Chapter 14
Machine Learning Algorithms for Modeling Carbon Flux in Ecosystems

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ABSTRACT

Accurately modeling carbon flux in ecosystems is essential for understanding the global carbon cycle and developing effective strategies to combat climate change. Machine learning (ML) algorithms have emerged as powerful tools to address the complexity of carbon flux dynamics. This book chapter explores the application of ML techniques, including regression models, decision trees, random forests, and deep learning, to model critical components of carbon flux, such as gross primary production, ecosystem respiration, and net ecosystem exchange. These algorithms

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excel in capturing nonlinear relationships and interactions among environmental variables, offering insights into the effects of land-use changes, deforestation, and climate variability. The chapter also addresses key challenges, including data integration, uncertainty quantification, and computational demands, while identifying opportunities for future research. The transformative potential of ML in advancing carbon flux modeling underscores its importance for ecosystem monitoring and sustainable environmental management.

1. INTRODUCTION:

Understanding carbon flux in ecosystems is crucial for managing climate change and developing strategies to mitigate its impacts. Carbon flux refers to the movement of carbon between different components of the ecosystem, including the atmosphere, plants, soil, and water. This flux is driven by various processes such as photosynthesis, respiration, decomposition, and carbon sequestration, which play a significant role in regulating the Earth's climate. Monitoring and predicting carbon flux at different scales is essential for understanding how ecosystems respond to environmental changes, land-use activities, and climate variability. Traditional methods for modeling carbon flux, such as process-based models, often require extensive field measurements and can be computationally intensive, limiting their application at larger spatial and temporal scales. Furthermore, these models may struggle to capture the complex, nonlinear relationships between environmental factors and carbon dynamics. As a result, there is a growing need for more efficient, scalable, and accurate modeling techniques. (Hoffman & Randerson, 2013)

1.1 Overview of Carbon Flux in Ecosystems:

Carbon flux in ecosystems refers to the movement of carbon between various reservoirs, including the atmosphere, living organisms (plants, animals, microbes), soil, and water bodies. It is a central component of the global carbon cycle, which regulates the flow of carbon across different parts of the Earth system. Understanding the dynamics of carbon flux is critical for comprehending how ecosystems contribute to and are affected by climate change.