Applying Ecological and Evolutionary Science to Improve Agricultural Sustainability

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Levels of organization in biology

biosphere *
ecosystem *
community *
population *
individual
organ
tissue
cell
molecule

increasing complexity

decreasing understanding

Most current biological problems in agriculture occur at the higher levels of organization: populations, communities and ecosystems.

Yield, the most fundamental agronomic variable, is a characteristic of the population, not the individual. The farmer is not interested in the yield of the individual plant but the yield per hectare.

Agriculture can best be understood scientifically as an ecological process.

Agricultural production as
applied ecology
or
ecological engineering:

The manipulation of populations, communities and ecosystems for human purposes

The crop is a population.

Pest and diseases: populations of organisms with which the crop population interacts

Ecological community: not only the crop and its pests, but also natural enemies of the pests, other species with which the crop interacts (e.g. N-fixing bacteria, mycorrhizal symbionts, and decomposers in the soil)

The agricultural field is an ecosystem, embedded within a landscape.

So what?

Four examples

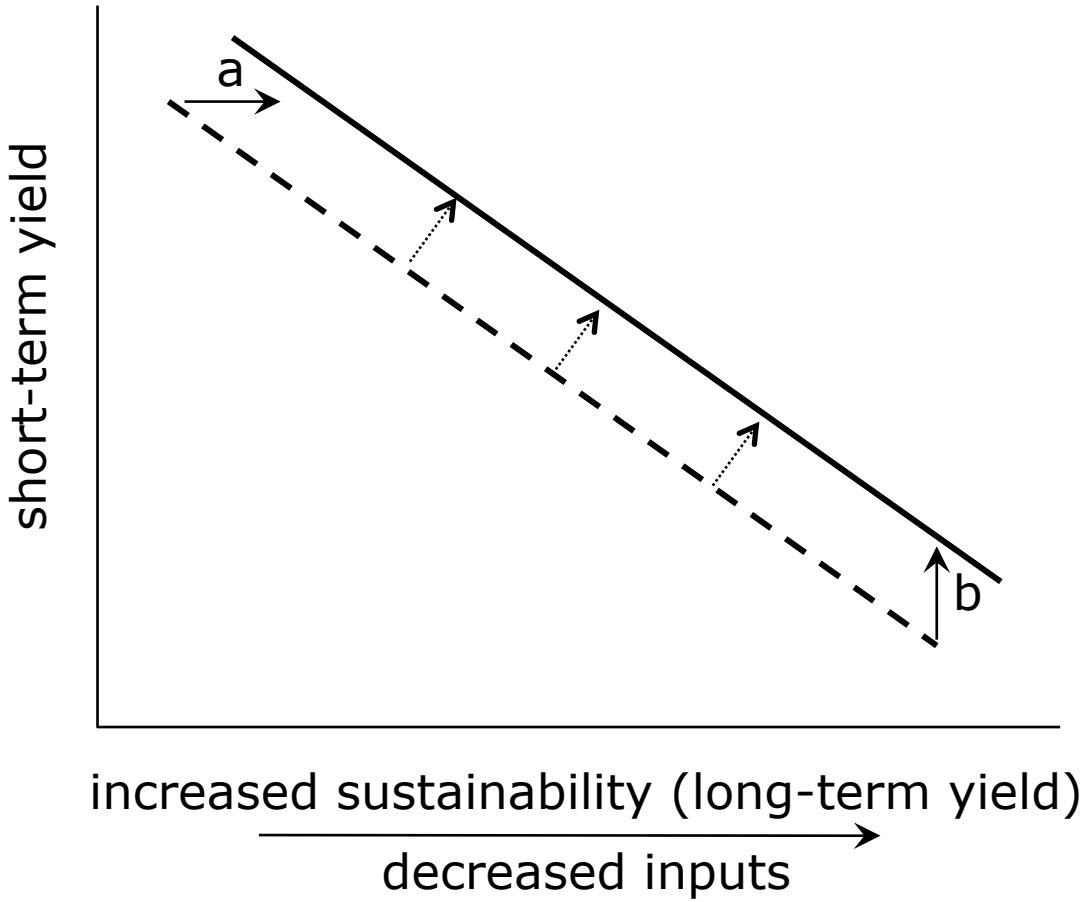
1. Trade-offs over timescales

2. Productivity of natural ecosystems

3. Engineering agriculture for sustainability

4. Agricultural research in an adaptive landscape

1. Trade-offs over timescales
   There is a negative relationship between short-term yield and long-term sustainability



2. Productivity of natural ecosystems

In temperate regions, natural ecosystems with the highest sustainable production are those with moderately high levels of standing biomass and high levels of dead, decomposing biomass, not early successional systems.

Increased plant biomass density in the field is the key to increasing sustainability.

Many of the negative environmental impacts of modern agriculture are the results of low quantities of living and dead biomass in the field.

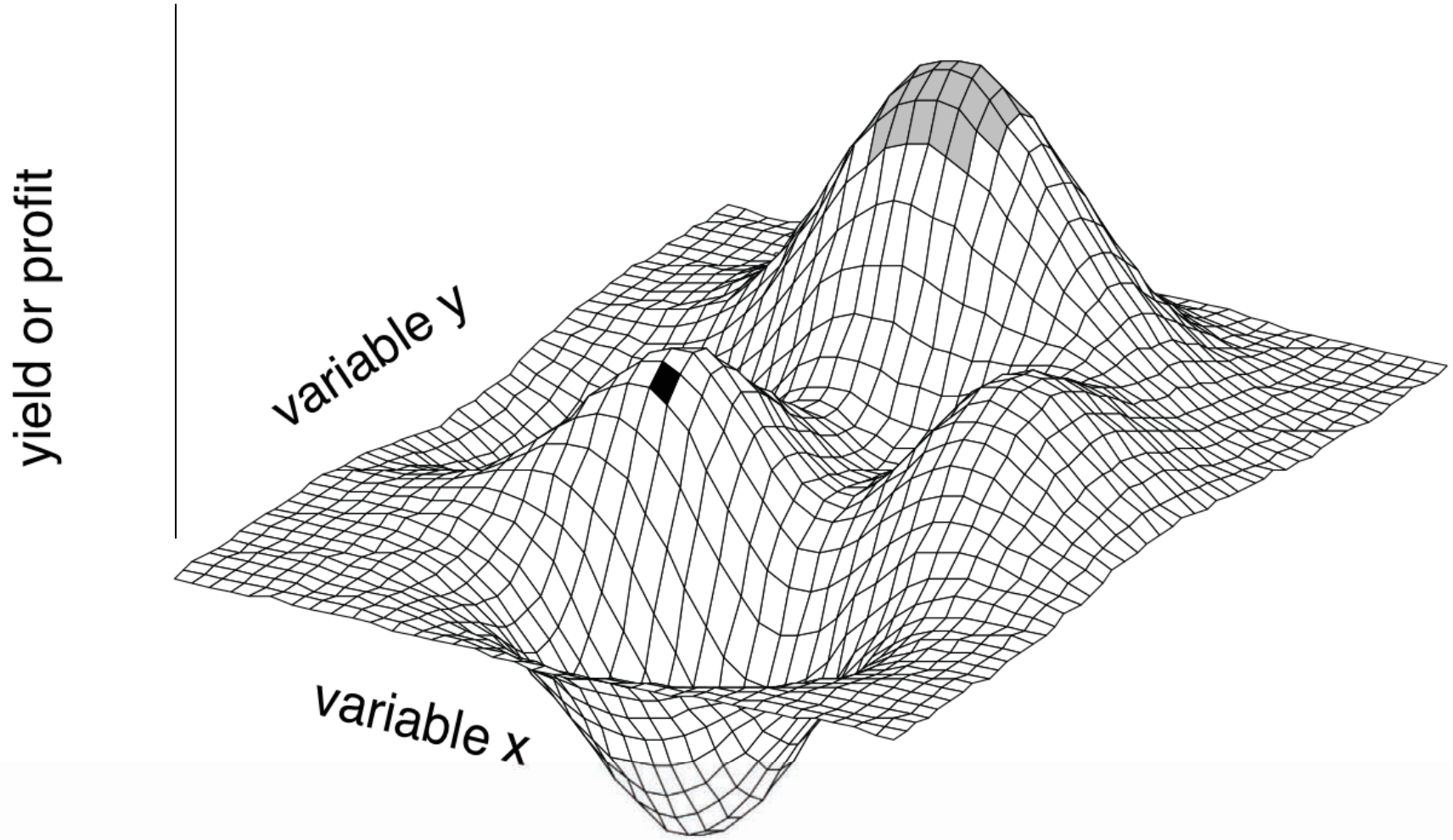
There is no theoretical or empirical basis for the widely held assumption that low standing biomass is a necessary condition for high yields.

3. Engineering agriculture for sustainability.
   What quantity should we engineer to maximize?

Three possible objectives for yield management, in biological and economic terms

Biological	Economic
Yield	Short term profit
Sustainable yield	Long term profit
Yield stability	Economic survival

3. Agricultural research in an adaptive landscape



5. A vision of more sustainable agriculture: □High Biomass Cropping Systems□

Biological sustainability at the local level is about maintaining and improving soil fertility.

Increased plant biomass density in the field is the key to increasing agricultural sustainability, while producing high yields.

- More standing biomass (and less bare soil)
- More dead biomass (soil organic matter input)

Invest unutilized potential biomass production for soil improvement. Maximize biomass production and biomass persistence (living, semi-decomposed).

Communal crop plants, that do not □waste□resources competing with one another, but cooperate to suppress weeds