Research Article

Spatial pattern of coniferous and deciduous forest patches in an Eastern North America agricultural landscape: the influence of land use and physical attributes

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Received 29 November 1999; Revised 7 June 2000; Accepted 5 July 2000

Key words: agricultural landscape, Canada, forest patch, geographical information system, land use, physical attributes, Quebec, remote sensing, spatial pattern.

Abstract

In agricultural landscapes, most studies have investigated the influence of the spatial pattern of forest patches on other ecological phenomena and processes, such as animal movement and biodiversity. However, few have focused on explaining the spatial pattern of the forest patches themselves. Understanding how these patterns relate to the processes that generate them is fundamental in developing a sound theory of landscape ecology, and in devising rational management strategies. In this paper, the pattern of the overall forest patches, as well as the pattern of deciduous and coniferous patches in an agricultural landscape of Southern Quebec, Canada, were analyzed and related to landscape physical attributes and land use, using remote sensing, geographic information systems and statistical methods. Results show that the role of landscape physical attributes on forest patch pattern has been modified by land use. In the study area, coniferous or deciduous patches are not associated with a specific surface deposit. In addition, physical attributes explain only a small proportion of the abundance of conifers on past abandoned land compared with land-use factors. Physical attributes only indirectly influence the forest pattern because they strongly influence the land-use practices. Our results reveal a conifer recovery process with the abandonment of agricultural land. On past abandoned land, conifers expand with increasing stand age, mostly by invasion from neighboring coniferous patches. Spatially, coniferous patches are usually located on the margins of the overall forest patches, and they are connected to non-forest land-use types such as crop and pasture, the latter being the most important. By showing the importance of some coniferous forest types that did not exist in the precolonial forest, a new perspective emerges when landscape, especially, land-use dynamics are taken into account.

Introduction

The pattern of forest patches in the matrix of agricultural lands has long been, and is still, an important research topic in landscape ecology. Most studies have investigated the influence of the spatial pattern (location, shape and size) of forest patches on other ecological phenomena and processes, such as animal movement and biodiversity (Harris 1984; Van Dorp and Opdam 1987; Bolger et al. 1991; Van Apeldoorn et al. 1994; McIntyre 1995; and many others). Few, however, have focused on explaining the spatial pattern of the forest patches themselves (Burgess
Thuja coniferous patches dominated by white cedar (as pastureland (Domon 1989). A prominent pattern patches are mainly used as a source of firewood or abandoned agricultural land. Nowadays, these forest the forest patches in the study area recovered from natural landscape. Further investigations are needed to link the vegetation dynamics and the pattern of forest patches at the landscape level. This investigation is intended to give some insight into the dynamics and patterns of forest patches at the landscape level. It will also facilitate agricultural landscape planning and management.

In this paper, we explore the pattern of forest patches in an agricultural landscape of southern Que-bec, where forest patches occupy approximately 30% of the whole landscape. Like many other agricultural landscapes of eastern North America, most of the forest patches in the study area recovered from abandoned agricultural land. Nowadays, these forest patches are mainly used as a source of firewood or as pastureland (Domon 1989). A prominent pattern which draws our attention, is the creation of numerous coniferous patches dominated by white cedar (Thuja occidentalis L.), and few dominated by white pine (Pinus strobus L.), or by a mixture of white pine and white cedar on upland mesic sites. Although white cedar grows in a wide variety of environmental conditions, it is usually associated with wetland habitats (Fowells 1965; Blanchet 1982; Johnston 1990). Cur-tis (1944, 1946) first reported that white cedar can form pure stands in old fields in Maine. He suggested that cattle browsing was favoring white cedar over deciduous competitors. In our study site, de Blois and Bouchard (1995), using quantitative methods, showed that cattle grazing has played a significant role in the appearance of white cedar stands on mesic sites. Similar to white cedar, white pine can grow on nearly all the soils within its range (Wilson and McQuilkin 1965). However, it generally competes best on well drained sandy soils of low to medium site quality (Wendel and Smith 1990). It was reported that in New England white pine frequently pioneers on abandoned agricultural land, but only on the well-drained to ex-cessively drained deposits (Wendel & Smith 1990). In our study site, white pine is usually distributed on thin, dry soil over bedrock or mixed with white cedar on abandoned land (Meilleur et al. 1994). In order to better understand the creation and dynamics of conifer patches of all species in the agricultural setting, aside from research at the species and community level, further investigation is also required at the landscape level.

Using remote sensing, geographic information sys-tems and statistical methods, the patterns of the overall forest patches, as well as the patterns of deciduous and coniferous patches, were analyzed and related to the landscape’s physical attributes and land use. The main objective of this paper is to reveal the pattern of these two broad forest types, especially conifers, at the landscape level and to explore the factors which govern forest patch pattern in the agricultural landscape. Among the landscape’s physical attributes, we have emphasized surface deposit, as it is the most stable feature over time (Bouchard et al. 1985). In order to better understand the influence of land use on the forest patch pattern, we investigated the effects of both present and past land-use types. The current investiga-tion is part of a long-term multidisciplinary project which has produced several ecological and land man-agement studies in the same area (for an overview see Bouchard and Domon 1997) and, in particular, com-pliments the study of Pan et al. (1999) which analyzed the overall land-use pattern for the same landscape. This investigation is intended to give some insight into the dynamics and patterns of forest patches at the landscape level. It will also facilitate agricultural landscape planning and management.