Simulations of Selective Logging Behaviors and Spatial Patterns of Forest Fragmentation

Xanic J. Rondon, Graeme C. Cumming, Rosa Cossio, Jane Southworth

In this study, we presented a meso-scale approach to model a socio-ecological system, consisting of timber loggers and the forest. Using data from southwestern Amazonia, we modeled three timber selective logging scenarios or behaviors in a forest concession consisting of timber of high and low value. The purpose of this study was to determine whether these behaviors could create different spatial patterns of forest fragmentation, and differ in the timing of reaching a regime shift, defined in this study as the transition from a landscape state dominated by old-growth forest, where timber is abundant, to a landscape state dominated by degraded forest where little timber is left. In scenario 1, selective logging took place randomly, and there was no preference for timber harvesting. In scenario 2, loggers had a harvesting preference for timber trees of high value, and in scenario 3 for timber trees of low value. Logging dispersal in scenario 2 was based on a linear function (‘more strict’), whereas in scenario 3 logging dispersal was based on a logistic function (‘more relaxed’). After each scenario reached a regime shift, we estimated the return time or resilience of the forest concession to a restorative goal of minimum commercial volume, assuming the use of intensive silvicultural practices as enrichment planting of timber trees and thinning to enhance tree growth rates.

To simulate timber growth and harvesting, we used Lotka-Volterra’s predator-prey model with Holling’s functional response II. This model was coupled with a cellular automaton model to simulate forest fragmentation. Simulated time-series of timber harvesting over 80 years showed that the number of degraded forest patches and edge length varied non-linearly through time; furthermore, these patterns were different among the three logging scenarios. Scenario 3 reached a regime shift about 10 years earlier than scenarios 1 and 2. Scenario 2 had a faster return time to the restorative goal or was more resilient than scenarios 1 and 3, because of higher levels of silvicultural practices. In conclusion, this model approach is a useful tool for exploring different logging behaviors and assessing their impact to the forest landscape.