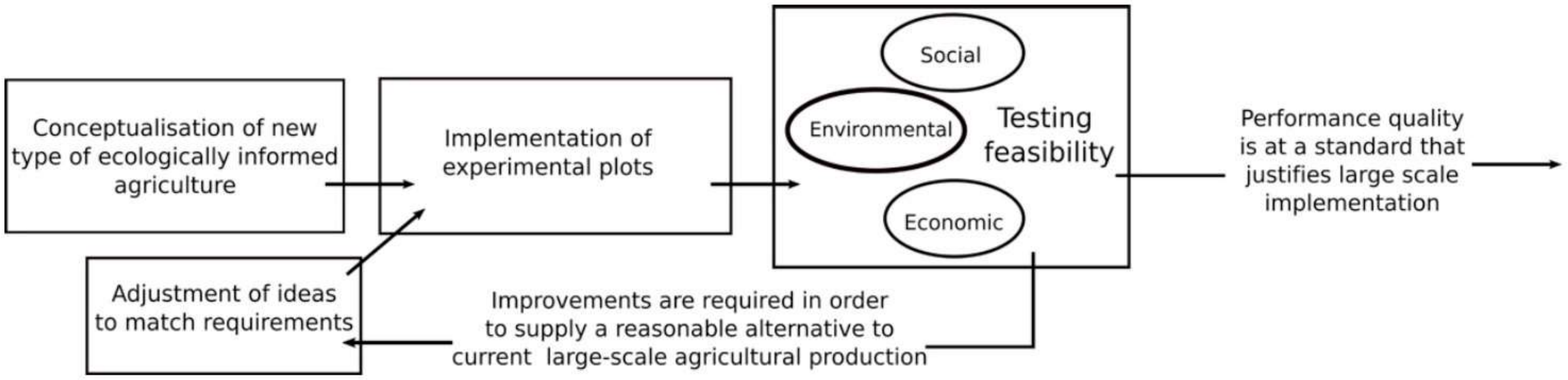
We are all aware of Agriculture's negative impacts on the Ecosystems that support us, the global resource shortages, the pollution of the atmosphere, soil and water, the damages that agrochemicals have caused and the erosion of soils.

This is not a problem that modern agriculture has caused, it is an inherent problem in almost all agricultural systems throughout history.

Modern agriculture has globalized and exaugurated these problems to a breaking point.


Any process involving the removal and suppression of ecosystem development, for replacement by a system managed to perform a comparatively narrow set of functions i.e. production of one crop, will inevitably feature less of the stabilising and re-enforcing features which secured the prosperity of the original ecosystem; increasing the potential for environmental overshoot



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Principle	Explanation	Examples	Sources
1.Maximum power principle	The tendency for healthy ecosystems to maximise energy intake and reinforce future productivity is an essential quality for achieving sustainability. Agro-ecosystems should be either getting better or remaining productive. (4th thermodynamic law)	• High density planting • Niche maximisation • Selection of productive/ low maintenance varieties • Reluctance to export biomass	Bergen, Bolton and Fridley (2001) Odum (2007)
2.Species and genetic diversity	Ecosystems are composed of few common species and many rare species, they exhibit species diversity patterns that ensure temporal and spatial niches are realised, within a species there also exists considerable genetic diversity. Agro-ecosystems however have largely ignored the importance of diversity.	• Crop rotation • Intercropping • Multiple varieties • No use of general biocides	Kevan and Thomas (1993) Altieri (1999) Loreau *et al.* (2002) Vandermeer (1989)
3.Compositional diversity	Also called gamma diversity or landscape diversity: agro-ecosystems with more than one farming type will benefit from interactions between systems if designed to be mutually beneficial.	• Farm forestry • Ponds, hedges etc. • Regional produce diversification	Altieri (1999) Benton, Vickery and Wilson (2003)
4.Functional diversity	A late 20th century development from ecosystem stability-diversity discussions was that functional traits and combinations in ecosystems play a larger role than simply the number of species. Theoretically a stable agro-ecosystem could be created with relatively few species.	• Plants with nitrogen fixing root associates • Pest deterrent/predator attracting plants	Moonen and Bàrberi (2008)
5.Succession	The development of ecological communities towards a state of greater stability and resource utilisation: often involving a 'climax community' and K type species. Early successional agro-ecosystems require energy to prevent this process. Linked with principle 1.	• Forest gardening, some orchards • Aquaculture • Semi-wild agriculture e.g. beekeeping	Kevan and Thomas (1993) Bergen, Bolton and Fridley (2001)
6.Soil health	The increases in soil organic carbon, nutrient balances and microbial biomass are key indicators of stability and health in ecosystems. Agriculture has often benefited from but degraded these soil properties. Linked with principles 1 & 6.	• Zero-till cropping • Perennial cropping • Mulching with crop residues	Kulmatiski et *al.* (2008) Van Der Heijden, Bardgett and Van Straalen (2008)
7.Energy throughput	The net energy yield from natural (autotrophic) ecosystems is high because only 'natural' energies are imported. Agro-ecosystems must aim for a high net energy production by minimising continual work requirements, this aids in minimising negative energy outputs (pollutants).	• Avoidance of annual machinery needs • Implementing renewable energy e.g. gravity irrigation • Work with succession (5.)	Kevan and Thomas (1993) Horrigan, Lawrence and Walker (2002) Bergen, Bolton and Fridley (2001)
8.Cycling & conserving	Developed ecosystems involve pathways for the cycling and conserving of nutrients and water through the system, preventing leaching of resources away from where they can be utilised. If agro-ecosystems are capable of cycling resources, required inputs will be minimised. A key component of principle 1.	• Bound residues in soil organics • Nutrients 'held' in vegetation • Water holding capacity • Aggregate stability	Odum (1969) Vitousek and Reiners (1975) Scott D. Bergen, Bolton and Fridley (2001)

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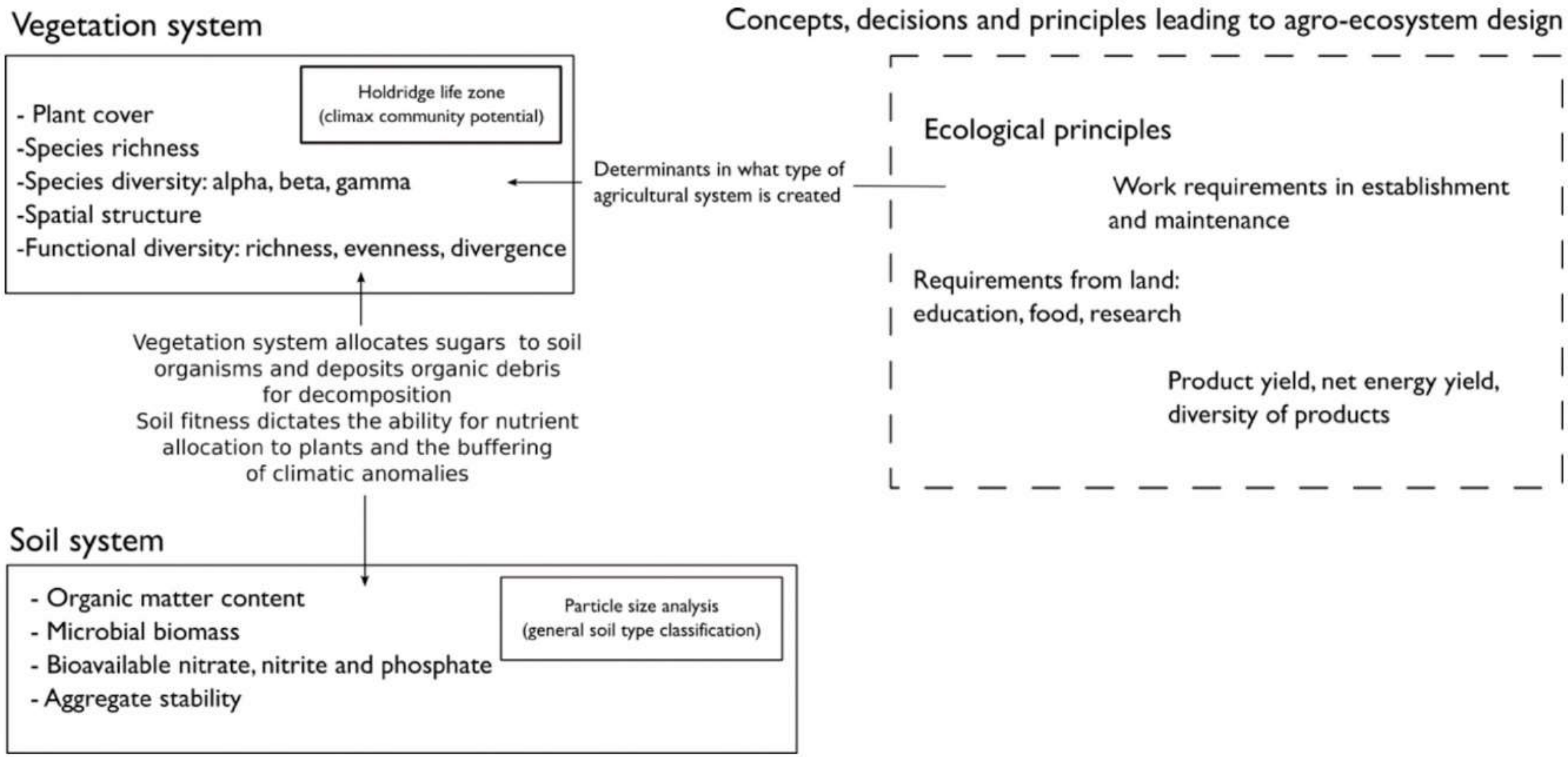

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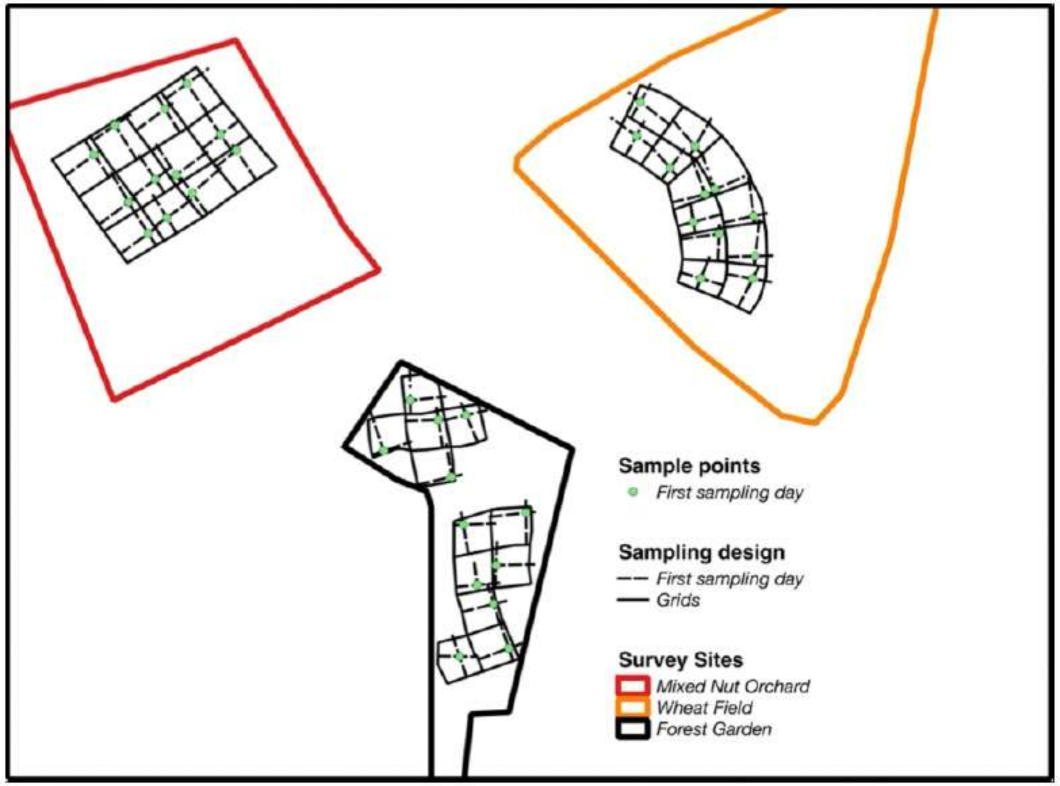
- Random stratified sampling
- 2m quadrat used to record plant species (domin scale)
- Soil core taken at each sample location to 15cm depth
- Microbial biomass – Fumigation extraction
- SOM and soil carbon – loss on ignition
- Nitrate, nitrite and phosphate – segmented flow analyser
- Aggregate stability – rainfall simulator (4 – 5.6mm aggregates)
- Particle size distribution and pH were also analysed



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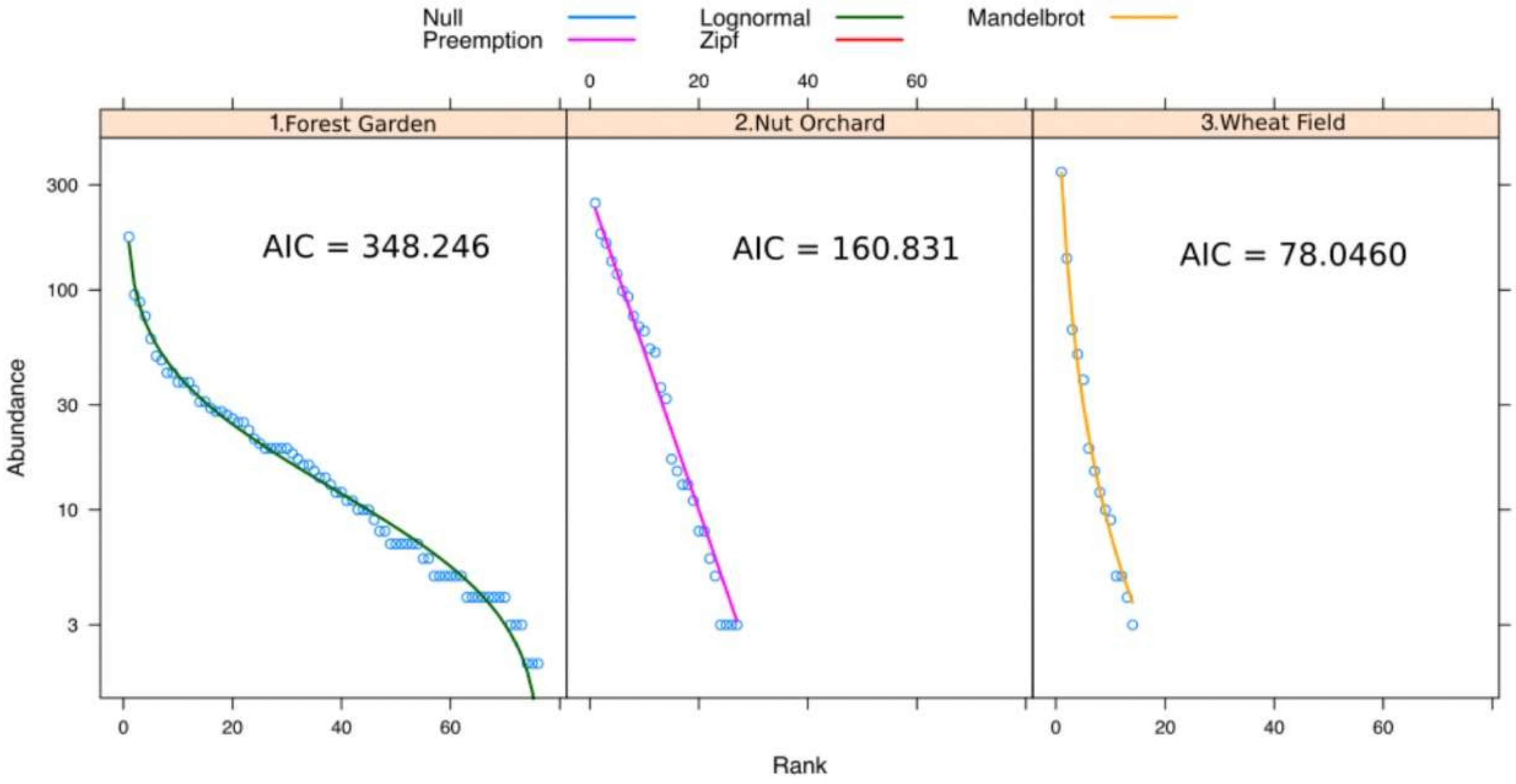

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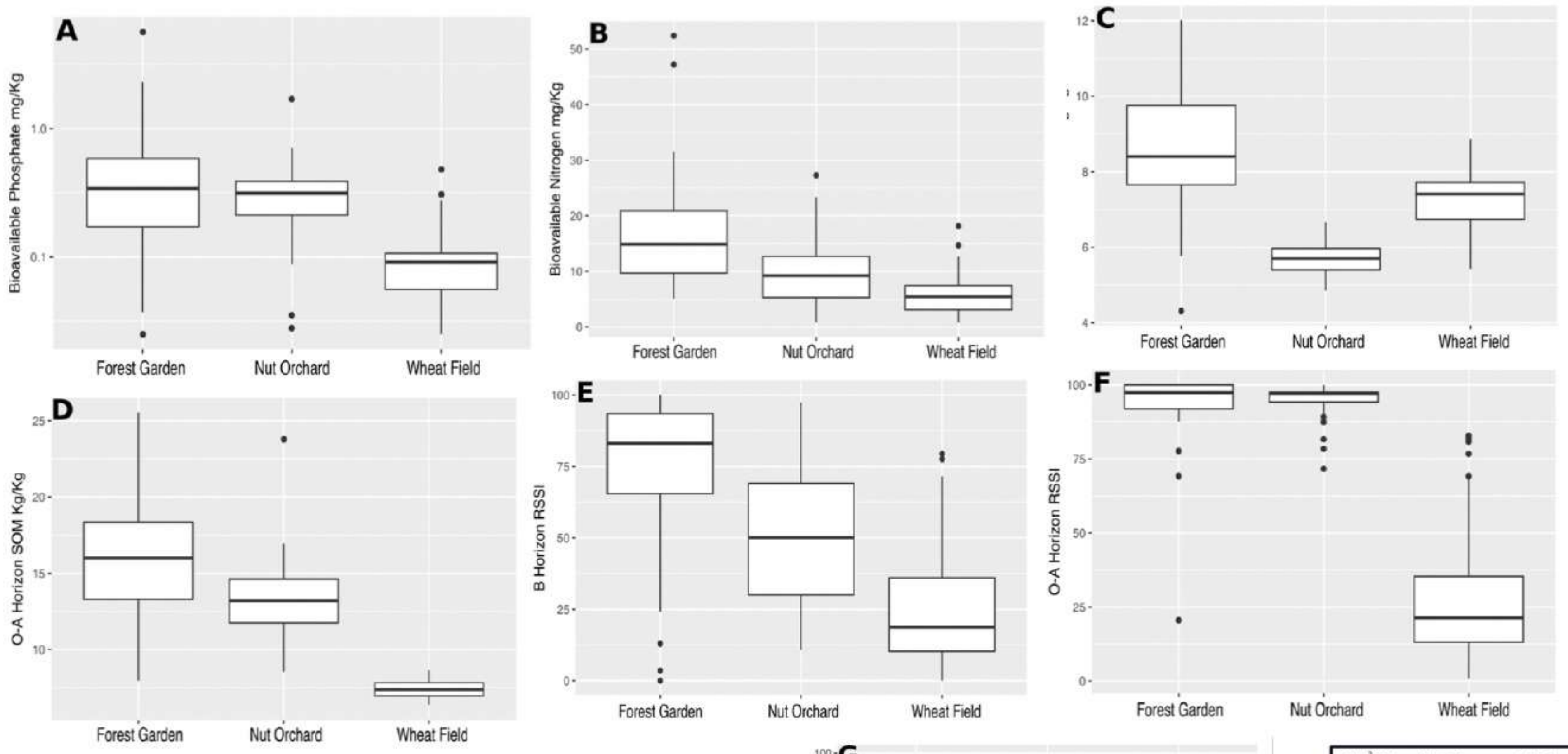
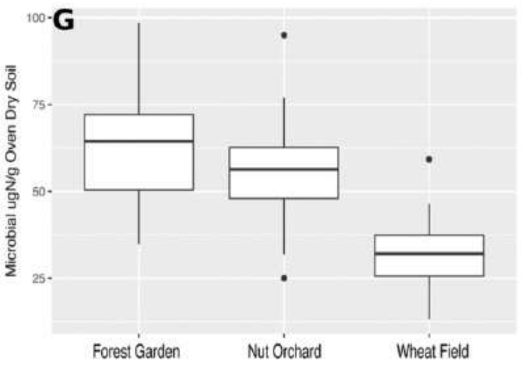
	Functional richness (F_R)		Functional evenness (F_{Eve})		Functional divergence ($SESF_{Dis}$)	
Site	Gamma	Alpha	Gamma	Alpha	Gamma	Alpha
Forest Garden	51	5.146±1.688	0.524	0.829*±0.099	0.158	0.111**±0.727
Nut Orchard	24	6.042±1.597	0.498	0.821±0.076	0.685	1.045± 0.830
Wheat Field	14	3.792**±1.148	0.523	0.777*±0.096	0.622	1.155± 0.756

Site	Alpha Diversity (α_t)	Gamma Diversity (${}^qD_\gamma$)	Beta Diversity (β_{Mt})
Forest Garden	5.035154±1.709	46.050507	9.145799
Nut Orchard	5.628669 ±1.674	15.298717	2.717999
Wheat Field	3.309705** ±0.941	5.556583	1.678876





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A) $X^2(2) = 61.021$, $p = <0.001$ **B)** $F(2,141) = 38.39$, $p = <0.001$

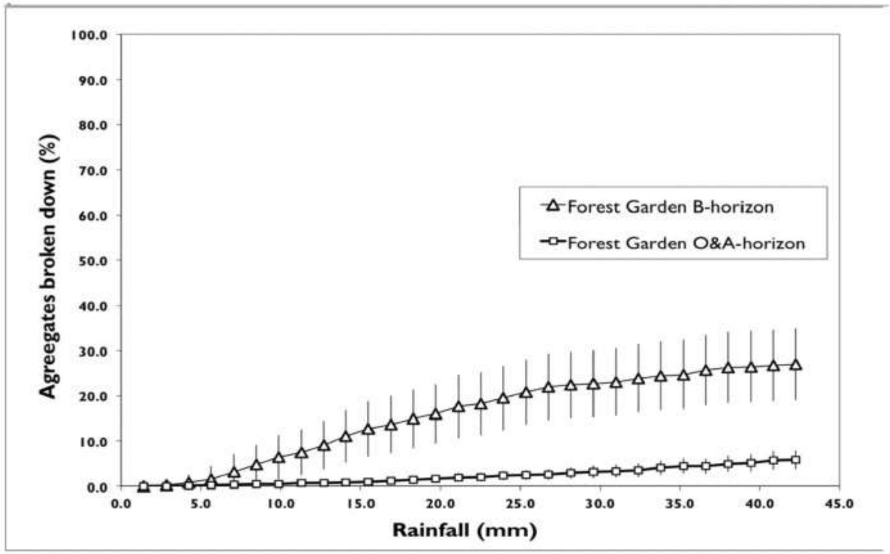
C) $F(2,141) = 99.56$, $p = <0.001$ **D)** $X^2(2) = 115.55$, $p = <0.001$

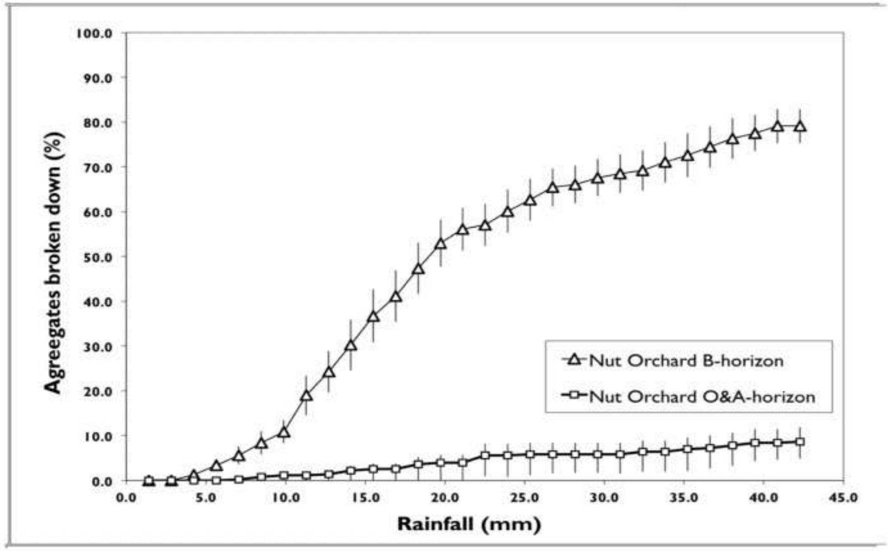
E) $X^2(2) = 58.774$, $p = <0.001$ **F)** $X^2(2) = 92.615$, $p = <0.001$

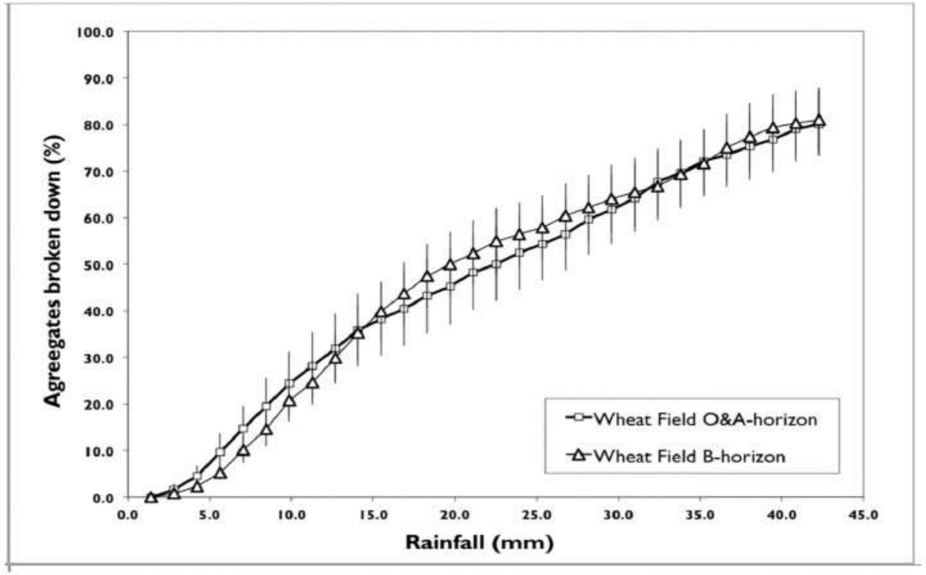
G) $F(2,141) = 79.75$, $p = <0.001$

A) Forest Garden - Nut Orchard. $z = 0.5309476$. $p = 1.00$

F) Forest Garden - Nut Orchard $z = 0.1351446$. $p = 1.00$







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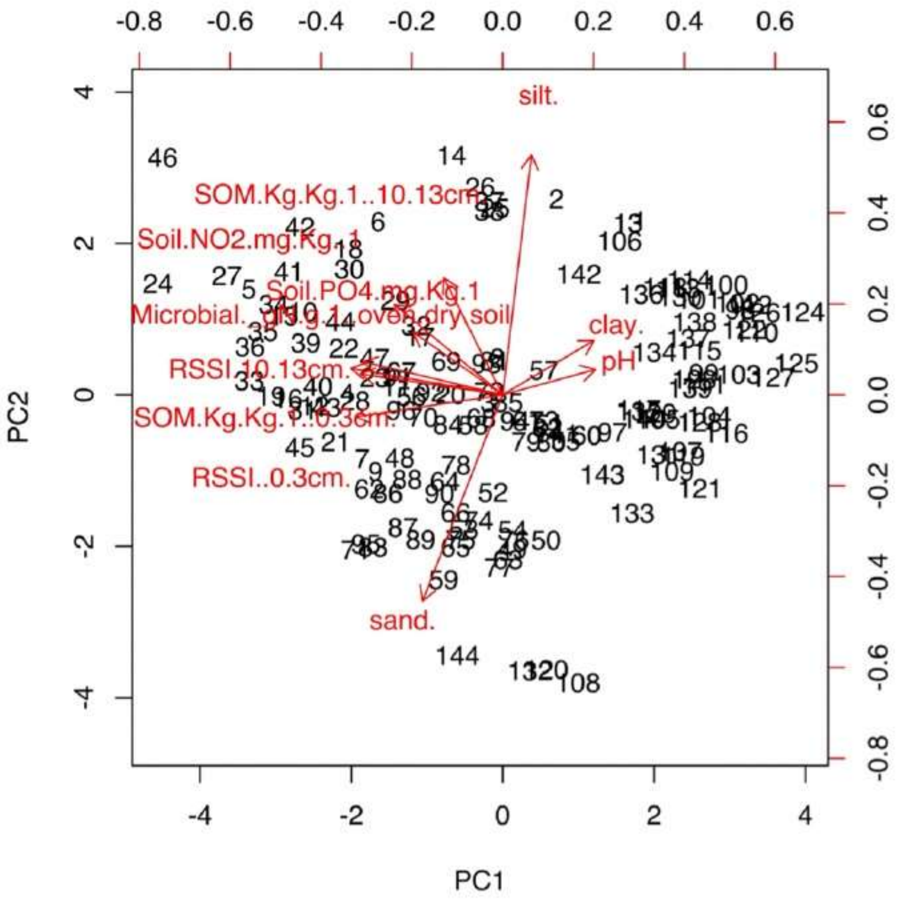

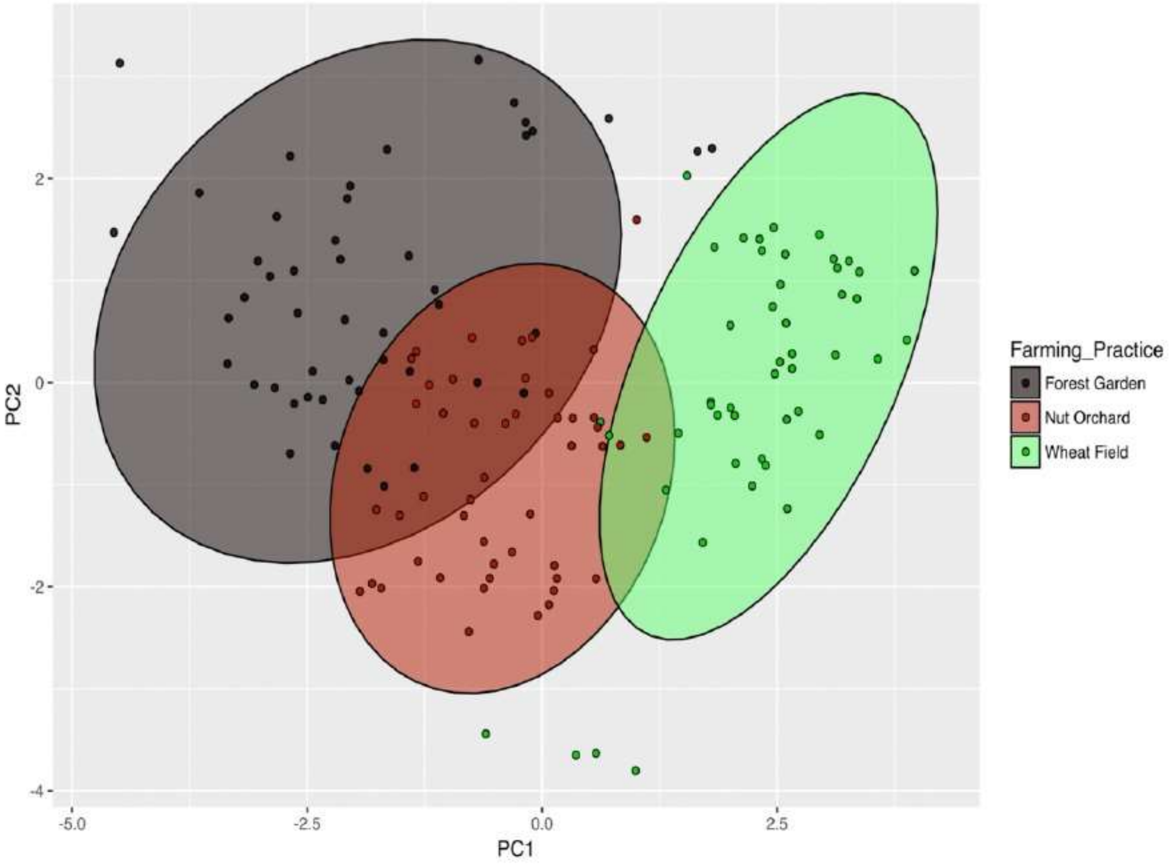

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Principal components	PC1	PC2	PC3	PC4
Standard deviation	2.002325	1.389658	1.347664	0.9187864
Proportion of variance	0.36448	0.17556	0.16511	0.07674
Cumulative proportion	0.36448	0.5404	0.70515	0.78189
Microbial N µg g^{-1} oven dry soil	**-0.38504038**	0.09127844	-0.17671881	0.07966866
Soil.NO_2 mg Kg^{-1}	-0.2983316	0.24913891	0.02459682	**0.46625345**
Soil PO_4 mg Kg^{-1}	-0.24691608	0.17250938	0.17567958	**0.69052615**
Sand	-0.2200191	**-0.56699908**	**0.31127458**	0.05012998
Silt	0.07960588	**0.6598246**	0.05892719	-0.19413914
Clay	0.2510977	0.14936845	**-0.54303484**	0.13545266
SOM Kg Kg^{-1} 0-3cm	**-0.41841754**	0.07300353	-0.1101502	-0.26357147
SOM Kg Kg^{-1} 10-13cm	-0.16201649	0.32169326	**0.47434768**	-0.25255723
RSSI 0-3cm	**-0.40556836**	-0.06076148	-0.29824015	-0.13478019
RSSI 10-13cm	**-0.39101387**	0.05752561	0.06388179	-0.29587906
pH	0.25549743	0.06967026	**0.46030878**	0.04380223

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A problem with ecological design principles is that despite having reasonable clarity in theory, there exists no agreed process for quantifying their physical conversion into the field. The more purely ecological methods of vegetation community description adopted by this study, have presented a quick and effective way of quantitatively assessing the presence or absence of ecologically sound patterns in agro-ecosystems. Then, using soil fitness as a proxy for whole ecosystem health, a considerable improvement in environmental quality was observable in agro-ecosystems with vegetation indicative of good ecological practice. It is suggested that this approach is a rigorous and widely applicable way to continue testing the hypothesis introduced in this study. Such research will need to be performed across multiple climates and farming types if agro-ecology and ecological engineering are to become fit for transforming the current agricultural paradigm. The application of within-site and between-site observations has been a powerful tool in developing an understanding of the scales at which land use patterns become apparent. Both levels of observation should continue and there is scope for extending observations out to entire catchments. It is imperative that this environmental research be conglomerated with studies of a similar theoretical outlook, which enquire to into the economic and social constituents of a transition in agriculture.

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