DESIGN, VALIDATION, AND APPLICATION IN
MANAGEMENT OF OAK DECLINE

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Abstract

Forest landscape models (FLMs) have increasingly become important tools for exploring forest landscape changes by predicting forest vegetation dynamics over large spatial scales. However, two challenges confronting FLMs have persisted: how to simulate fine, site-scale processes while making large-scale (landscape and regional) simulation feasible, and how to fully take advantage of extensive U.S. Forest Service Inventory and Analysis (FIA) data to initialize and constraint model parameters. In this dissertation, first, a new FLM, LANDIS PRO was developed. In LANDIS PRO, forest succession and dynamics are simulated by incorporating species-, stand-, and landscape-scale processes by tracking number of trees by species age cohort. Because stand-scale resource competition is achieved by implementing rather than simulating the emergent properties of stand development, LANDIS PRO is computationally efficient, which makes large-scale simulation feasible. Since model parameters and simulation results are comparatively straightforward to forest inventory data, current intensive forest inventory data can be directly applied for model initialization and to constrain model parameters.

Validation of FLMs is essential to ensure users' confidence in model predictions and achieve reliable management decision making. To date, validation of FLMs has been limited due to lack of suitable data. However, recent advances in FLMs, together with increasingly available spatiotemporal data make FLM validation feasible. In this dissertation, second, I proposed a

framework for validating forest landscape projections from LANDIS PRO using Forest Inventory Analysis (FIA) data. The proposed framework incorporated data assimilation techniques to constrain model parameters and the initial state of the landscape by verifying the initialized landscape and iteratively calibrating the model parameters. The model predictions were rigorously validated against independent FIA data at multiple scales, and the long-term natural successional pattern was also verified against empirical studies. Results showed model predictions were able to capture much of the variation overtime in species basal area and tree density at stand-, landtype- , and landscape-scales. Subsequent long-term predictions of natural succession patterns were consistent with expected changes in tree species density of oak-dominated forests in the absence of disturbance.

Lastly, I used LANDIS PRO, a forest landscape model that includes stand-scale species density and basal area to evaluate the potential landscape-scale effects of alternative harvest methods (thinning, clearcutting and group selection) on oak decline mitigation. Projections indicated that forest harvesting can be effective in mitigating oak decline. The effectiveness of forest harvesting varied among the three harvest methods. Group selection and clearcutting were the most effective methods in the management of oak decline in the short-term (20 years) and mid-term (50 years), respectively. However, in the long-run (100 years), there was no significant difference predicted among the three methods.