Farmbird - an interdiciplinary modelling project on the coviability of farming systems and bird biodiversity

Francois Leger Léger, Gilles G. Allaire, Thierry Bonaudo, Eric E. Cahuzac, Luc Doyen, Frédéric Jiguet, Romain Julliard, Eric Kerneis, David Makowski, Brigitte B. Remy, et al.

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Léger[1] F., Allaire[2] G., Barbottin[1] A., Bonaudo[1] T., Cahuzac[2] E., Doyen[3] L., Jiguet[3] F., Julliard[3] R., Kernéïs[4] E., Makowski[5] D., Rémi[1] B., Souchère[1] V., Teillard[1] F., and Tichit[1] M.
[1]UMR INRA 1048 SADAPT – AgroParisTech, Paris, France ; [2]UR INRA ESR, Toulouse, France ; [3]UMR 5173 CERSP, MNHN, Paris, France ; [4]UE INRA SLP, Saint Laurent de la Prée, France ; [5]UMR 211 Agronomie, AgroParisTech, Paris, France. Presenting author : felix.teillard@ens.fr

INTRODUCTION

Intensification of European agriculture induced sharp decline of biodiversity, common bird populations being particularly affected. This erosion of biodiversity is mainly due to decrease in habitat quality and homogenisation of agro-landscapes (Benton et al., 2003). Heterogeneity, defined as the spatial configuration of a habitat mosaic, determines the carrying capacity for several species using different habitats. It is generated by the spatial and temporal distribution of management intensity. In the FarmBird project, we develop an interdisciplinary modelling framework to analyze the coviability between agricultural production and biodiversity conservation in heterogeneous agro-landscapes. This framework links different scales (field, farm, landscape) and combines ecological, agronomic and economic knowledge We present the first framework developed for a grassland farm in which grazing and mowing influence bird population dynamics in the long term. Several studies have demonstrated that some grazing or mowing regimes can create suitable grass structure for birds. They also showed that these management regimes directly impact bird life traits due to nest and chick destruction. To date, no study has examined the joint and interacting effects of grazing and mowing regimes on bird populations. The farm scale is the first level at which both management regimes interact. It is therefore a relevant scale, to analyse the trade-off between agricultural production and biodiversity conservation in different livestock farming systems differing in their overall intensity.

DESCRIPTION OF MODEL

The dynamic model is a spatially implicit extension of that proposed by Tichit et al. (2007) for an homogeneous grassland. It considers a grassland farm which combines three management regimes: (i) "ecological grazing" providing a suitable habitat for birds (ii) "productive grazing" maximising the harvest and (iii) mowing for cattle winter feeding. These management regimes produce the feeding resources for suckling cattle and they also induce the level of habitat quality for two ground nesting bird species: lapwings and redshanks. The model comprises two interactive sub models describing the dynamics of (1) three grassland fields controlled through grazing or mowing and (2) the bird populations. Grass dynamics and management regimes influence either indirectly or directly bird life traits. Grazing intensity and mowing periods have direct impact on bird fecundity. Both management regimes determine the habitat quality i.e. grass height, which is a variation factor of chicks' survival. Another important feature of the model is that different strategies of bird movement are formalized between the three grassland fields. This feature makes it possible to account for an impact of the proportion of the three management regimes on bird population dynamics at farm scale.

The mathematical framework of viable control theory (VCT) (De Lara and Doyen, 2008) is used to analyse long-term grassland dynamics. The VCT deals with the control of uncertain dynamic systems under state and control constraints. It first requires the identification of a set of constraints that represents the "good health" of a system: here ecological and production constraints. Ecological constraints are defined by specifying, at key periods of bird life cycle, minimal and maximal grass heights as well as maximal stocking densities for each bird species. Production constraints include considerations on livestock feeding requirements. The viability of the grassland farm is related to the maintenance of these conditions at all times, including both present and future. We use VCT to determine the viable proportion of management regimes at farm scale as well as the viable grazing strategies (i.e. timing and intensity). For any given amount of "ecological grazing", the model computes the viable proportions of mowing and productive grazing i.e. those maximising the harvest of dry matter.

RESULTS AND DISCUSSION

Figure 1a shows the trade-off between production and conservation in extensive and intensive farms. Each point of the trade-off curve stands for a grassland farm composed with different amount of the three management regimes. For the same amount of ecological pasture, the quantity of harvested biomass was always slightly higher in intensive farms (up to 5%) but bird populations were smaller after ten years. In order to maintain bird populations in intensive farms, it was thus necessary to allocate a larger proportion of farmland to "ecological grazing". For instance, 30% of "ecological grazing" were enough to maintain bird populations in extensive farms which was not the case for intensive farms (Fig. 1b). The coviable proportions of management regimes ensuring bird population maintenance while maximising the harvest of dry matter were 25%, 50%, 35% (respectively for "ecological grazing", "productive grazing" and mowing) in extensive farms whereas they reached 35%, 40%, 35% in intensive farms (results not shown). Interestingly, for such viable proportions, the biomass harvest was higher in extensive farms (Fig 1a, dotted lines). This was due to the lower proportion of ecological grazing and the higher proportion of productive grazing. Consequently, extensive farms had a higher grassland self sufficiency than intensive ones.

Our model enables to compute the proportion of management regimes and their intensity leading to the production/conservation coviability in a grassland farm. It underlines the need to consider the overall farm intensity when determining such coviable strategies. Further research in the FarmBird project will extend this approach to arable farming systems as well as to landscape scales. Future models will take into account public policies as drivers of farmers' land use decisions. Such models will be used as support for the design and evaluation of policies aimed at supporting the diffusion of biodiversity friendly farming systems.

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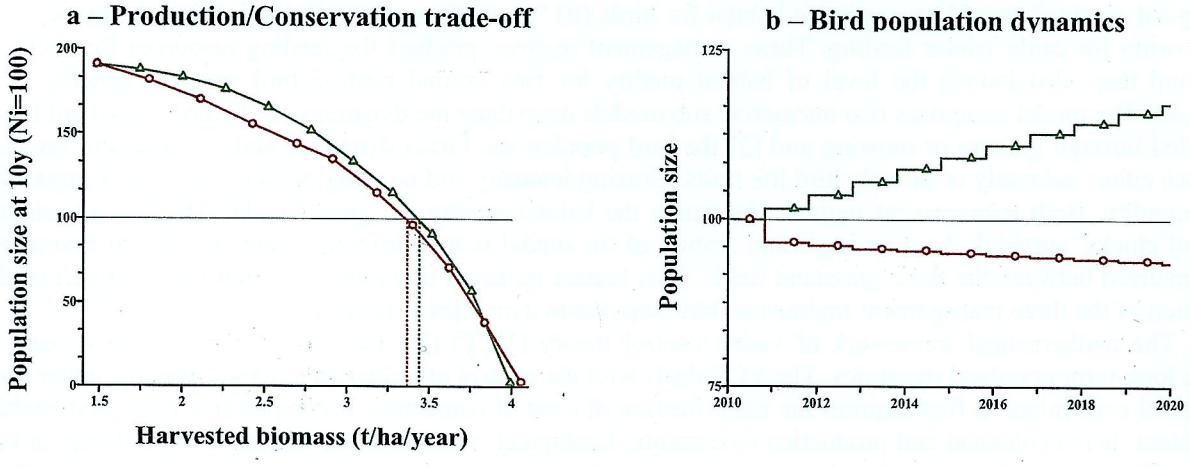

Fig. 1 Conservation and production values of extensive (green triangles) and intensive farms (red circles). (a) Trade-off between production and ecological performances. (b) Bird populations' dynamics in farms with 30% of "ecological grazing".