A MODEL FOR NUTRIENT CYCL[ING]

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Forest tree growth and its sustenance over long periods of time depend on nutrient availability and local environmental factors. As most of the site factors, including climatic conditions, are predetermined and fixed, nutrients play a varying and dominant role while raising a forest crop in a given area.

Trees accumulate the absorbed nutrients in stem and nonstem components during their lifetimes and return a major portion of these to the site on completing their life cycles. The nutrient return is usually in the form of gradual decomposition of dead tree boles and foliage and through litterfall. This cycle of nutrient uptake/return is an important link in the sustained growth and yield of forest vegetation through successive rotations.

TIMBER HARVEST AND NUTRIENTS

The harvesting of trees for lumber or other uses is a disruption of the natural cycle to some extent. When trees or their portions are exported from the site, the land is deprived of the nutrient capital accumulated in trees over a large period of their growth. The deprivation of the site will be further aggravated if the trees are harvested in a relatively short rotation and removed completely with all their components. This is likely to occur when energy production from the forest becomes an additional management objective in the future. Such practices are likely to result in losses in site quality unless remedial measures are taken in time to reverse the trend.

It is difficult to observe losses in site quality, particularly when dealing with forest crops which usually extend over a major span of human life and sometimes exceed it. Unlike agricultural crops, the nutrient trends cannot be readily noticed from the vigor and quality of succeeding crops because of the comparatively slower rates of growth in forest trees. However, it is essential that we be able to assess the existing and future status of nutrient capital to help plan and regulate forest production at optimum levels.

NUTRIENT TREND ANALYSIS

FORCYTE (FORest nutrient Cycling and Yield Trend Evaluator) simulation model is presently being used in Canada and other parts of the world to examine the long-term effects of forest growth and harvest on the nutrient budget of forest sites. The model was developed by Dr. J.P. Kimmins and his associates at the University of British Columbia and has gone through a number of evolutionary stages since its inception. The current version is FORCYTE-10 and is already nearing updating as FORCYTE-11. Another version of the model will have the added capability of simulating forest vegetation growth in response to moisture regulation (FORCYTE-12).

MODEL STRUCTURE

The model assumes nutrient availability to be the most critical factor influencing forest growth at a given site. It uses site- and species-specific data in a climatic/ecological zone or region, and incorporates some process modelling features, to simulate the effects of long-term intensive management on nutrient capital, biomass production, and economic return.

The driving function of the model is in the form of Chapman-Richards growth equations:

$$Y = a(1.0 - e^{bX})^{c} + e$$

where Y is the biomass or volume of a tree at age X.

The driving function of FORCYTE-11 will use the foliar nitrogen content of the growing tree in producing tree biomass. The capability of the model is being expanded to include input and output information for up to 10 trees, shrubs, herbs, mosses and additional vegetation strata (e.g., the agricultural crops raised in agro-forestry).

FORCYTE-10 simulates only one nutrient (usually nitrogen) at a time. FORCYTE-11 will have the capability to simulate the growth and nutrient capital trends of up to five different nutrients. Thus, the updated version should have the competence to deal with highly complex data systems to be managed under a variety of management scenarios.

MODEL OUTPUTS

The model outputs for FORCYTE-10 include 12 multiple information plots to depict the behavior of the model in response to different input conditions. These inputs, for example, may be thinning and fertilization regimes at different time periods during successive rotations. A total of 180 years (or time periods) is simulated from the start of the run. For a rotation period of 60 years, this means three successive simulated forest rotations. Any rotation length can be devised depending on the objectives of management.

The outputs of FORCYTE-10 include such information as total biomass yield, stemwood biomass, whole tree biomass, biomass from thinnings, economic costs, energy values, and various benefit/cost ratios. Nutrient capital of the site and the status of the forest floor biomass are also provided in the summary reports at the end of each rotation to show the trend in nutrient accumulation or depletion as a result of particular operational management plans.

Biological systems are extremely complex natural systems. Any attempt to model this complexity may never achieve exact duplication of inherent realities. Utmost caution should therefore be exercised in considering model predictions of such systems. As the name implies, the forest nutrient cycling model predictions are more an indicator of nutrient capital trends rather than of exact values. The model is an attempt to utilize the currently available knowledge of ecosystem processes for improving the quality of forest management by comparing different strategies and available options.

REFERENCE

Kimmins, J. P., and K. A. Scoullar. 1983. FORCYTE-10: A user's manual. University of British Columbia, Vancouver, B.C., Canada.