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Introduction to Remote Sensing Report.

December 17, 2024

Title

Department of Conservation and Recreation **(**DCR) Land Change in DCR State Forests of Worcester County.

Research Questions

1. What is the amount of forest cover lost and gained in DCR lands in Worcester County from 2010 to 2023?

2. What are the driving forces for DCR land change in the state forests of Worcester County?

Research Goals

This project aims to map and analyze changes in forest cover within the Department of Conservation and Recreation (DCR) lands in Worcester County between 2010 and 2023. The study shows the areas of both forest gain and loss and the area of unchanged.

Abstract

This project analyses change in forest cover within DCR lands in Worcester County in Massachusetts from 2010 to 2023. Based on land cover data obtained from the NLCD and various spatial data from MASSGIS and DCR, the study assessed the changes in forest cover and highlighted areas of net gain and loss as well as areas of relative stability. It is found that there is a change in the extent of the forest cover within the 13-year period. The extent of forest area in 2010 was 303.66 km^2, which constituted 76.21%, and this decrease in 2023 to 303.62 km^2 (76.20%). A net loss of 2.74 km^2 or 0.69% of forest area was recorded with a net gain of 2.68 km^2 or 0.67% of forest area. Most of the land area, 393.93 km^2 (98.64%), remain unchanged over the period. The study emphasizes the role of systematic spatial analysis in determining priorities for action that can better prevent continued and future forest conversion across DCR-managed lands.

Key Words: Department of Conservation and Recreation (DCR), Multi-Resolution Land Characteristics (MRLC), National Land Cover Database (NLCD), and Massachusetts Bureau of Geographic Information (MassGIS), and ArcGIS Pro.

Study area

The study area is Worcester County DCR land. Worcester county is one of the biggest counties in Massachusetts State. It is located in the central part of Massachusetts (Figure 1). This county was established on April 2, 1731. The total area of Worcester County is 4,090 km2 (Wikipedia, 2024). DCR controls and manages natural and cultural resources, and recreational facilities of 450,000 acres of DCR land in the state of Massachusetts (DCR, 2024). The total DCR Land of Worcester County is 398.43 km^2 (DCR Shape file).

Worcester County in Massachusetts is shaped by unique history, geographical features, and ecology. African Americans migrated here during the time of civil war (Greenwood, 2016). Environmentally, the county has experienced numerous problems evidenced by nonnative plant species occupying between 21%–36% of its landscape and are invasive to the natural ecosystem (Bertin & Parise, 2014). Other invasive pests have also posed a threat to the indigenous vegetation including maples through invasion by pests such as the Asian long horned beetle (Shatz et al., 2013). Urban development, pest management, ice storms and other activities during the year 2008-2010 quantitatively reduced tree canopy cover by 2 percent (Hostetler et al., 2013). However, the increase in factors such as urbanization, and later colonization by non-native species persists to pose a threat to increasing ecological insensibility, hence the call for sustainable conservation measures (Bertin, 2013; Hostetler et al., 2013).

Methods

In this study, the analysis of forest cover changes on DCR land in Worcester County from 2010 to 2023 has been done systematically. The process has involved the application of land cover maps with ArcGIS Pro software (Figure 2).

Data acquisition, preparation and processing

The forest cover data for the year 2010 and 2023 have been collected from Multi-Resolution Land Characteristics (MRLC) Consortium's National Land Cover Database (NLCD), DCR land shape file from DCR and Worcester County polygon from MassGIS.

Data Description: See Table 1.

All the datasets have been processed by software ArcGIS Pro for standardized analysis. This has also involved ensuring that the data is re-projected into the same coordinate system. The yearly (2010 and 2023) NLCD data have been extracted to the DCR land boundary shapefile by extract by mask tool. After that this extracted layer is again extracted with Worcester County polygon. Then pixel values of extracted layers were filtered according to NLCD pixel classification list which allows to get more particular land cover types. As per the classification list, forest cover has been described under pixel value of 41 (Deciduous Forest), 42 (Evergreen Forest) and 43 (Mixed Forest). For my analysis I have classified pixels 41, 42 and 43 as forest and other pixels are taken as non-forest area. After using reclassify tool two land cover maps (2010 and 2023) are produced based on two land use categories such as forest and non-forest area.

Forest cover mapping and change detection analysis

Two sets of land cover maps of Worcester County have been generated, one for the year 2010 and the other one for 2023. These maps have been used as reference to determine differences over the period of study. Raster calculators have been used for estimating forest cover variations. In this process, the 2010 forest cover layer has been subtracted from the 2023 layer which produced a new map layer indicating the areas of forest gain, loss, and unchanged. Total area and percentage of gain, loss and unchanged is calculated by calculate geometry and calculate field tools. Besides, the area and percentage of forest and non-forest area is also calculated by same tools.

Mapping spatial patterns

The given maps show the spatial distribution of changes in forest cover within the study area that is under the management of DCR. The trend in the forest cover gain and loss can help to focus on areas where attention is required in terms of conservation or management.

Results and discussion

The analysis shows that Worcester County DCR state forests have undergone slight land cover changes between 2010 and 2023. The share of forest and non-forest areas has shown low fluctuations over the period. Of the total DCR land area in 2010, about 94.78 km^2 of the area comprises of non-forested land which is 23.78% of the total area; 76.21% or about 303.66 km^2 represent forest land. Non-forest land had a slight rise to 94.81 km^2 (23.79 %) by 2023, while the forest parts reduced to 303.62 km^2 (76.20 %) (Table 2).

Shifts in the total land cover for this period underscore a minor variation in forest cover. A total of 2.74 km^2 (0.69%) of forest was lost as the study shows and 2.68 km^2 (0.67%) of forest were gained. However, it was also observed that the total area, approximately 393.93 km^2 or 98.64%, has remained relatively unchanged thus depicting that this region did not experience large scale forest cover change (Table 3).

Forest Cover Change Pattern as per Zone

Northern and Southern zone: Northern and Southern part of the study area does not show significant change. Very minor losses and gains are observed in this area (Figure 4)

Central zone: In this area forest cover change evidence is found. Forest cover loss and gain are highly observed in this area over the period. This zone has a very low forest persistence rate (Figure 5).

Central East Zone: In this zone, forest cover has also changed and loss and gain in forest cover has also found in low level. This area reflects the low level of persistence over the period (Figure 5).

Central West Zone: This zone showed slightly higher loss compared to forest gain. That reflected the moderate level of forest stability or persistence (Figure 5).

Determinants of Forest Cover Changes

By analyzing some published data sources this paper found that both endogenous and exogenous factors have contributed to the current state of the Worcester County DCR forest. Residential areas play an important role in the process of deforestation and urbanization, particularly in the formation of new residences, causing 47% loss of tree canopy between 2008 and 2010 and two thirds of the forest cover loss in the Worcester city (Hostetler et al., 2013). Other factors that hindered forest cover restoration include ice storms, the outbreak of the Asian long horned beetle and climate change (Hostetler et al., 2013; Scheller, 2020).

However, despite these challenges notwithstanding, there are significant signs of forest resilience throughout Worcester County, especially in DCR land. The fact that there is no large-scale conversion from forest to non-forest or from non-forest to forest over the study period

demonstrates the steadiness of the ecosystems in the region. The minimal net gain or loss of the forests proves that the region has rather high resilience to anthropogenic and natural influences. However, zonal variations imply the need for special management approaches. The central zone required higher level of attention where the fluctuation of loss and gain are evidenced, and the central west and central east zone also need few supervisions.

These findings, therefore, highlighted the need to maintain a balance between the objectives of conservation and development. Improving the laws regarding the management of the forests, state as well as the local plans to deal with issues such as urbanization, pest invasions, and climate change, are some of the ways through which the sustainability of the state DCR forests in Worcester County DCR land can be maintained more better way.

Conclusion

Analyzing the changes in DCR forest cover in Worcester County from 2010 to 2023 in DCR lands indicates that most of the area has remained relatively unchanged with slight gains and losses of forested areas. The data of the present research states that 98.64% of the analyzed land remains unchanged during this 13-year period proving the stability of ecosystems in the region and the efficiency of the applied conservation measures. Gains and losses in the amount of forest were shown very little difference, with an overall slight increase in forest loss indicating that processes and uses within such areas are natural and limited. They can also produce minor oscillations of woodland health that do not necessarily signify immediately impending threats, but for the discovery and consequently the possibility to counter threats to forests, such as invasive species, climate change impacts, or unregulated changes in land use. Therefore, these results support future research and protection activities in the Worcester County DCR land where forest degradation occurred and stabilization or management plans for long-term sustainability of forests and maintain balance between ecological health and the pressures of urbanization and climate change.

Acknowledgement

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Figures and Tables

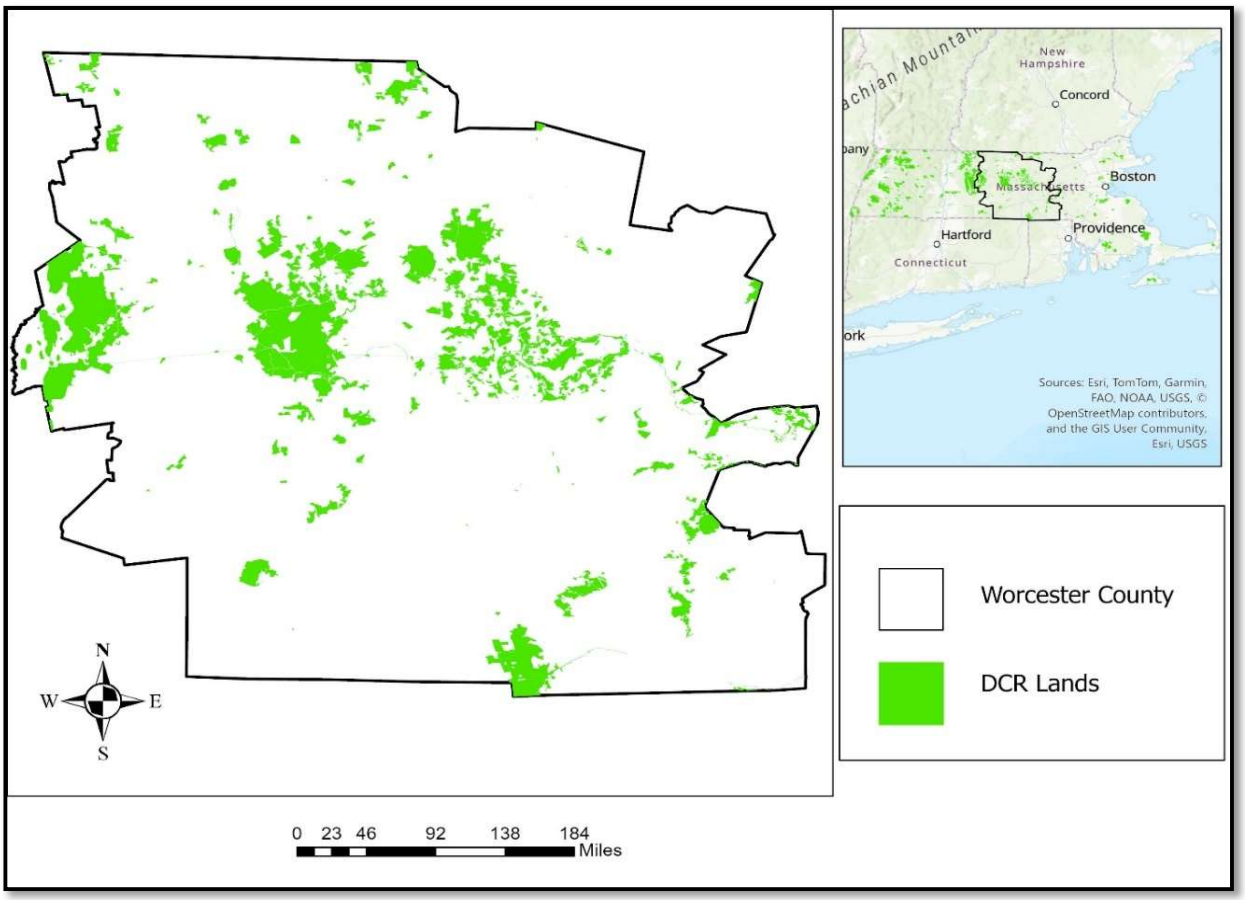


Figure 1: Map of DCR Land in Worcester County

Table 1. Type and Sources of data

Variable	Type	Source	Spatial Resolution
Forest cover data (2010)	Raster	MLRC (NLCD)	30 m
Forest cover data (2023)	Raster	MLRC (NLCD)	30 m
DCR Land	Polygon	DCR	
Worcester County boundary	Polygon	MASSGIS	

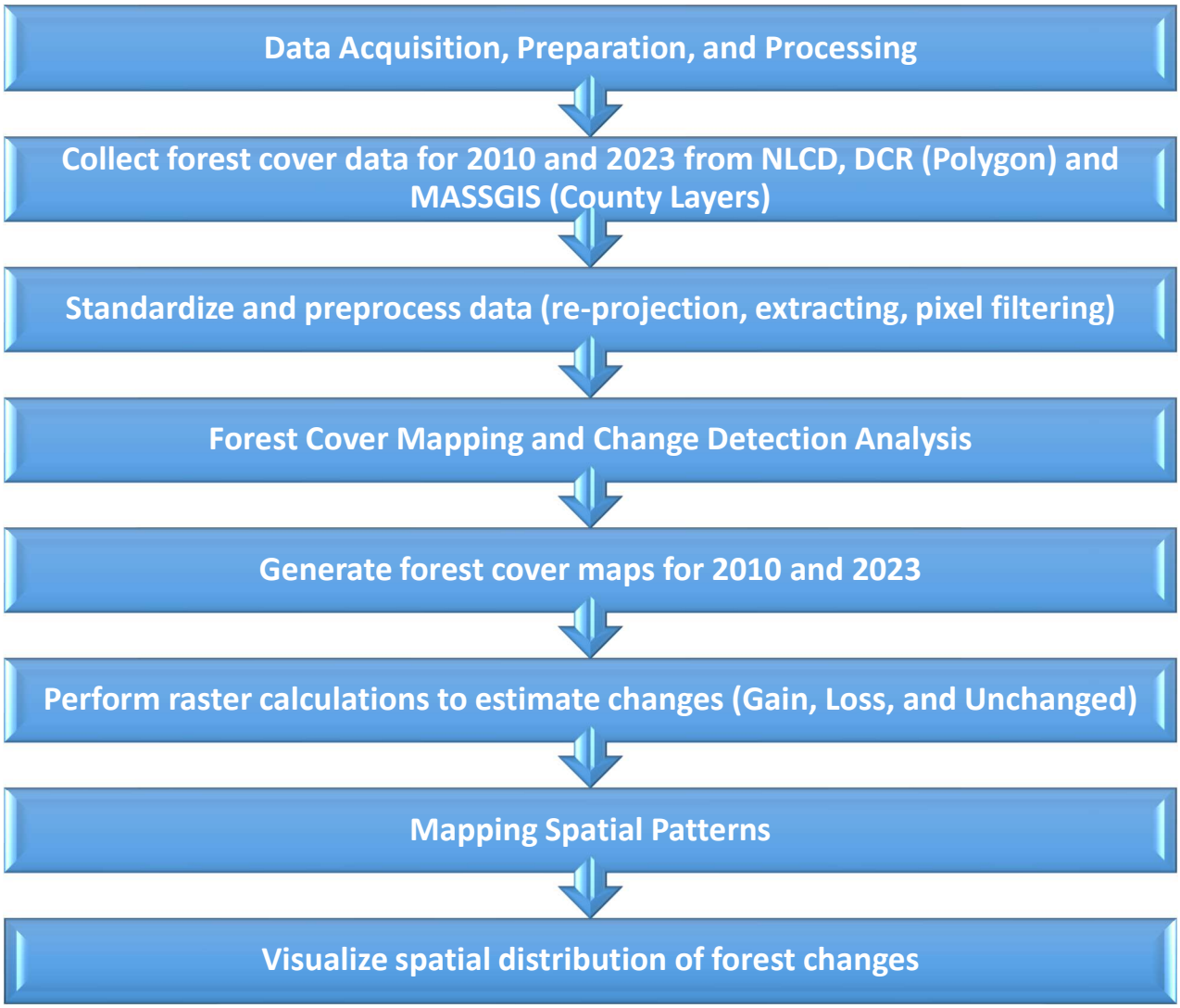


Figure 2: Working flow chart

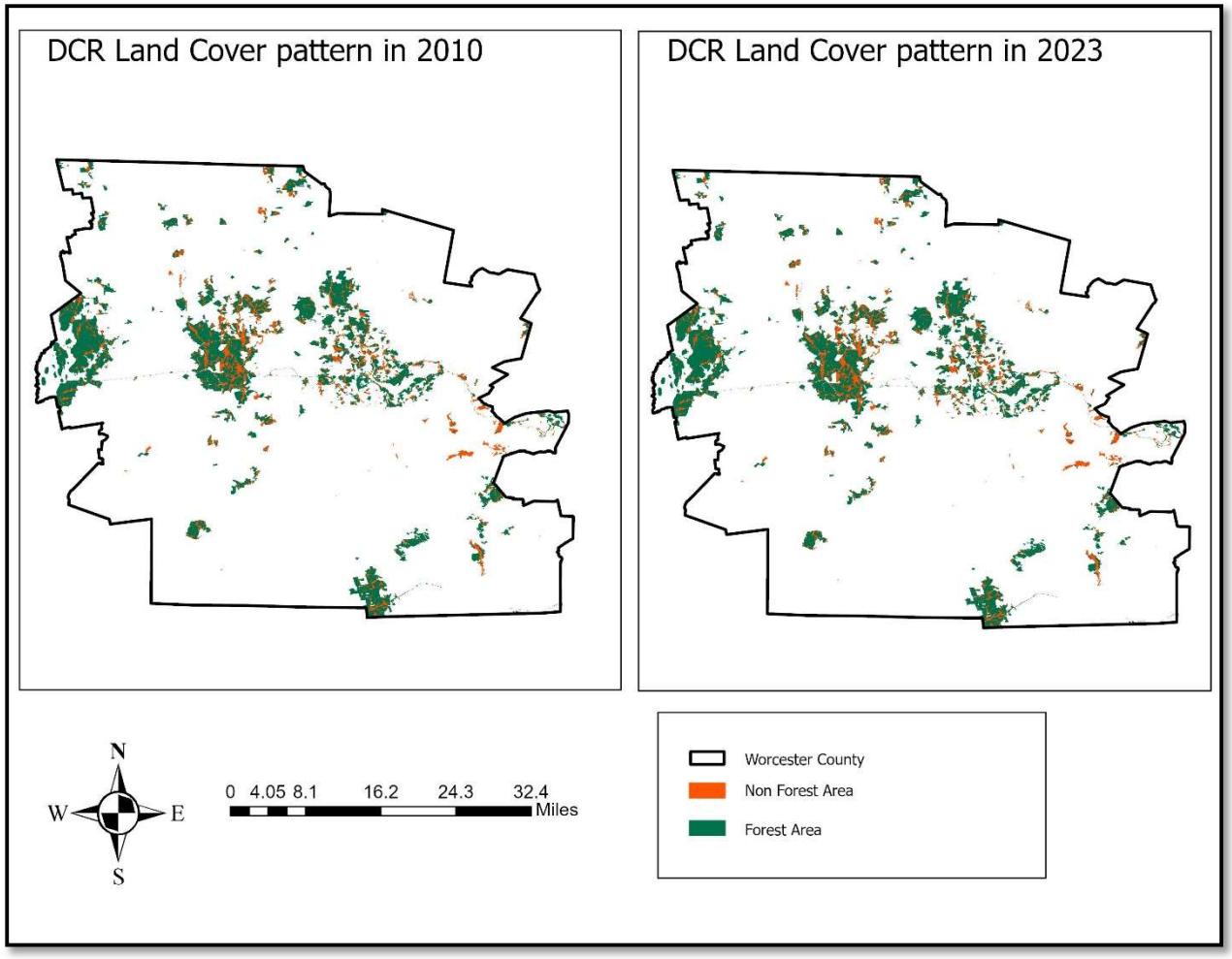


Figure 3: DCR Land Cover Pattern of Worcester County in 2010 and 2013

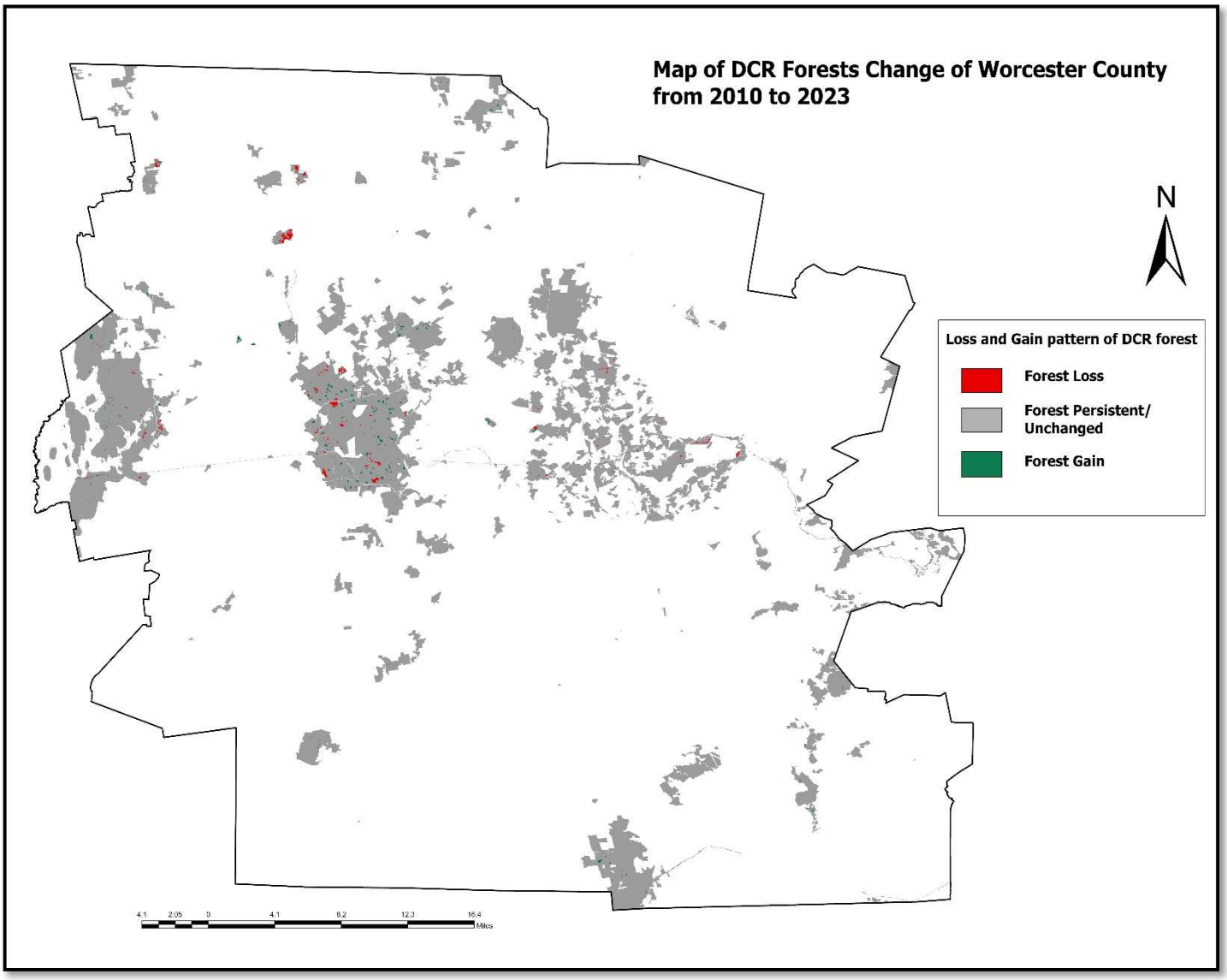


Figure 4: Map of DCR Forest change from 2010 to 2023

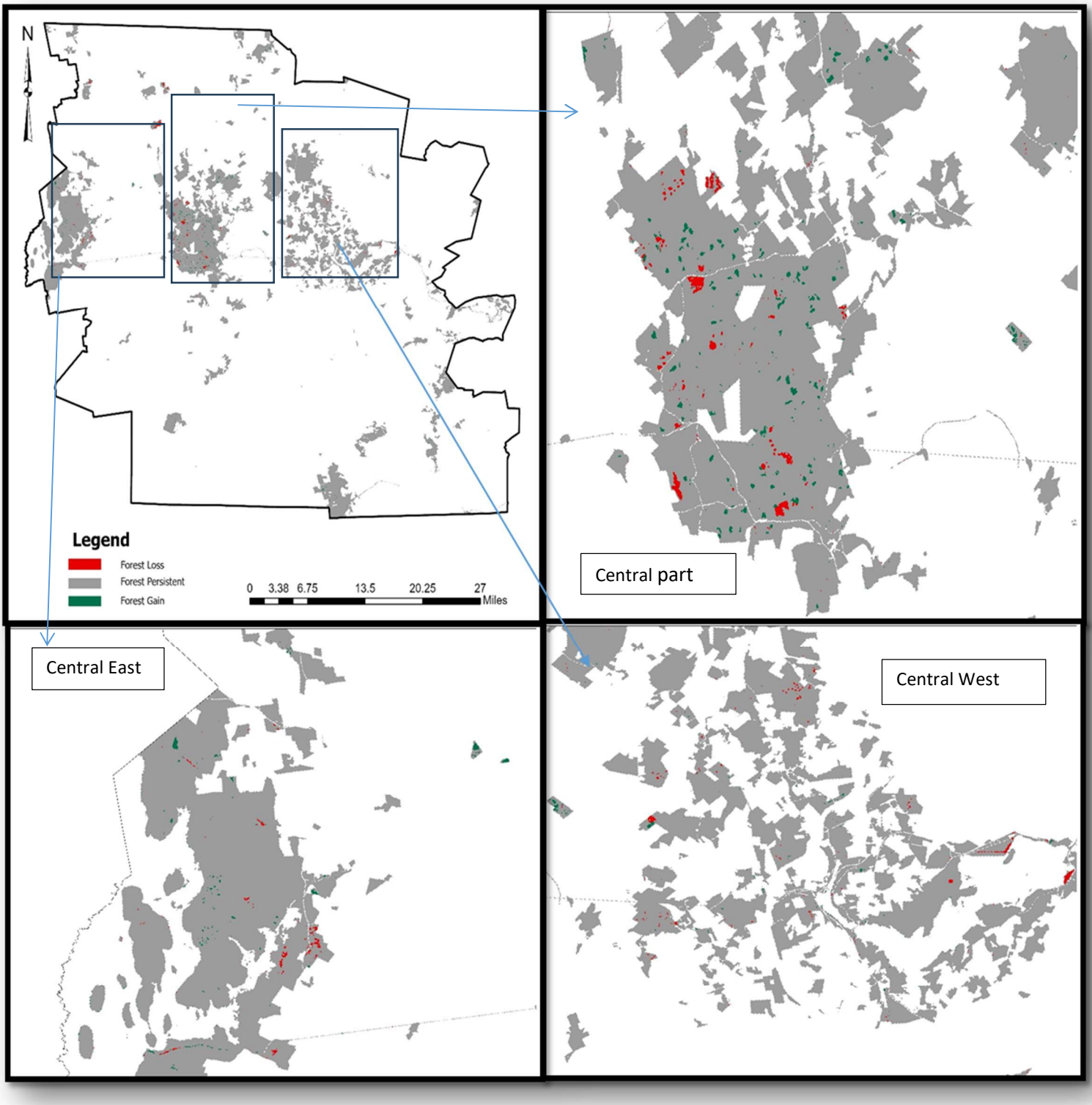


Figure 5: Forest Change scenario in different parts of the DCR land

Table 2: DCR Land Cover Scenario in 2010 and 2023

Land cover type	Total Area (km^2)	Percentage (%)
Forest	303.66	76.21
Non-Forest	94.78	23.78

Land cover type	Total Area (km^2)	Percentage (%)
Forest	303.62	76.20
Non-Forest	94.81	23.79

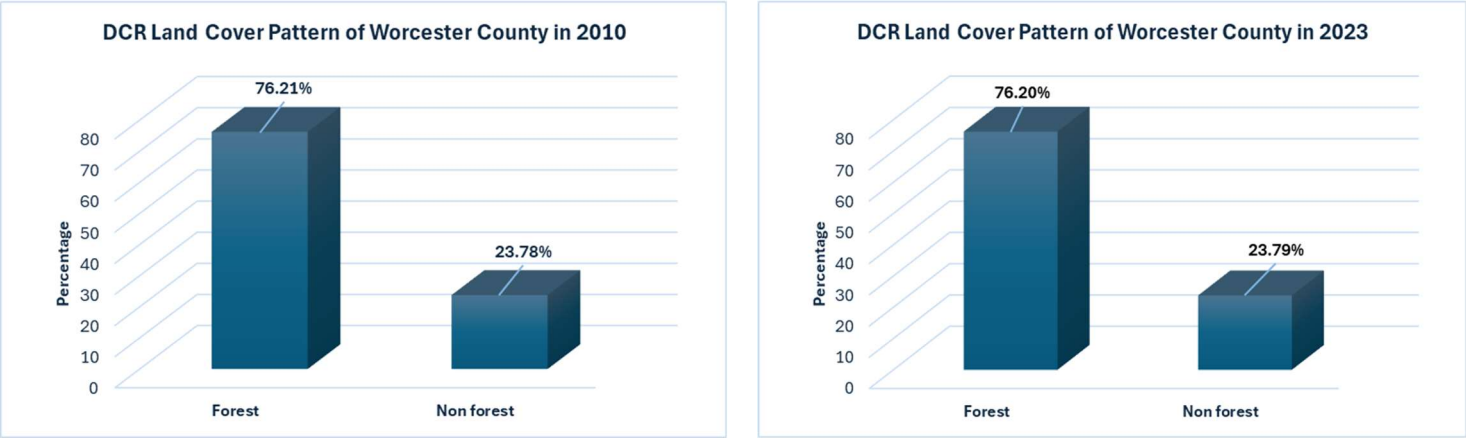


Figure 6: DCR Land Cover Percentage of Forest and Non-Forest Area in 2010 and 2023

Table 3: DCR Forest Cover Change pattern from 2010 to 2023

Forest Pattern	Total Area (km^2)	Percentage (%)
Gain	2.68	0.67
Unchanged/ No change	393.93	98.64
Loss	2.74	0.69

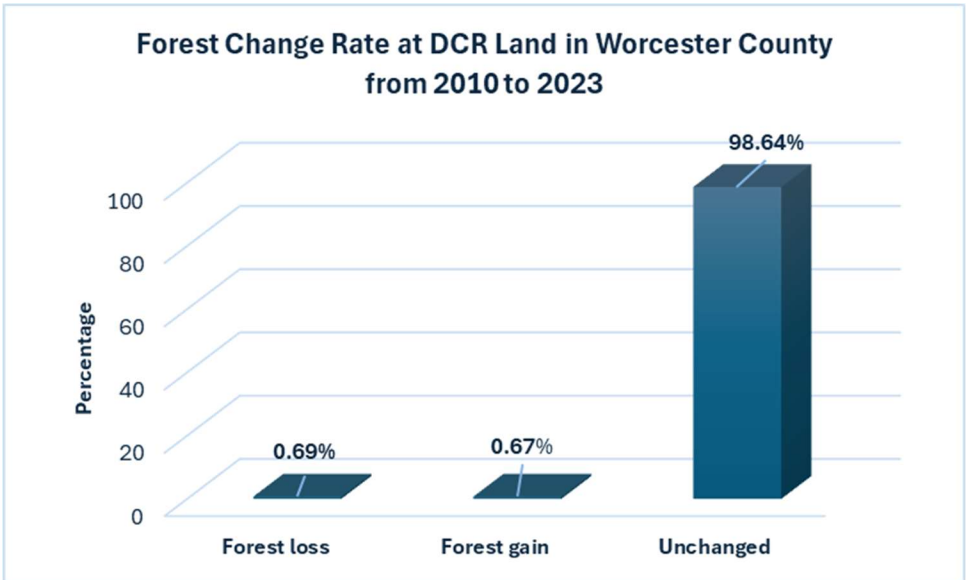


Figure 7: Changes in DCR Forest Cover Percentage over the period (2010 to 2023)

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