

BIODIVERSITY ENHANCEMENT

Biodiversity can be a sensitive topic in agriculture and is highly contextual. A diverse mix of native plant species in an arid grassland of southern Alberta, Canada, is entirely different than a diverse mix of native plants in a coastal subtropical region of south-eastern Queensland, Australia. The commonality though, is that different soils and landscape positions favour certain species over another, regardless of what that landscape is growing. This provides opportunity to use the landscape in a way that supports profitable agriculture as well as biodiversity.

As an example, salt-affected soils are not well suited to most annual grain crops, but there are many different perennial forage species that are adapted to these soils (Figure 1). *The ability to map areas that do not economically support annual crops supports changes in land use that will benefit the farm economically, improve soil health, and support plant and animal biodiversity.* As salinity is related to groundwater discharge it is also related to plant water use. Annual crops in a saline area that are unproductive will not use

much water. In a case like this, planting high water use perennials like alfalfa or trees can increase water use, draw down the water table and protect the surrounding crop from salinity. This provides enhanced productivity of the marginal areas and generally a reduction of inputs. Additionally, the increased water use can intercept dissolved nutrients and pesticides preventing them from contaminating groundwater or surface water bodies.

Historically, farms have been reluctant to surrender annual cash crop land to perennial forages or other species for several reasons. Changing of field boundaries can increase overlap and over-application of inputs, or cause application inefficiency due to implement turning. But increasing adoption of technology with automated sectional control, row, or nozzle shut off has greatly reduced the negative consequences of irregularly shaped boundaries. It also helps reduce off-target application of pesticides, for example overspray of an insecticide onto flowering native species in non-crop areas where pollinators are active.



Figure 1. Productive perennial grass hay mix growing in a flood prone sodic soil (SWAT zone 10) in SE Queensland, Australia.

Research on diverse, non-crop areas has reported several benefits, such as pollination services, biocontrol of pests through habitat for beneficial insects, sequestration of carbon, protection of crops from wind, improvements in water quality (Muringai & Goddard, 2019), as well as increased species richness and abundance (Outhwaite et al., 2022). Others have reported mixed results; for example water use by trees potentially outweighing the benefits they provide (Robinson et al., 2022). Shelterbelts have been used extensively for wind erosion control. In arid to semi-arid environments they have the additional benefit of reducing evapotranspiration rates on windy days. In water limited regions this can amount to productivity increases. Brandle (2000) reported yield increases from shelterbelts of 6-44% depending on crop type and conditions. The net effect is that there is greater productivity of the field overall despite a smaller land base being cultivated.

Biodiversity does not always need to be at the expense of arable acres. Under-seeding can provide erosion control particularly in water erosion sensitive areas. Planting a leguminous cover crop can provide nitrogen fixation and green manure for the next season provided there is adequate moisture support. Timing of under-seeding is important to reduce competition between the cash crop and the cover crop. Growth rates and maturation times are linked to availability of moisture and as such SWAT MAPS can be a valuable tool in determining where and when to under-seed. *Understanding the spatial variability of a field highlights the opportunities to increase productivity and sustainability of the whole system, including cash crops, rather than merely decreasing the arable land base for production.*

SWAT MAPS combined with yield data to calculate spatial returns allows a farm to analyze fields in detail, making land use change decisions easier and more informed. The example shown in Figure 2 would suggest that SWAT zones 9-10 may be better suited to a different purpose. The farm could potentially plant less acres, improve profits, and contribute to the ecosystem by adding species diversity. Multiple years of spatial data can reinforce land use change decisions, such as a yield stability map produced from multiple years of yield data (Figure 3).

Metrics

Biodiversity can be assessed by extent of non-crop area and/or species richness. Both are important but extent is often a more accessible metric for biodiversity. Extent can be measured as the percentage of a field that is in non-crop perennial

vegetation. An additional measurement is the percentage of the linear extent of boundaries in the field (field edges, water bodies, etc.) that contains some type of non-crop/buffer land use. The extent of biodiversity can also be measured as the distance within a field to a non-crop area. This metric can be used to set a maximum acceptable distance to avoid extensive monocultures. It is also helpful to assess the potential of pollinator species to reach the interior of large fields.

Recommended Metrics:

- **Extent of non-crop area;**
- **% of linear extent of field boundaries in non-crop use;**
- **maximum distance in field to non-crop area**

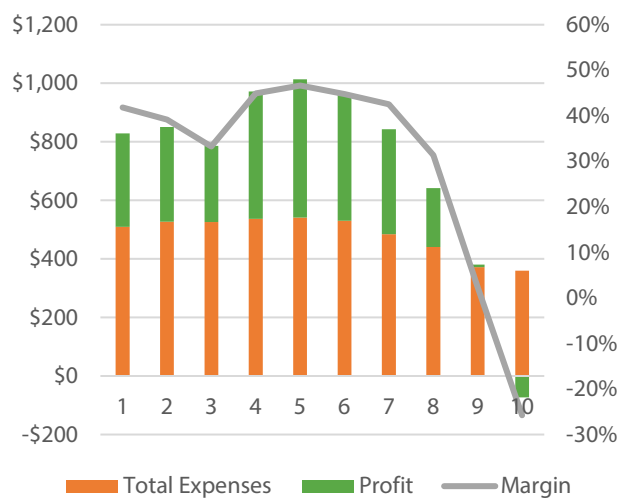


Figure 2. Example of a profit analysis by SWAT zone.

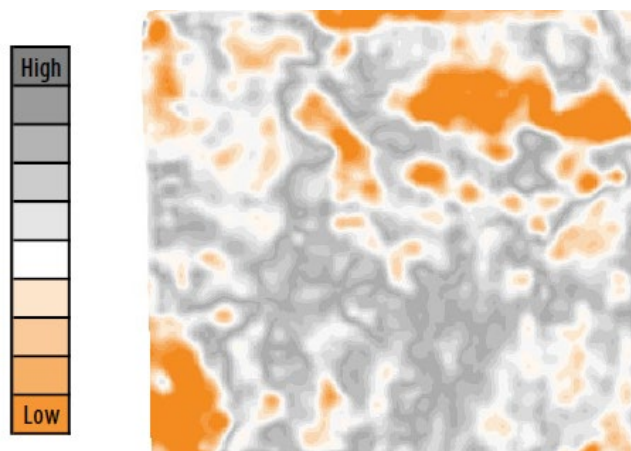


Figure 3. Yield stability map delineating areas of a field with yield instability and higher risk of negative returns.

References

- Brandle, James R., "Windbreak Practices" (2000). *Papers in Natural Resources*. 1147. <https://digitalcommons.unl.edu/natrespapers/1147>
- Muringai, V., & Goddard, E. (2019). Economic Benefits of Biodiversity to Crop Producers in Canada: A Literature Review.
- Outhwaite, C. L., Ortiz, A. M. D., Spooner, F. E., Dalin, C., & Newbold, T. (2022). Availability and proximity of natural habitat influence cropland biodiversity in forest biomes globally. *Global Ecology and Biogeography*, 31(8), 1589-1602.
- Robinson, S. V., Nguyen, L. H., & Galpern, P. (2022). Livin'on the edge: Precision yield data shows evidence of ecosystem services from field boundaries. *Agriculture, Ecosystems & Environment*, 333, 107956.

Acronym & Abbreviation Guide

ROI — Return On Investment

Common financial indicator indicating the profitability of an investment.

SWAT — Soil, Water, and Topography

A spatial soil landscape framework for mapping stable properties that drive yield potential and environmental interactions.

SWAT MAPS

High-resolution soil, water, and topography maps forming the foundation of precision agronomy within the SWAT ECOSYSTEM.

