44 040	1 403	587	-146 411
Birch, Alder, Poplar	405	165 366	15 780	322	181 875
Hornbeam	-1 515	1 699	2 589	6	2 779
All coniferous	**121 523**	**-215 007**	**-43 086**	**-2 724**	**-139 295**
All deciduous	**-109 328**	**224 900**	**13 033**	**1 372**	**129 976**
All species	**12 195**	**9 892**	**-30 053**	**-1 352**	**-9 318**

Accordingly, during the study period, there was a decrease in the area of pine forests with DBH of 21-40 cm, 41-60 cm, and 61+, indicating a decrease in the growing stock and in carbon stored in biomass.

It is important to note that for deciduous species, there was a decrease in the area of stands with diameters of 6-20 cm and an increase in the area of stands with larger diameters.

It is difficult to explain the decrease in the area of forests of the 'Ash, Linden, Maple, Black locust' group with diameters of 6-20 cm and 21-40 cm and the increase in the area of oak plantations with diameters of 21-40 cm. There seems to be some confusion in the classification of oak stands and the 'Ash, Linden, Maple, Black locust' group.

It is important to note that a decrease in the area of all tree species is observed on the plateau and in the mountains (above 601 m above sea level). This may be due to more extreme tree growth conditions, deterioration of forest health, or the impact of forest use.

Changes in the distribution of diameter at breast height of stands of Ukraine by age, cm (2023-2019)

A decrease in average diameter of -3 cm occurred in pine stands older than 120 years, which may be justified by the intensification of decay due to approaching biological maturity. Such stands may belong to the nature reserve fund. In such stands, a decrease in average height by -1 m was noted.

Changes in the distribution of diameter at breast height of stands of Ukraine by height, cm (2023-2019)

There was a decrease in average diameter by -2 cm in oak stands with an average height of over 30 m. This may be due to the impact of forest use in productive oak stands.

At the same time, stands with an average diameter of more than 60 cm show an increase in average height of 1 m. Such stands may likely belong to the nature reserve fund.

Changes in the distribution of the basal area of stands of Ukraine by age, m2/ha (2023-2019)

An increase in BA by 1 m2 was observed in pine stands aged 1-20 years and 21-40 years, as well as a decrease in BA by -1 m2 in spruce stands aged 1-20 years.

Changes in the distribution of the basal area of stands of Ukraine by diameter, m2/ha (2023-2019)

During the study period, there was a decrease in BA by -7 m2/ha in spruce stands with an average diameter >60 cm and by -1 m2/ha in spruce stands with an average diameter of 41-60 cm, as well as by -2 m2/ha in stands of the groups 'Ash, Linden, Maple, Black locust' with an average diameter >60 cm.

Growing stock

Changes in age distribution

Country totals

Changes in distribution of growing stock volume of stands of Ukraine by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	4	7	6	5	8	11	2	-4
Spruce (Fir)	2	-4	0	-8	-16	-15	-20	-17
Oak	1	4	7	2	-3	-9	-7	3
Beech	0	7	3	2	2	0	7	2
Ash, Linden, Maple, Black locust	1	6	4	0	-2	-11	-7	6
Birch, Alder, Poplar	-3	4	7	5	3	5	4	7
Hornbeam	3	0	0	5	-8	-19	-6	3
All coniferous	**4**	**5**	**6**	**4**	**5**	**-8**	**0**	**-6**
All deciduous	**0**	**6**	**6**	**1**	**-1**	**-4**	**6**	**6**
All species	**2**	**7**	**5**	**0**	**-5**	**-9**	**8**	**0**

The average stock of pine stands by 20-year age groups increased by 2-11 cubic metres per hectare, but the average value decreased by -4 cubic metres per hectare, which needs to be clarified. The most significant increase in stock (+11 cubic metres/hectare) was found for pine stands aged 101-120 years.

A significant decrease in average stock within 20-year age groups occurred for spruce stands older than 120 years by -20 cubic metres/ha, 101-120 years by -15 cubic metres/ha, and 81-100 years by -16 cubic metres/ha. On average, the decrease in stock was -17 cubic metres per hectare.

Oak, ash, linden, maple, black locust and hornbeam stands also showed a decrease in stock for 20-year age groups of 81-100 years, 101-120 years and >120 years. However, overall, the average stock for these groups increased.

The total change in stocks for all species groups showed zero dynamics.

Regional features of changes in wood stocks by age include:

Ivano-Frankivsk region:

A decrease in the average stock within the 20-year age groups occurred for spruce stands older than 120 years by -26 cubic metres/hectare, 101-120 years by -16 cubic metres/hectare, and 81-100 years by -17 cubic metres/hectare. On average, the decrease in average stock was recorded at -21 cubic metres/hectare.

A decrease in average stock within 20-year age groups occurred for beech stands older than 120 years by -17 cubic metres/hectare, 101-120 years by -7 cubic metres/hectare, and 81-100 years by -5 cubic metres/hectare. On average, a decrease in the beech stand stock was observed at -6 cubic metres/ha.

An increase in the average stock within the 20-year age groups occurred for oak stands aged 81-100 years by 17 cubic metres per hectare, and for stands aged 61-80 years by 11 cubic metres per hectare, although there was no change in the stock for stands older than 120 years. On average, an increase in the average stock of oak stands was observed at the level of 15 cubic metres per hectare.

The overall change in the stock of stands of all species groups showed a negative trend (-9 cubic metres per hectare = -2.25 cubic metres per hectare per year).

Changes in distribution of growing stock volume of stands of Ivano-Frankivsk obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	-5	6	1	13	2	-4	-18	4
Spruce (Fir)	3	-4	-2	-9	-17	-16	-26	-21
Oak	5	8	16	11	17	2	0	15
Beech	4	0	-1	-1	-5	-7	-17	-6
Ash, Linden, Maple, Black locust	4	11	8	0	19	20	6	12
Birch, Alder, Poplar	3	9	6	2	1	-3	10	6
Hornbeam	5	3	3	8	33	49	-29	9
All coniferous	**3**	**-3**	**-1**	**-8**	**-17**	**-16**	**-26**	**-21**
All deciduous	**3**	**6**	**5**	**1**	**-5**	**-3**	**-12**	**2**
All species	**4**	**7**	**2**	**-6**	**-15**	**-13**	**-23**	**-9**

Chernivtsi region:

A decrease in average stock within 20-year age groups occurred for spruce stands older than 120 years by -10 cubic metres/hectare, 101-120 years by -27 cubic

metres/hectare, and 81-100 years by -8 cubic metres/hectare. On average, the decrease in average stock was recorded at -5 cubic metres per hectare.

An increase in average stock within 20-year age groups occurred for beech stands older than 120 years by 48 cubic metres/hectare, 101-120 years by 21 cubic metres/hectare, and 81-100 years by 9 cubic metres/hectare. On average, an increase in the average stock of beech stands was observed at the level of 20 cubic metres per hectare.

The overall change in the stock of stands of all species groups showed positive dynamics (8 cubic metres per hectare = 2 cubic metres per hectare per year).

Changes in distribution of growing stock volume of stands of Chernivtsi obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	-7	-8	5	14	5	23	-2	0
Spruce (Fir)	2	0	16	5	-8	-27	-10	-5
Oak	-2	9	15	-1	7	26	16	8
Beech	1	13	0	-8	9	21	48	20
Ash, Linden, Maple, Black locust	-2	0	6	8	13	12	20	10
Birch, Alder, Poplar	0	10	7	6	18	0	26	15
Hornbeam	2	8	-7	-6	-7	23	-14	18
All coniferous	**1**	**1**	**15**	**8**	**-7**	**-23**	**-10**	**-3**
All deciduous	**-2**	**8**	**4**	**-4**	**6**	**22**	**50**	**16**
All species	**2**	**15**	**10**	**-8**	**-13**	**-10**	**22**	**8**

Zakarpatia region:
A decrease in the average stock within 20-year age groups occurred for spruce stands older than 120 years by -23 cubic metres/hectare, 101-120 years by -16 cubic metres/hectare, and 81-100 years by -15 cubic metres/hectare. On average, the decrease in stock was -17 cubic metres per hectare.

The overall change in the stock of all species groups showed a negative trend (-1 cubic metre per hectare = -0.25 cubic metres per hectare per year).

Changes in distribution of growing stock volume of stands of Zakarpattia obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	-7	-8	-1	12	19	-3	-6	0
Spruce (Fir)	0	-8	-4	-11	-15	-16	-23	-17
Oak	2	3	4	5	8	18	-4	3
Beech	0	8	5	4	6	7	-6	2
Ash, Linden, Maple, Black locust	0	8	7	6	18	0	-2	9
Birch, Alder, Poplar	3	7	3	2	-1	-5	-1	2
Hornbeam	-5	0	-2	6	2	23	12	-3
All coniferous	**-2**	**-9**	**-6**	**-12**	**-16**	**-16**	**-23**	**-18**
All deciduous	**0**	**8**	**4**	**4**	**5**	**8**	**-4**	**3**
All species	**0**	**6**	**2**	**0**	**0**	**0**	**-16**	**-1**

Lviv region:

A decrease in average stock within 20-year age groups occurred for spruce stands older than 120 years by -9 cubic metres/hectare, 81-100 years by -14 cubic metres/hectare, and 61-80 years by -15 cubic metres/hectare. On average, the decrease in average stock was recorded at -13 cubic metres per hectare.

A decrease in average stock within 20-year age groups was observed for pine stands older than 120 years by -4 cubic metres per hectare, 101-120 years by -9 cubic metres per hectare, 81-100 years old by -8 cubic metres/hectare, and 61-80 years old by -4 cubic metres/hectare. On average, the decrease in average stock was recorded at -12 cubic metres/hectare.

No overall change in the stock of all species groups was recorded (0 cubic metres/hectare).

Changes in distribution of growing stock volume of stands of Zakarpattia obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	-7	-8	-1	12	19	-3	-6	0
Spruce (Fir)	0	-8	-4	-11	-15	-16	-23	-17
Oak	2	3	4	5	8	18	-4	3
Beech	0	8	5	4	6	7	-6	2
Ash, Linden, Maple, Black locust	0	8	7	6	18	0	-2	9
Birch, Alder, Poplar	3	7	3	2	-1	-5	-1	2
Hornbeam	-5	0	-2	6	2	23	12	-3
All coniferous	**-2**	**-9**	**-6**	**-12**	**-16**	**-16**	**-23**	**-18**
All deciduous	**0**	**8**	**4**	**4**	**5**	**8**	**-4**	**3**
All species	**0**	**6**	**2**	**0**	**0**	**0**	**-16**	**-1**

Volyn region:
A decrease in the average stock within 20-year age groups occurred for pine stands older than 120 years by -14 cubic metres/ha, and for stands aged 101-120 years by -2 cubic metres/ha. On average, an increase in stock was observed at 8 cubic metres/hectare. This change may indicate an intensification of pine tree mortality in overmature stands.

A significant increase in average stock within the 20-year age groups occurred in oak stands aged 81-100 years by 48 cubic metres per hectare, whereas stands aged >120 years showed a decrease of 23 cubic metres per hectare. On average, an increase in the average stock of oak stands was noted at the level of 24 cubic metres/hectare.

Probable inconsistency (errors) in data on changes in the stock of spruce stands (-4 cubic metres/hectare) and forest beech stands (-12 cubic metres/hectare).

The overall change in the stock of all tree species showed a positive trend (5 cubic metres/hectare = 1.25 cubic metres/hectare per year).

Changes in distribution of growing stock volume of stands of Volyn obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	10	12	10	12	25	-1	-18	3
Spruce (Fir)	10	-3	13	3	-22	0	0	-4
Oak	6	11	4	-12	27	47	38	8
Beech	2	3	-5	4	0	0	0	-12
Ash, Linden, Maple, Black locust	-4	10	9	-1	38	47	0	10
Birch, Alder, Poplar	0	4	9	12	7	9	-32	10
Hornbeam	2	4	7	7	11	10	0	5
All coniferous	**10**	**12**	**10**	**12**	**25**	**-1**	**-18**	**3**
All deciduous	**0**	**5**	**8**	**8**	**37**	**6**	**-3**	**9**
All species	**3**	**8**	**9**	**10**	**26**	**1**	**-13**	**5**

Rivne region:
The average stock within 20-year age groups decreased by 18 cubic metres per hectare for spruce stands older than 120 years and by 1 cubic metre per hectare for stands aged 101-120 years. On average, an increase in stock of 3 cubic metres/hectare was observed. This change may indicate an intensification of pine tree mortality in overmature stands.

A significant increase in average stock within the 20-year age groups occurred for oak stands older than 120 years by 38 cubic metres/hectare, 101-120 years by 47 cubic metres/hectare, 81-100 years by 27 cubic metres/hectare, although for stands aged 61-80 years, there was a decrease in timber stock by -12 cubic metres/ha. On average, an increase in the average stock of oak stands was noted at the level of 8 cubic metres/ha.

There was a significant decrease in the average stock for stands of the 'Birch, Alder, Poplar' group older than 120 years by -32 cubic metres/hectare, although overall there was an increase in the average stock of such stands at the level of 10 cubic metres/hectare.

There is a probable discrepancy (error) in the data on changes in the stock of spruce (-4 cubic metres/hectare) and beech (-12 cubic metres/hectare) stands.

The overall change in the stock of all species groups showed positive dynamics (7 cubic metres/hectare = 1.75 cubic metres/hectare per year).

Changes in distribution of growing stock volume of stands of Rivne obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	11	14	10	12	23	-2	-14	8
Spruce (Fir)	-89	-35	-5	-1	-36	0	0	-4
Oak	2	14	21	29	48	-7	-23	24
Beech	-8	1	6	0	-70	-29	0	4
Ash, Linden, Maple, Black locust	0	7	8	26	17	114	43	6
Birch, Alder, Poplar	-3	3	9	12	3	12	7	7
Hornbeam	22	-10	0	16	-56	-1	0	3
All coniferous	**11**	**14**	**10**	**12**	**23**	**-2**	**-14**	**8**
All deciduous	**-3**	**3**	**8**	**15**	**9**	**-9**	**-2**	**8**
All species	**3**	**7**	**9**	**12**	**22**	**-15**	**-6**	**7**

Zhytomyr region:

A decrease in the average stock within 20-year age groups occurred for pine stands aged 101-120 years by -7 cubic metres/hectare, although the stock of pine stands older than 120 years increased by 6 cubic metres/hectare. On average, the stock decreased by 4 cubic metres/hectare. This change may indicate an intensification of pine tree mortality in overmature stands.

A significant increase in the average stock within the 20-year age groups occurred for oak stands aged 101-120 years by 26 cubic metres/ha, 81-100 years by 20 cubic

metres/ha, and 61-80 years by 27 cubic metres/ha. However, for stands older than 120 years, timber stock decreased by 13 cubic metres/ha. On average, an increase in the average stock of oak stands was noted at the level of 25 cubic metres/ha.

An abnormal decrease in average stock within the 20-year age groups occurred for spruce stands aged 41-60 years by -103 cubic metres/hectare and 61-80 years by -15 cubic metres/hectare. On average, a decrease in the average stock of spruce stands was observed at the level of -78 cubic metres/hectare. This change may indicate the limited extent of spruce forests in the Zhytomyr region and shortcomings in remote sensing-based mapping.

Possible inconsistencies (errors) in data on changes in the stock of beech (-36 cubic metres/ha) and hornbeam (20 cubic metres/ha) stands.

The overall change in the stock of all tree species showed positive dynamics (3 cubic metres/hectare = 0.75 cubic metres/hectare per year). However, the stock of all conifers decreased by -4 cubic metres/hectare, and the stock of all deciduous trees increased by 12 cubic metres/hectare.

Changes in distribution of growing stock volume of stands of Zhytomyr obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	5	5	4	-1	0	-7	6	-4
Spruce (Fir)	0	4	-103	-15	2	0	0	-78
Oak	9	0	16	27	20	26	-13	25
Beech	-4	-4	-56	-4	30	0	0	-36
Ash, Linden, Maple, Black locust	2	10	10	12	9	-27	3	10
Birch, Alder, Poplar	-3	4	8	10	7	7	6	9
Hornbeam	10	10	16	31	23	-153	0	20
All coniferous	**5**	**5**	**4**	**-1**	**0**	**-7**	**6**	**-4**
All deciduous	**-2**	**5**	**9**	**15**	**11**	**16**	**-7**	**12**
All species	**-3**	**5**	**6**	**1**	**3**	**15**	**-6**	**3**

Kyiv region:

A decrease in average stock within 20-year age groups occurred for pine stands older than 120 years by -8 cubic metres/hectare, although the stock of pine stands up to 120 years increased by 2-12 cubic metres/hectare. Overall, the average stock of pine forests decreased by 2 cubic metres per hectare. This change may indicate an increase in pine tree mortality in overmature stands, as well as possible discrepancies in the determination of pine forest stock.

A significant decrease in average stock within 20-year age groups occurred for stands of birch, alder and poplar older than 120 years by -16 cubic metres/hectare, 101-120 years by -14 cubic metres/hectare, 81-100 years by -3 cubic metres/hectare, although for stands up to 80 years old, there was an increase in timber stock of 1-7 cubic metres/hectare. On average, an increase in the stock of softwood stands was observed at 5 cubic metres/hectare. A similar trend was observed for the group of species 'Ash, Linden, Maple, Black locust'.

An abnormal change in the average stock within 20-year age groups occurred for spruce, beech and hornbeam stands. On average, the stocks of such stands showed a positive trend. Such changes in stock levels by age group may indicate a small area of spruce, beech, and hornbeam plantations in the Kyiv region and shortcomings in remote sensing-based mapping.

No overall change in the stock of all species groups was found (0 cubic metres/hectare). However, the stock of all conifers decreased by -2 cubic metres/hectare, and the stock of all deciduous trees increased by 5 cubic metres/hectare.

Changes in distribution of growing stock volume of stands of Kyiv obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	5	12	8	2	10	6	-8	-2
Spruce (Fir)	-21	20	-33	62	220	0	0	71
Oak	6	7	7	6	1	-9	-8	3
Beech	7	-2	6	-18	49	57	0	6
Ash, Linden, Maple, Black locust	3	9	7	4	-6	-37	-20	6
Birch, Alder, Poplar	1	7	6	4	-3	-14	-16	5
Hornbeam	1	-3	4	1	3	-9	-95	3
All coniferous	**5**	**12**	**8**	**2**	**10**	**6**	**-8**	**-2**
All deciduous	**2**	**8**	**7**	**4**	**-2**	**-18**	**-12**	**5**
All species	**3**	**9**	**6**	**1**	**2**	**10**	**-12**	**0**

Chernihiv region:

The average stock within 20-year age groups decreased for pine stands older than 120 years by -3 cubic metres/hectare, 101-120 years by -10 cubic metres/hectare, although the stock of pine stands aged 41-100 years increased by 2-9 cubic metres/hectare. Overall, the average stock of pine forests decreased by 32 cubic metres per hectare. This change is abnormal and may indicate inconsistencies in

determining the total average stock of pine plantations and an increase in pine tree losses in overmature stands.

A certain increase in the average stock within the 20-year age groups occurred for oak stands aged 101-120 years by 12 cubic metres/hectare, 81-100 years by 3 cubic metres/hectare, 41-60 years by 27 cubic metres/hectare. However, for stands older than 120 years, timber stock decreased by 2 cubic metres/ha. On average, an increase in the average stock of oak stands was noted at the level of 7 cubic metres/ha.

An abnormal change in the average stock within 20-year age groups occurred for spruce, beech and hornbeam stands. On average, the stocks of such stands showed a positive trend. Such changes in stock levels across age groups may indicate a small area of spruce, beech, and hornbeam plantations in the Chernihiv region and shortcomings in mapping based on remote sensing data.

The overall change in the average stock across all species groups indicated a significant decrease (-15 cubic metres, or -3.75 cubic metres/hectare per year). However, the stock of all conifers decreased by -32 cubic metres/hectare, and the stock of deciduous trees remained unchanged.

Changes in distribution of growing stock volume of stands of Chernihiv obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	-1	-1	9	2	2	-10	-3	-32
Spruce (Fir)	-17	7	25	114	33	0	0	85
Oak	-7	-11	3	-1	3	12	-2	7
Beech	-24	2	43	62	38	0	0	89
Ash, Linden, Maple, Black locust	-5	-10	-10	-4	2	15	0	-6
Birch, Alder, Poplar	-6	-13	-4	-6	5	17	-2	-3
Hornbeam	0	32	44	186	0	0	0	100
All coniferous	**-1**	**-1**	**9**	**2**	**2**	**-10**	**-3**	**-32**
All deciduous	**-7**	**-12**	**-3**	**-4**	**6**	**17**	**-2**	**0**
All species	**-1**	**-6**	**1**	**-7**	**-7**	**1**	**-2**	**-15**

Sumy region:
An increase in the average stock within 20-year age groups occurred for pine stands older than 120 years by 18 cubic metres/ha, 101-120 years by 52 cubic metres/ha, 81-100 years by 23 cubic metres/ha, although the stock of pine stands aged 21-40 years decreased by -8 cubic metres/hectare. Overall, the average stock of pine forests decreased by 19 cubic metres per hectare. This change is abnormal and may indicate inconsistencies in determining the total average stock of pine plantations due to an increase in the stock of middle-aged, mature, ripe and even overmature stands.

There was a slight increase in the average stock within the 20-year age groups for oak stands aged 81-100 years by 13 cubic metres per hectare, although there was a decrease in the average stock in stands older than 120 years by -4 cubic metres/ha, 101-120 years by -23 cubic metres/ha, and 21-40 years by -5 cubic metres/ha. On average, no changes in the average stock of oak stands were observed (0 cubic metres/hectare).

An abnormal change in the average stock within 20-year age groups occurred for spruce (47 cubic metres/hectare), beech (38 cubic metres/hectare) and hornbeam (-20 cubic metres/hectare) stands. Such changes in stock by age group may indicate a small area of spruce, beech, and hornbeam plantations in the Sumy region and/or shortcomings in remote sensing-based mapping.

The overall change in the average stock across all species groups indicated a significant decrease (-12 cubic metres/ha, or -3 cubic metres/ha per year). In particular, the stock of all conifers decreased by -19 cubic metres/ha, and the stock of deciduous trees decreased by -6 cubic metres/ha.

Changes in distribution of growing stock volume of stands of Sumy obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	0	-8	7	11	23	52	18	-19
Spruce (Fir)	-1	32	-22	2	-262	0	0	47
Oak	8	-5	0	3	13	-23	-4	0
Beech	-29	-10	37	29	-91	0	0	38
Ash, Linden, Maple, Black locust	7	1	0	13	7	29	-46	1
Birch, Alder, Poplar	3	-1	-1	2	-32	13	-10	-8
Hornbeam	-4	-4	-2	-8	-66	-74	0	-20
All coniferous	**0**	**-8**	**7**	**11**	**23**	**52**	**18**	**-19**
All deciduous	**7**	**0**	**-1**	**4**	**-4**	**17**	**-6**	**-6**
All species	**3**	**0**	**-2**	**1**	**-4**	**26**	**-6**	**-12**

Poltava region:

An increase in the average stock within 20-year age groups occurred for pine stands aged 101-120 years by 82 cubic metres/hectare, aged 81-100 years by 33 cubic metres/hectare. However, the stock of pine stands older than 120 years decreased by -10 cubic metres/hectare, which may be due to the intensification of tree mortality in overmature pine stands. Overall, an increase in the average stock of pine forests was observed at the level of 27 cubic metres/hectare. This change may indicate sustainable management of pine forests.

There was a slight increase in the average stock within the 20-year age groups for oak stands aged 81-100 years by 7 cubic metres per hectare, 61-80 years by 6 cubic metres per hectare, and 41-60 years by 13 cubic metres per hectare, although there was a decrease in the average stock in stands older than 120 years by -14 cubic metres/ha, and in stands aged 101-120 years by -33 cubic metres/ha. On average, an increase in the average stock of oak stands was observed at the level of 6 cubic metres/ha.

A certain increase in the average stock within the 20-year age groups occurred for hornbeam stands aged 1-21 years by 15 cubic metres per hectare, 21-40 years by 13 cubic metres per hectare, 41-60 years by 11 cubic metres per hectare, although there was a decrease in the average stock in hornbeam stands aged 101-120 years by -13 cubic metres/ha, and 81-100 years by -30 cubic metres/ha. On average, a decrease in the average stock of hornbeam stands was observed at the level of -10 cubic metres/ha.

An abnormal change in the average stock within 20-year age groups occurred for spruce (35 cubic metres/hectare) and beech (16 cubic metres/hectare) stands. Such a change in stock levels for individual age groups may indicate a likely insignificant area of spruce and beech plantations in the Poltava region and/or shortcomings in mapping based on remote sensing data.

The overall change in the average stock of all species groups indicated an increase (17 cubic metres/hectare = 4.25 cubic metres/hectare per year), with the stock of all conifers increasing by 27 cubic metres/hectare and the stock of deciduous trees by 20 cubic metres/hectare. The specifics of calculating the average stock of all tree species need to be clarified and/or justified.

Changes in distribution of growing stock volume of stands of Poltava obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	1	8	28	18	33	82	-10	27
Spruce (Fir)	0	6	-31	13	0	0	0	35
Oak	12	26	13	6	7	-33	-14	6
Beech	4	-10	15	19	-4	-13	0	16
Ash, Linden, Maple, Black locust	7	13	6	11	25	11	-57	18
Birch, Alder, Poplar	17	22	4	5	14	12	-15	8
Hornbeam	15	13	11	-17	-30	-13	0	-10
All coniferous	**1**	**8**	**28**	**18**	**33**	**82**	**-10**	**27**
All deciduous	**8**	**20**	**10**	**10**	**23**	**-2**	**-24**	**20**
All species	**8**	**17**	**8**	**4**	**28**	**5**	**-23**	**17**

Cherkasy region:

The average stock within 20-year age groups decreased for pine stands older than 120 years by 5 cubic metres/hectare, and for stands aged 101-120 years by 16 cubic metres/hectare, which may be associated with the deterioration of mature and overmature stands. At the same time, the stock of pine stands increased in the 81-100-year-old groups by 5 cubic metres/hectare and in the 61-80-year-old groups by 19 cubic metres/hectare, which may be due to the natural growth processes of pine stands. Overall, an increase in the average stock of pine forests was observed at the level of 17 cubic metres per hectare.

There was a slight decrease in the average stock within the 20-year age groups for oak stands older than 120 years by 17 cubic metres per hectare, 101-120 years by 11 cubic metres per hectare, and 81-100 years by 3 cubic metres per hectare,

although there was an increase in the average stock in stands aged 1-60 years by 1-5 cubic metres per hectare. On average, a decrease in the average stock of oak stands was observed at the level of -1 cubic metre per hectare. Forest use in oak stands needs to be analysed for sustainability.

There was a slight increase in the average stock within the 20-year age groups for stands of ash, linden, maple and black locust aged 1-80 years by 3-6 cubic metres per hectare, although there was a decrease in the average stock in stands aged >120 years by -33 cubic metres/ha, and in stands aged 101-120 years by -27 cubic metres/ha. On average, an increase in the average stock of Ash, Linden, Maple, and Black locust stands was observed at the level of 12 cubic metres/ha.

An abnormal change in the average stock within 20-year age groups occurred for spruce, hornbeam and beech stands. Such a change in stock levels across age groups may indicate a possibly insignificant area of spruce and beech plantations in the Cherkasy region and/or shortcomings in mapping based on remote sensing data.

The overall change in the average stock of all species groups indicated an increase (8 cubic metres/hectare = 2 cubic metres/hectare per year). In particular, the stock of all conifers increased by 17 cubic metres/hectare, while the stock of deciduous trees decreased by 8 cubic metres/hectare.

Changes in distribution of growing stock volume of stands of Cherkasy obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	8	5	3	19	5	-16	-5	17
Spruce (Fir)	52	18	-6	-21	-123	0	0	-1
Oak	1	4	5	0	-3	-11	-17	-1
Beech	-5	17	9	6	26	24	0	13
Ash, Linden, Maple, Black locust	3	6	6	6	16	-27	-33	12
Birch, Alder, Poplar	11	20	8	1	3	-8	-9	5
Hornbeam	0	-3	3	-2	-22	2	277	-1
All coniferous	**8**	**5**	**3**	**19**	**5**	**-16**	**-5**	**17**
All deciduous	**3**	**9**	**7**	**3**	**3**	**-13**	**-18**	**8**
All species	**3**	**7**	**3**	**6**	**4**	**-11**	**-14**	**8**

Kirovohrad region:
A significant decrease in the average stock within 20-year age groups occurred for oak stands older than 120 years by -52 cubic metres/ha, 81-100 years by -2 cubic metres/ha, although there was an increase in the average stock in stands aged 21-80 years by 3-10 cubic metres per hectare and 101-120 years by 3 cubic metres per

hectare. On average, an increase in the average stock of oak stands was noted at the level of 7 cubic metres per hectare.

A decrease in the average stock within the 20-year age groups occurred in pine stands older than 120 years by -63 cubic metres/ha and in 101-120 years by -61 cubic metres/ha, which may be associated with the deterioration in the health of mature and overmature stands. At the same time, the stock of pine stands increased in the 61-80 age groups by 38 cubic metres per hectare, in the 41-60 age groups by 27 cubic metres per hectare, and in the 21-40 age groups by 33 cubic metres per hectare, which may be due to the natural growth processes of productive pine stands. Overall, an increase in the average stock of pine forests was observed at the level of 30 cubic metres per hectare.

A certain increase in the average stock within the 20-year age groups occurred for stands of Ash, Linden, Maple, and Black locust aged 1-80 years by 4-28 cubic metres per hectare, although there was a significant decrease in the average stock in stands aged >120 years by -76 cubic metres per hectare, and 101-120 years old by -79 cubic metres/hectare, which may be associated with the intensive disturbance of ash stands by the mass reproduction of the emerald ash borer (Agrilus planipennis). On average, an increase in the average stock of Ash, Linden, Maple, and Black locust stands was observed at the level of 16 cubic metres per hectare.

An abnormal change in the average stock within 20-year age groups was observed in spruce and beech stands. Such a change in stock for individual age groups may indicate a probable insignificant area of spruce and beech plantations in the Kirovohrad region and/or shortcomings in mapping based on remote sensing data.

The overall change in the average stock of all species groups indicated an increase (15 cubic metres/hectare = 3.75 cubic metres/hectare per year). In particular, the stock of all conifers increased by 30 cubic metres/hectare, while the stock of deciduous trees decreased by 16 cubic metres/hectare.

Changes in distribution of growing stock volume of stands of Kirovohrad obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	28	33	27	38	-7	-61	-63	30
Spruce (Fir)	0	39	16	61	0	0	0	87
Oak	-1	3	10	4	-2	3	-52	7
Beech	-8	3	-1	-1	10	-52	0	-4
Ash, Linden, Maple, Black locust	4	4	10	4	28	-79	-76	16
Birch, Alder, Poplar	-5	-1	-12	-17	21	-38	-46	-11
Hornbeam	-5	-3	1	-6	-4	5	0	-8
All coniferous	**28**	**33**	**27**	**38**	**-7**	**-61**	**-63**	**30**
All deciduous	**4**	**4**	**11**	**3**	**12**	**-31**	**-71**	**16**
All species	**4**	**6**	**10**	**3**	**11**	**-31**	**-74**	**15**

Kharkiv region:

An increase in the average stock within 20-year age groups occurred for pine stands older than 120 years by 10 cubic meters/ha, 61-100 years by 4 cubic meters/ha. At the same time, the stock of pine stands decreased in groups 101-120 years by -3 cubic meters/ha, 41-60 years by -10 cubic meters/ha, and 21-40 years by -7 cubic meters/ha, which may be due to the disturbance of pine stands as a result of hostilities. In general, a decrease in the average stock of pine forests was noted at the level of -17 cubic meters/ha. Considering much smaller changes within age groups, it is necessary to analyse the reliability of the average stock value additionally.

A certain decrease in the average stock within 20-year age groups occurred for oak stands 101-120 years old by -6 cubic meters/ha. m/ha, 81-100 years by -10 cubic m/ha, 61-80 years by -7 cubic m/ha, although there was a slight increase in the average stock in stands aged >120 years by 1 cubic m/ha and 21-40 years by 2 cubic m/ha. On average, the decrease in the stock of oak stands was -3 cubic m/ha.

A certain increase in the average stock within the 20-year age groups occurred for stands of "Ash, Linden, Maple, Black locust" >120 years by 1 cubic m/ha and 101-120 years by 4 cubic m/ha, although there was a decrease in the average stock in stands aged 81-100 years by -3 cubic m/ha. On average, the increase in the average stock of "Ash, Linden, Maple, Black locust" stands was 9 cubic m/ha.

An anomaly in the average stock within 20-year age groups occurred for spruce and beech stands. Such changes in stock by age group may indicate a likely

insignificant area of such spruce and beech stands in the Kharkiv region and/or shortcomings in mapping based on remote sensing data.

The overall change in the average stock of all species groups indicated a certain decrease (-2 cubic meters per hectare = -0.5 cubic meters per hectare per year). In particular, the stock of all conifers decreased by -17 cubic meters per hectare, and the stock of deciduous trees increased by 3 cubic meters per hectare.

Changes in distribution of growing stock volume of stands of Kharkiv obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	0	-7	-10	4	4	-3	10	-17
Spruce (Fir)	0	39	215	48	0	0	0	110
Oak	-5	2	-6	-7	-10	-6	1	-3
Beech	2	17	31	39	0	0	0	95
Ash, Linden, Maple, Black locust	-7	9	0	5	-3	4	1	9
Birch, Alder, Poplar	0	9	8	12	-10	-4	2	1
All coniferous	0	-7	-10	4	4	-3	10	-17
All deciduous	**-5**	**8**	**-2**	**0**	**-7**	**-4**	**1**	**3**
All species	**0**	**7**	**0**	**-5**	**-7**	**-4**	**1**	**-2**

Luhansk region:

A decrease in the average stock within 20-year age groups occurred for pine stands 101-120 years old by -2 cubic meters per hectare, 81-100 years old by -11 cubic meters per hectare, which may be due to the disturbance of pine stands as a result of hostilities. At the same time, the stock of pine stands increased in groups >120 years by 1 cubic m/ha, 61-80 years by 5 cubic m/ha, and 41-60 years by 3 cubic m/ha. In general, the decrease in the average stock of pine stands was noted at the level of -9 cubic m/ha.

A certain decrease in the average stock within 20-year age groups occurred for oak stands 101-120 years by -10 cubic m/ha, 81-100 years by -7 cubic m/ha, 61-80 years by -7 cubic m/ha, although there were no changes in the average stock in stands aged >120 years and 41-60 years. On average, the decrease in the stock of oak stands was -4 cubic m/ha.

A certain increase in the average stock within 20-year age groups occurred for stands of "Ash, Linden, Maple, Black locust" >120 years old by 6 cubic m/ha and 101-120 years old by 3 cubic m/ha. On average, the increase in the average stock

of stands of "Ash, Linden, Maple, Black locust" was noted at the level of 11 cubic m/ha.

The overall change in the average stock of stands across all species groups indicated a slight decrease (-2 cubic m/ha = -0.5 cubic m/ha per year). In particular, the stock of all conifers decreased by -9 cubic m/ha, and the stock of deciduous trees increased by 6 cubic m/ha. There is a decrease in the productivity of stands of the main forest-forming species - Scots pine and Scots oak.

Changes in distribution of growing stock volume of stands of Luhansk obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	2	-8	3	5	-11	-2	1	-9
Oak	-3	4	0	-7	-7	-10	0	-4
Ash, Linden, Maple, Black locust	5	4	1	9	2	3	6	11
Birch, Alder, Poplar	-1	0	3	1	-5	-9	0	5
All coniferous	2	-8	3	5	-11	-2	1	-9
All deciduous	2	3	1	3	-3	-8	1	6
All species	2	-1	0	-10	-9	-7	1	-2

Donetsk region:
The average stock within 20-year age groups decreased for pine stands >120 years by -107 cubic m/ha, 101-120 years by -1 cubic m/ha, 81-100 years by -6 cubic m/ha, which may be due to the disturbance of pine stands as a result of hostilities. At the same time, the stock of pine stands increased by 3 cubic m/ha in groups 1-20 years and by 6 cubic m/ha in groups 21-40 years. In general, the average stock of pine stands decreased by -17 cubic m/ha.

A certain decrease in the average stock within 20-year age groups occurred for oak stands >120 years by -2 cubic m/ha, 101-120 years by -2 cubic m/ha, 81-100 years by -7 cubic m/ha. m/ha, 61-80 years old by -3 cubic m/ha, although there was a certain increase in the average stock in stands aged 1-60 years. On average, a decrease in the average stock of oak stands was noted at the level of -3 cubic m/ha.

A slight increase in the average stock within 20-year age groups occurred for stands of "Ash, Linden, Maple, Black locust" aged 21-120 years, by 4-22 cubic m/ha. On average, an increase in the average stock of stands of "Ash, Linden, Maple, Black

locust" was noted at the level of 21 cubic m/ha. The average stock for this group of species requires clarification/verification to ensure data reliability.

An abnormal change in the average stock within 20-year age groups occurred in spruce and beech stands. Such a change in stock by age group may indicate a likely insignificant area of spruce and beech plantations in the Donetsk region, and/or may be due to shortcomings in the mapping of remote sensing data.

The overall change in average stock across all species groups indicated a slight increase (from 11 cubic meters/ha to 2.75 cubic meters/ha per year). In particular, the stock of all conifers decreased by -17 cubic meters/ha, and the stock of deciduous trees increased by 15 cubic meters/ha. The decrease in the productivity of conifers is probably associated with the greater vulnerability of pine plantations to the effects of hostilities.

Changes in distribution of growing stock volume of stands of Donetsk obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	3	6	-8	-4	-6	-1	-107	-17
Spruce (Fir)	0	0	0	0	0	0	0	210
Oak	1	25	4	-3	-7	-2	-2	-3
Beech	0	22	0	0	0	0	0	76
Ash, Linden, Maple, Black locust	4	22	7	6	6	4	-6	21
Birch, Alder, Poplar	0	18	6	7	-6	-7	-46	11
All coniferous	3	6	-8	-4	-6	-1	-107	-17
All deciduous	**3**	**23**	**7**	**3**	**-1**	**-2**	**-20**	**15**
All species	**2**	**25**	**7**	**-1**	**-2**	**-2**	**-22**	**11**

Kherson region:

An increase in average stock was observed in pine plantations >120 years old by 40 cubic meters/ha, 101-120 years old by 4 cubic meters/ha, and 1-20 years old by 8 cubic meters/ha. m/ha. At the same time, the stock of pine stands increased in the groups 81-100 years old by -1 cubic m/ha, 61-80 years old by -2 cubic m/ha, 41-60 years old by -2 cubic m/ha, 21-40 years old by -3 cubic m/ha, which may be due to the disturbance of pine stands as a result of hostilities. In general, the decrease in the average stock of pine stands was noted at the level of -3 cubic m/ha.

A certain decrease in the average stock within 20-year age groups occurred for oak stands 81-100 years old by -2 cubic m/ha, 61-80 years old by -5 cubic m/ha, 41-60 years old by -7 cubic m/ha, although there was an anomalous increase in the

average stock in stands aged 101-120 years by 71 cubic m/ha. On average, the decrease in the stock of oak stands was -5 cubic meters per hectare.

A sharp decrease in the average stock within 20-year age groups occurred for stands of "Ash, Linden, Maple, Black locust" >120 years old by -116 cubic meters per hectare. On average, no changes in the average stock of stands of "Ash, Linden, Maple, Black locust" were noted; however, the average stock of this group of species requires clarification/verification for data reliability.

An abnormal change in the average stock within 20-year age groups occurred in spruce and beech stands. Such changes in stock by age group may indicate a likely insignificant area of spruce and beech stands in the Donetsk region, and/or be due to deficiencies in the mapping of remote sensing data.

The overall change in the average stock of stands of all species groups indicated a certain increase (4 cubic meters per ha = 0.5 cubic meters per ha per year). In particular, the stock of all conifers decreased by -3 cubic meters per ha, and the stock of broadleaved trees increased by 2 cubic meters per ha. The decrease in conifer productivity is probably associated with the greater vulnerability of pine stands to the effects of hostilities.

Changes in distribution of growing stock volume of stands of Kherson obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	8	-3	-2	-2	-1	4	40	-3
Spruce (Fir)	0	-10	103	0	0	0	0	40
Oak	0	17	-7	-5	-1	71	0	-5
Beech	0	-36	-20	0	0	0	0	16
Ash, Linden, Maple, Black locust	9	-3	-5	0	14	2	-116	0
Birch, Alder, Poplar	9	-11	20	40	20	26	0	27
All coniferous	8	-3	-2	-2	-1	4	40	-3
All deciduous	**8**	**-3**	**-2**	**1**	**9**	**5**	**-118**	**2**
All species	**7**	**-6**	**0**	**0**	**7**	**5**	**-90**	**4**

Autonomous Republic of Crimea:

An increase in the average stock within 20-year age groups occurred for pine stands 101-120 years old by 5 cubic m/ha, 81-100 years old by 12 cubic m/ha. At the same time, the stock of pine stands decreased in the group >120 years old by -2 cubic m/ha, which may be due to the fall of pine stands at the age of maturity. In general,

an increase in the average stock of pine forests was noted at the level of 3 cubic m/ha.

A certain decrease in the average stock within 20-year age groups occurred for oak stands 1-20 years old by -14 cubic m/ha, 61-80 years old by -1 cubic m/ha. At the same time, there was a significant increase in the average stock in stands aged 81-100 years by 45 cubic m/ha. On average, the increase in the stock of oak stands was 3 cubic meters per hectare.

A sharp decrease in the average stock within 20-year age groups occurred for stands of "Birch, Alder, Poplar" >120 years old by -27 cubic meters per hectare, 81-100 years old by -41 cubic meters per hectare, 61-80 years old by -32 cubic meters per hectare. On average, the change in the average stock of "Birch, Alder, Poplar" stands is only -1 cubic meter per hectare.

The inventory results must not show the presence of beech stands, whose area can reach about 50 thousand hectares. Of course, this is due to the lack of sample areas in the peninsula's occupied territory and to shortcomings in mapping based on remote sensing data.

The overall change in the average stock across all species groups indicated a slight decrease (-3 cubic meters/ha, or -0.75 cubic meters/ha per year). In particular, the stock of all conifers increased by 3 cubic meters/ha, and the stock of deciduous trees decreased by -4 cubic meters/ha.

Changes in distribution of growing stock volume of stands of AR of Crimea by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	14	2	0	0	12	5	-2	3
Oak	-14	13	-2	-1	45	9	0	3
Ash, Linden, Maple, Black locust	0	3	-1	-3	-2	-6	-4	-4
Birch, Alder, Poplar	-1	4	9	-32	-41	9	-27	-1
All coniferous	14	2	0	0	12	5	-2	3
All deciduous	1	3	-1	-3	-2	-6	-4	-4
All species	8	2	-2	-3	-2	-2	-4	-3

Zaporizhia region:

The increase in the average stock within 20-year age groups occurred for pine stands >120 years old by 3 cubic meters/ha, 101-120 years old by 14 cubic

meters/ha, and 61-80 years old by 37 cubic meters/ha. At the same time, the pine stand stock decreased in the 81-100-year-old group by 26 cubic meters/ha, which may be due to the impact of hostilities. In general, the average pine forest stock increased by 3 cubic meters/ha.

A certain decrease in the average stock within 20-year age groups occurred for oak stands 101-120 years old by -15 cubic m/ha. At the same time, there was an increase in the average stock in stands aged 81-100 years by 9 cubic m/ha and in stands aged 61-80 years by 6 cubic m/ha. On average, the increase in the average stock of oak stands was 8 cubic m/ha.

A sharp decrease in the average stock within 20-year age groups occurred in stands of "Birch, Alder, Poplar": 81-100 years by -15 cubic m/ha, 61-80 years by -7 cubic m/ha, and 41-60 years by -9 cubic m/ha. On average, the change in the average stock of stands of "Birch, Alder, Poplar" is only -15 cubic m/ha, which requires additional verification of the indicator's reliability.

An abnormal change in the average stock within 20-year age groups occurred for spruce, hornbeam and beech stands. Such changes in stock by age group may indicate a likely insignificant area of such spruce, hornbeam, and beech stands in Zaporizhzhia, and/or may be due to mapping deficiencies based on remote sensing data.

The overall change in the average stock across all species groups indicated a slight increase (2 cubic meters/ha to 0.5 cubic meters/ha per year). In particular, the stock of all conifers increased by 3 cubic meters/ha, and the stock of deciduous trees decreased by 4 cubic meters/ha. These indicators have some inconsistencies and should be checked for reliability.

Changes in distribution of growing stock volume of stands of Zaporizhzhia obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	8	2	6	37	-26	14	3	3
Spruce (Fir)	0	0	-84	0	-196	0	0	10
Oak	0	8	1	6	9	-15	0	8
Beech	0	-4	-31	0	0	0	0	67
Ash, Linden, Maple, Black locust	7	7	1	-3	11	-32	-99	6
Birch, Alder, Poplar	13	-4	-9	-7	-15	21	0	-15
Hornbeam	0	0	99	0	0	0	0	144
All coniferous	**8**	**2**	**6**	**37**	**-26**	**14**	**3**	**3**
All deciduous	**8**	**6**	**0**	**-3**	**8**	**-30**	**-105**	**4**
All species	**8**	**6**	**0**	**-7**	**6**	**-20**	**-38**	**2**

Mykolaiv region:
An increase in the average stock within 20-year age groups occurred for pine stands 61-80 years old by 4 cubic meters/ha, 41-60 years old by 9 cubic meters/ha. m/ha. At the same time, the stock of pine stands decreased in the group of 101-120 years by -88 cubic m/ha and 81-100 years by -4 cubic m/ha. In general, the increase in the average stock of pine stands was noted at the level of 7 cubic m/ha.

A significant decrease in the average stock within 20-year age groups occurred for oak stands of 101-120 years by -38 cubic m/ha and 81-100 years by -13 cubic m/ha. At the same time, there was an increase in the average stock in stands of >120 years by 2 cubic m/ha and in stands of 61-80 years by 3 cubic m/ha. On average, the increase in the average stock of oak stands was noted at the level of -2 cubic m/ha.

Anomaly change in the average stock within 20-year age groups occurred for spruce, hornbeam and beech stands. Such changes in stock by age group may indicate a likely insignificant area of such spruce, hornbeam, and beech stands in the Mykolaiv region and/or may be due to mapping shortcomings based on remote sensing data.

The overall change in the average stock across all species groups indicated a slight decrease (-1 cubic m/ha = 0.25 cubic m/ha per year). In particular, the stock of all conifers increased by 7 cubic m/ha, while the stock of deciduous trees remained unchanged. These indicators have some inconsistencies and should be checked for reliability.

Changes in distribution of growing stock volume of stands of Mykolaiv obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	-1	-2	9	4	-4	-88	0	7
Spruce (Fir)	0	15	-10	81	0	0	0	26
Oak	0	-2	0	3	-13	-38	2	-2
Beech	-8	5	33	-1	60	0	0	23
Ash, Linden, Maple, Black locust	2	-2	-17	-14	-20	-40	0	-2
Birch, Alder, Poplar	0	3	-10	-2	-3	0	0	0
Hornbeam	-1	-3	-7	-5	-18	-29	0	-2
All coniferous	**-1**	**-2**	**9**	**4**	**-4**	**-88**	**0**	**7**
All deciduous	**1**	**-1**	**-11**	**-8**	**-24**	**-64**	**0**	**0**
All species	**1**	**-2**	**-9**	**-8**	**-23**	**-66**	**0**	**-1**

Odesa region:

A significant decrease in the average stock within 20-year age groups occurred for pine stands 101-120 years old by -69 cubic m/ha. At the same time, the stock of pine stands increased by 3 cubic m/ha in the group 81-100 years old, by 2 cubic m/ha in the group 61-80 years old, and by 5 cubic m/ha in the group 41-60 years old. In general, no changes in the average stock of pine stands were detected.

A significant decrease in the average stock within 20-year age groups occurred for oak stands >120 years old by -5 cubic m/ha, 101-120 years old by -25 cubic m/ha and 81-100 years old by -4 cubic m/ha. On average, the decrease in the stock of oak stands was -1 cubic m/ha.

An abnormal change in the average stock within 20-year age groups occurred for stands of spruce, hornbeam, beech and "Birch, Alder, Poplar". Such changes in stock by age group may indicate a likely insignificant area of such stands in the Odessa region and/or a connection to shortcomings in mapping based on remote sensing data.

There was no overall change in the average stock of stands of all species groups, but the stock of all conifers increased by 1 cubic m/ha.

Changes in distribution of growing stock volume of stands of Odeska obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	2	-1	5	2	3	-69	0	0
Spruce (Fir)	-6	22	56	208	0	0	0	75
Oak	1	0	0	0	-4	-25	-5	-1
Beech	22	4	-6	-5	-8	0	0	-27
Ash, Linden, Maple, Black locust	2	0	3	-2	-4	-34	0	3
Birch, Alder, Poplar	-2	-10	-5	-7	0	-61	0	3
Hornbeam	-2	-5	1	-6	0	-27	0	-4
All coniferous	**2**	**-1**	**5**	**2**	**3**	**-69**	**0**	**1**
All deciduous	**2**	**-1**	**2**	**-2**	**-7**	**-85**	**0**	**0**
All species	**2**	**-1**	**0**	**-2**	**-7**	**-85**	**0**	**0**

Vinnytsia region:
A decrease in the average stock within 20-year age groups occurred for pine stands older than 120 years by -3 cubic m/ha, 101-120 years by -21 cubic m/ha, which may be associated with a deterioration in the health of mature and overwintered stands. At the same time, the stock of pine stands did not change in the groups of 81-100 years, 61-80 years and 41-60 years. In general, the decrease in the average stock of pine stands was noted at the level of -7 cubic m/ha.

A certain decrease in the average stock within 20-year age groups occurred for oak stands older than 120 years by -8 cubic m/ha, 101-120 years by -3 cubic m/ha, 81-100 years by -1 cubic m/ha, although there was an increase in the average stock in stands aged 41-60 years by 1 cubic m/ha. On average, the decrease in the stock of oak stands was -6 cubic m/ha. Forest use in oak stands needs to be analysed for non-exhaustion.

A certain decrease in the average stock within 20-year age groups occurred for stands of "Ash, Linden, Maple, Black locust", "Birch, Alder, Poplar", and hornbeam.

An abnormal change in the average stock within 20-year age groups was observed in spruce stands. Such changes in stock by age group may indicate a likely insignificant area of such spruce stands in Vinnytsia and/or shortcomings in mapping based on remote sensing data.

The overall change in the average stock of stands across all species groups indicated a decrease (-3 cubic meters/ha, or -0.75 cubic meters/ha per year). In

particular, the stock of all conifers decreased by -7 cubic meters/ha, and the stock of deciduous trees decreased by -3 cubic meters/ha.

Changes in distribution of growing stock volume of stands of Vinnytsia obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	0	-6	0	0	0	-21	-3	-7
Spruce (Fir)	-9	-6	-4	8	2	152	0	-3
Oak	-6	0	1	0	-1	-3	-8	-6
Beech	2	6	-3	-2	2	38	8	0
Ash, Linden, Maple, Black locust	-1	0	1	-5	-3	-25	0	-3
Birch, Alder, Poplar	0	0	-7	-6	10	-4	0	-6
Hornbeam	0	5	-1	-2	-18	61	58	-1
All coniferous	**0**	**-6**	**0**	**0**	**0**	**-21**	**-2**	**-7**
All deciduous	**-2**	**1**	**1**	**-2**	**-1**	**-11**	**-6**	**-3**
All species	**-1**	**1**	**1**	**-2**	**-1**	**-11**	**-6**	**-3**

Khmelnytskyi region:

A decrease in the average stock within 20-year age groups occurred for pine stands of 101-120 years by -17 cubic meters. m/ha, 81-100 years old by -15 cubic m/ha, which may be associated with the deterioration of the health of mature and overgrown stands. At the same time, the stock of pine stands did not change in the 61-80-year-old group. In general, the decrease in the average stock of pine stands was noted at the level of -15 cubic m/ha.

A significant decrease in the average stock within 20-year age groups occurred for oak stands older than 120 years by -28 cubic m/ha. At the same time, there was an increase in the average stock in stands aged 101-120 years by 10 cubic m/ha, 81-100 years by 16 cubic m/ha, and 61-80 years by 6 cubic m/ha. On average, the decrease in the stock of oak stands was 4 cubic m/ha.

A significant decrease in the average stock within 20-year age groups occurred for spruce stands 41-60 years old by -40 cubic m/ha. At the same time, there was an increase in the average stock in stands 81-100 years old by 22 cubic m/ha and in stands 61-80 years old by 11 cubic m/ha. On average, a decrease in the stock of spruce stands was observed at 23 cubic m/ha.

The total change in the average stock of stands of all species groups indicated no changes (0 cubic m/ha); however, the stock of all conifers decreased by -15 cubic m/ha, and the stock of deciduous trees increased by 4 cubic m/ha.

Changes in distribution of growing stock volume of stands of Khmelnytskyi obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	1	-1	-9	0	-15	-17	1	-15
Spruce (Fir)	13	-3	-40	11	22	0	0	-23
Oak	0	0	5	6	16	10	-28	4
Beech	5	6	3	9	12	-3	74	22
Ash, Linden, Maple, Black locust	2	2	-1	-1	10	18	-7	0
Birch, Alder, Poplar	1	12	7	5	8	5	3	10
Hornbeam	2	5	-1	4	-1	-17	4	2
All coniferous	**1**	**-1**	**-9**	**0**	**-15**	**-17**	**1**	**-15**
All deciduous	**1**	**5**	**1**	**2**	**14**	**12**	**-18**	**4**
All species	**5**	**5**	**0**	**0**	**1**	**11**	**-17**	**0**

Ternopil region:

A decrease in the average stock within 20-year age groups occurred for pine stands >120 years old by -5 cubic m/ha, 101-120 years old by -2 cubic m/ha, which may be partly related to the deterioration of the health of mature and overgrown stands. At the same time, the pine stand stock slightly increased in the 61-80-year-old group by 2 cubic m/ha and in the 81-100-year-old group by 3 cubic m/ha. In general, a decrease in the average pine stand stock of -13 cubic m/ha was noted, which requires clarification or additional verification.

A certain increase in the average stock within 20-year age groups occurred for oak stands 101-120 years old by 14 cubic m/ha, 81-100 years old by 16 cubic m/ha. m/ha, 61-80 years by 8 cubic m/ha. At the same time, there was a slight decrease in the average stock in stands >120 years old by -1 cubic m/ha. On average, the increase in the average stock of oak stands was 14 cubic m/ha.

A significant increase in the average stock within 20-year-old age groups occurred for spruce stands 101-120 years old by 74 cubic m/ha, 81-100 years old by 11 cubic m/ha, and 61-80 years old by 9 cubic m/ha. At the same time, the average stock of spruce stands increased by 2 cubic m/ha, which seems insufficient given the change in stock by age groups.

The total change in the average stock of all species groups was 0 (4 cubic meters per ha = 1 cubic meter per ha per year); however, the stock of all conifers decreased by -13 cubic meters per ha, and the stock of deciduous trees increased by 7 cubic meters per ha.

Changes in distribution of growing stock volume of stands of Ternopil obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	-2	-9	-4	2	3	-2	-5	-13
Spruce (Fir)	10	2	10	9	11	74	0	2
Oak	7	4	15	8	16	14	-1	14
Beech	3	4	10	8	-15	2	45	6
Ash, Linden, Maple, Black locust	6	7	3	-2	19	35	-11	6
Birch, Alder, Poplar	3	2	2	2	15	32	3	3
Hornbeam	9	2	-3	2	-1	-1	-16	1
All coniferous	**-2**	**-9**	**-4**	**2**	**3**	**-1**	**-5**	**-13**
All deciduous	**6**	**6**	**4**	**2**	**17**	**13**	**-1**	**7**
All species	**13**	**5**	**2**	**2**	**13**	**13**	**-1**	**4**

Dnipropetrovsk region:

The decrease in the average stock within 20-year age groups occurred for pine stands 101-120 years old by -18 cubic meters per ha. At the same time, the stock of pine stands significantly increased in the group >120 years old by 43 cubic meters per ha, in the 61-80 years old group by 22 cubic meters per ha, and in the 81-100 years old group by 12 cubic meters per ha. In general, the increase in the average stock of pine stands was noted at the level of 16 cubic meters per ha.

A certain increase in the average stock within 20-year age groups occurred for oak stands 101-120 years old by 4 cubic m/ha, 81-100 years old by 13 cubic m/ha, and 61-80 years old by 1 cubic m/ha. At the same time, there was a significant decrease in the average stock in stands >120 years old by -61 cubic m/ha. On average, the increase in the average stock of oak stands was 12 cubic m/ha.

A significant decrease in the average stock within 20-year age groups occurred for stands "Ash, Linden, Maple, Black locust" >120 years old by -96 cubic m/ha, 101-120 years old by -60 cubic m/ha. m/ha, which may be associated with intensive disturbance of ash stands by mass reproduction of the emerald ash borer (Agrilus planipennis). At the same time, an increase in the average stock of these stands was observed at 6 cubic meters/ha.

An abnormal change in the average stock within 20-year age groups was detected for spruce and beech stands. Such changes in stock by age group may indicate a likely insignificant area of such stands in the Dnipropetrovsk region and/or shortcomings in mapping based on remote sensing data.

The total change in the average stock of stands of all species groups indicated a decrease in the stock of stands (11 cubic meters/ha = 2.75 cubic meters/ha per

year). In particular, the stock of all conifers increased by 16 cubic meters/ha, and the stock of deciduous trees increased by 10 cubic meters/ha.

Changes in distribution of growing stock volume of stands of Dnipropenrovsk obl. by age, m3/ha (2023-2019)

Species	1-20 years	21-40 years	41-60 years	61-80 years	81-100 years	101-120 years	> 120 years	Mean value
Pine	0	14	5	22	12	-18	43	16
Spruce (Fir)	4	-5	-1	63	-17	0	0	44
Oak	2	11	2	1	13	4	-61	12
Beech	-8	16	-21	-12	-155	0	0	7
Ash, Linden, Maple, Black locust	1	4	0	-5	29	-60	-96	6
Birch, Alder, Poplar	2	0	-18	-24	10	-4	-78	-21
Hornbeam	0	2	3	9	-14	0	0	4
All coniferous	**0**	**14**	**5**	**22**	**12**	**-18**	**43**	**16**
All deciduous	**1**	**6**	**1**	**-3**	**37**	**6**	**-88**	**10**
All species	**1**	**7**	**0**	**1**	**30**	**5**	**-90**	**11**

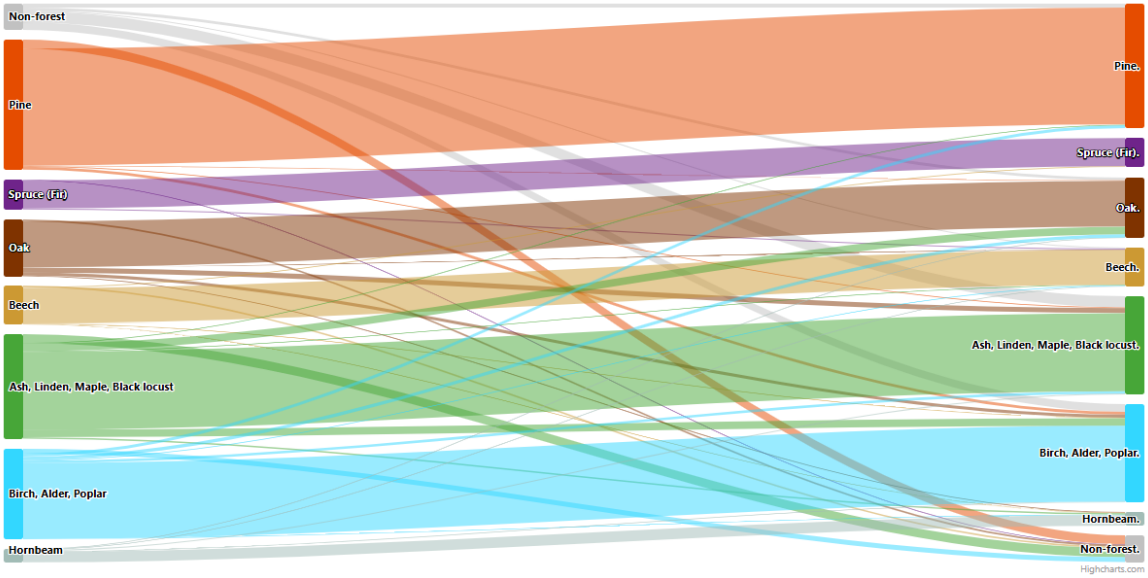
It should be noted that the tendency to reduce stock or change in stock is inherent in forest plantations on steeper slopes, which may be due to more complex forest vegetation and spatial conditions for stand growth. For example, the stock of spruce stands on slopes >20% decreased by 19 cubic meters/ha, and the stock of spruce stands on slopes 11-20%.

Changes in distribution of growing stock volume of stands of Ukraine by slope, m3/ha (2023-2019)

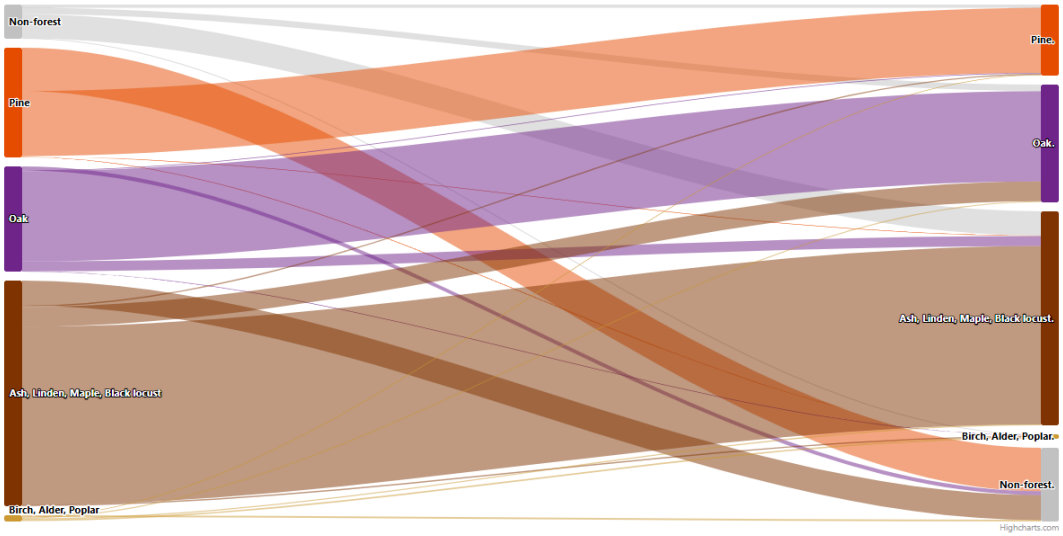
Species	0-10 %	11-20 %	>20 %	Mean value
Pine	-4	-1	0	-4
Spruce (Fir)	-10	-19	-19	-17
Oak	3	2	0	3
Beech	5	1	1	2
Ash, Linden, Maple, Black locust	7	-2	-5	6
Birch, Alder, Poplar	7	0	-11	7
Hornbeam	3	5	1	3
All coniferous	**-5**	**-17**	**-18**	**-6**
All deciduous	**7**	**1**	**1**	**6**
All species	**2**	**-6**	**-6**	**0**

Analysis of changes using Sankey diagrams.

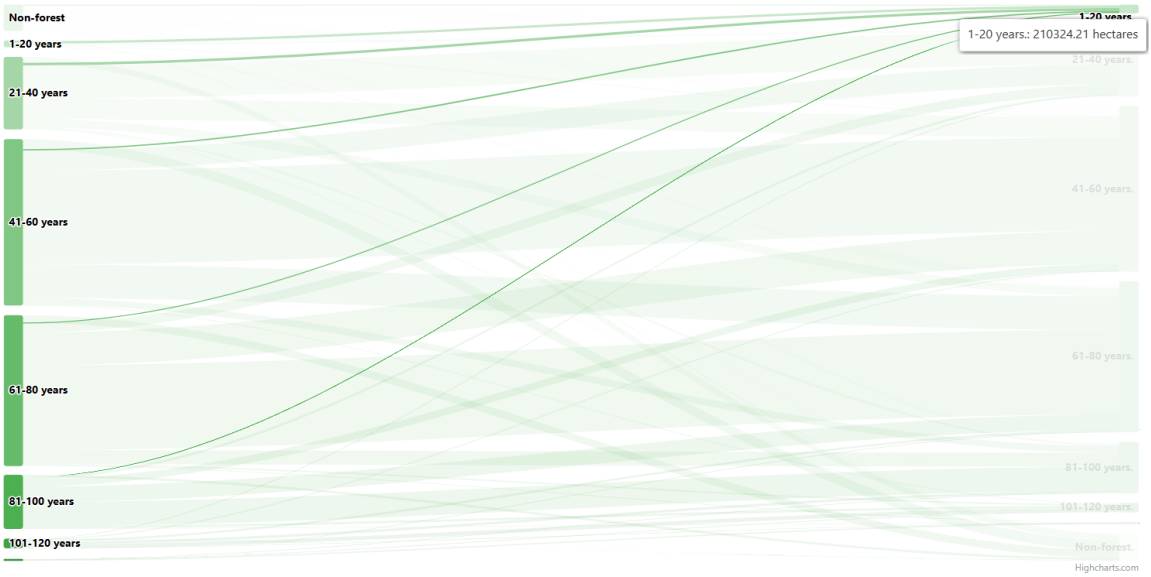
Analysis of changes in the distribution of the forest fund area indicates partial changes in the main species in the stands, which may be due to successions and economic reconstructions of stands, but is most likely the result of errors in the classification of tree species, particularly deciduous ones. A significant feature is the transition of ≈218 thousand hectares of pine forests to non-forest lands, and ≈217 thousand hectares of stands of the "Ash, Linden, Maple, Black locust" group to non-forest lands. Such changes are probably caused by forest disturbances (military operations, fires, mass insect reproduction).



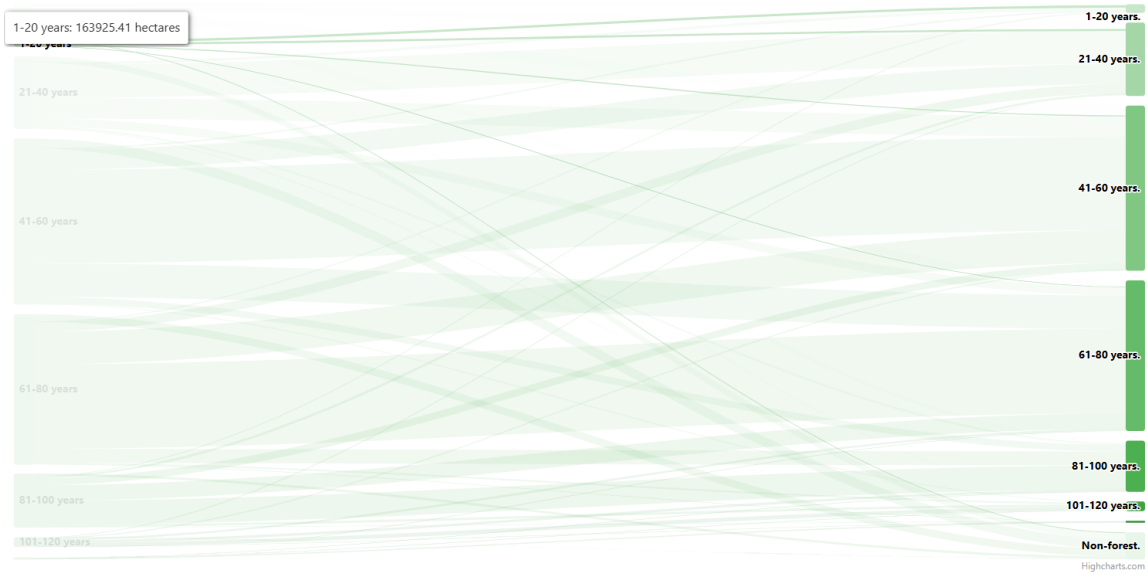
The example of changes in forest cover in the Luhansk region shows the impact of the war on forests, with ≈30 thousand hectares of pine forests transformed into non-forest land, likely due to military operations. In addition, probably under the influence of the war, 17 thousand hectares of stands of the "Ash, Linden, Maple, Black locust" group were transformed into the category of non-forest lands.



The change in the area of forest plots across different age groups (classes) to plots aged 1-20 years indicates possible transformations in the forest cover resulting from continuous sanitary felling. Over the study period, more than 210 thousand hectares of forest stands could have been transformed into non-forest areas, which may correspond to disturbed stands resulting from hostilities, continuous main-use clear-cutting, and continuous sanitary felling.



The change in the area of forest plots aged 1-20 years, and in the groups of stands aged 41-60 and 61-80 years, raises questions. This is probably due to errors and inaccuracies in deciphering remote-sensing data across various types of landscapes.


1-20 years: 163925.41 hectares
21-40 years
41-60 years
61-80 years
81-100 years
101-120 years
1-20 years.
21-40 years.
41-60 years.
61-80 years.
81-100 years.
101-120 years.
Non-forest.
Highcharts.com

Conclusions and recommendations

The main advantages of the RS-Inventory 2023 results:

- a unique information database on quantitative and qualitative indicators of the state of the forest fund of Ukraine has been created;
- the main trends in transformation and changes in land use types at the regional and national levels are substantiated (confirmed);
- trends in changes in forests of the main forest-forming species that prevail in the forest fund of the region are reflected;
- allows for a comprehensive assessment of the area of forests, wood stock, biomass volume and deposited carbon of forest stands.

The main problems and possible solutions for the analysis of the results of the RS-Inventory 2023:

- it is necessary to check the algorithms for calculating average indicators (Age, year; DBH, cm; Height, m; BAS, m2/ha; Growing stock, m3/ha; Density, n/ha; Carbon stock, t/ha), since the formed tables contain incorrect data that do not allow for a comprehensive analysis of the inventory results;
- It is worth abandoning the analysis of the distribution of forest area by age classes or using 40-year age classes;
- It is necessary to limit the participation of spruce and beech in the composition of the plantations for the Forest-Steppe and Steppe;
- to apply the classification group "Other deciduous species";
- to take into account the ability of tree species to grow in mountainous conditions according to a certain height above sea level;
- to use a system of "safety devices" to prevent unnatural changes in the structure of the forest fund;
- to limit (combine) changes between land use types, the numerical value of which is less than the decoding error.