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PAST AND FUTURE - A PERSPECTIVE OF THE EVOLUTION OF INEU`S FORESTS

Marinela BODOG, Alexandru RACZ, Nicu Cornel SABĂU

University of Oradea, 1 Universitatii Street, Oradea, Romania

Corresponding author email: mbodog@uoradea.ro

Abstract

This paper aims to investigate the evolution of the land base by land use categories: arable land, grassland, forests, and other wooded land. Specifically, the case study will analyse the evolution of the areas occupied by forest vegetation, included in the National Forest Fund, and managed by the Bihor Forestry Directorate through the Oradea Forestry Office, within the U.P.U.III Ineu, according to forest management plans referring to period 2007-2016 and 2017-2026. The research focuses on the evolution of the structural and qualitative characteristics of the stands, respectively the implementation and the results of the forest management plans for the studied stands, during the mentioned period, using the QGIS software. A comparative analysis will also be made of the ten-year plans for harvesting wood products and carrying out natural and artificial regeneration. The importance of these analyses lies in their ability to provide quick solutions to various problems encountered in current practical activities in the forestry sector.

Key words*: geographic information system, forestry, forest regime, trees.*

INTRODUCTION

Today, Geographic Information Systems (GIS) represent a crucial tool in advancing and implementing contemporary urban and regional research within planning processes. Recent developments in GIS focus primarily on improving its technical functionality as a tool for storing, processing, integrating, and representing spatial data. Additionally, a diverse range of applications in planning has emerged (Bilașco et al., 2017; Wieslaw, 1993; Pica et al., 2022).

GIS serves as a modern approach for the continuous improvement of services and decisions, essential to confront current trends of globalisation and European integration efforts. The ability to manage, to correlate, to model, to predict and to disseminate geographical information makes GIS an analytical tool par excellence (Băduț, 2007; Franch-Pardo et al., 2020).

The applicability of GIS is practically limitless, considering that the significant trait of most human activities is spatial location (Șmuleac et al., 2020). The purpose of information technology is to produce information for analysis by individuals and decision-making based on it for the implementation of any action. The synergistic use of remotely sensed images and GIS vector data has gained significant interest in recent years (Gancz & Pătrășcoiu, 2000).

Analysing the historical evolution of forests over the past 10 years, we aim for a closer integration of remote sensing and GIS technologies, along with the requirements of integrated software systems, for facilitating the combination of remote sensing data with vector datasets for maximum impact.

The main categories of software include system programs, application programs, and software development tools. System programs primarily include operating systems that ensure the interaction of all other programs with hardware and the user's interaction with personal computer programs. Utilities or service programs are also included in this category (Roșca et al., 2017).

QGIS is a multi-platform, free, and open-source GIS application that supports the visualisation, editing, printing, and analysis of geospatial data. QGIS functions as a GIS software, allowing users to analyse and edit spatial information, as well as compose and export graphical maps (https://qgis.org/ro/site/).

Modern land mapping technologies, which replace traditional mapping techniques, enable

the development of GIS, essential for the collection and processing of data required for land and forest assessment. Geographic reference and base maps serve as frameworks for the geographic reference and coordination of all data entering the GIS, mutual alignment of informational layers, and subsequent analysis using overlay procedures. New types of digital and electronic maps promise to be created using automated mapping systems and GIS for mapping purposes (Anji Reddy, 2018).

GIS typically provides spatial analysis tools for calculating statistics for entities and conducting geoprocessing activities such as data interpretation. In this case, we will analyse a forest area, emphasising the importance of tree analysis, age, distribution of forest species to better understand the modelling in the studied space. We will also highlight access routes, topographic height, and water circulation in this area.

GIS is experiencing exponential growth, being applied in various fields, from navigation systems in automobiles (Park et al., 2020) to analyses of urban crime (Ristea & Leitner, 2020), disease spread (Murad & Khashoggi, 2020), archaeological research (Dell'Unto & Landeschi, 2022), and forest studies (Soubry, 2021).

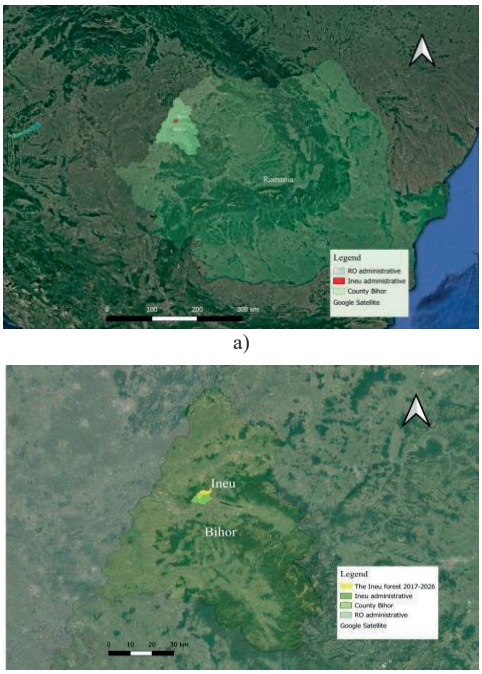
GIS proves indispensable when seeking answers related to location, territorial modelling, local trends, and conditions. GIS cannot be conceived without a database linked on a map to a specific geographical position. Data sources can be obtained through satellite imagery processing, orthophoto plans, statistics from surveys or censuses, data collected through Global Navigation Satellite Systems (GNSS), and field research and measurements.

This paper aims to highlight both the evolution of the forest in Ineu, Bihor County, as described in the forest management plans, and the implementation of proposed works to achieve the established management objectives.

The commune of Ineu is situated in the central part of Bihor County, being the easternmost locality within the Oradea Metropolitan Area. The total area of the Ineu commune is 49,51 km^2, located 20 km away from the city of Oradea (https://zmo.ro/componenta/comuna-ineu).

MATERIALS AND METHODS

The selected area for this analysis is the forest within the administrative-territorial unit of Ineu, under the administration of the National Forest Administration ROMSILVA (Figure 1).



a)

b)

Figure 1. The location of the Ineu forest: a) national level location; b) location at the level of Bihor County

The geographic coordinates of the forest under study are 47°06′05″N - 22°06′10″E.

Within the territory of the Ineu commune, there are two Natura 2000 sites: ROSCI0050 Crişul Repede and ROSCI0267 Valea Roşie. In the Crişul Repede site, upstream of Oradea, the habitat of White Willow (*Salix alba*) and White Poplar (*Populus alba*) groves is present and the Valea Roşie site is representative of beech forests of the Asperulo-Fagetum type, part of which is included in the Valea Roşie Hay Meadow Natural Reserve.

The Natura 2000 network can become effective and properly managed if the financial sustainability of forests is ensured through compensation systems covering all types and categories of property rights (Winter et al., 2014).

The method used to highlight administrative data, location, composition, topography, species distribution, and a comparative analysis of the two forestry plans used as data sources (DSB, 2007; DSB, 2017) involves the use of a GIS, graphics, tables, and their correlation using the QGIS software after creating, managing, analysing, and mapping all types of data.
The QGIS software connects data to a map, integrating location with all types of descriptive information. This provides a basis for mapping and analysis used in science and nearly every industry. Regarding forest management, QGIS is an extremely useful tool as it can assist foresters with information about the status, location, development, and future trends necessary in decision-making.
According to the current Forest Code regulations (Law no. 46/2008):
- "The management of the national forest fund is regulated through forest management plans, which constitute the basis of the specialised cadastre and the state property title for the state-owned forest fund.
- The objectives of forest management are established through forest management plans, in accordance with ecological and socio-economic objectives and with respect to the property rights exercised over the forests, in accordance with the provisions of this code.
- The drafting of forest management plans is mandatory for forest properties larger than 10 hectares."
Forestry is defined as "the art and science of controlling and establishing the growth, composition, health, and quality of forests and other lands with forest vegetation for the purpose of achieving sustainable values and needs imposed by the owner and society on a sustainable basis" (FAO, 2015).
The implementation of the concept of sustainable forest management reflects the social perception of realities, a perception determined culturally and varying in relation to historical and institutional contexts (Schanz, 1997).
The ecological and functional diversity of the forest fund, the management goals set by forest management plans, and the technical-economic conditions for forest management require the application of the selection forest regime, based on seed regeneration and the management of stands at old ages.
At the level of the forest fund in Romania, the selection forest regime is applied to 91%, justified by silvicultural and economic reasons to produce large and medium-sized timber for industrial and commercial purposes.
The silvicultural practices analysed are regulated by the forest management plan (forest management plan), in accordance with current legislation (Sîngeorzan et al., 2022).
Due to the desire to ensure the permanence of forests by avoiding interventions that could strip the soil on large surfaces, as these forests serve a protective function, the management of forests towards multiple protection and production structures is necessary.
Treatment is the set of silvicultural interventions carried out in stands reaching maturity to ensure their regeneration, constituting the main tool for normalising the forest structure (Duduman & Drăgoi, 2019). The treatment of progressive cuttings is part of the group of treatments with repeated cuttings and regeneration under the stand.
In the case of the Ineu forest, the adopted treatment is that of progressive cuttings (in gaps) with long periods of regeneration in oak, hornbeam, and slope clearings (SDLI, 2020).
Regeneration works are carried out in gaps of variable sizes depending on the temperament of the species and site conditions. The aim is to ensure natural regeneration under the standby applying successive uneven-aged cuttings placed irregularly throughout the stand.
The treatment of progressive cuttings in the wood harvesting process, correlated with the regeneration process, separates three types of cuttings:

- opening cuts;
- thinning and widening cuts;
- connecting cuts.

RESULTS AND DISCUSSIONS

The non-agricultural land area in the commune is 1960 hectares, of which 1631 hectares (83.21% of the non-agricultural area) consist of forests and other forest lands, 160 hectares (8.16% of the non-agricultural area) are properties and yards, 50 hectares (2.55%) are water bodies, and 109 hectares (5.56%) are occupied by communication routes. The length of forest roads is 2.5 km (Figure 2).

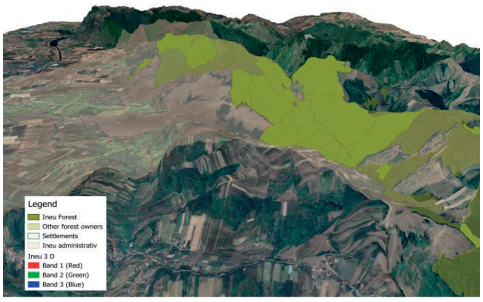


Figure 2. Ineu Forest
(3D view performed in QGIS 3.34 PRIZEREN)

The forest management plans of the Oradea Forestry Department, Bihor Silvicultural Direction, U.P. III Ineu, for the periods 2007-2016 and 2017-2026, respectively, highlight differences in terms of area, number of plots, and subplots (Table 1, Figure 3 a,b) due to the land restitution processes carried out based on:
- Law no. 18 of February 19, 1991 - The Land Fund Law, with subsequent amendments, for an area of 3 hectares.
- Law no. 1 of January 11, 2000, for the re-establishment of ownership rights over agricultural and forest lands, in its updated form, for an area of 103.72 hectares.

Table 1. Differences in Forest Management Plans of the Oradea Forestry Department, U.P. III Ineu

Period	Surface (ha)	No. of parcels	No. sub-parcels
2007-2016	883.0	72	162
2017-2026	776.28	64	136

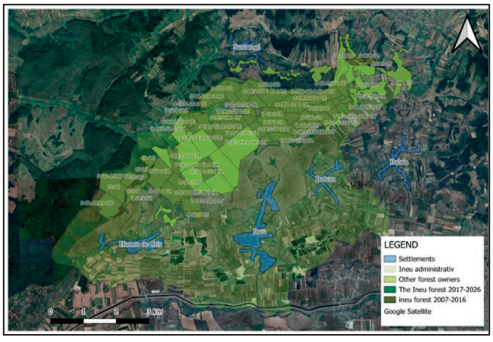


Figure 3a. Production Unit III, Ineu Forest District: 2007-2016

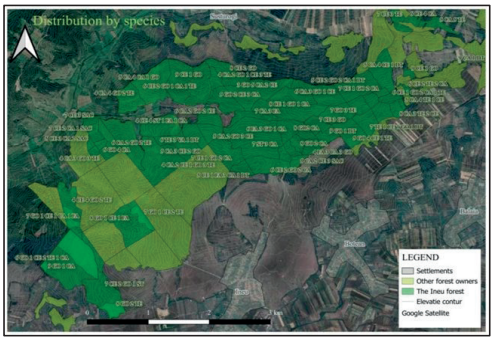


Figure 3b. Production Unit III, Ineu Forest District: 2017-2026
(3D view performed in QGIS 3.34 PRIZEREN)

It is important to mention that the individuals who received property rights were obligated to manage the forest under silvicultural regulations, based on forest management plans, either through their own structures or through management contracts with specialized forestry entities, in accordance with the applicable legislation.
The main structural characteristics of the forest stands, compared between the two analysed periods, are highlighted in Table 2, Figure 4 and Figure 5. For differentiating forest management and the regulation of the production process comparative management units were established during the analysed periods (Table 3, Table 4).
Quantitative indicators, crucial for characterising the dynamics of forest fund development in comparative periods, are presented in Table 5.
These quantitative indicators are comparable for the analysed periods, the differentiated values being justified by alterations in the forest area, primarily due to land restitutions as per legal provisions. The forest structure, composition, and average age are easily identifiable in the two management plans used for comparison.
The graphical representation of forest management activities has adhered to the specific care needs outlined in the management plans, ensuring the conservation of valuable timber resources.

Table 2. Tree structure

Pr.	Parameters	CE	CA	GO	TE	FA	ST	SAC	DR	DT	DM	UP
2007-2016	Composition %	35	25	27	3	4	1	2	-	3	-	100
	Consistency	0.77	0.81	0.74	0.83	0.77	0.82	0.83	-	0.82	-	-
	Average Age (years)	57	47	65	32	62	41	25	-	31	-	-
2017-2026	Composition %	40	27	19	6	3	1	1	-	3	-	100
	Consistency	0.75	0.82	0.72	0.87	0.79	0.74	0.90	0.70	0.77	0.88	0.77
	Average Age (years)	63	51	71	31	75	66	14	50	43	23	59

Note: CE - *Quercus cerris*, CA - *Carpinus betulus*, GO - *Quercus petraea*, TE - *Tilia cordata*, FA - *Fagus sylvatica*, ST - *Quercus robur*, SAC - *Robinia pseudoacacia*, DR - Various conifers, DT - Various hardwoods, DM - Various softwoods, UP - Production Unit

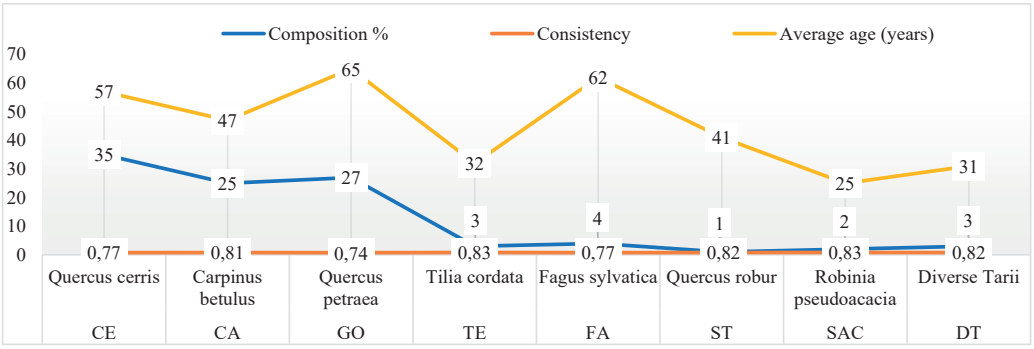


Figure 4. Structure of the management plan for Production Unit Ineu, 2007-2016

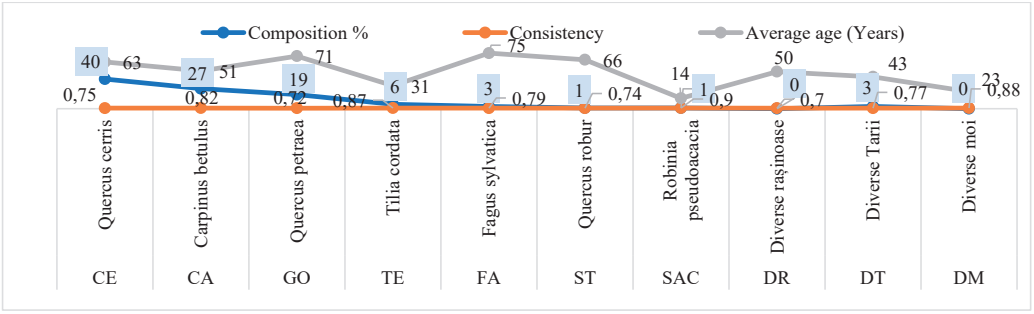


Figure 5. Structure of the management plan for Production Unit Ineu, 2017-2026

The utilisation of QGIS has significantly contributed to the forest inventory, emerging as a crucial management tool for the forests. It has provided valuable information related to monitoring, planning, research, evaluation, timber production, and sales. The spatial inventory of trees offers essential insights from both economic and ecological perspectives, projecting the intended changes in the forest structure over time. The Forest Management Plan for the Oradea Forestry Department, Bihor Silvicultural Direction, U.P. III Ineu for the period 2017-2026 outlines the intention to replace certain fewer valuable species with more economically valuable ones, thus modifying the production structure by species from 42CE 28CA 16GO 6TE 3FA 1ST 1SAC 3DT to 28CE 27GO 13ST 8GI 8TE 5FA 1FR 10DT.The use of GIS facilitates forest inventory and provides both qualitative and quantitative information about the forests in the Ineu region. The obtained data can be used to formulate long-term forest plans aimed at the protection and conservation of wildlife.

Table 3. Comparative forest management

Decade	Type	Regime	Composition goal	Treatment	Exploitability	Cycle
2007-2016	S.U.P. "A"	regular forest common assortments - 825.4 ha	corresponding to the fundamental natural types of forest improved with valuable species of mixtures (maple Acer, ash Fraxinus, cherry Prunus)	progressive cuttings, clearcut regeneration cutting, thinning cutting	for protection, all trees being in group I	100 years for the trees in Production Unit A
	S.U.P. "K"	seed reserves - 28.0 ha				
2017-2026	S.U.P. "A"	regular forest common assortments – 719.53 ha	corresponding to the fundamental natural types of forest improved with valuable species of mixtures (maple Acer, ash Fraxinus, cherry Prunus)	progressive cuttings	technique for trees in group II	100 years for the trees in Production Unit A
	S.U.P. "K"	seed reserves 28.83 ha				

Table 4. The annual area covered by care works

	L.P	D.	C.	R.	T.ig.	L. im
2007-2016	Area (ha)	7.5	5.5	27.9	253.4	30.04
2017-2026	Area (ha)	1.96	12.8	24.37	245.86	24.17

Note: L.P - proposed works, D - clearings, C - cleanings, R - thinning, T.ig. - hygiene cuttings, L.im. - reforestation works

Table 5. Quantitative indicators

No.	Quantitative indicators	U.M	Values 2007-2016	Values 2017-2026
1	The proportion of forests in the total area of the forest fund	%	97	96
2	Standing timber volume - total	m³	153525	140046
3	Standing timber volume - average	m³/year	179	187
4	Average production class	-		II a
5	Total production class	m³	4892	4408
6	Average production class	m³/year/ha	5.7	5.9
7	Total current increment - production fund	m³	4814	4333
8	Total current growth - production fund	m³/year	5.8	6.0
9	Increment indicators - total	m³/year	2466	2075
10	Increment indicators - average	m³/year/ha	3.0	2.9
11	Possibility of main products - total	m³/year	1320	1215
12	Possibility of main products - hectares	m³/year	120	144
13	Possibility of secondary products - total	m³/year	495	545
14	Possibility of secondary products - hectares	m³/year	15	15

CONCLUSIONS

The comparative analysis of the forest fund in Production Unit III, Ineu Forestry Department, for the two management plans has highlighted the location, topography, and the structure of the Ineu forest stand and shed light on the undertaken activities for the maintenance, valorisation, and conservation of valuable tree species.

Furthermore, it emphasised comparable indicators for the two analysed periods, except for changes in the secondary forest area, which were retroceded to former owners.

The use of QGIS has significantly enhanced the quality of forest inventory data, enabling a

strategic and long-term vision for forest improvement, short and long-term planning and for dynamic development of the forest found, estimating the forest growth, and replacing less valuable tree species with other competitive valuable species.

The versatility of QGIS allowed for the expansion of its application beyond forest inventory, encompassing the evaluation of wildlife populations, flora, and soil resources, facilitating a holistic approach to climate changes and biodiversity monitoring.

Although QGIS significantly improves data quality, we must consider whether the granularity of the data suffices for all study aims. The analysis has temporal limitations because only comparing two periods and additional temporal checkpoints could provide a more dynamic and continuous understanding of forest evolution.

In the future the continuation of the study could cover various components like wildlife and flora, or other crucial factors such as hydrological impacts or non-native invasive species that could influence forest health.

Also, local community interaction with the forest (eg, logging, recreation) could provide insights into human influence on forest dynamics.

By addressing these areas, the study could enhance its impact and provide a more robust framework for managing and conserving the Ineu forest in a sustainable and scientifically informed manner.

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