Managing tradeoffs between food production, biodiversity, and ecosystem services: exploring win-no-loss scenarios with an evolutionary technique.

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Abstract

Models and optimization techniques are useful tools supporting the management of land for the provision of conflicting ecosystem services. Such tools meet the following difficulties. (i) Modelling the spatial heterogeneity of ecosystem services provision requires a high computational effort. (ii) Optimization techniques need to cope with many policy and physical constraints and with several management variables interacting in non-linear way. (iii) Different services are often not substitutable, thus optimization techniques must treat them separately without building aggregated indices. In this study we aim at proposing a methodological framework for supporting the design of win-no-loss scenarios, i.e., allocating land uses and land covers for maximizing the provision of a service, without causing losses in other services. We apply our methodological framework at the French scale. For addressing (i) we use Small Agricultural Regions (SARs) as spatial units. Those units are not too big, so the spatial heterogeneity is represented, and not too small, so to have a low computational demand. We build ecological production functions to estimate the provision of ecosystem services at the SAR level using management and geographical variables. The ecosystem services we consider are crop and livestock production, biodiversity, carbon sequestration and storage, pollination, timber production, and recreation. Management variables are the fraction of land covers in each SAR, and crop cultivation intensity (e.g., pesticide inputs). We design scenarios for assigning management variables to the different SARs and, in turn, we optimize one service at the French scale, imposing a constraint of no-loss on the others. For the optimization we use an evolutionary algorithm, which is able to address (ii) and, (iii). The evolutionary technique promotes land covers that deliver multiple services and softens the tradeoffs by allocating land covers delivering competing services in different SARs. We discuss the strength and weak points of the modelling framework and of the evolutionary technique for optimization.

Keywords: Scenarios, ecosystem services, tradeoffs, evolutionary techniques, Optimization techniques

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