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LAND-USE SUSTAINABILITY

Precision conservation for a changing climate

Landscape diversity is critical to enhance agricultural sustainability and resilience. A realistic and achievable route towards adding complexity and biodiversity into agricultural landscapes may be through precision conservation.

Bruno Basso

Agricultural landscapes, once diverse and heterogenous, are now increasingly simplified, with biodiversity-based ecosystem services drastically reduced. There is abundant evidence of nature's contributions to society[1,2], but agricultural intensification continues to undermine these contributions through soil erosion, water and soil quality degradation, greenhouse gas emissions, and biodiversity loss at local and landscape scales[3].

Landscape structure plays a determining role in agriculture. The contents (composition) and spatial arrangement (configuration) of crops and habitats influence biodiversity as well as the abundance of pests and service-providing organisms (such as bees for pollination, and lady beetles, carabid beetles, hoverfly larvae and parasitoid wasps for biocontrol pest suppression)[4]. In general, landscapes with

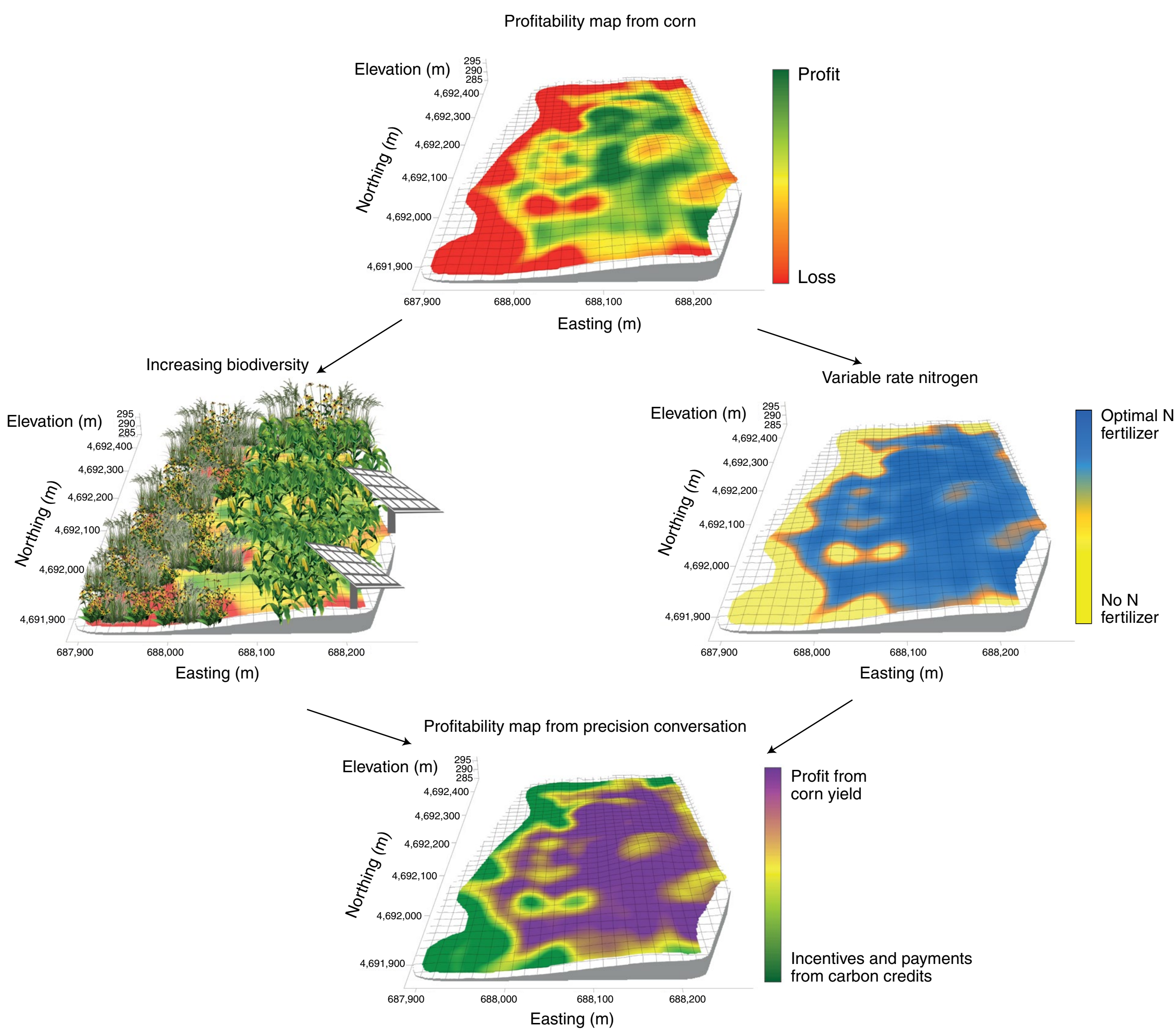

Fig. 1 | Precision conservation. Precision conservation and digital agriculture can increase profitability, reduce losses of fertilizer to water and atmosphere, and increase soil carbon and biodiversity-based ecosystems services[12].

greater compositional and configurational complexity can have enhanced biodiversity, ecosystem services and crop productivity[5–7]. Findings like these are mostly drawn from linking outcomes in individual fields to the structure of landscapes in their surroundings.

In this issue of *Nature Food*, Nelson and Burchfield[8] take a different approach using county-level data from the conterminous US. They report that compositional complexity, particularly landscape diversity, is associated with higher yields in commodity grain crops (~10%), with an impact on par with those of soil productivity and favourable climate. Nelson and Burchfield find that landscape composition has a stronger influence on yields than landscape configuration, but that the two variables interact and configurational complexity can modulate the effects of composition on yield. These findings agree with studies leveraging large-scale datasets from other regions and evidence that landscape diversity, habitat amount and configuration can interact in complex ways to affect biodiversity levels and abundance of service-providing organisms in crop fields[5–7].

How could this knowledge be applied towards agricultural sustainability? While farmers may wish for positive environmental outcomes, and aesthetic and biodiversity-related multifunctionalism of land[9], there is general resistance to crop diversification and other practices that maximize biodiversity-based ecosystem services. This may be due to the market's lower demand for alternative crops, farm and supply chain costs of moving away from traditional commodities such as corn and soybean, and cultural inertia. Digital agriculture technologies (sensors, crop models and AI/data analytics) may help us leverage the beneficial effects of landscape complexity. Precise monitoring of crop fields using tractor-mounted sensors or remote sensing images from drones, airborne platforms or satellites, offers a tremendous opportunity to identify low productivity at subfield scales. Basso et al.[10] reported that about one-third of corn and soybean land across the 35 million hectares of the US Midwest is characterized by stable low productivity, half by stable high productivity and the remainder by unstable areas changing from year to year depending on dynamic interactions among climate, topography and soil. The low productivity areas within a given field were assessed for spatial extent, location within the field and continuity (contiguous pixels) to allow their allocation to alternative crops, including conservation planting such as native perennial vegetation. Digital technologies have given farmers better visuals of their land performance and they are becoming more receptive to the idea that consistently low productivity areas within a field, which are also unprofitable, might be removed from corn–soybean production in exchange for financial incentives. These might include payments for ecosystems services related to climate change mitigation (for example, soil carbon), water quality (for example, phosphorus conservation), biodiversity (for example, pollination) or some other environmental benefit. To match current levels of production, we would need to replace the yield removed from unprofitable areas with yield grown elsewhere[11]. The good news is that less land would be needed to produce the lost yield if the yield was produced in more suitable areas. Lost yields could also be somewhat offset by using technology to increase yields in other parts of the fields[10,12]. Precision technologies capable of varying fertilizer application rates to account for localized crop demand, can increase yields by capitalizing more fully on productive areas of fields[12] (Fig. 1).

The persistence of linear systems in US grain production and the large associated environmental costs is clear evidence of US agricultural and environmental policy's failure to induce commercial grain farms to reduce their environmental impacts. This is especially true for biodiversity-based ecosystem services. Many of these impacts could be substantially reduced by converting low-productivity subfield areas, where most of the nitrate leaching and greenhouse gas emissions occur[10], to perennial conservation plantings[13] with their substantial capacity to deliver biodiversity-related services. Another way to incentivize the adoption of practices that enhance ecosystem services is through consumers, who could choose to favour supply chains, and thus farmers, who promote and adopt conservation practices.

The contribution by Nelson and Burchfield[8] underscores the relevance of landscape structure for agricultural sustainability. Precision conservation technologies may present a realistic and achievable route towards adding complexity and biodiversity back into agricultural landscapes. Given past accomplishments in developing a highly productive agricultural enterprise, we should now consider intentionally shaping agricultural landscapes to build secure, resilient food systems that are environmentally sustainable over the long term. ❐

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Competing interests

The author declares no competing interests.