Clustering Forest Harvest Stands on Spatial Networks

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Abstract:
The aim of this investigation is to present an optimisation method for clustering the stands scheduled for harvesting during the planning phase. The unfavourable topographic conditions and the great number of harvest stands at the Eucalyptus plantations of Aracruz, Brazil, stimulated the development of an analytical approach for clustering harvest stands. The typical landscape of this region is characterised by complex spatial pattern of mutually nested plantations, gallery and alluvial forests. Rivers often separate the harvest stands. Similar difficult conditions can occur in steep mountainous terrain in Europe. Despite Euclidian distances between the different stand locations, the actual road travel distances are much longer in order to circumnavigate topographic obstacles. Clustering forest harvest stands reduces the movements of the harvesters, forwarders and staff. Moreover, it simplifies the subsequent log transport, when compared with dispersed stands. Harvesting activities are generally based on silvicultural motivated planning data. The development of an analytical method to cluster harvest stands with respect to the spatial network of roads should improve the harvesting effort. The method of clustering harvest stands was developed for Aracruz (Brazil), where it is applied successfully. The hierarchical method 'single linkage cluster analysis' is used. As distance function, the Euclidian distance was substituted by the shortest path on the spatial network of roads. The clustering method is based on the minimum spanning tree, which is the spatial equivalent to the dendrogram of an ordinary cluster analysis. Applying the Delaunay-triangulation to fill the distance matrix reduces the distance calculation time from $O(n^2)$ to $O(n)$. The method is illustrated by a planning district of the Aracruz enterprise. Harvesting units are properly clustered spatially by the discussed method. Topographic obstacles are automatically avoided and the need to relocate machinery is reduced as well as the total driving distance.

Keywords: clustering harvest stands, optimising harvest operations, cluster analysis, spatial