FEASIBILITY OF USING LITHUANIAN FOREST DATA FOR SUPPORTING EU FOREST HABITAT ASSESSMENT IN THE CONTEXT OF CLOSER-TO-NATURE FOREST MANAGEMENT

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Abstract

The decline of biodiversity and the degradation of forest habitats remain among the most significant environmental challenges in Europe. The European Union Habitats Directive and the Natura 2000 network require the identification and monitoring of habitats of Community importance. However, traditional field-based habitat inventory methods are often time-consuming and resource-intensive. This study evaluates the feasibility of using Lithuanian national forest stand data for the identification of EU forest habitats and the differentiation of their conservation status within the context of closer-to-nature forest management. The research was conducted using forest stand inventory data from the Šimoniai Forest area. Habitat distribution, ecological condition classes, and structural forest indicators were analysed. The results revealed that habitat type 9010 (Western taiga) is dominant, accounting for nearly 40% of the analysed habitats. The analysis also showed that larger habitat patches tend to be associated with better ecological condition and that stand age correlates with habitat conservation status. The findings indicate that national forest inventory data can serve as an additional tool for habitat identification and conservation status assessment. The study contributes to the development of methodological approaches for more effective use of existing forest data in biodiversity conservation and the implementation of closer-to-nature forest management practices.

Keywords: forest habitats, Natura 2000, closer-to-nature forestry, forest inventory, biodiversity.

Introduction

Forests are among the most important terrestrial ecosystems, providing essential ecological, economic, and social functions and benefits (Millennium Ecosystem Assessment, 2005). They play a key role in biodiversity conservation, climate regulation, carbon sequestration, soil protection, and water cycle stabilization (Pan et al., 2011). Despite their importance, many forest habitats in Europe remain in an unfavourable conservation status due to intensive forest management, habitat fragmentation, and impacts of climate change (European Environment Agency, 2020).

To address biodiversity loss, the European Union established a legal framework for nature conservation based on the Habitats Directive and the Natura 2000 ecological network (European Commission, 1992). These instruments require the identification of habitats of Community importance and the assessment of their conservation status. Habitat condition is evaluated using structural, functional, and compositional criteria, allowing classification into favourable, unfavourable-inadequate, or unfavourable-bad status categories (Evans & Arvela, 2011).

In recent years, increasing attention has been given to the concept of closer-to-nature forest management (CTNFM) (European Commission, 2021). This approach aims to maintain natural forest processes, increase structural diversity, and enhance ecosystem resilience (Manton et al., 2025). The implementation of such management strategies requires reliable and systematic data on forest structure and habitat characteristics (European Commission, 2023).

Lithuania has developed a comprehensive national forest stand database containing information on species composition, stand age, productivity, and structural characteristics of forest stands. These data are widely used for forest management planning; however, their potential application in ecological habitat identification and conservation status assessment has not been sufficiently explored (Tomppo et al., 2021).

The aim of this study: to evaluate the feasibility of using Lithuanian national forest stand data for the identification and differentiation of EU forest habitats according to their conservation status within the framework of closer-to-nature forest management.

Research objectives:

1. To analyse the distribution and conservation status of EU forest habitats in the study area.
2. To integrate EU habitat data with Lithuanian National Forest Stand Database using GIS methods.
3. To evaluate structural forest indicators (stand age, height, and growing stock volume) across different habitat types and conservation status classes.
4. To assess the relationships between forest structural characteristics and habitat conservation status.
5. To evaluate the potential of national forest inventory data for supporting closer-to-nature forest management.

Research object and methods

Study area

The study was conducted in the Šimoniai Forest massif, located in north-eastern Lithuania within the territories of Anykščiai and Kupiškis districts. The study area forms part of the Šimoniai Forest Biosphere Polygon, which is designated as an important area for biodiversity conservation and ecological monitoring. The forest complex covers approximately 13,500 hectares, of which about 10,870 hectares are forested.

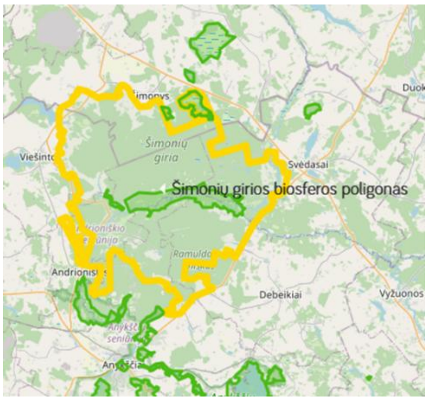

Figure 1. Šimoniai Forest Biosphere Polygon (https://saugoma.lt/lt/teritorijos/simoniu-girios-biosferos-poligonas)

The landscape is characterized by undulating terrain formed by glacial processes, with sandy and sandy loam soils typical of eastern Lithuanian forest ecosystems. Hydrologically, the territory belongs to the Šventoji River basin and includes several tributaries, lakes, and wetland areas, contributing to the diversity of forest habitats

Research object

The research object of this study was forest habitats of European Union importance and their structural characteristics derived from the Lithuanian National Forest Stand Database. The study focused on analysing habitat types, their conservation status, and structural indicators such as stand age, height, and growing stock volume.

In addition, the study examined how these structural characteristics can be interpreted in the context of closer-to-nature forest management (CTNFM), particularly in relation to forest naturalness, structural complexity, and biodiversity-supporting features.

Data sources

Two main data sources were used in this study:

1. EU forest habitat data obtained from the Biomon.lt database. Within the Šimoniai Forest massif, 416 EU forest habitat polygons covering 1,277 ha were identified. These represent habitats mapped according to the EU Habitats Directive classification system. Only state forest habitats were included in the analysis, while privately owned forest areas were excluded.
2. Lithuanian National Forest Stand Database, which provides detailed stand-level information used for forest management planning. The dataset includes variables such as dominant tree species, stand composition, stand age, productivity (site index), growing stock, tree height, diameter, and stocking density. These variables represent key indicators of forest structure and ecological condition and are widely applied in forest monitoring and biodiversity-related assessments (Tomppo et al., 2021; McRoberts et al., 2022).

GIS data processing

Spatial data processing and integration were carried out using ArcGIS Pro (Esri Inc.). The EU habitat polygons were intersected with the National Forest Stand Database to create a combined dataset linking each habitat unit with corresponding forest stand attributes.

The resulting dataset included information on habitat type, conservation status, habitat area, dominant tree species, stand age, height, diameter, growing stock, and stocking density. This integration enabled the analysis of structural characteristics within individual habitat units and is consistent with approaches used in spatial forest inventory analysis (Tomppo et al., 2021).

Data analysis

The analysis was conducted in several steps:

1. Habitat-level analysis. Descriptive statistical analysis was performed to identify habitat types, their conservation status classes (good, satisfactory, bad, potential), and their spatial distribution. Habitat frequency, total area, and mean patch size were calculated for each habitat type.

2. Data integration and preparation. The combined GIS dataset was used to link habitat polygons with forest stand attributes. This allowed the analysis of relationships between habitat characteristics and stand-level structural indicators.

3. Structural indicator analysis. Key structural variables - mean stand age, mean height, and growing stock volume per hectare - were analysed by habitat type and conservation status, as well as compared with surrounding state production forests not classified as EU habitats. These structural features are widely used to evaluate stand maturity, ecological continuity, and forest naturalness (Manton et al., 2025).

Habitat types with insufficient sample size (Wooded pastures (9070), Lichen Scots pine forests (91T0), and Alluvial forests (91E0)) were excluded from detailed structural comparison.

The selected structural indicators are particularly relevant in the context of closer-to-nature forest management, as they reflect forest structural complexity, ecological stability, and the capacity to support biodiversity (Manton et al., 2025; McRoberts et al., 2022).

Research results and discussion

The analysed dataset revealed clear differences in habitat distribution and conservation status across the study area. Overall, the largest proportion of the assessed area was classified as satisfactory conservation status (398 ha; 98 habitats), while the smallest share was classified as potential conservation status (222 ha; 80 habitats).

Western taiga (9010) covered the largest total area (515 ha; 161 habitats). Within this habitat, the greatest area was classified as potential (178 ha), whereas the smallest share occurred in good condition (32 ha) (Table 1). Bog woodlands (91D0) represented the second largest habitat type (331 ha; 108 habitats), with the largest area in good condition (124 ha) and the smallest in potential status (4 ha) (Table 1). Bog woodland with deciduous trees (9080) covered 260 ha (83 habitats), where the largest share occurred in good condition (129 ha) and the smallest in potential status (1 ha). Smaller habitat types included Herb-rich spruce forests (9050), covering 129 ha (41 habitats), with the largest area in good condition (60 ha) and the smallest in bad condition (9 ha) (Table 1). Alluvial forests (91E0) covered 38 ha (20 habitats), where the largest share occurred in bad condition (17 ha) and the smallest in potential status (2 ha) (Table 1). The rarest habitat types were Lichen Scots pine forests (91T0) and Wooded pastures (9070), each covering 2 ha and recorded exclusively in bad conservation status (Table 1).

Overall, the results indicate that although a substantial portion of the assessed habitat area remains in good or satisfactory condition, more than 500 ha fall within bad or potential categories, highlighting notable degradation or insufficient structural development in several habitat types, particularly in the extensive 9010 and 91D0 forest systems. In addition, these habitat types are characteristic of boreal and hemi-boreal forest ecosystems in Northern and Eastern Europe, where coniferous and wetland-associated forest communities dominate the landscape structure (Angelstam et al., 2020; Forest Europe, 2020). Similar patterns have been reported across Europe, where many forest habitats remain in unfavourable conservation status due to historical forest management and landscape fragmentation (European Environment Agency, 2020; Sabatini et al., 2018).

Assessment of habitat ecological condition showed that the largest proportion of sites belonged to the satisfactory condition class (139 sites). In addition, 99 sites were classified as poor and 98 as good condition, while 80 sites were identified as potential habitats, indicating areas where ecological conditions are partially suitable but may require restoration (Table 1). Similar distributions of habitat condition classes have been observed in European forest ecosystems, where a significant proportion of habitats remain in unfavourable or intermediate conservation status due to historical land-use practices and intensive forest management (European Environment Agency, 2020; Sabatini et al., 2018).

The analysis of habitat type and ecological condition revealed notable differences among habitat categories. Habitat type 9010 contained the largest number of potential sites, suggesting considerable restoration potential within this ecosystem type. Large areas of Western taiga forests across Northern Europe have experienced structural changes due to historical management practices, which may influence their current conservation status and restoration potential (Angelstam et al., 2020). In contrast, 9080 and 91D0 habitats demonstrated relatively stable ecological conditions, as the majority of habitats were classified as either good or satisfactory. Previous studies indicate that wetland and peatland-associated forest ecosystems often retain higher ecological stability due to more natural hydrological conditions that limit intensive forest management (Angelstam et al., 2020; Stanturf et al., 2014).

Table 1. Overview of the EU habitats in Šimoniai Forest massif

	Area hectares (Number count)				
EU Habitat	**Good**	**Satisfactory**	**Bad**	**Potential**	**Total**
9010 Western taiga	32 (40)	144 (17)	161 (41)	178 (63)	**515 (161)**
9050 Herb-rich spruce forests	60 (6)	23 (13)	9 (13)	37 (9)	**129 (41)**
9070 Wooded pastures	0 (0)	0 (0)	2 (1)	0 (0)	**2 (1)**
9080 Bog woodland with deciduous trees	129 (15)	94 (33)	36 (34)	1 (1)	**260 (83)**
91D0 Bog woodlands	124 (27)	122 (32)	82 (45)	4 (4)	**331 (108)**
91E0 Alluvial forests	3 (8)	16 (3)	17 (6)	2 (3)	**38 (20)**
91T0 Lichen Scots pine forests	0 (0)	0 (0)	2 (2)	0 (0)	**2 (2)**
Grand Total	**348 (99)**	**398 (98)**	**309 (139)**	**222 (80)**	**1277 (416)**

Values represent area in hectares, with the number of habitat polygons indicated in parentheses.

Habitat patch size also appeared to influence ecological condition. The mean area of habitats classified as good condition was approximately 3.5 ha, while potential habitats averaged around 2.77 ha. This suggests that larger habitat patches may provide greater ecological stability and resilience. These patterns are also relevant in the context of closer-to-nature forest management, as larger and less fragmented habitat areas contribute to ecological continuity, reduced edge effects, and improved conditions for biodiversity conservation. Larger habitat patches generally support higher species richness and more stable ecological processes, whereas fragmented habitats often experience reduced biodiversity and ecological connectivity (Haddad et al., 2015; Rybicki et al., 2023). Landscape ecology research has consistently shown that larger habitat areas tend to support higher biodiversity levels and maintain more stable ecological processes compared to fragmented or smaller habitat patches (Haddad et al., 2015; Rybicki et al., 2023).

Structural characteristics such as stand age, tree size diversity, and canopy stratification are widely recognized as important indicators of forest ecosystem naturalness and biodiversity value (Messier et al., 2021; Thorn et al., 2022). Older forest stands typically contain more deadwood and complex vertical structure, which provide important habitats for many forest-dependent species (Bütler et al., 2020; Lindenmayer et al., 2012).

Stand age analysis further revealed structural differences among habitat types with the average stand age varying distinctly among EU forest habitat types and conservation status classes (Fig. 2). Western taiga (9010) showed consistently high stand ages across all status categories, with most values close to or exceeding 100 years. Herb-rich spruce forests (9050) exhibited moderately high ages (approximately 80-95 years), with slightly lower values in the bad category. Bog woodland with deciduous trees (9080) displayed lower average ages than the previous types, with stands generally ranging between 70-80 years, and visibly younger ages in degraded (bad) conditions. In Bog woodlands (91D0), good and satisfactory stands again reached high average ages (near or above 100 years), while bad and especially potential conditions included substantially younger stands, some dropping below 50 years.

For comparison, the production forest group showed distinctly younger stands overall, generally between 30-80 years depending on dominant tree species. These contrasts indicate that older stand structures are strongly associated with high-quality conservation status within natural habitat types, whereas degraded or potential-quality areas correspond to noticeably younger stand age profiles. Indeed, older forests typically contain higher amounts of deadwood, more complex vertical structure, and a greater diversity of ecological niches, which contribute to improved habitat quality and biodiversity conservation (Bütler et al., 2020; Lindenmayer et al., 2012). Such structural characteristics are central to closer-to-nature forest management approaches, which prioritize the maintenance of older, structurally diverse forest stands to enhance ecosystem resilience and biodiversity.

These results demonstrate that structural variables available in national forest inventory datasets, particularly stand age and habitat patch size, may provide valuable indicators for habitat identification and conservation status assessment. Recent studies emphasize that integrating forest inventory data with habitat classification systems can significantly improve the efficiency of biodiversity monitoring and support the implementation of closer-to-nature forest management approaches (Tomppo et al., 2021; McRoberts et al., 2022). In this context, the use of national forest inventory data provides a practical basis for implementing closer-to-nature forest management, as it allows the identification of structurally valuable stands and supports decision-making aimed at maintaining or enhancing ecological forest functions.

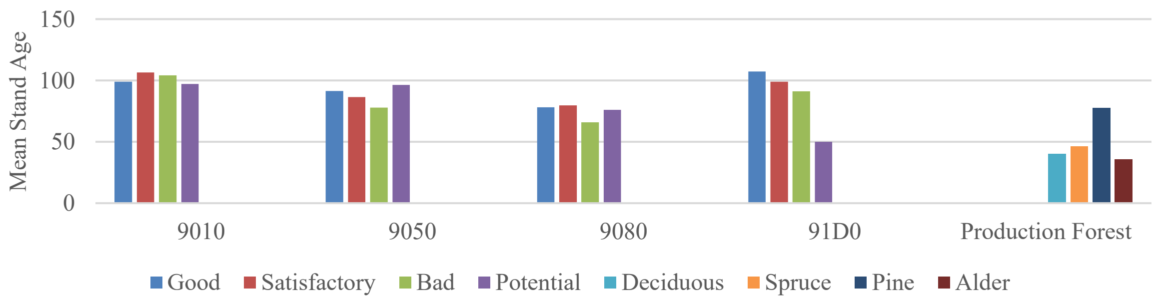

Figure 2. Mean Stand Age Across EU Forest Habitat Types and Conservation Status Classes and the mean stand age of 4 types of state production forests in the Šimoniai Forest massif

Mean stand height was consistently greater in the natural EU forest habitats than in production forests older than 50 years (Fig. 3). Western taiga (9010) and Herb-rich spruce forests (9050) showed the tallest structures, with most condition classes clustering around 26-30 m. Heights were slightly lower in Bog woodland with deciduous trees (9080) and Bog woodlands (91D0), yet still generally above 20 m even in degraded conditions. In contrast, production forests displayed markedly shorter stands, with species group means ranging only from 15 m to 28 m, reflecting younger age profiles and simplified structure compared with the older, taller habitat types.

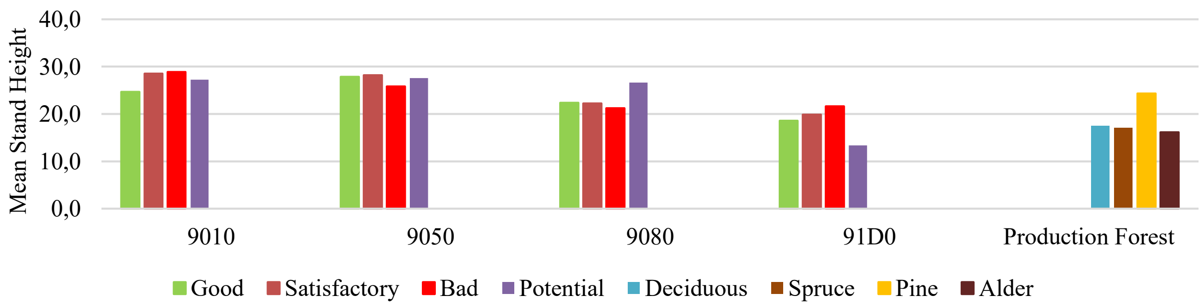

Figure 3. Mean stand height across EU forest habitat types shown by conservation status and four types of production forests older than 50 years

Results showed that mean stand volume was consistently higher in the EU forest habitats than in production forests older than 50 years (Fig. 4

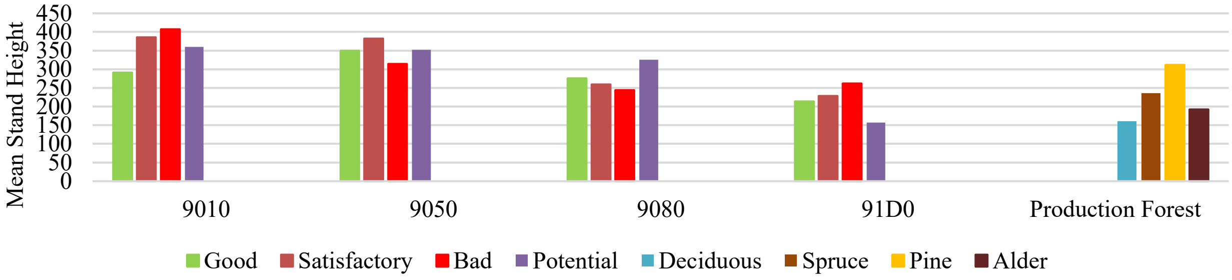

Figure 4. Mean stand volume across EU forest habitat types and their status and production forests older than 50 years

). Western taiga (9010) and Herb-rich spruce forests (9050) showed the largest volumes, often exceeding 350-400 m³/ha, with only minor variation among conservation status classes. However, the 9010 habitats with good status showed lower mean stand volumes compared to the other habitat status classes indicating a more open forest structure. This may reflect more open stand structures and natural dynamics typical of well-preserved habitats. Volumes were lower but still substantial in Bog woodland with deciduous trees (9080) and Bog woodlands (91D0), ranging roughly from 230-300 m³/ha depending on condition. In contrast, production forests displayed markedly smaller volumes, generally between 150-230 m³/ha across the main tree species groups, reflecting younger stand structure and lower biomass accumulation compared with the habitat-classified forests. Higher stand volume and structural complexity observed in EU forest habitats further support the principles of closer-to-nature forest management, which emphasize heterogeneous stand structure and the presence of large trees as key elements for biodiversity.

Conclusions

1. The analysis of EU forest habitats in the Šimoniai Forest massif showed that habitat type 9010 (Western taiga) dominates the study area, while the overall conservation status is mostly classified as satisfactory, with a substantial proportion of habitats in bad and potential condition.
2. The integration of EU habitat data with the Lithuanian National Forest Stand Database using GIS methods proved to be an effective approach for linking habitat information with forest structural characteristics.
3. The evaluation of structural indicators revealed that EU forest habitats are characterized by higher stand age, height, and growing stock volume compared to surrounding production forests, indicating more complex and mature forest structures.
4. The results demonstrated clear relationships between forest structural characteristics and habitat conservation status, with older stands and larger habitat patches generally associated with better ecological condition.
5. The findings indicate that national forest inventory data have strong potential to support closer-to-nature forest management by providing relevant information on forest structure, ecological condition, and biodiversity-related indicators.

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