An integrated cell-based dynamic mathematical model that takes into account the role of the photon absorbing process, the partition of excitation energy, and the photoinactivation and repair of photosynthetic units, under variable light and dissolved inorganic carbon (DIC) availability is proposed. The modeling of the photon energy absorption and the energy dissipation is based on the photoadaptive changes of the underlying mechanisms. The partition of the excitation energy is based on the relative availability of light and DIC to the cell. The modeling of the photoinactivation process is based on the common aspect that it occurs under any light intensity and the modeling of the repair process is based on the evidence that it is controlled by chloroplast and nuclear-encoded enzymes.

The present model links the absorption of photons and the partitioning of excitation energy to the linear electron flow and other quenchers with chlorophyll fluorescence emission parameters, and the number of the functional photosynthetic units with the photosynthetic oxygen production rate. The energy allocation to the LEF increases as DIC availability increases and/or light intensity decreases. The rate of rejected energy increases with light intensity and with DIC availability. The resulting rate coefficient of photoinactivation increases as light intensity and/or as DIC concentration increases. We test the model against chlorophyll fluorescence induction and photosynthetic oxygen production rate measurements, obtained from cultures of the unicellular green alga \( \text{Scenedesmus obliquus} \), and find a very close quantitative and qualitative correspondence between predictions and data. Were longer during feeding and stress.