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The effect of intra- and interspecific diversity of cover crop mixtures on ecosystem services in agricultural systems

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With the push towards reduced environmental impact from agriculture using **multifunctional agriculture**, how can we enhance delivery of agriculturally important ecosystem services?

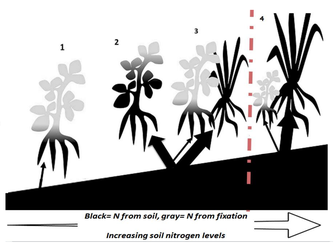
Natural ecosystem research can inform methods for improved management of agroecosystems.

Multifunctional agriculture

- Emphasis on yield and other functions
- Increased ecosystem functions allows for reduced inputs through substitution with ecosystem services
- Fertilizer > internal nutrient cycling
- Herbicides > weed population control
- Pesticides > increased beneficial insects

Why mixtures?

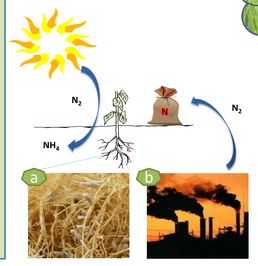
1) In lower fertility soils where nutrients are adequate, legumes fix more N.
2) As N availability increases, legumes are able to capture more soil N.
3) If a grass is planted with the legume, it will draw down soil N forcing the legume to fix more N.
4) If soil N availability is very high, the grass will grow very quickly and legume growth will be suppressed.



Nitrogen in agroecosystems

a Legumes, in symbiosis with rhizobia bacteria and powered by the sun through photosynthesis, fix atmospheric nitrogen (N_2) into plant-available nitrogen (NH_4). This also recouples carbon and nitrogen for tighter nutrient cycling.

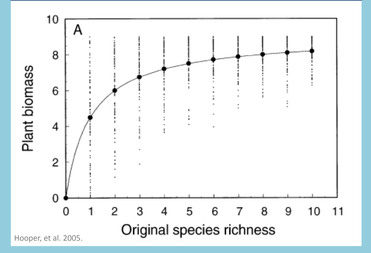
b Nitrogen (N) can also be added to agroecosystems through the industrial fixation of N_2, where the required energy typically comes from fossil fuels, and applied to plants as N fertilizer.



The term **cover crop** is used to describe crops that are seeded and grown, but not harvested or grazed (generally)

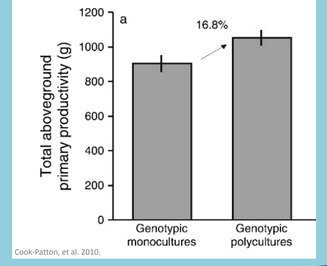
Biodiversity and ecosystem function (BEF) research in natural ecosystems has established the relationship between producer diversity and productivity, with increasing evidence for other functions as well.

Interspecific diversity



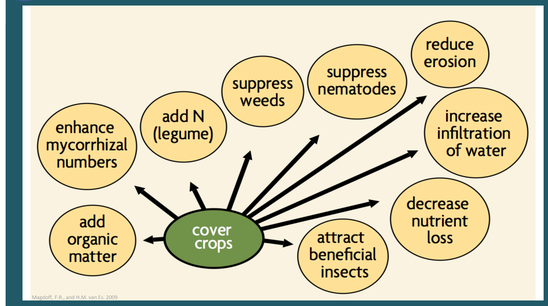
Hooper, et al. 2005.

Intraspecific diversity



Cook-Patton, et al. 2010.

We can create diverse communities in agroecosystems with cover crop mixtures, which can provide multiple ecosystem services.



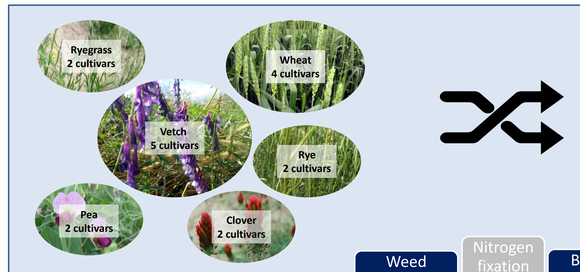
Magdoff, F.R., and H.M. van Es. 2009

Advantages of cover crops for ecological research

- Large pool of existing diversity:
  - *Species*
  - *Cultivars (genotypes)*
- Breeding has enhanced traits and functions
- Direct applicability to agricultural management

References

- Cardinale, B. J., et al. 2011. The functional role of producer diversity in ecosystems. American Journal of Botany 98:572–592.
- Cook-Patton, S. C., et al. 2010. A direct comparison of the consequences of plant genotypic and species diversity on communities and ecosystem function. Ecology 92:915–923.
- Hooper, D. U., et al. 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecological Monographs 75:3–35.
- Magdoff, F.R., and H.M. van Es. 2009. Building Soils for Better Crops: Sustainable Soil Management. Handbook Series Book 10. Sustainable Agric. Research and Education



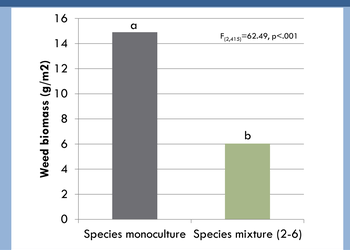
Qty.	Species	Cultivar
17	single species	single cultivars
8	single species	cultivar mixtures
17	species mixtures	single cultivars
7	species mixtures	cultivar mixtures
49	**cover crop treatments total forming a diversity gradient**	

More species-rich mixtures suppress weeds better and produce more cover crop biomass.

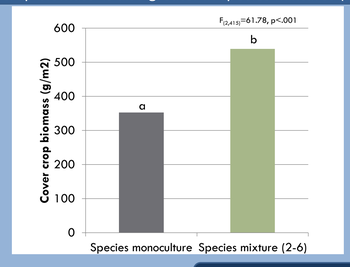
Cultivar mixtures provide increased weed suppression, with variable increases in cover crop biomass.

Preliminary results

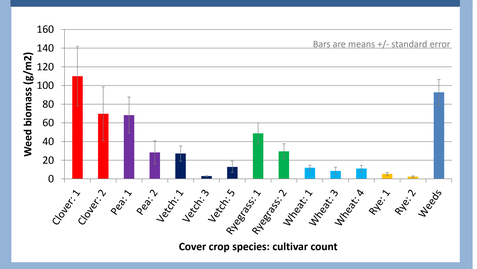
Weed biomass is less in species mixtures compared to species monocultures (*2015*)



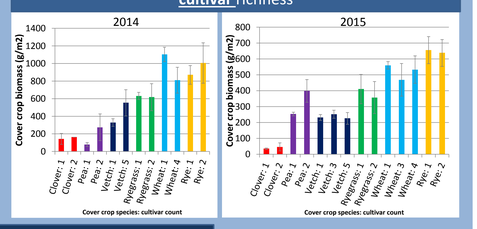
Cover crop biomass is also greater in species mixtures (2015)



Weed biomass decreases with the increasing **cultivar** richness of cover crop mixtures *(2014, 2015)*



Cover crop biomass responds variably with increasing **cultivar** richness



Future work includes continued analysis of biomass and weed suppression data, results from nitrogen fixation analysis, and integration of available phylogenetic diversity information.

Fields prepared for cover crop planting

Experimental design

- 49 cover crop treatments forming a diversity gradient
- Randomized, complete block, split-plot, replacement series design, with 4 replicates.
- 8ft^2 split-plots, for +/- N fertilizer treatment
- 27 viable seeds/ft^2 for all treatments
- 2 field seasons at Musgrave Research Farm, Aurora, NY
  fall 2013-spring 2014 (2014) & fall 2014-spring 2015 (2015)
- Subsample of aboveground biomass taken in spring
- Weight and count of cover crop and weeds recorded separately