Plant diversity in grasslands: Multi-species swards outperform even in drought conditions

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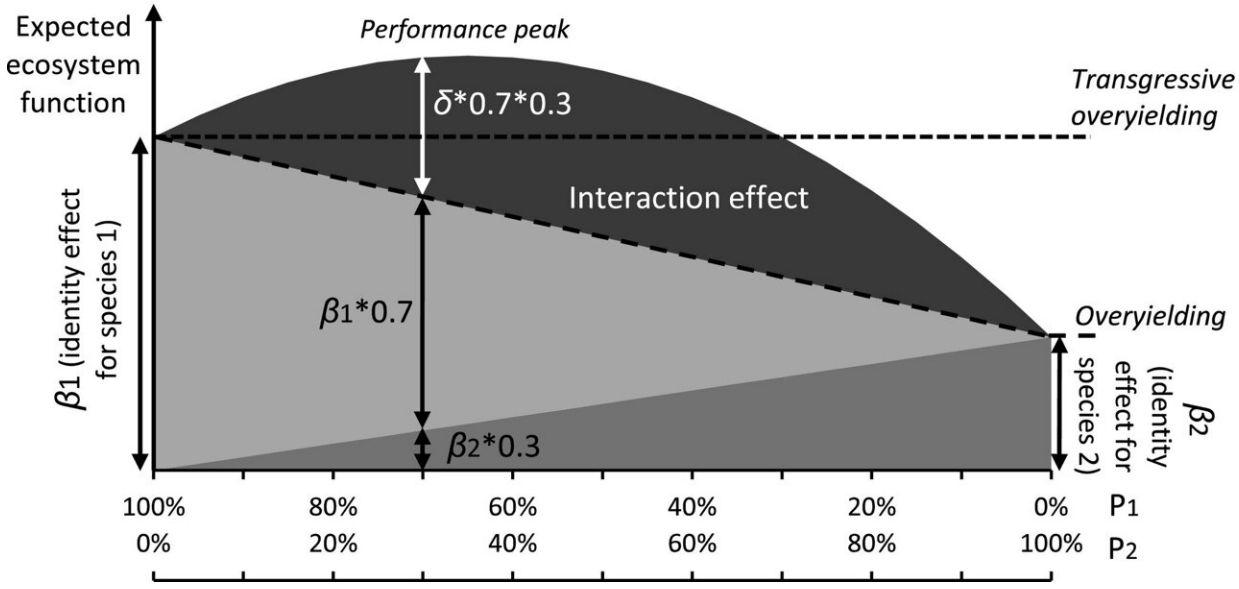

Illustration of the Diversity-Interactions modeling approach of an ecosystem function (y, here total annual biomass production) in a two-species system. For the equation y = β1P1 + β2P2 + δP1P2 + ε (adapted from Equation 1 for two species), we illustrate the expected ecosystem function for all possible communities involving the two species, ranging from a monoculture of species 1 (on the left) to a monoculture of species 2 (on the right), and all possible two-species mixtures in between (e.g. 50:50% in the center point). The identity effect for species 1 is β1 and this is the expected performance of species 1 in monoculture (similarly it is β2 for species 2). In mixture, the expected performance is a weighted average of the identity effects (β1P1 + β2P2) plus the interaction effect scaled by the product of the two proportions (δP1P2). The

expected ecosystem function for the 70:30% mixture is $\beta1 \times 0.7 + \beta2 \times 0.3 + \delta \times 0.7 \times 0.3$. In this example, species 1 performs better than species 2, and so has a higher identity effect; and δ is positive reflecting synergistic interaction; however, it could also be negative or 0. These concepts scale up for systems with >2 species. Because the ecosystem function of interest is the biomass production in this case, the sloped dashed line shows the 'overyielding' threshold, that is, where a mixture outperforms the weighted monoculture performance. The horizontal dashed line shows the 'transgressive overyielding' threshold, that is, where a mixture outperforms the best-performing monoculture. Credit: DOI: 10.1111/1365-2664.13894

Six-species swards outperformed perennial ryegrass monocultures and were considerably more resistant to drought, research has found.

The research from Teagasc, Johnstown Castle and Trinity College Dublin shows that multi-species mixtures receiving 150 kg per hectare per year of nitrogen fertilizer out-yielded perennial ryegrass monocultures receiving double that amount of fertilizer (300 kg per hectare per year).

Increases in plant diversity up to six species in intensively-managed grasslands reduced the impact of drought and produced more yield with less fertilizer.

Higher-diversity lower-input mixtures produced higher yields than low-diversity high-input monoculture

Averaged across the two years of the trial, mixtures with all six species produced the highest yields, and yielded more than the best of the six monocultures. Under rainfed conditions, the mixture with equal

proportions of all six species at sowing (produced 11.8 tons/ha/year) outperformed the best-performing monoculture (produced 10.5 tons/ha/year).

Even after increasing fertilizer on perennial ryegrass in monoculture, it did not yield as much as the highest diversity mixture.

Higher-diversity mixtures produced similar yields under drought as other comparisons under rainfed conditions

As expected, total annual yields were generally reduced by the experimental drought. Nevertheless, the higher-diversity lower-input mixtures under unfavorable drought conditions achieved similar yields to those from the low-diversity, high-input comparison under favorable rainfed conditions. This indicates the potential for multi-species mixtures to mitigate the effect of more variable weather conditions on grassland yields across the whole year.

Dr. John Finn, a senior researcher at Teagasc's Environment Research Centre at Johnstown Castle, said: "The need for research on drought in Irish grasslands has become all too obvious in recent years, and that need will only increase in the coming decades. The use of multi-species is one strategy to improve the resilience of grassland production."

Dr. Caroline Brophy, Associate Professor at Trinity College Dublin, said: "It is crucial that we reduce nitrogen fertilizer inputs to improve the sustainability of Irish agricultural grasslands. Using innovative statistical approaches, we show that multi-species mixtures provide a solution to reduce fertilizer usage, without compromising on grassland production."

The most productive swards were a combination of species from the

three functional groups of grasses, legumes and herbs. With legume proportion between 30 and 70%, yields were better than the best monoculture.

Teagasc Walsh Scholar Guylain Grange, who conducted the experiment, said: "Multi-species mixtures can be a practical, farm-scale solution for intensive grassland production with lower nitrogen fertilizer input, and can mitigate the risk associated with summer droughts due to climate change. Further research at Teagasc is investigating the use of multi-species mixtures under grazed conditions."

More information: Guylain Grange et al, Plant diversity enhanced yield and mitigated drought impacts in intensively managed grassland communities, *Journal of Applied Ecology* (2021). DOI: 10.1111/1365-2664.13894

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