Prospects of mycorrhizas and their role in agroforestry systems and ecological restoration: An analytical framework

Mycorhizes 2017

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Presentation Outline

- Background and Objectives
- Rational and Concept
- Framework
- Conclusion

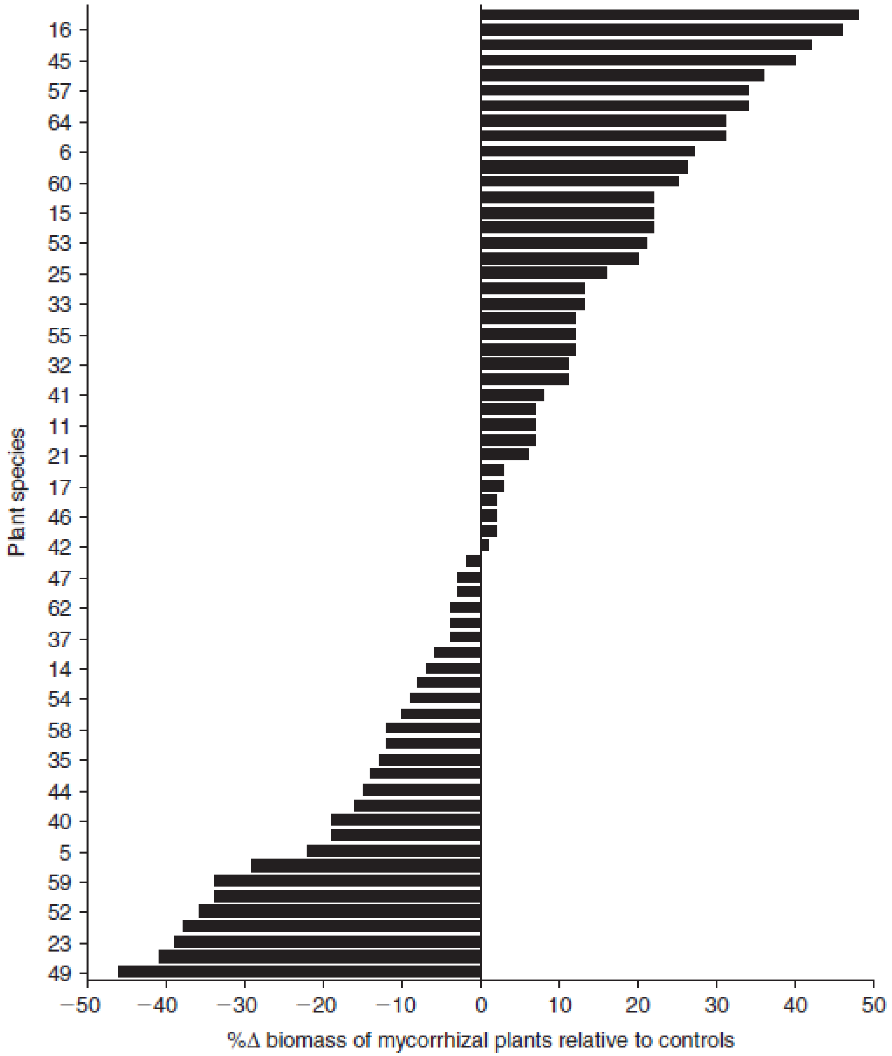
Background

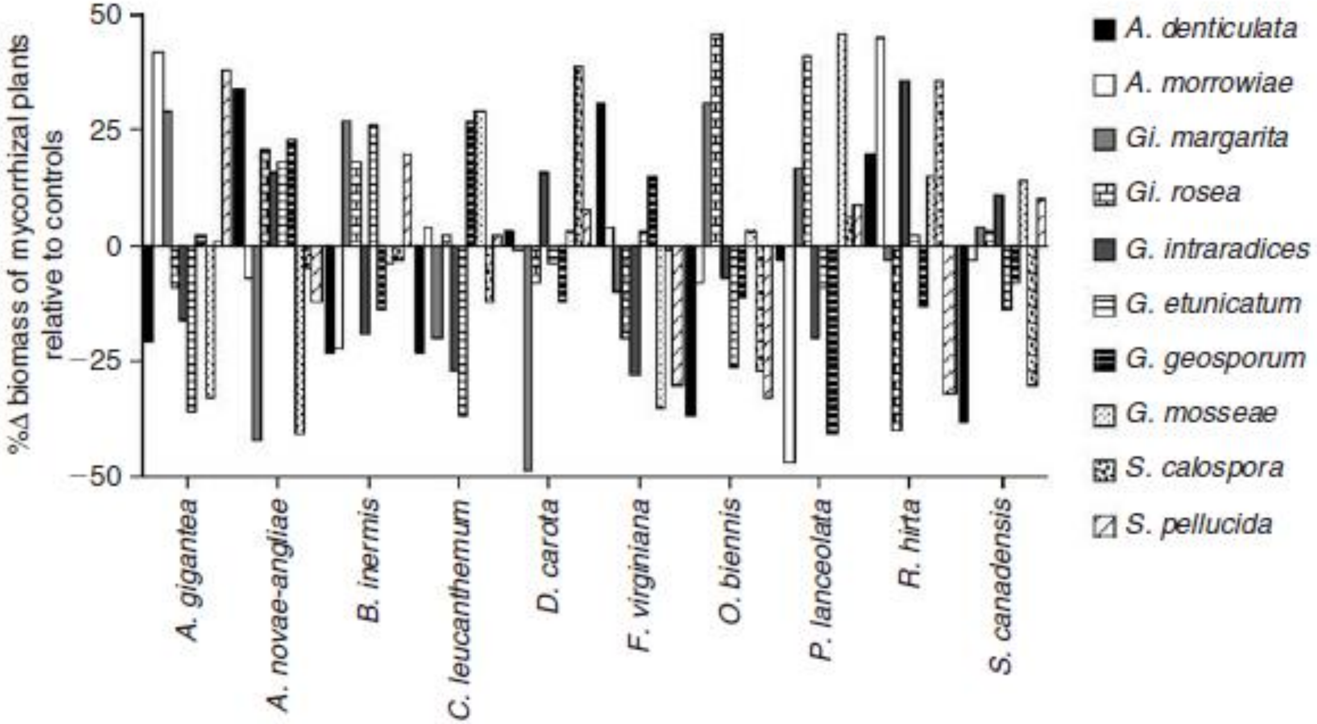
- The role of mycorrhizas in the functioning of soil is very important
- The interactions are complex
- Practical implication on sustainable agriculture and ecological restoration are very essential

Objectives

- Developing an analytical framework on mycorrhizal dynamic interactions

With and without mycorrhiza





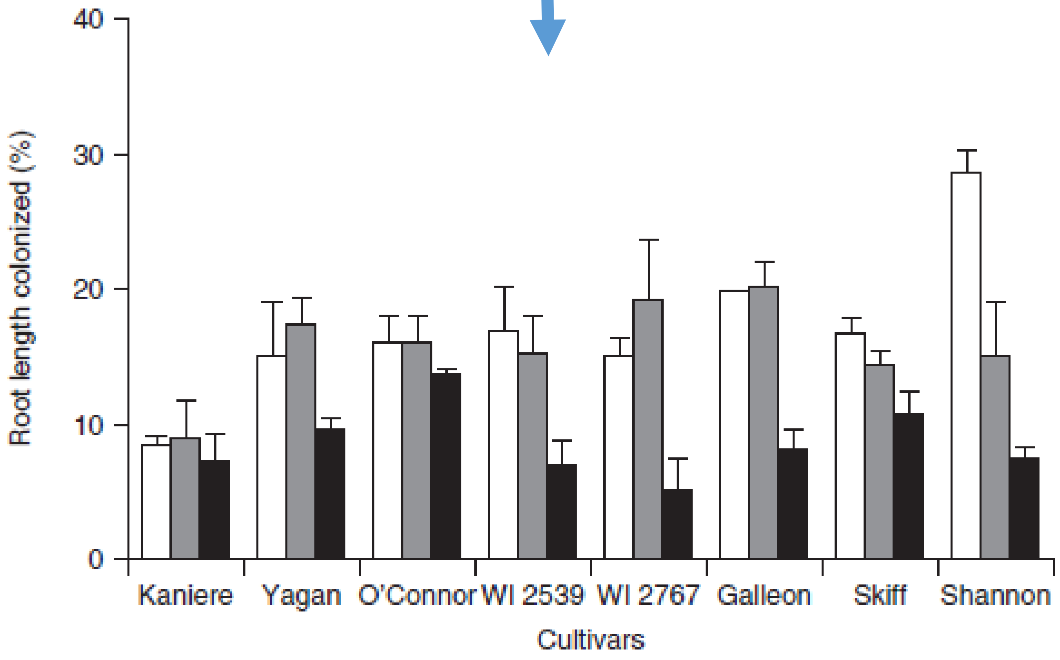
Smith & Read (2009)

Colonization

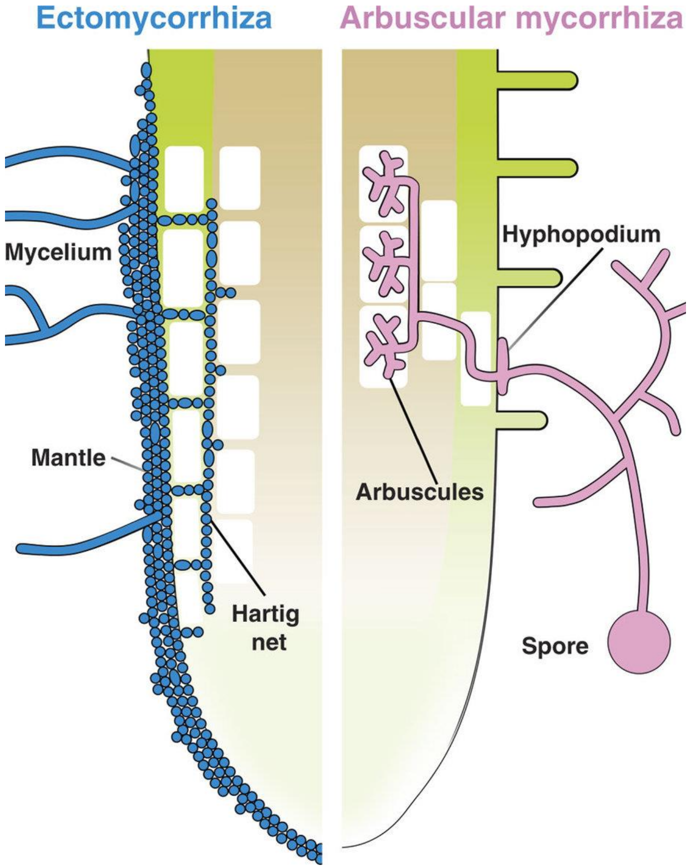
Added P (mmol/kg)	Colonization (%)	DW (mg/plant)			R/S	P concentration (µg/mg DW)		Response (%)
		Root	Shoot	Total		Root	Shoot	
0	0	36 (6)	39 (4)	75 (9)	0.92	0.53	0.79	
0	74	51 (1)	58 (3)	109 (2)	0.88	1.34	1.98	45
0.2	0	57 (4)	63 (6)	120 (10)	0.90	0.75	1.02	
0.2	72	57 (3)	90 (3)	147 (5)	0.63	2.12	2.83	22
0.4	0	70 (8)	97 (6)	172 (14)	0.72	1.20	1.29	
0.4	63	60 (2)	104 (3)	164 (5)	0.58	3.00	3.11	0
0.67	0	87 (11)	132 (8)	218 (20)	0.66	1.77	1.57	
0.67	53	67 (1)	120 (2)	187 (2)	0.56	2.33	2.83	−14

the effect of P concentrations on growth of *Trifolium subterraneum* (31–35 days old) and roots-shoots biomass partition. Standard errors of means in parentheses (Smith & Read 2009)

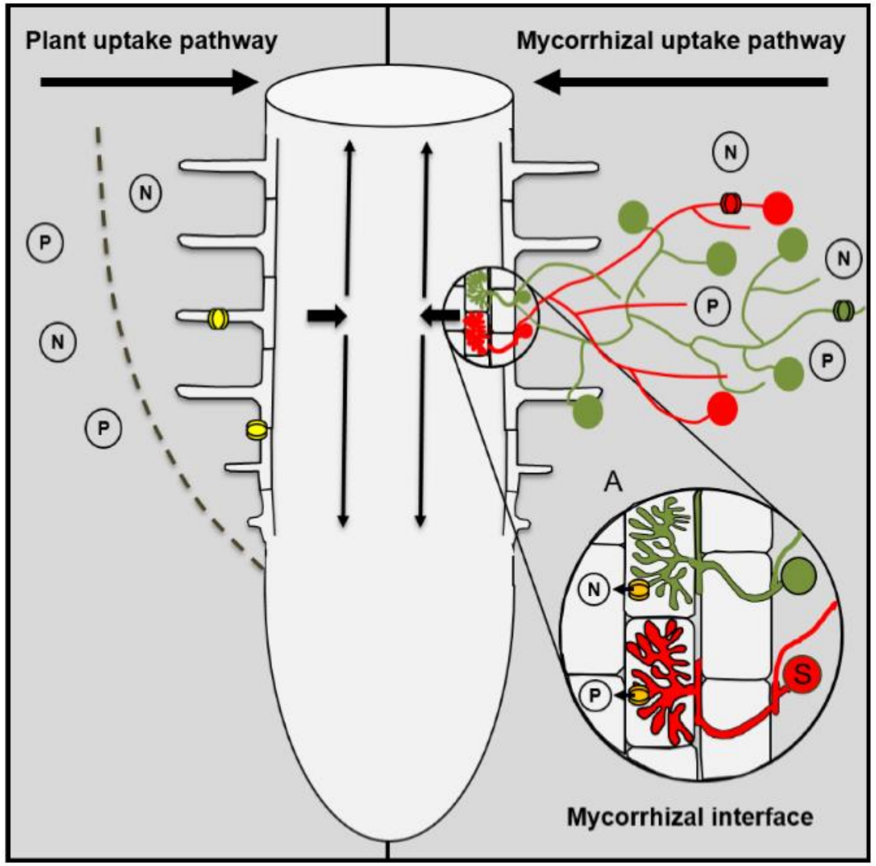
Effects of P addition (0, 10, 20 mg/kg)on per cent mycorrhizal colonization of cultivars of H. vulgare by Glomus etunicatum. (Baon et al. 1993 in Smith & Read 2009)



Plant uptake pathway



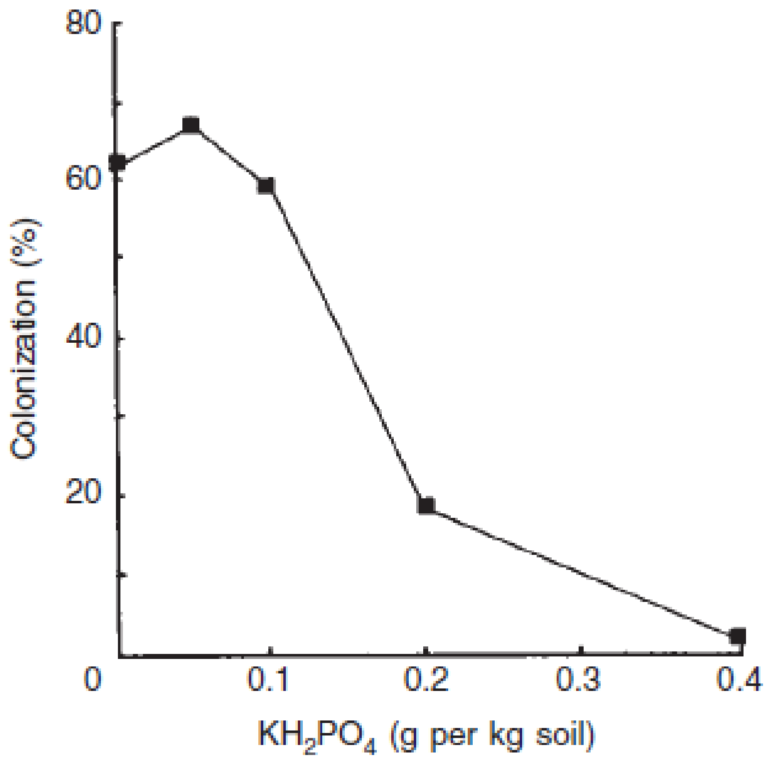
Bonfante & Genre (2010)



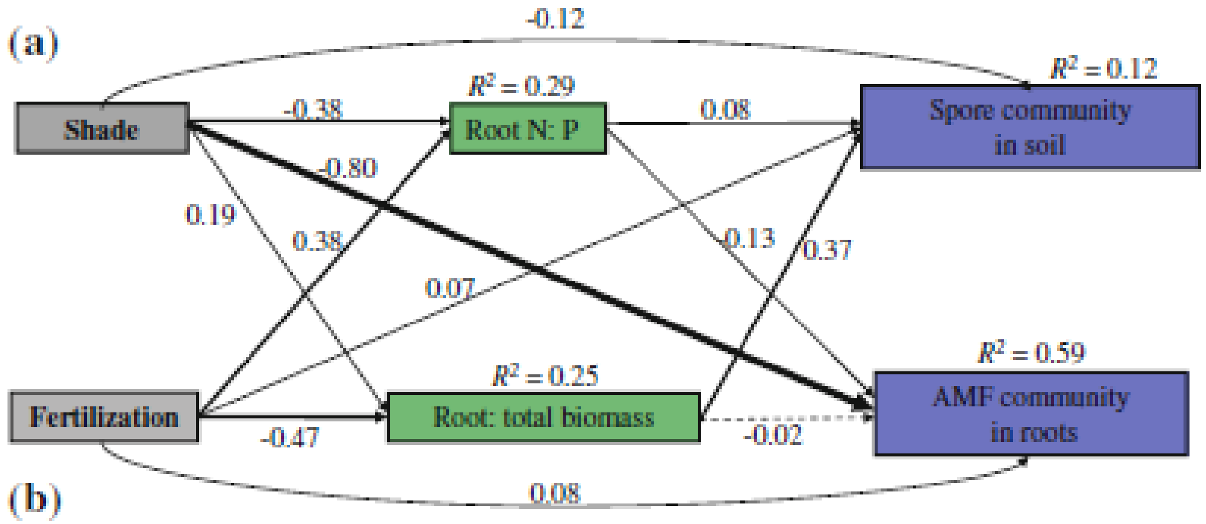
When nutrient resources is abundant, the plant was tend to use the **direct pathway** than the **mychorizal pathway**

Bücking, H., & Kafle, A. (2015).

Colonization cont.



The effect of additions of KH2 PO4 (Potassium phosphate) on Allium cepa colonization by AM fungi after 8 weeks (Sanders and Tinker 1983 in Smith & Read 2009)



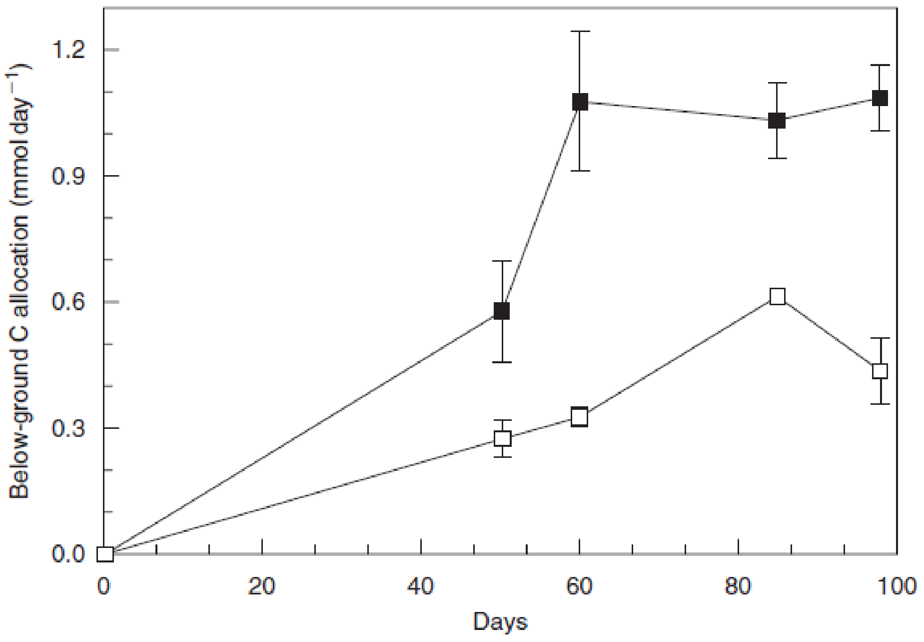
(b)

	Shade			Fertilization		
	Direct path	Indirect path	Total effects	Direct path	Indirect path	Total effect
Root: total biomass	0.189	0	0.189	-0.466	0	-0.466
Root N: P	-0.385	0	-0.385	0.377	0	0.377
Spore community	-0.122	0.040	-0.081	0.071	-0.143	-0.072
AMF community in roots	-0.804	0.047	-0.757	0.076	-0.041	0.035

The mycorrhiza colonization is known to increase with the increase of light intensity in inoculated plants (Shukla et al 2009, Shi et al. 2014)

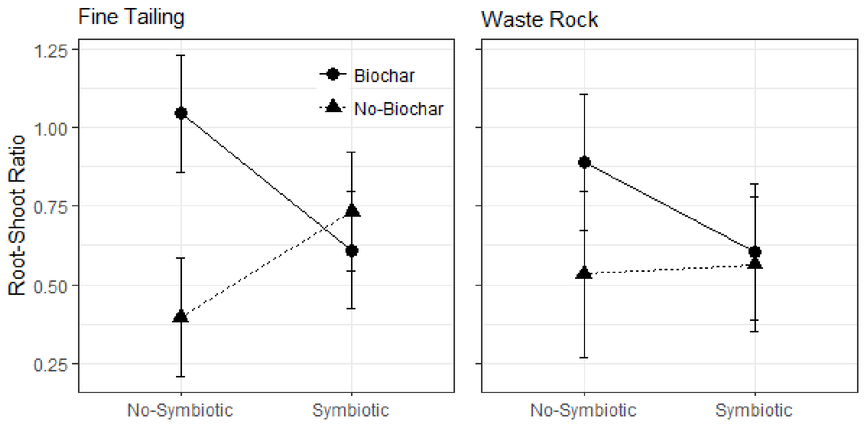
Background

Belowground carbon allocation



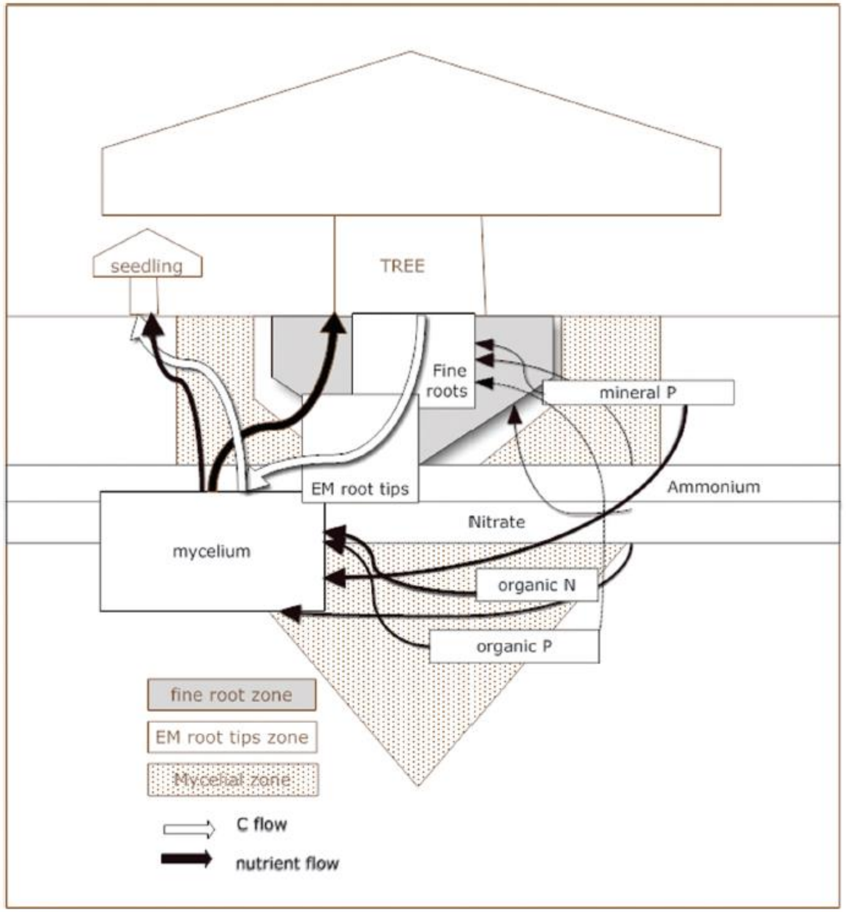
Below-ground carbon allocation of mycorrhizal and non-mycorrhizal Salix viminalis. The amount of C allocated below ground was 1.75 times greater in ECM than non-mycorrhizal plants (Jones et al. 1991 in Smith & Read 2009)

Root-Shoot Ratio

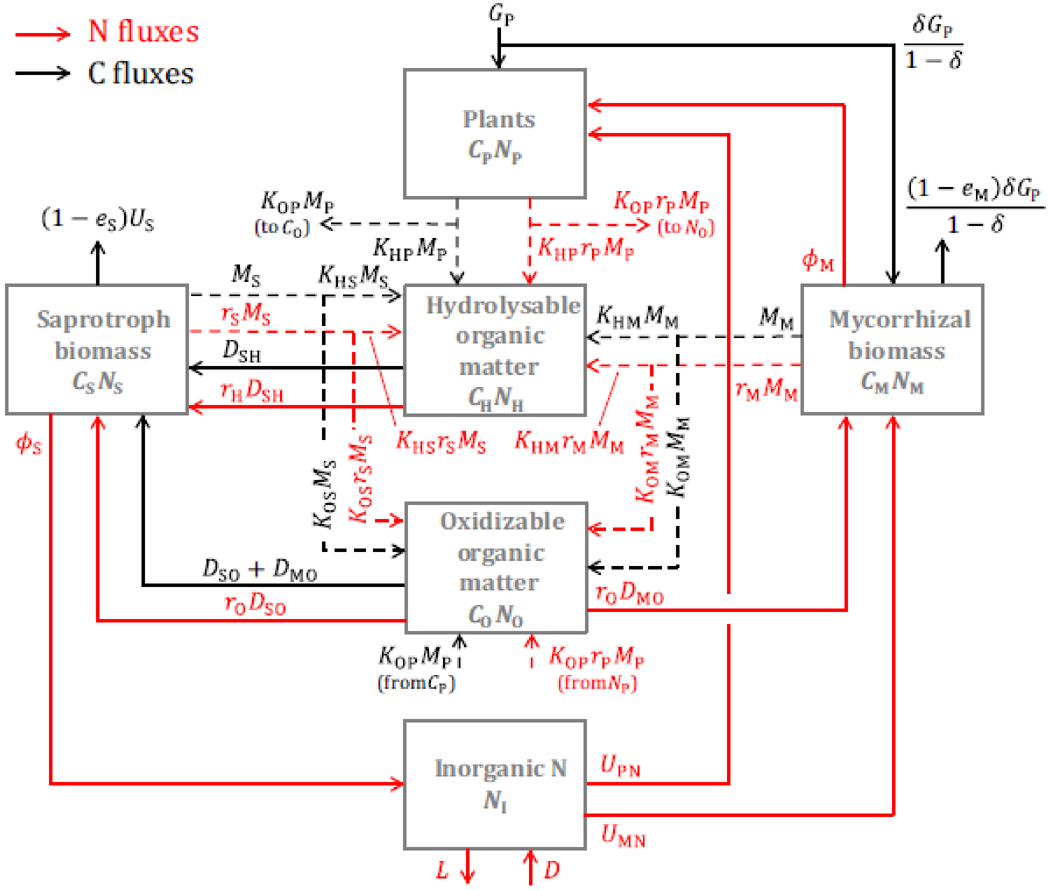


Phytobiomix Experiment

Mycorrhizal dynamic modeling

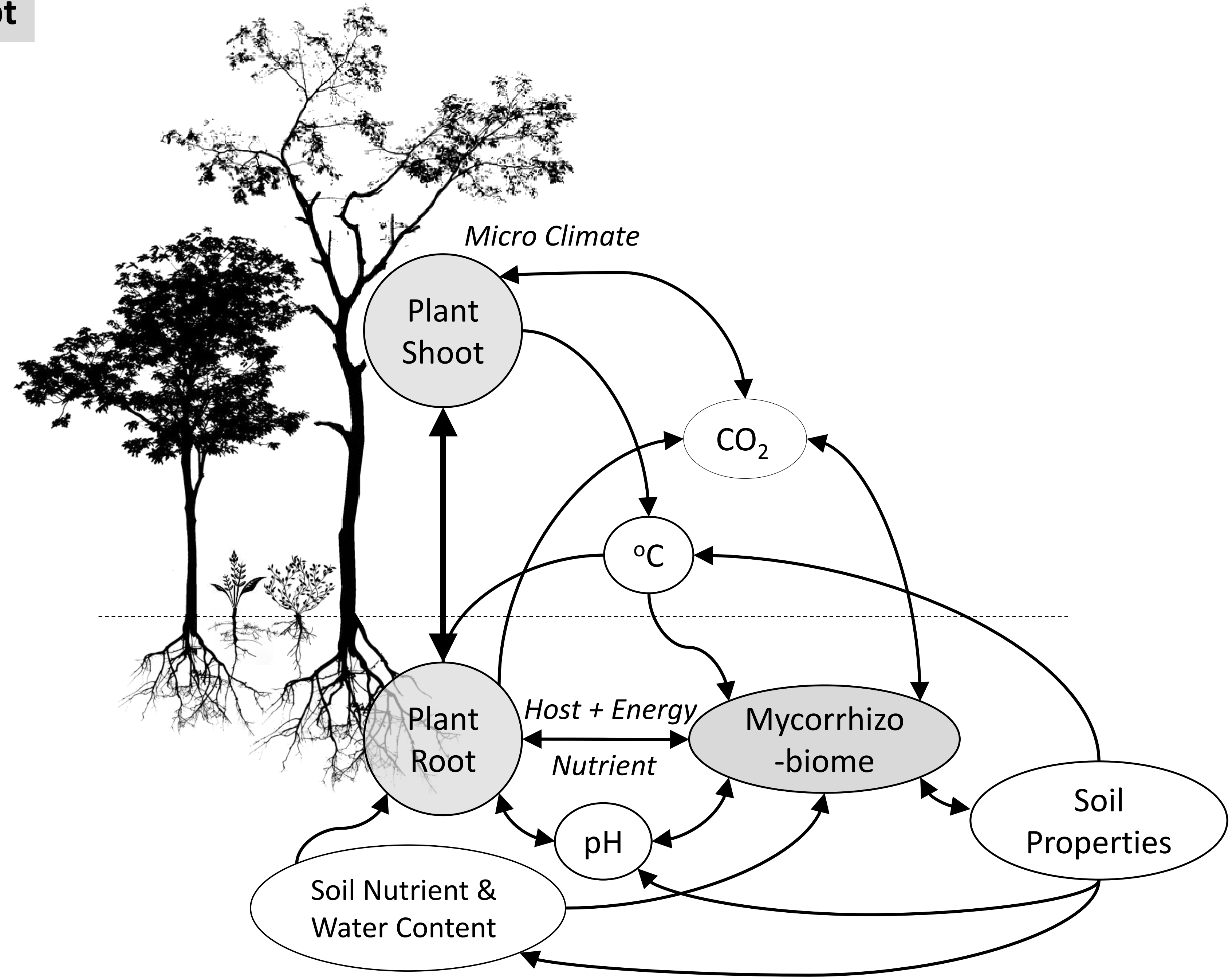


(Deckmyn et al. 2014)

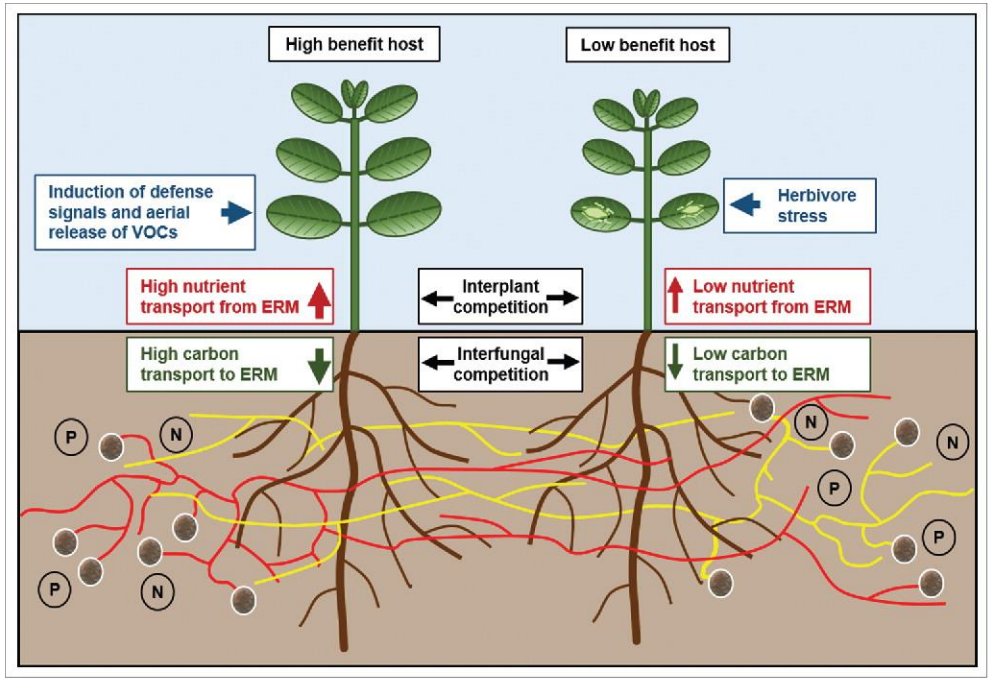


(Baskaran et al. 2017)

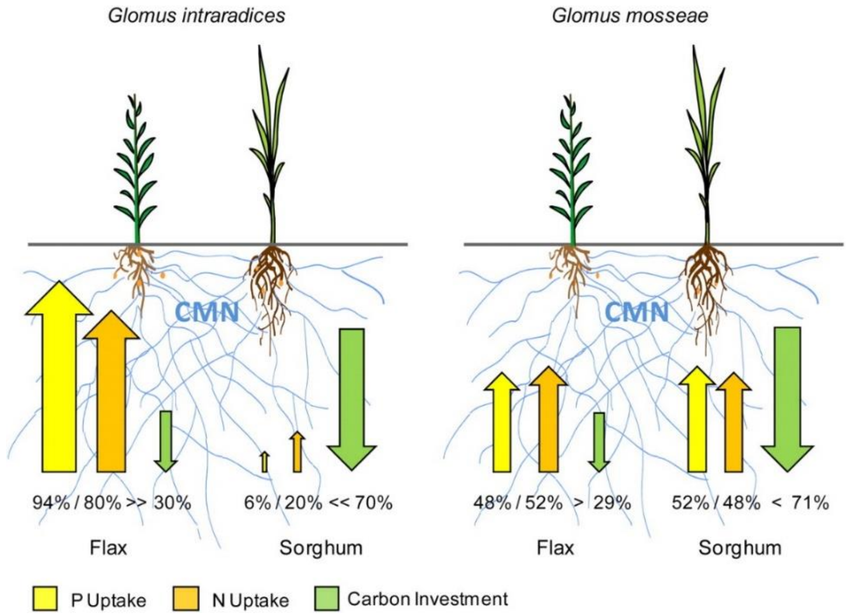
Rational and Concept



Common mycorrhizal networks



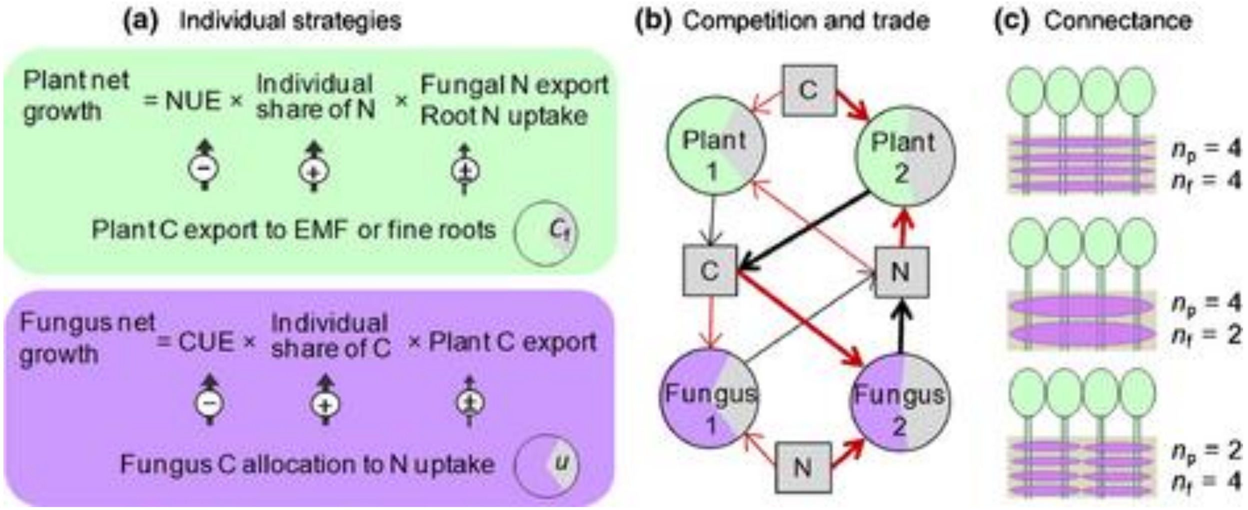
Common mycorrhizal networks and their effect on the bargaining power of the fungal partner in the arbuscular mycorrhizal symbiosis (Bücking et al. 2016)



Interplant facilitation by CMNs (Walder et al. 2012)

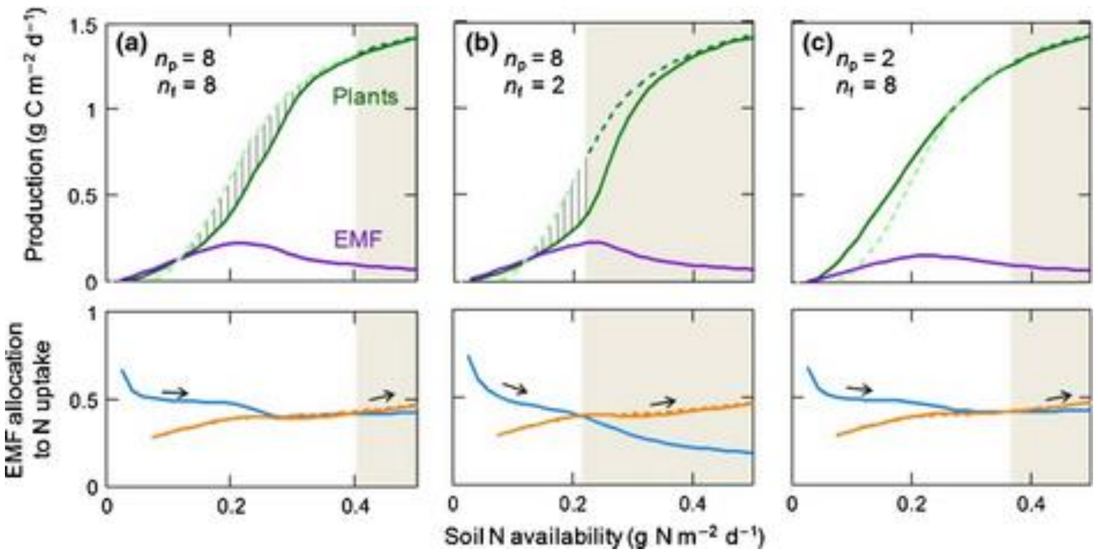
Forests trapped in nitrogen limitation – an ecological market perspective on ectomycorrhizal symbiosis

(Franklin et al. 2014)

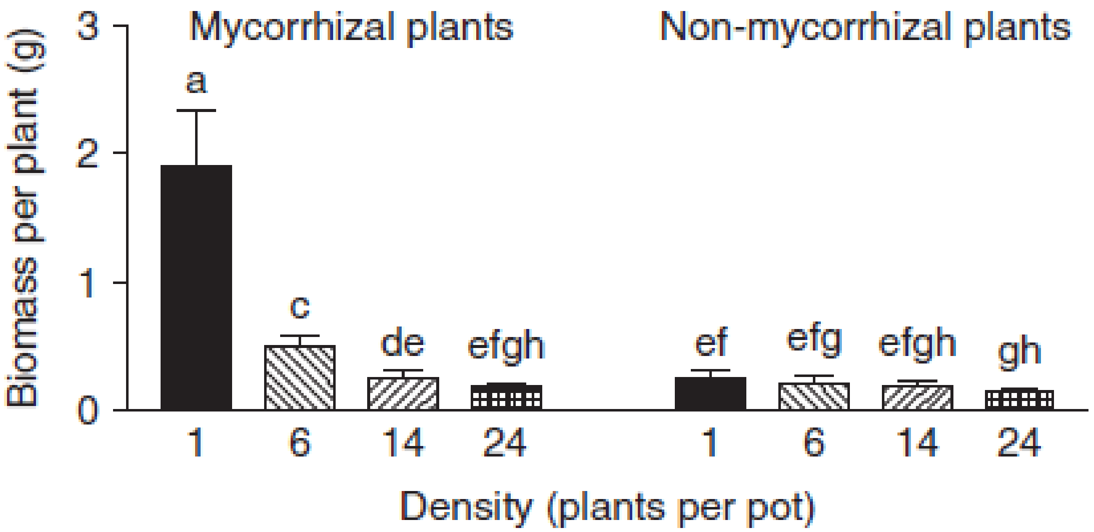


An individual's strategy of plant carbon (C) export to ectomycorrhizal fungi (EMF) and fungal allocation to nitrogen (N) uptake

Modeled net growth of plants with and without mycorrhiza (solid and dashed green lines, respectively) and ectomycorrhizal fungi (EMF; purple lines)

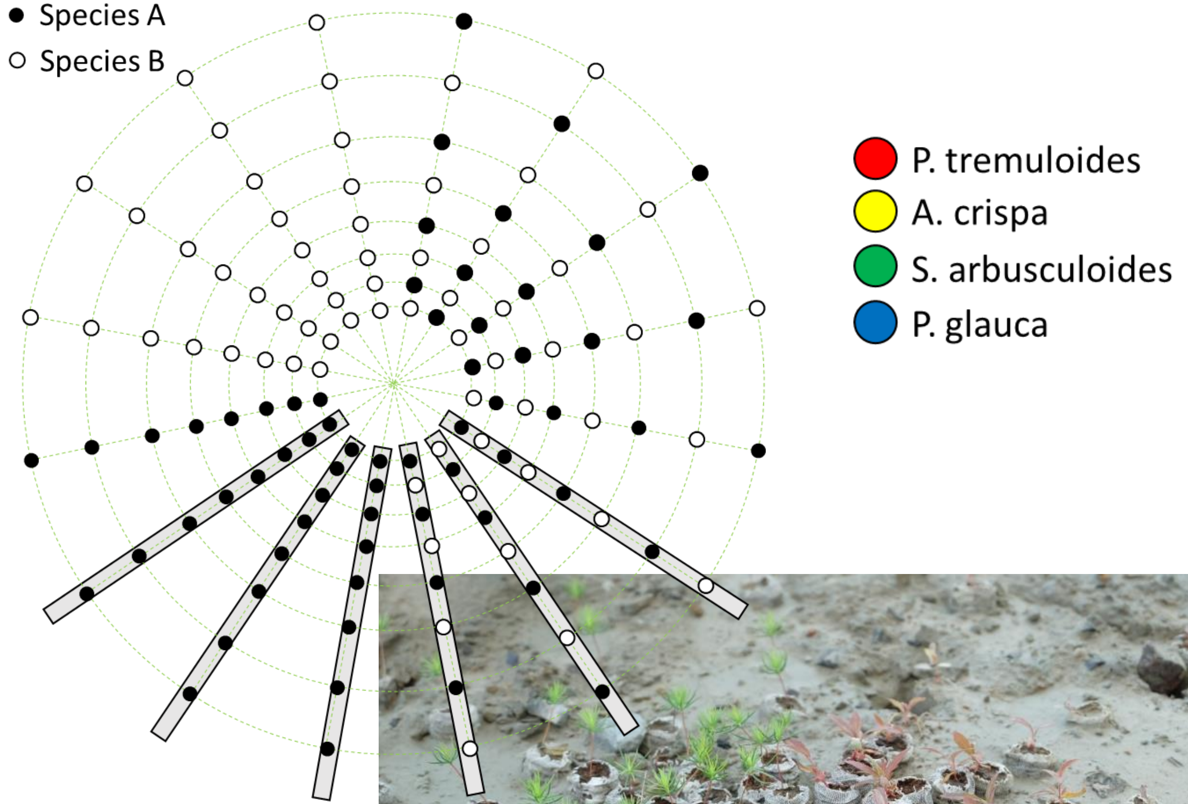


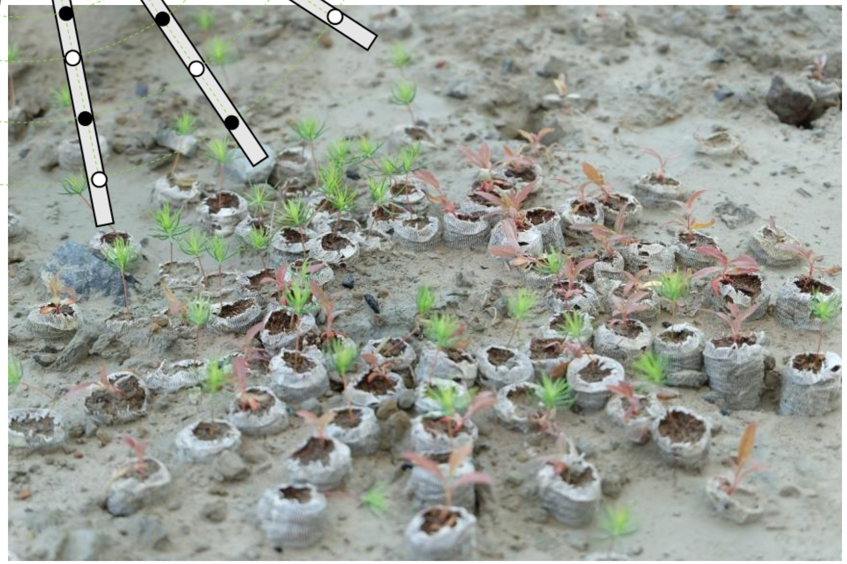
Plant density effect



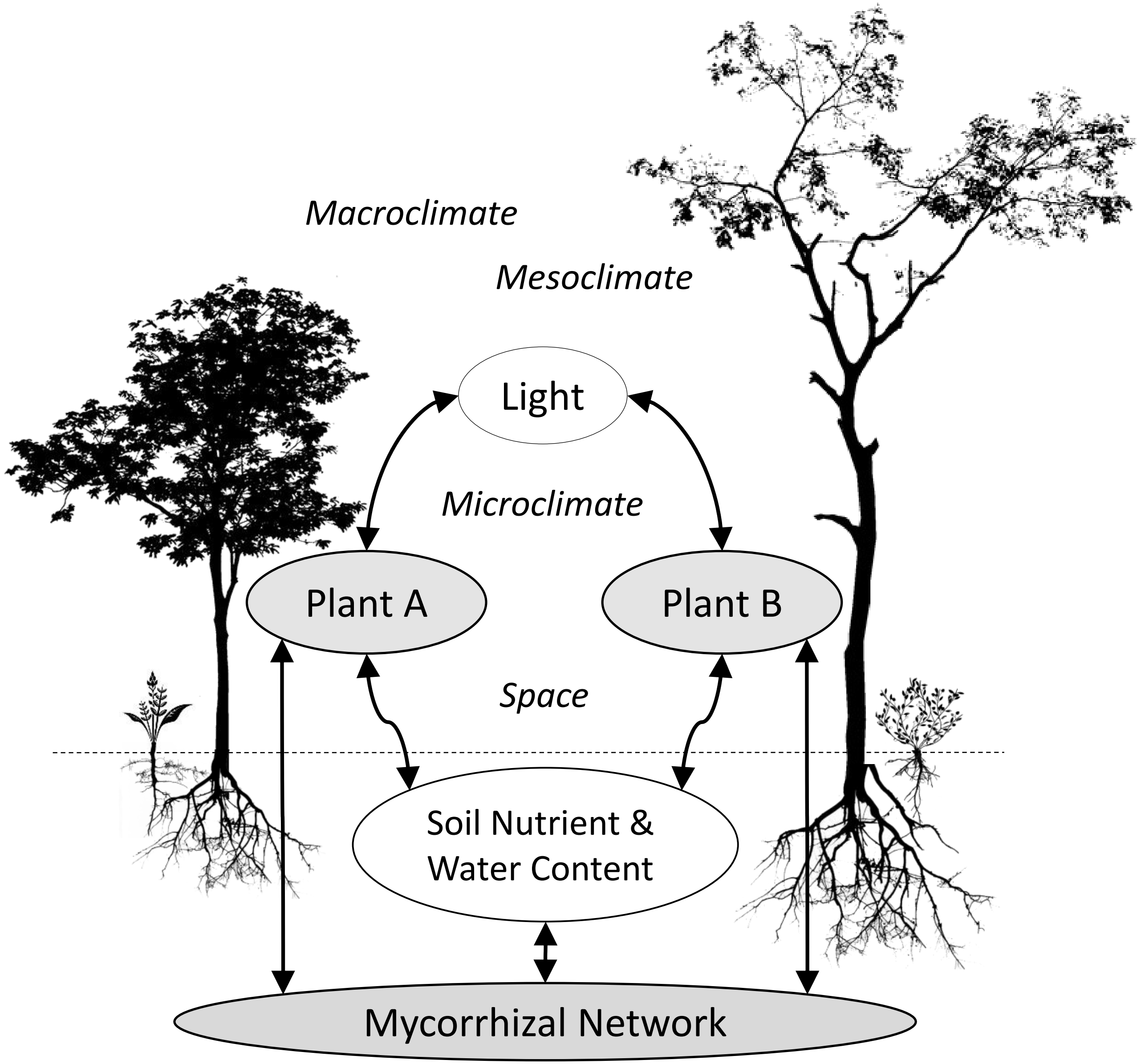
Effects of plant density on biomass of plants of Trifolium subterraneum, with and without Gigaspora margarita inoculation (Facelli et al. 1999 in Smith & Read 2009)

Nelder design experiment

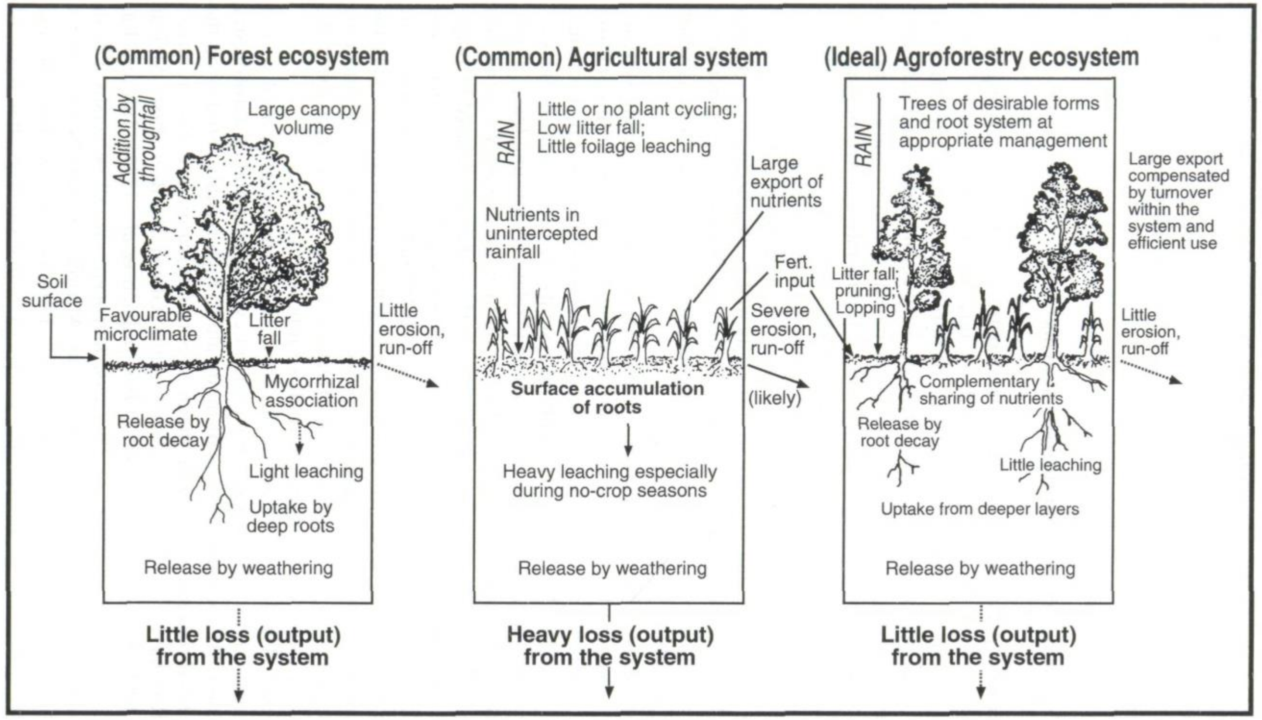


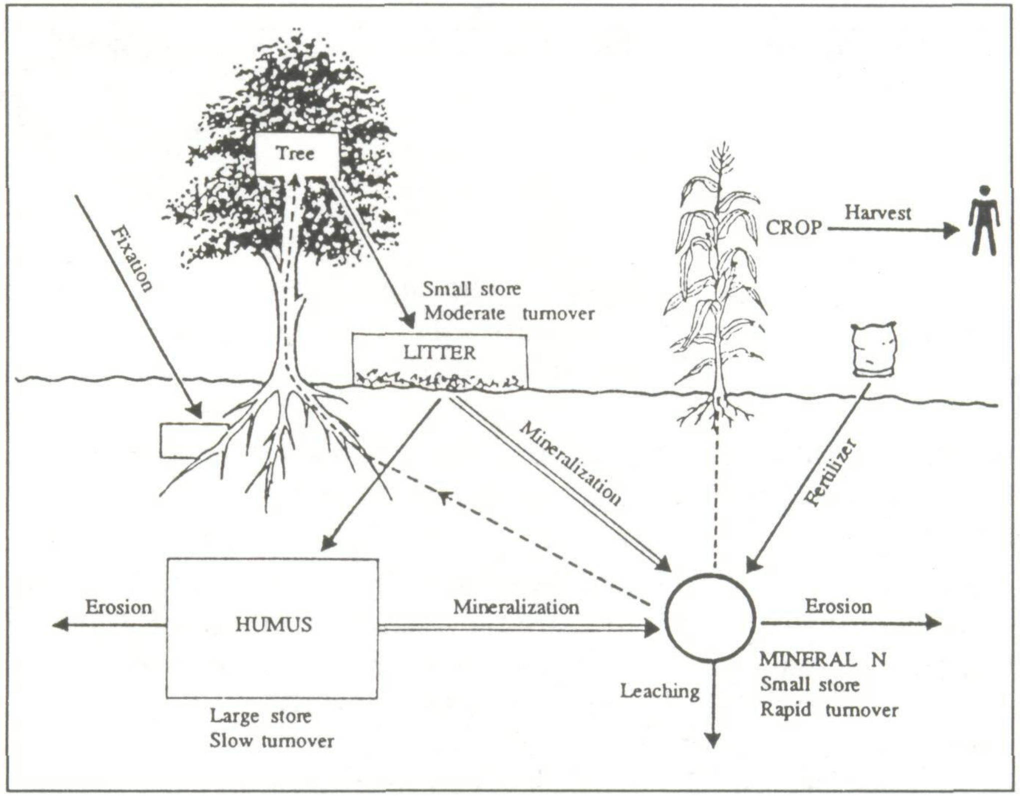


Rational Concept

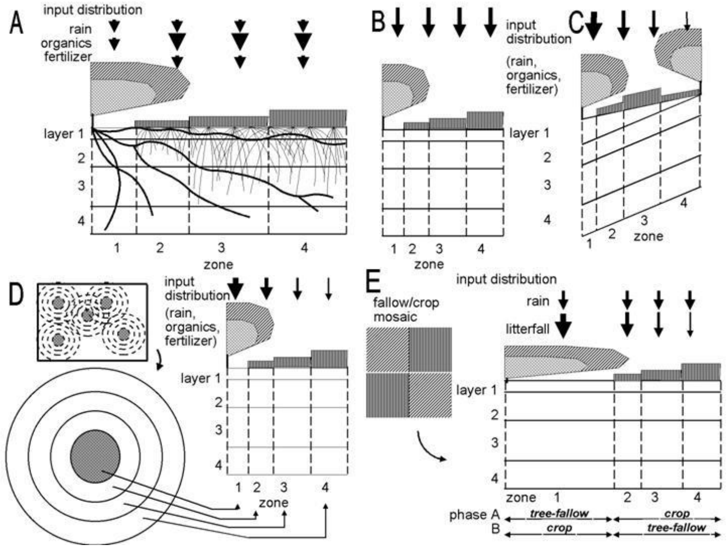


Agroforestry Concept

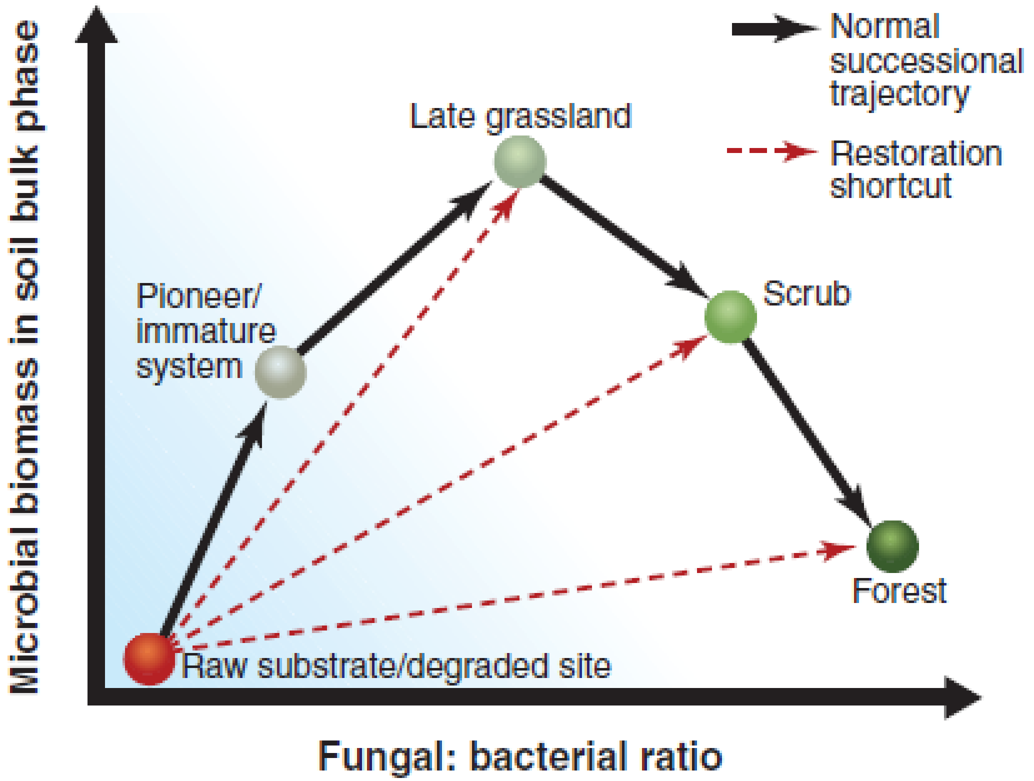




General layout of WaNuLCAS model (van Noordwijk et al. 2011)

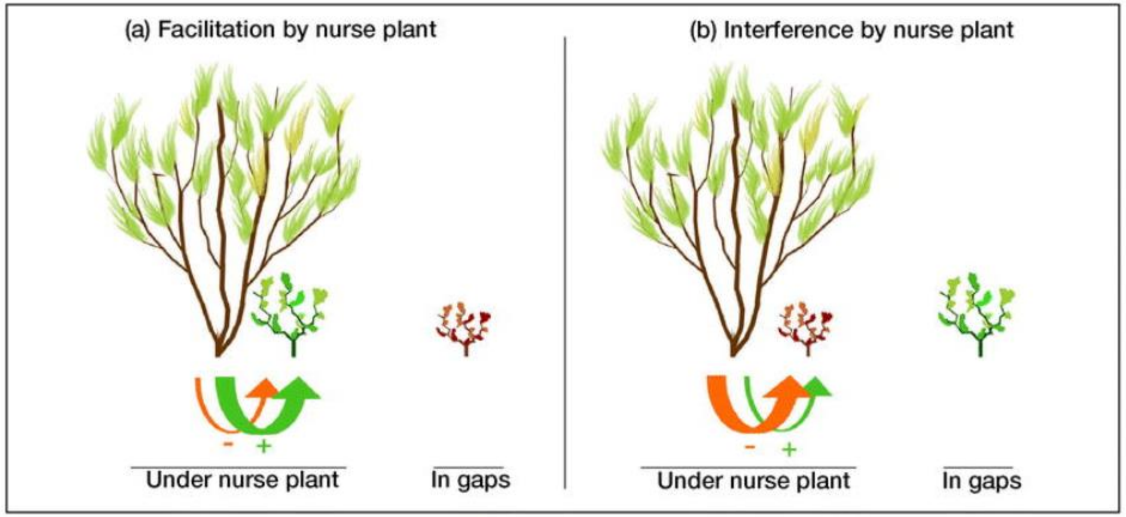


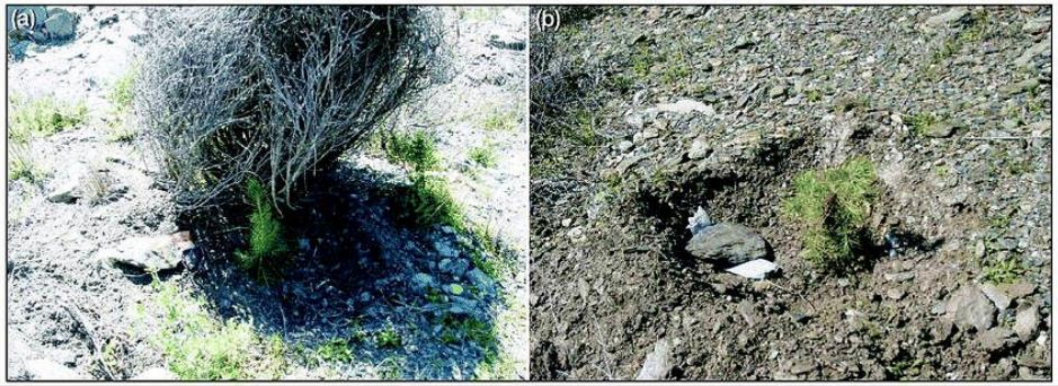
Ecological Restoration



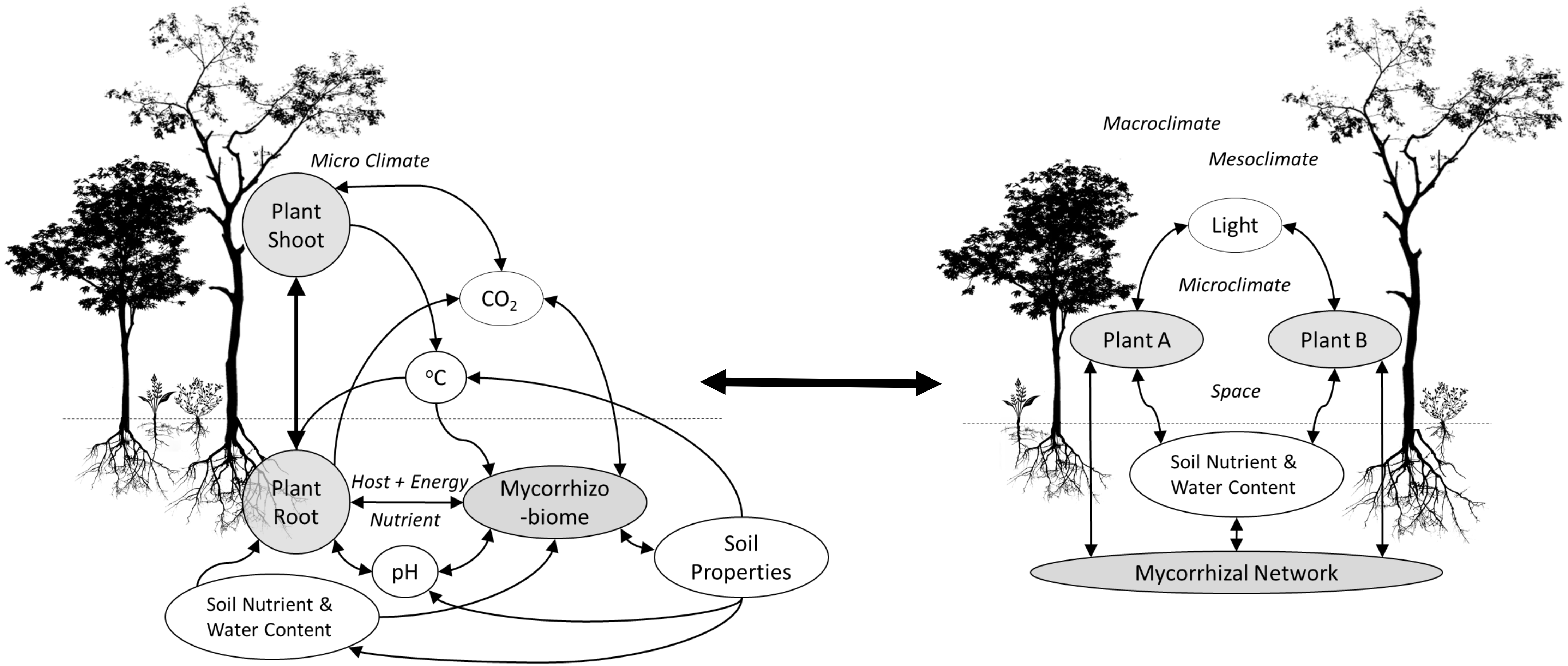
the succession processes based on microbial availability (Harris 2009)

The role of nurse plants in the restoration of degraded environments (Padilla & Pugnaire 2006)



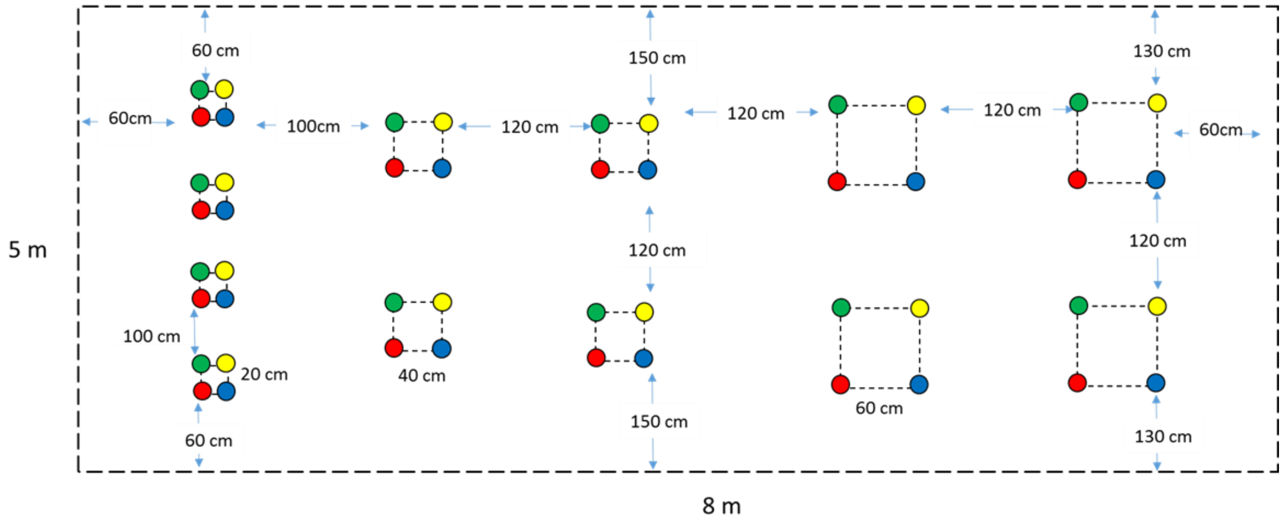


Mycorrhizal dynamic framework



Field trial experiment for data calibration

	Control			Micro-symbiont		
	Crop Only	**Tree + Crop**	**Tree Only**	**Crop Only**	**Tree + Crop**	**Tree Only**
Control	A11	A12	A13	A21	A22	A23
Biochar	B11	B12	B13	B21	B22	B23



Tree Species

- 🔴 P. tremuloides
- 🟡 A. crispa
- 🟢 S. arbusculoides
- 🔵 P. glauca

Herbaceous Species

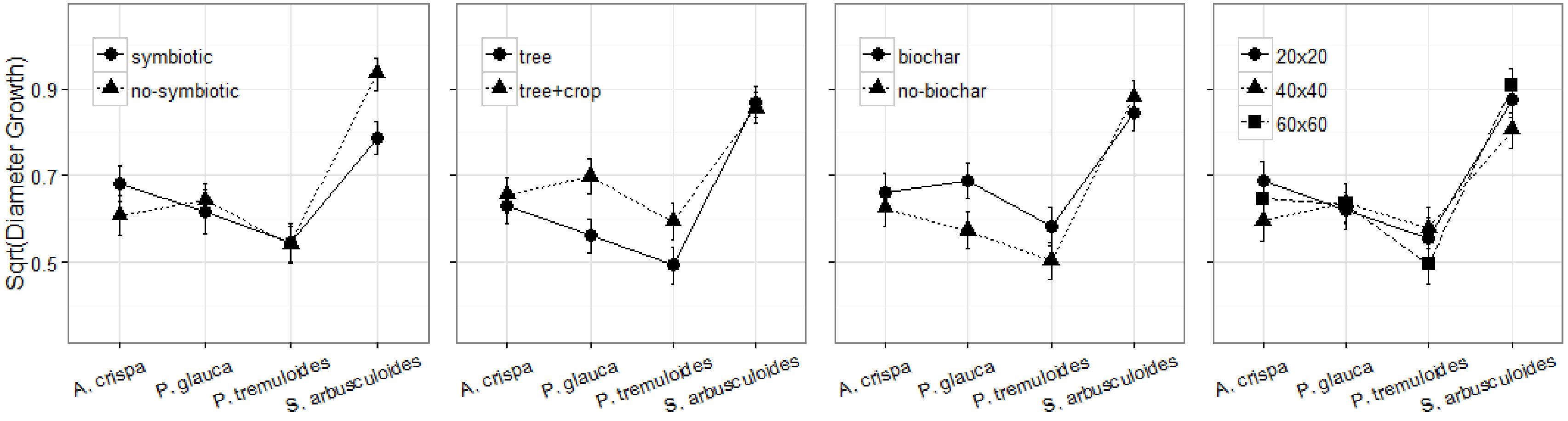
- Avena sativa
- Festuca rubra
- Trifolium repens

Diameter Growth (3 Months)

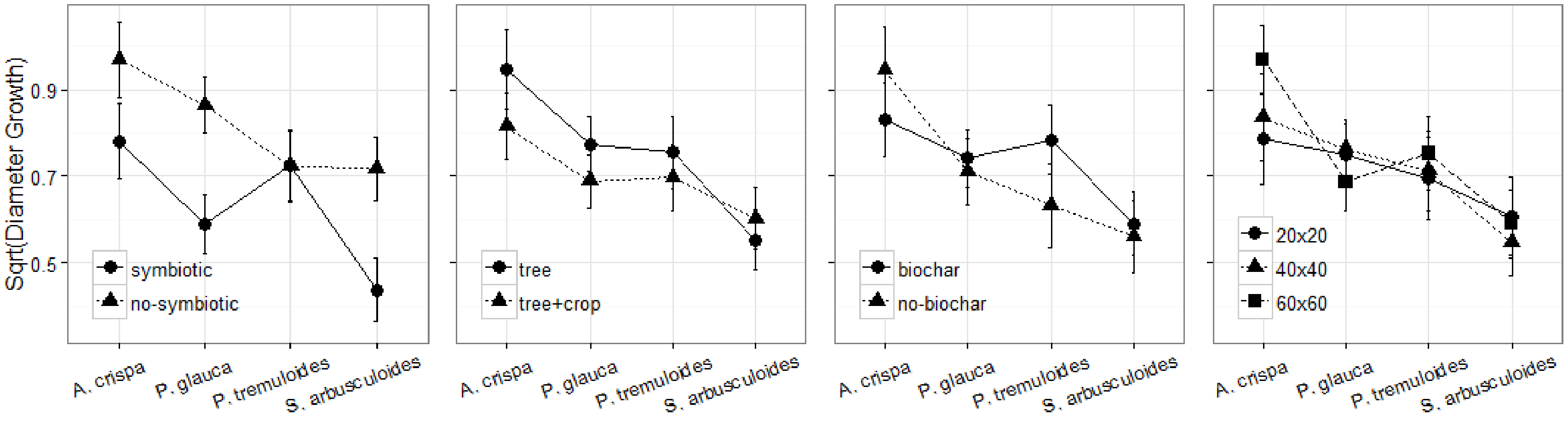
	DF	Fine Tilling Pr(>F)		Waste Rock Pr(>F)	
Species	**3**	**0.000**	*******	**0.008**	******
Biochar	1	0.224		0.682	
Symbiotic	**1**	**0.559**		**0.003**	******
Plants	**1**	**0.047**	*****	**0.261**	
Spacing	2	0.505		0.484	
InitDiameter	**1**	**0.000**	*******	**0.000**	*******
Species:Biochar	**3**	**0.095**	**.**	**0.246**	
Species:Symbiotic	**3**	**0.004**	******	**0.075**	**.**
Biochar:Symbiotic	**1**	**0.610**		**0.019**	*****
Species:Plants	**3**	**0.059**	**.**	**0.444**	
Biochar:Plants	1	0.934		0.938	
Symbiotic:Plants	1	0.469		0.115	
Species:Spacing	6	0.262		0.462	
Biochar:Spacing	2	0.192		0.473	
Symbiotic:Spacing	2	0.170		0.451	
Plants:Spacing	2	0.534		0.597	
Species:InitDiameter	**3**	**0.000**	*******	**0.101**	
Species:Biochar:Symbiotic	**3**	**0.043**	*****	**0.301**	
Species:Biochar:Plants	3	0.948		0.869	
Species:Symbiotic:Plants	3	0.448		0.061	.
Biochar:Symbiotic:Plants	1	0.330		0.198	
Species:Biochar:Spacing	6	0.231		0.632	
Species:Symbiotic:Spacing	6	0.808		0.222	
Biochar:Symbiotic:Spacing	2	0.606		0.414	
Species:Plants:Spacing	6	0.548		0.310	
Biochar:Plants:Spacing	2	0.715		0.364	
Symbiotic:Plants:Spacing	2	0.556		0.893	
Species:Biochar:Symbiotic:Plants	**3**	**0.047**	*****	**0.608**	
Species:Biochar:Symbiotic:Spacing	6	0.500		0.294	
Species:Biochar:Plants:Spacing	6	0.961		0.440	
Species:Symbiotic:Plants:Spacing	6	0.506		0.238	
Biochar:Symbiotic:Plants:Spacing	2	0.822		0.249	
Species:Biochar:Symbiotic:Plants:Spacing	6	0.948		0.766	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Fine Tilling



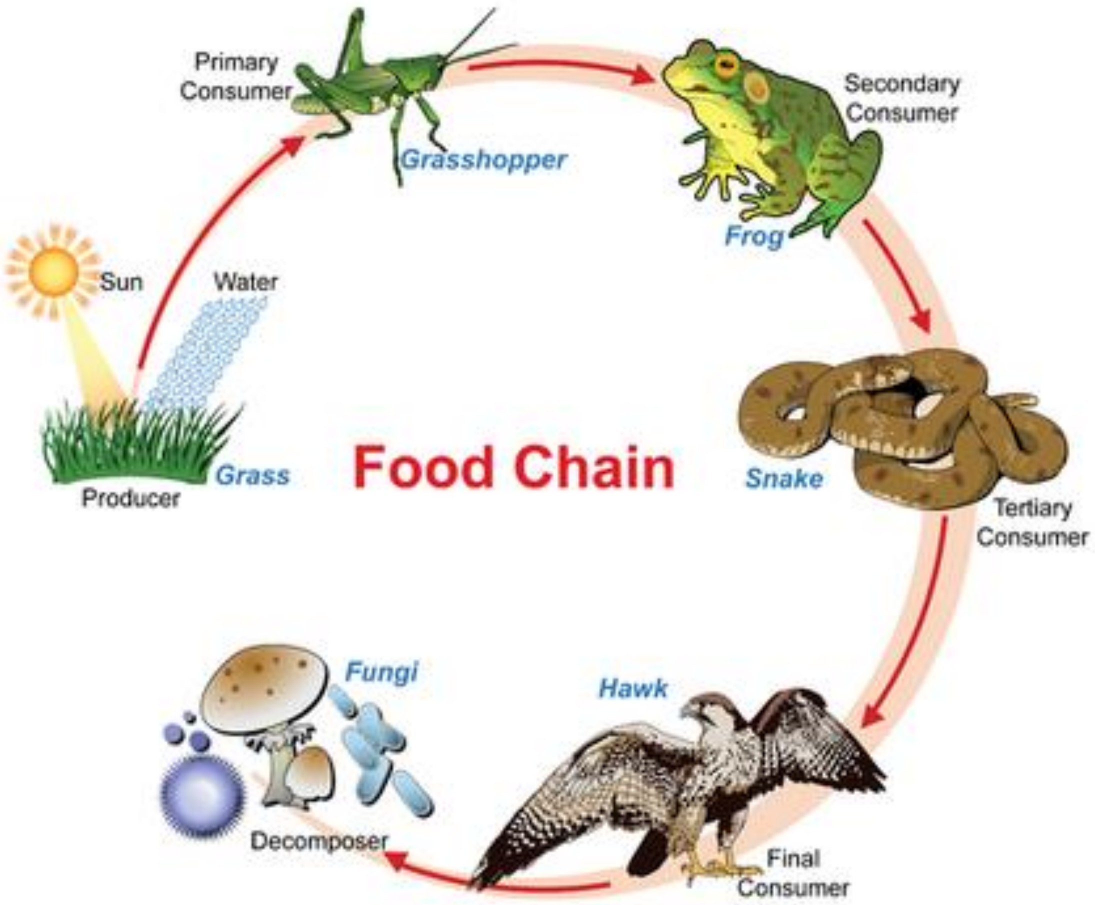
Waste Rock



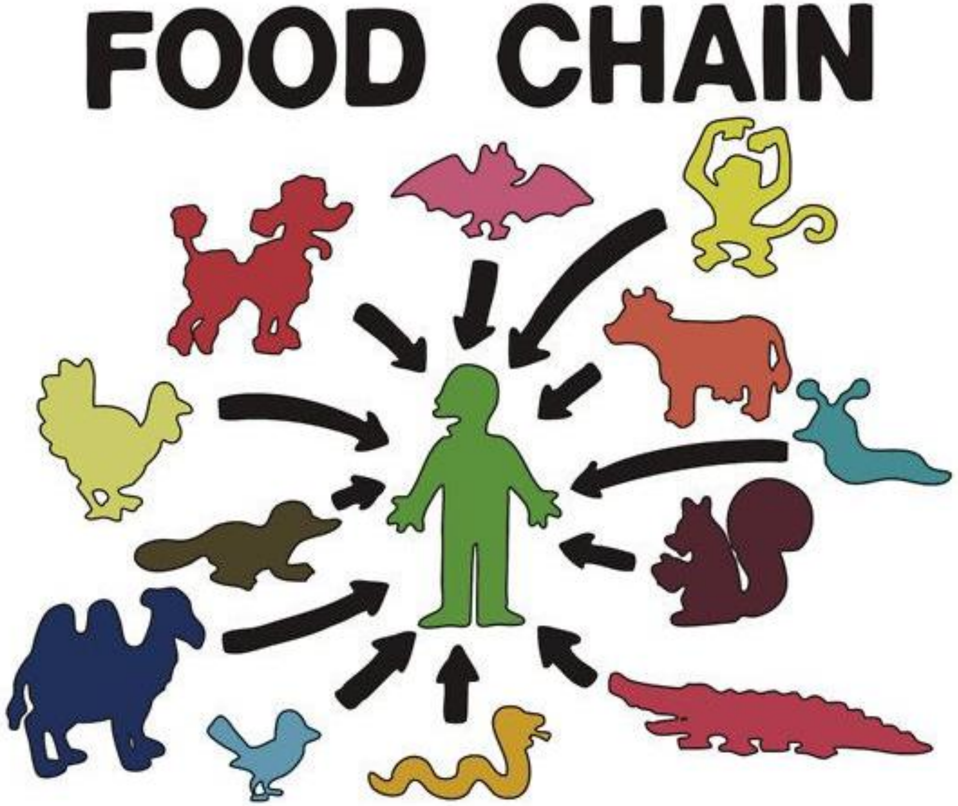
*Error bar is standard error

Conclusion

- The analytical framework is very importance for understanding the trade-off on the intervention strategies of the system
- The intervention may consider the sustainability of ecosystem



The Simpsons



Thank you

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