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A dynamic ecosystem growth model for forests at high complexity structure

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Forests ecosystem play an important role in carbon cycle, biodiversity conservation and for other ecosystem services and changes in their structure and status perturb a delicate equilibrium that involves not only vegetation components but also biogeochemical cycles and global climate. The approaches to determine the magnitude of these effects are nowadays various and one of those include the use of models able to simulate structural changes and the variations in forests yield The present work shows the development of a forest dynamic model, on ecosystem spatial scale using the well known light use efficiency to determine Gross Primary Production. The model is predictive and permits to simulate processes that determine forest growth, its dynamic and the effects of forest management using eco-physiological parameters easy to be assessed and to be measured. The model has been designed to consider a tri-dimensional cell structure composed by different vertical layers depending on the forest type that has to be simulated. These features enable the model to work on multi-layer and multi-species forest types, typical of Mediterranean environment, at the resolution of one hectare and at monthly time-step. The model simulates, for each layer, a value of available Photosynthetic Active Radiation (PAR) through Leaf Area Index, Light Extinction Coefficient and cell coverage, the transpiration rate that is closely linked to the intercepted light and the evaporation from soil. Using this model it is possible to evaluate the possible impacts of climate change on forests that may result in decrease or increase of productivity as well as the feedback of one or more dominated layers in terms of CO_2 uptake in a forest stand and the effects of forest management activities during the forest harvesting cycle. The model has been parameterised, validated and applied in a multi-layer, multi-age and multi-species Italian turkey oak forest (Q. cerris L., C. betulus L. and C. avellana L.) where the medium-term (10 years) development of forest parameters were simulated. The results obtained for net primary production and for stem, root and foliage compartments as well as for forest structure i.e. Diameter at Breast Height, height and canopy cover are in good accordance with field data (R2>0.95). These results show how the model is able to predict forest yield as well as forest dynamic with good accuracy and encourage testing the model capability on other sites with a more complex forest structure and for long-time period with an higher spatial resolution.