Journal of Maps

ISSN: 1744-5647 (Online) Journal homepage: www.tandfonline.com/journals/tjom20

Types of forest dynamics in Europe (2000–2018)

Rui Machado

To cite this article: Rui Machado (2026) Types of forest dynamics in Europe (2000–2018), Journal of Maps, 22:1, 2622821, DOI: 10.1080/17445647.2026.2622821

To link to this article: https://doi.org/10.1080/17445647.2026.2622821

JOURNAL OF MAPS
2026, VOL. 22, NO. 1, 2622821
https://doi.org/10.1080/17445647.2026.2622821

Taylor & Francis
Taylor & Francis Group

SCIENCE

OPEN ACCESS Check for updates

Types of forest dynamics in Europe (2000–2018)

Rui Machado

MED – Mediterranean Institute for Agriculture, Environment and Development & CHANGE – Global Change and Sustainability Institute, Institute for Advanced Studies and Research, Universidade de Évora, Évora, Portugal

ABSTRACT
This work delivers a map of the spatiotemporal dynamics of forests, in the NUTS of the European Union, for the period 2000–2018. The types of dynamics are defined by considering variations in forest amount and configuration, and then assigned to each NUTS. The motivation for the production of such map stems from the opportunity to derive new information from official datasets, therefore contributing to enhance the knowledge base and provide new insights for forest monitoring and planning. The methodology involves the use of a GIS analytical tool to compute a sequence of geoprocessing and data management operations, required to compare two forest datasets, detect changes between them within predefined analytical units, and generate an easy to interpret output from which the final map was produced.

ARTICLE HISTORY
Received 22 September 2025
Revised 8 January 2026
Accepted 18 January 2026

KEYWORDS
Forest; LULC dynamics; landscape metrics; spatial patterns

1. Introduction

Forests are of paramount importance for planetary life: without them, life as we know it would not exist (FOREST EUROPE, 2020). At a landscape and regional scale, they deliver multiple ecosystem services vital for humans, such as water regulation, biodiversity conservation, recreation, etc. (Ninan & Inoue, 2013). Ecosystem services are not always visible and obvious but their relevance is such that in some countries, the most relevant products (usually timber and fuelwood) account for less than a third of the total economic value of forests when watershed protection and carbon sequestration are considered (Millennium Ecosystem Assessment, 2005).

Forests and other wooded land cover over 43,5% of the European Union's land space and their importance for hosting and preserving biodiversity is highlighted in the New EU Forest Strategy for 2030, set out in the communication of the European Commission (EC) of 16 July 2021 (European Commission, 2021b). Forests' role for nature conservation is recognized and reflected by their strong representation in the Natura 2000 network, which is the world's largest coordinated network of nature conservation areas, currently totalling 27,165 sites, covering almost 20% of the EU's terrestrial land area and around 10% of its seas (Natura 2000 Barometer, https://www.eea.europa.eu/en/analysis/maps-and-charts/natura-2000-barometer-dashboards, accessed 21/07/2025). Forests and grasslands make up over 60% of the network's terrestrial area (European Environment Agency, 2020). In 2015, the United Nations introduced the Sustainable Development Goals (SDGs), as a call to action on several topics, among them 'end poverty' and 'protect the planet'. References to forests can be found or inferred in some of the 17 SDGs since they are intertwined to different degrees, but forests are directly related to 'SDG13 Climate Action' and 'SDG 15 Life on Land' (https://www.undp.org/sustainable-development-goals).

Despite their importance, forests worldwide are being degraded and destroyed for different reasons and by multiple actions (European Environment Agency, 2019; IPBES, 2019), compelling institutions to assume extended efforts and take measures, regulatory and others, to halt and revert the current circumstances. In the European Green Deal (European Commission, 2019), the EC states that forest ecosystems are under increasing pressure as a result of climate change and acknowledges that EU's forested area needs to improve in quantity and quality for the EU to reach climate neutrality. Additionally, the new EU Strategy on Adaptation to Climate Change (European Commission, 2021a), identifies forest sustainable management as a tool for higher resilience to climate change and disaster preventions. In the resolution of 9 June 2021 on the EU Biodiversity Strategy for 2030 (European Commission, 2020), the European

CONTACT Rui Machado rdpm@uevora.pt MED – Mediterranean Institute for Agriculture, Environment and Development & CHANGE – Global Change and Sustainability Institute, Institute for Advanced Studies and Research, Universidade de Évora, Polo da Mitra, 7000-083 Nª Srª da Tourega, Évora, Portugal

Supplemental map for this article is available online at https://doi.org/10.1080/17445647.2026.2622821.

Parliament set out a commitment to draw a legislative proposal aiming to protect a minimum of 30% of the land, including all remaining primary and old-growth forests. The Nature Restoration Law (European Parliament & Union, 2024) emphasises the aim of enhancing the biodiversity of forest systems across the Union and measure the fulfilment of that obligation via a set of indicators, among them the tree species diversity, the share of forests with uneven-aged structure and forest connectivity. Habitat loss and fragmentation are intrinsically related to connectivity, since they decrease habitat amount and accessibility (Saura & Rubio, 2010), thus reducing connectivity, defined as the degree to which the landscape facilitates or impedes the movement among resource patches (Taylor et al., 1993). Recently, Romanillos et al. (2024) mapped the anthropogenic landscape fragmentation worldwide, which focuses on urban settlements and linear infrastructure, and can be useful for a wide range of disciplines and spatial planning. Jaeger et al. (2011) conducted a comprehensive study on landscape fragmentation in Europe, caused by man-made (transportation infrastructure and built-up areas) and natural barriers (mountains, lakes and major rivers), and reported a wide range of fragmentation values, the lowest found in Iberian and Scandinavian peninsulas and the highest found in the Benelux countries and Germany. That particular report focuses on overall landscape fragmentation, yet the authors acknowledge the interest of assessing the fragmentation of particular types of ecosystems, namely forests. The work by Saura et al. (2011) represents such an approach, that monitors changes in functional landscape connectivity based on an improved index and focuses on the trends of European forests, at the province level for the period 1990–2000.

The present work delves into the recent spatiotemporal dynamics of European forests, aiming to identify spatial patterns of forest changes occurred between 2000 and 2018, project possible upcoming tendencies and provide useful insights concerning forest conservation, restoration and increase. The ultimate goal is to provide a portrait of the forest fragmentation and dynamics through an informative map.

2. Methods

The processes described below involving geodata and spatial analysis were performed using QGIS 3.22 Białowieża (QGIS.org, 2021). The primary intent was to cover the 27 EU member states but Malta was dropped from the analysis due to scale and analytical unit (AU) incompatibility reasons. In the end, the countries included are: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden (Figure 1). The study area boundaries were obtained by merging the NUTS regions (EUROSTAT, 2024) and then discarding the smaller islands.

Following a procedure adopted in previous studies over Europe (Haines-Young & Weber, 2006; Saura et al., 2011), NUTS 3 were used for most countries with the exceptions of Austria, Belgium, Germany and Netherlands in which NUTS 2 were used as a way to reduce variability in the size of the analytical units (AU). The before and after forest maps required for the assessment were obtained based on the CORINE Land Cover (CLC) 2000 (European Union's Copernicus Land Monitoring Service Information, 2000) and 2018 (European Union's Copernicus Land Monitoring Service Information, 2018). The CLC nomenclature includes 44 land cover classes grouped in a three-level hierarchy, with thematic accuracy of 85%, minimum width of linear elements of 100 m and minimum map unit of 25ha (Büttner & Kosztra, 2017). The subcategories '3.1.1 Broad-leaved forest', '3.1.2 Coniferous forest' and '3.1.3 Mixed forest' of CORINE Land Cover 2000 were merged resulting in a general forest category for each date. These encompass areas occupied by forests and woodlands of native or exotic coniferous and/or broad-leaved trees, that can be used for the production of timber or other forest products.

The spatiotemporal analysis was conducted using LDT4QGIS (Paixão & Machado, 2023), a Python tool for QGIS, that implements the method Landscape Dynamic Typology (LDT) (Machado et al., 2018). LDT is based on calculations involving 'area', 'number of patches' (NP) and their combinations, and assigns a Type of Dynamic (ToD) to preselected AU, usually user-provided districts or automatically-generated quadrats (Table 1). In this work, only forest polygons larger then 25ha were considered and computed using NUTS, totalling 708 single polygons (composing 689 NUTS) (Figure 2). The option 'forecast' was also activated, which added a layer of information to the analysis. Provided that some spatial processes of land transformation precede others, and despite the existence of transitional overlaps, it is possible to organize them in a temporal sequential logic (Forman, 1995). The LDT forecast scheme shows how the ToD are interconnected in trends of amount gain or loss, considering the ongoing trajectory remains (Figure 3). Focusing on the losing trend, the 'ToD I – Fragmentation by loss' can be understood as an early degradation phase while the 'ToD H – NP decrement by loss' represents an advanced degradation phase. In between, is 'ToD E – Loss' that is usually an intermediary stage, although it can also be the final phase in specific contexts. The forecast complements the core LDT analysis, providing additional information regarding the trajectory of the forest cover in each AU.

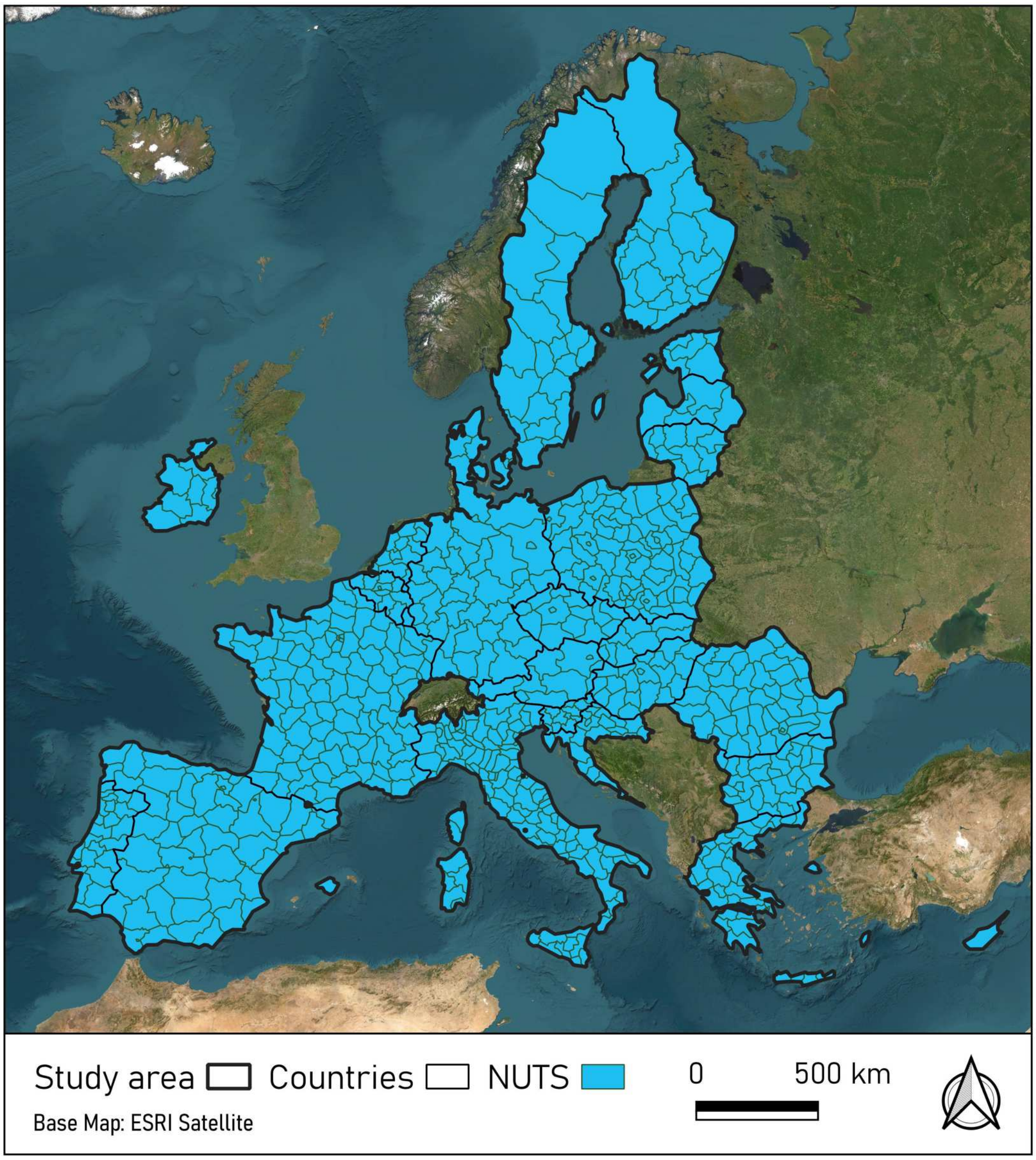


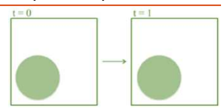
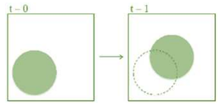
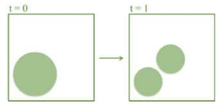
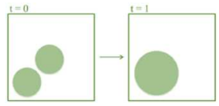
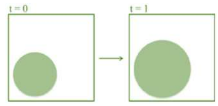
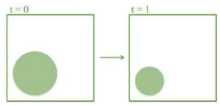
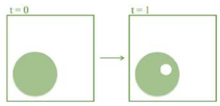
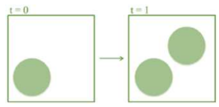
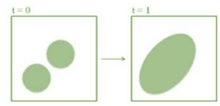
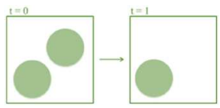
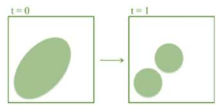
Figure 1. Study area and analytical units (combination of NUTS 2 and 3).

3. Results and discussion

For the entire study area, forest area increased by 4.8 million ha, and the NP increased by 11,215, indicating an overall 'ToD F – NP increment by gain'. The forest area gain is in line with recent reports that point in the direction of a forest coverage expansion in Europe thanks to afforestation, sustainable management and active restoration (European Commission, 2021b; FOREST EUROPE, 2020). Despite this overall trend, some local or regional patterns can differ and display aggravated forest losses due to specific reasons, such as increased harvesting for economic purposes, or reflect the impacts of severe and recurrent wildfires. More localized ToD arise from a NUTS-level calculation of the forest dynamics (Figure 4), allowing to visually identify spatial clusters of the same or related ToD. The Main Map stemming from the LDT calculation is an enhanced and more comprehensive version, available as supplementary material. The generalized trend of forest area gain is spread across the study area while the NUTS with losses are mostly clustered, which may be due to distinctive biophysical conditions, national policies, etc. There is a clear group of close or adjacent NUTS revealing forest loss that covers most of Austria, Northern Italy, also partially Slovenia, Croatia, Czechia, Slovakia and Hungary. Most Portuguese NUTS and some contiguous Spanish NUTS form another perceptible cluster. The same is true for the Netherlands and the Belgian Antwerp province, and for Latvia and the Lithuanian Šiauliai county. Southern Sweden together with Northern Denmark also constitute a group of close NUTS displaying forest loss. A few aggregated NUTS can be also found in Romania and in Bulgaria.

The most abundant ToD is 'F – NP increment by gain', found in 256 NUTS. Forests (> 25 ha) were absent in two NUTS (Milano, Italy; and Paris, France), and no changes were detected in the two other NUTS (Hainaut province, Belgium; and Venezia, Italy) in the

Table 1. Landscape dynamic types (adapted from Machado et al., 2018).

If	and	Type of dynamic	Spatial representation
ΔA = 0 ^ Symmetrical difference = 0	ΔNP = 0	A – No change	
ΔA = 0 ^ Symmetrical difference > 0	ΔNP = 0	A1 – Spatial shift	
ΔA = 0	ΔNP > 0	B – Fragmentation per se	
ΔA = 0	ΔNP < 0	C – Aggregation per se	
ΔA > 0	ΔNP = 0	D – Gain	
ΔA < 0 ^ Symmetrical difference output is not completely contained in the original patch(es)	ΔNP = 0	E – Loss	
ΔA < 0 ^ Symmetrical difference output is completely contained in the original patch(es)	ΔNP = 0	E1 – Perforation	
ΔA > 0	ΔNP > 0	F – NP increment by gain	
ΔA > 0	ΔNP < 0	G – Aggregation by gain	
ΔA < 0	ΔNP < 0	H – NP decrement by loss	
ΔA < 0	ΔNP > 0	I – Fragmentation by loss	

studied period. The two ToD purely related to amount variation register similar values, with ‘D – Gain’ $n = 13$ and ‘E – Loss’ $n = 12$. It is noticeable that the group of NUTS with ToD related to gain ‘D – gain’, ‘F – NP increment by gain’ and ‘G – aggregation by gain’ is more abundant than those involving loss (‘E – loss’, ‘H – NP decrement by loss’ and ‘I – fragmentation by loss’) ($n = 459$ vs. $n = 245$) (Figure 5).

The ‘forecast’ functionality was first developed with quadrats in mind, and therefore includes by default the extremes ‘no cover’ and ‘total cover’. In this particular analysis, NUTS were used as AU, and the meaning of those extremes would be NUTS with no forest at all, and the opposite, NUTS completely covered by forest. For that reason, the original extremes were not considered, and instead, ToD ‘G – aggregation by gain’ and ‘H – NP decrement by loss’ were used as plausible final stages, bringing the count as follows: ‘H – NP decrement by loss; $n = 245$, ‘G – aggregation by gain’; $n = 457$, and ‘D – Gain’; $n = 2$. These figures translate as, (i) if the NUTS that are losing forest keep losing it,

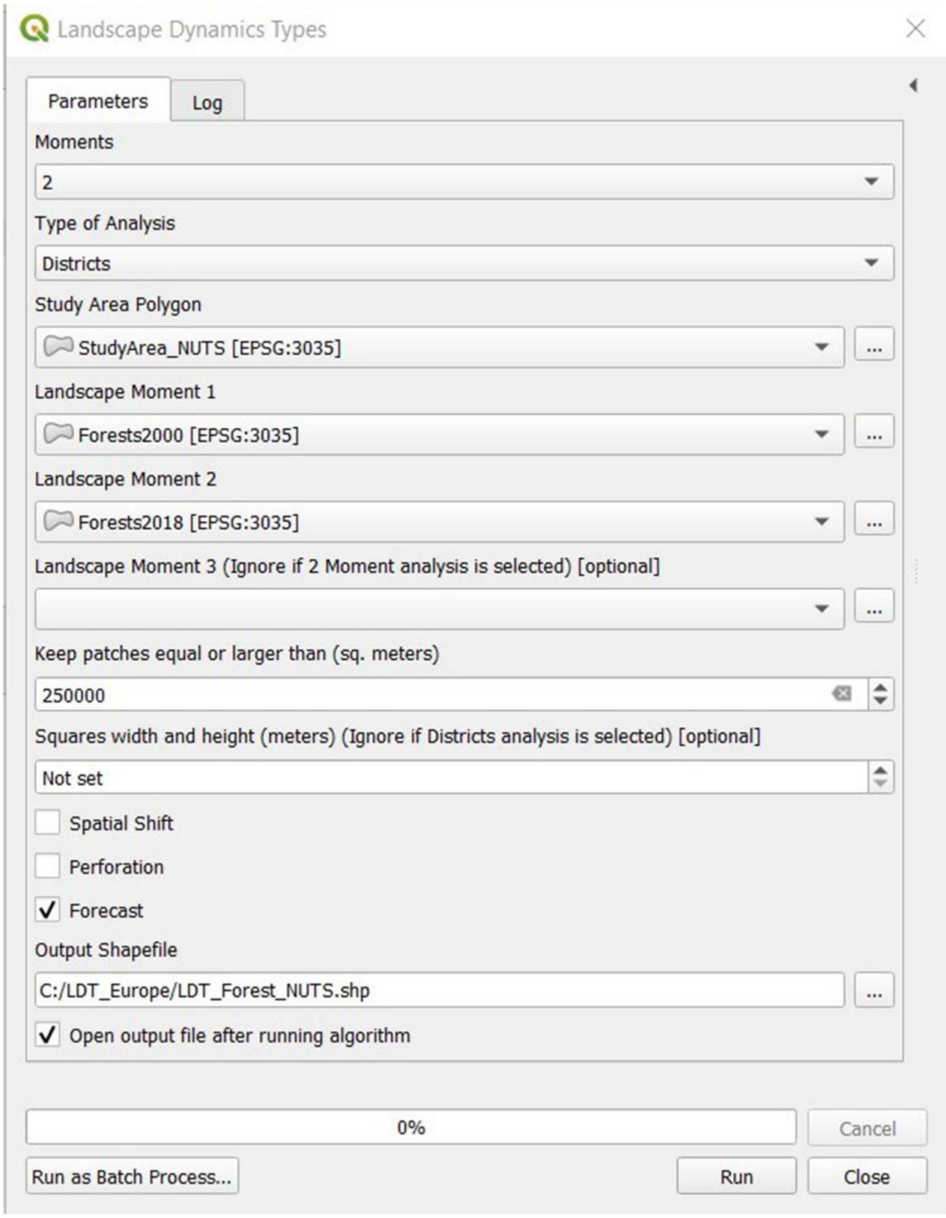


Figure 2. Inputs and settings for the analysis using LDT4QGIS.

the loss of area will ultimately provoke the loss of patches, and (ii) if the NUTS that are gaining forest keep gaining it, the area increase will likely merge individual patches together, bringing down the number of forest patches and increasing the mean patch size. The two NUTS with 'D – Gain' refer to NUTS with a single forest patch that have been expanding may continue to do so. The outputs obtained allow different analysis that may be helpful in other contexts. For instance, the results highlighted and discussed are focused on the number of NUTS, which informs on the location and direction of the dynamics, but not exactly on their magnitude. A complementary analysis could consider the sum of the area variation in each NUTS (and proportion of the NUTS affected) and categorize the NUTS accordingly. When using regular AU such approach acquires additional relevance because it allows direct comparison between AU since, except for partial quadrats in the boundaries of the study area, they all have the same size (see examples Godinho et al. (2014); Navarro-Cerrillo et al. (2023)).

It is important to highlight that the three forest types were merged together because the ultimate goal was to provide an overview of the European forests rather than a conduct a fine tracking of a specific forest type. Although consistent with the study purpose, the methodologic decision of losing thematic resolution demands additional caution in the interpretation of the results. Forest types differ from one another, and referring to them globally as forests may suit analysis like this, which is a diagnosis of patterns covering a large territory, but is hardly thorough enough for more specific and local contexts that usually require data with higher spatial and thematic resolution. Other elements that may arise as pertinent

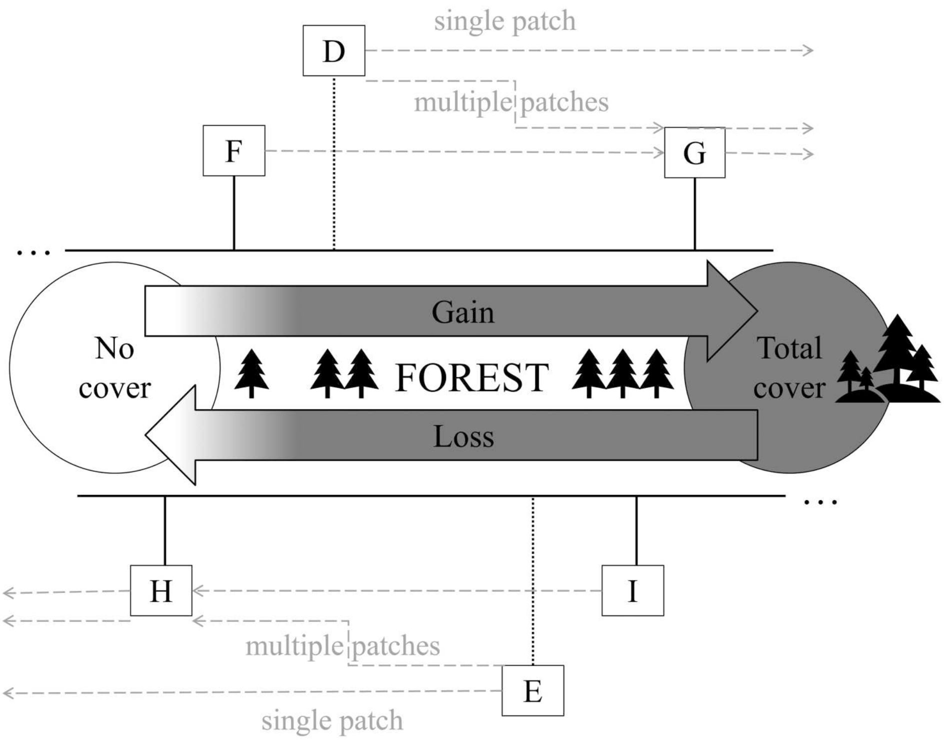


Figure 3. Landscape dynamic typology's forecast scheme (adapted from Machado et al., 2018). D – gain; E – loss; F – number of patches incremented by gain; G – aggregation by gain; H – number of patches decrement by loss; I – fragmentation by loss.

for certain studies are the distance between patches (highly relevant for connectivity assessments), edge contrast (how much two contiguous patches differ from one another according to a certain characteristic), and the edge effect, often represented by edge length.

The awareness of the current state of forests, together with its recent history and reasonable

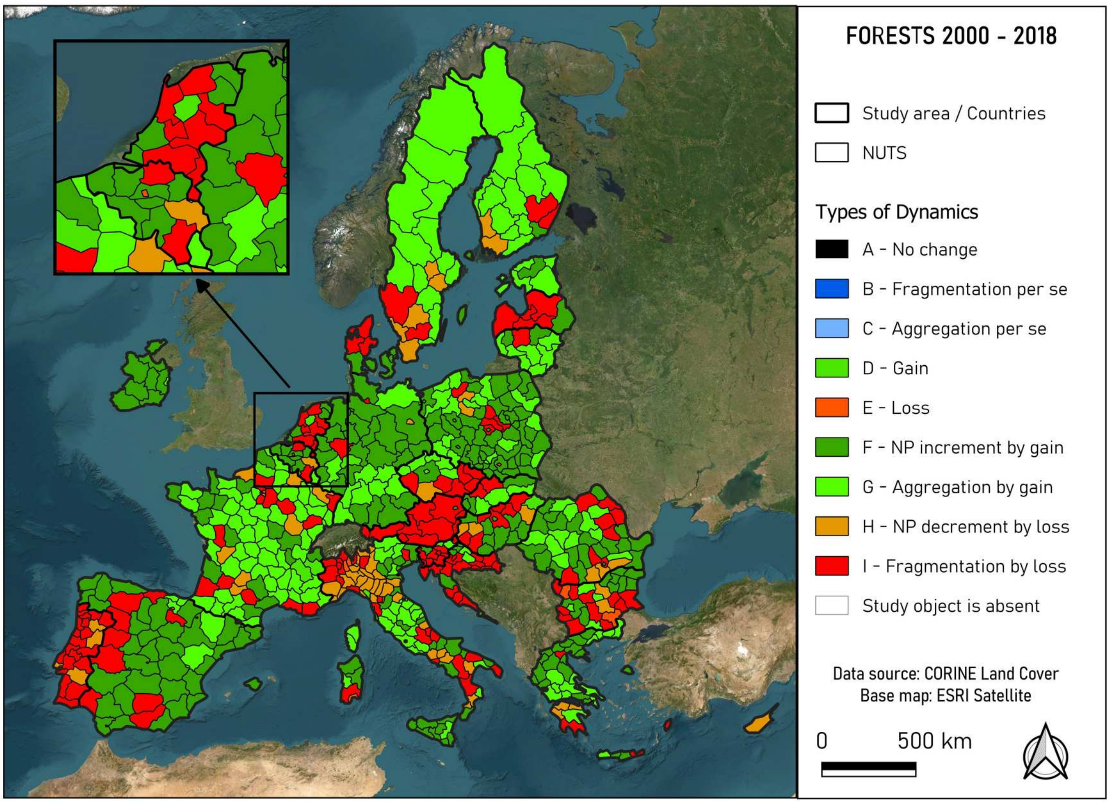


Figure 4. Types of dynamics occurred in forests in the period 2000–2018.

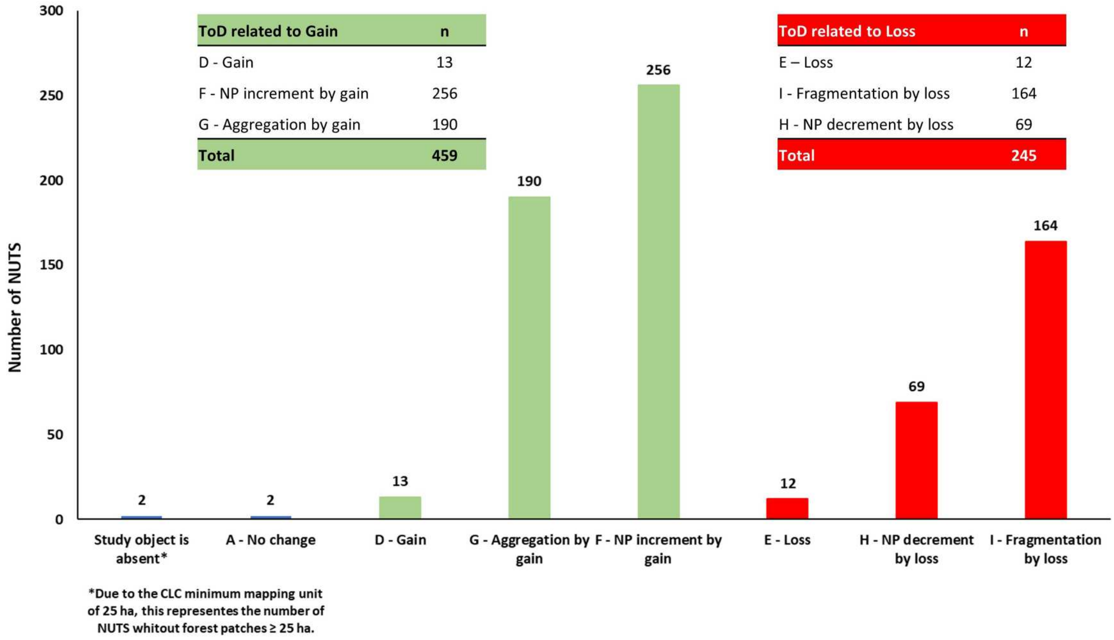


Figure 5. Number of NUTS assigned to each type of dynamic.

scenarios, offer a holistic view of the system, essential for effective strategy design and appropriate management. Reforestation, afforestation and restoration of degraded forests are pointed out as means to increase C02 absorption and improve forest resistance and resilience (European Commission, 2019), and thus are likely to keep being promoted, incentivised and followed closely. Land cover change monitoring, using the appropriate thematic, temporal and spatial resolutions, is of the utmost importance to diagnose, track changes, identify drivers, assess impacts, develop scenarios and ultimately to produce context-specific knowledge, required for policy making and transferable for concrete implementation, when moving from land cover to actors (Tulbure et al., 2022). National programs and supranational efforts, such as the CORINE Land Cover, have successfully been put in place and have made a difference in several sectors (e.g. forestry, agriculture, nature conservation, natural disaster risk assessment, etc.). The demand for more specific information is ongoing and due to the continuing technological advances, overall approaches and concrete methodological refinement, it is expected that the existing programs will be constantly upgraded and that new ones will emerge.

4. Conclusions

This research provides additional knowledge about European forest variation for the period 2000–2018 from the perspectives of its amount and configuration. Combinations of areal and geometric variations offer a comprehensive view of the forest changes and provide insights for relevant topics like forest fragmentation/aggregation, essential to study structural and functional connectivity of any habitat type or ecosystem. The main output is a map obtained through the application of a specialized tool to official geodata to create additional useful information and interpretative value. The study area included virtually all the EU member states and involved numerous geoprocessing, alphanumeric and tabular operations that ran in the background, to deliver the information about the main ToD occurred in each AU (708 polygons, representing 689 NUTS).

The overall balance shows an increase of forest area and forest patches, which is corroborated by the results at the NUTS scale, once the most abundant ToD is ‘F – NP increment by gain’. In fact, most of the analysed territory displayed forest gain and that also led to NP reduction, shown by the second more abundant ToD being ‘G – Aggregation by gain’. Despite the global forest expansion, there were local and regional losses that may deserve further thorough analysis, especially if they are clustered in a way that represent a large extension of territory and the phenomenon threatens the populations wellbeing.

LDT has a straightforward implementation that make it applicable *ad hoc* whenever the analytical protocol demands it. However, the output will always depend on the input data and analytical decisions, and therefore, conclusions should be drawn accordingly. For instance, using quadrats or hexagons as AU would overcome the disadvantage of NUTS’ size variation, but NUTS were used instead to deliver a spatial representation based on an official and widely used territorial unit. Also, the use of CLC for continental scale analysis is common due to its quality and homogeneity across national borders, but it is important to keep in mind it has a minimum mapping unit of 25 ha, and that the output would differ if other land use datasets were used instead (e.g. more detailed national land use coverage products). By being able to work on top of reliable, accurate official geodata, LDT can be easily integrated in specific monitoring programs and provide an additional layer of complementary information on LULC dynamics, particularly regarding forest cover.

Software

All the preliminary steps involving geodata preparation were performed using QGIS 3.22 Białowieża (QGIS.org, 2021) and the landscape dynamics analysis was made using LDT4QGIS (Paixão & Machado, 2023), available at https://gitlab.com/lgplgp/ldt4qgis.

Acknowledgements

The author would like to thank MED – Mediterranean Institute for Agriculture, Environment and Development https://doi.org/10.54499/UIDB/05183/2020 and CHANGE – Global Change and Sustainability Institute https://doi.org/10.54499/LA/P/0121/2020.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work is financed by National Funds through FCT – Foundation for Science and Technology [grant number UID/05183/2025].

Data availability statement

This work was conducted using the public datasets: CORINE Land Cover 2000 and CORINE Land Cover 2018 (provided by European Union's Copernicus Land Monitoring Service Information), available at https://doi.org/10.2909/8b85b479-6afb-42c6-817c-11d1a5260b83, and https://doi.org/10.2909/71c95a07-e296-44fc-b22b-415f42acfdf0, and GISCO NUTS (provided by EUROSTAT), available at https://ec.europa.eu/eurostat/web/gisco/geodata/statistical-units/territorial-units-statistics. The data produced in this work is openly available in zenodo at https://doi.org/10.5281/zenodo.16949865.

ORCID

Rui Machado http://orcid.org/0000-0002-4345-6636

References

Büttner, G., & Kosztra, B. (2017). *CLC2018 technical guidelines*. European Environment Agency. https://land.copernicus.eu/user-corner/technical-library/clc2018technicalguidelines_final.pdf

European Commission. (2019). The European green deal. https://doi.org/10.34625/issn.2183-2705(35)2024.ic-03

European Commission. (2020). EU biodiversity strategy for 2030. COM(2020) 380 final.

European Commission. (2021a). Forging a climate-resilient Europe – The new EU strategy on adaptation to climate change. COM(2021) 82 final.

European Commission. (2021b). New EU forest strategy for 2030. COM(2021) 572 final.

European Environment Agency. (2019). The European environment – State and outlook 2020. Knowledge for transition to a sustainable Europe. https://doi.org/10.15196/TS600305

European Environment Agency. (2020). State of nature in the EU. Results from reporting under the nature directives 2013-2018. (EEA Report No. 10/2020).

European Parliament, & Union, C. of the E. (2024). Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869. https://eur-lex.europa.eu/eli/reg/2024/1991/oj

European Union's Copernicus Land Monitoring Service Information. (2000). CORINE Land Cover 2000. Retrieved March 3, 2025 from: https://doi.org/10.2909/8b85b479-6afb-42c6-817c-11d1a5260b83

European Union's Copernicus Land Monitoring Service Information. (2018). CORINE land cover 2018. Retrieved March 11, 2025 from: https://doi.org/10.2909/71c95a07-e296-44fc-b22b-415f42acfdf0

EUROSTAT. (2024). GISCO NUTS. https://ec.europa.eu/eurostat/web/gisco/geodata/statistical-units/territorial-units-statistics

FOREST EUROPE. (2020). State of Europe's forests.

Forman, R. T. T. (1995). *Land mosaics – The ecology of landscapes and regions*. Cambridge University Press.

Godinho, S., Guiomar, N., Machado, R., Santos, P., Sá-Sousa, P., Fernandes, J. P., Neves, N., & Pinto-Correia, T. (2016). Assessment of environment, land management, and spatial variables on recent changes in Montado land cover in southern Portugal. *Agroforestry Systems*, *90*(1), 177–192. https://doi.org/10.1007/s10457-014-9757-7

Haines-Young, R., & Weber, J.-L. (2006). *Land accounts for Europe 1990–2000. Towards integrated land and ecosystem accounting. Report 11*. European Environment Agency, Copenhagen.

IPBES. (2019). *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn.

Jaeger, J. A. G., Soukup, T., Schwick, C., Madriñán, L. F., & Kienast, F. (2011). Landscape fragmentation in Europe. In *European Landscape Dynamics: CORINE Land Cover Data (Issue 2)*. https://doi.org/10.1201/9781315372860

Machado, R., Godinho, S., Pirnat, J., Neves, N., & Santos, P. (2018). Assessment of landscape composition and configuration via spatial metrics combination: Conceptual framework proposal and method improvement. *Landscape Research*, *43*(5), 652–664. https://doi.org/10.1080/01426397.2017.1336757

Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being: Synthesis*. http://www.ncbi.nlm.nih.gov/pubmed/12668653

Navarro-Cerrillo, R. M., Rivas, C. A., Quinto, L., Hernández Navarro, S., Varo-Martínez, M. Á., & Palacios-Rodrigues,

P. (2023). Afforestation on agricultural land in southern Spain: An important driver to improve forest landscape connectivity. *New Forests*, *54*, 1061–1084. https://doi.org/10.1007/s11056-022-09956-4

Ninan, K. N., & Inoue, M. (2013). Valuing forest ecosystem services: What we know and what we don't. *Ecological Economics*, *93*, 137–149. https://doi.org/10.1016/j.ecolecon.2013.05.005

Paixão, L., & Machado, R. (2023). LDT4QGIS: An open-source tool to enhance landscape analysis. *Ecological Informatics*, *75*(May 2022), 102073. https://doi.org/10.1016/j.ecoinf.2023.102073

QGIS.org. (2021). *QGIS geographic information system*. QGIS Association. http://www.qgis.org

Romanillos, G., Robazza, G., & Lovato, F. (2024). A fragmented world: Mapping the global extent of Anthropogenic Landscape Fragmentation. *Journal of Maps*, *20*(1), 1–13. https://doi.org/10.1080/17445647.2024.2307539

Saura, S., Estreguil, C., Mouton, C., & Rodríguez-Freire, M. (2011). Network analysis to assess landscape connectivity trends: Application to European forests (1990–2000). *Ecological Indicators*, *11*(2), 407–416. https://doi.org/10.1016/j.ecolind.2010.06.011

Saura, S., & Rubio, L. (2010). A common currency for the different ways in which patches and links can contribute to habitat availability and connectivity in the landscape. *Ecography*, *33*(3), 523–537. https://doi.org/10.1111/j.1600-0587.2009.05760.x

Taylor, P. D., Fahrig, L., Henein, K., & Merriam, G. (1993). Connectivity is a vital element of landscape structure. *Oikos*, *68*(3), 571–573. https://doi.org/10.2307/3544927

Tulbure, M. G., Hostert, P., Kuemmerle, T., & Broich, M. (2022). Regional matters: On the usefulness of regional land-cover datasets in times of global change. *Remote Sensing in Ecology and Conservation*, *8*(3), 272–283. https://doi.org/10.1002/rse2.248