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Balancing Biodiversity and Agriculture: A Broad-Scale Analysis of the Land Sparing/Land Sharing Trade-Off for South African Birds

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Abstract : Modern agriculture has revolutionised the planet's capacity to support humans, yet has simultaneously had a greater negative impact on biodiversity than any other human activity. Balancing the demand for food with the conservation of biodiversity is one of the most pressing issues of our time. Biodiversity-friendly farming ('land sharing'), or alternatively, separation of conservation and production activities ('land sparing'), are proposed as two strategies for mediating the trade-off between agriculture and biodiversity. However, there is much debate regarding the efficacy of each strategy, as this trade-off has typically been addressed by short term studies at fine spatial scales. These studies ignore processes that are relevant to biodiversity at larger scales, such as meta-population dynamics and landscape connectivity. Therefore, to better understand species response to agricultural land-use and provide evidence to underpin the planning of better production landscapes, we need to determine the merits of each strategy at larger scales. In South Africa, a remarkable citizen science project - the South African Bird Atlas Project 2 (SABAP2) – collates an extensive dataset describing the occurrence of birds at a 5-min by 5-min grid cell resolution. We use these data, along with fine-resolution data on agricultural land-use, to determine which strategy optimises the agriculture-biodiversity trade-off in a southern African context, and at a spatial scale never considered before. To empirically test this trade-off, we model bird species population density, derived for each 5-min grid cell by Royle-Nicols single-species occupancy modelling, against both the amount and configuration of different types of agricultural production in the same 5-min grid cell. In using both production amount and configuration, we can show not only how species population densities react to changes in yield, but also describe the production landscape patterns most conducive to conservation. Furthermore, the extent of both the SABAP2 and land-cover datasets allows us to test this trade-off across multiple regions to determine if bird populations respond in a consistent way and whether results can be extrapolated to other landscapes. We tested the land sparing/sharing trade-off for 281 bird species across three different biomes in South Africa. Overall, a higher proportion of species are classified as losers, and would benefit from land sparing. However, this proportion of loser-sparers is not consistent and varies across biomes and the different types of agricultural production. This is most likely because of differences in the intensity of agricultural land-use and the interactions between the differing types of natural vegetation and agriculture. Interestingly, we observe a higher number of species that benefit from agriculture than anticipated, suggesting that agriculture is a legitimate resource for certain bird species. Our results support those seen at smaller scales and across vastly different agricultural systems, that land sparing benefits the most species. However, our analysis suggests that land sparing needs to be implemented at spatial scales much larger than previously considered. Species persistence in agricultural landscapes will require the conservation of large tracts of land, and is an important consideration in developing countries, which are undergoing rapid agricultural development.

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