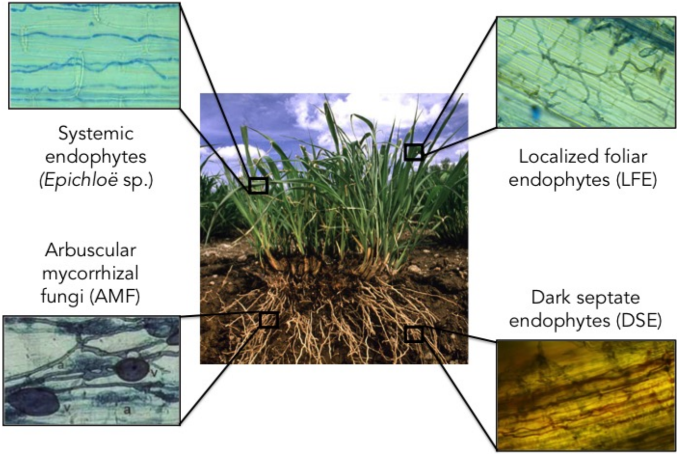
# Potential for climate-induced disruption of plant-fungal symbioses in the Rocky Mountains

Melanie Kazenel
7 April 2016

How will climate change alter plant-symbiont interactions?

# Plants and Fungal Symbionts



# Symbionts can mediate plant responses to climate change

American Journal of Botany

American Journal of Botany 100(7): 1445–1457. 2013.

SPECIAL INVITED PAPER—GLOBAL BIOLOGICAL CHANGE

**FUNGAL SYMBIONTS ALTER PLANT RESPONSES TO GLOBAL CHANGE[1]**

STEPHANIE N. KIVLIN[2,5], SARAH M. EMERY[3], AND JENNIFER A. RUDGERS[4]

Symbionts altered plant responses to drought, N deposition, and warming

# Climate change may disrupt symbioses as organisms experience range shifts

SCIENCE VOL 336 20 APRIL 2012

## Recent Plant Diversity Changes on Europe's Mountain Summits

Harald Pauli,[1*] Michael Gottfried,[2]† Stefan Dullinger,[2,3*] Otari Abdaladze,[4] Maia Akhalkatsi,[4] José Luis Benito Alonso,[5] Gheorghe Coldea,[6] Jan Dick,[7] Brigitta Erschbamer,[8] Rosa Fernández Calzado,[9] Dany Ghosn,[10] Jarle I. Holten,[11] Robert Kanka,[12] George Kazakis,[10] Jozef Kollár,[12] Per Larsson,[13] Pavel Moiseev,[14] Dmitry Moiseev,[14] Ulf Molau,[13] Joaquín Molero Mesa,[9] Laszlo Nagy,[15,16] Giovanni Pelino,[17] Mihai Puşcaş,[18] Graziano Rossi,[19] Angela Stanisci,[17] Anne O. Syverhuset,[11] Jean-Paul Theurillat,[20,21] Marcello Tomaselli,[22] Peter Unterluggauer,[8] Luis Villar,[5] Pascal Vittoz,[23] Georg Grabherr[1]

nature climate change
LETTERS
PUBLISHED ONLINE: 10 JANUARY 2012 | DOI: 10.1038/NCLIMATE1329

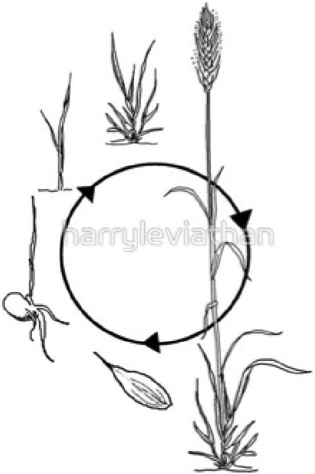
## Continent-wide response of mountain vegetation to climate change

Michael Gottfried[1], Harald Pauli[2*], Andreas Futschik[3], Maia Akhalkatsi[4], Peter Barančok[5], José Luis Benito Alonso[6], Gheorghe Coldea[7], Jan Dick[8], Brigitta Erschbamer[9], María Rosa Fernández Calzado[10], George Kazakis[11], Ján Krajči[5], Per Larsson[12], Martin Mallaun[13], Ottar Michelsen[14], Dmitry Moiseev[15], Pavel Moiseev[15], Ulf Molau[16], Abderrahmane Merzouki[10], Laszlo Nagy[17,18], George Nakhutsrishvili[19], Bård Pedersen[20], Giovanni Pelino[21], Mihai Puscas[22], Graziano Rossi[23], Angela Stanisci[21], Jean-Paul Theurillat[24,25], Marcello Tomaselli[26], Luis Villar[6], Pascal Vittoz[27], Ioannis Vogiatzakis[28] and Georg Grabherr[2]

# Mechanisms for disruption of plant-symbiont interactions

Plants and symbionts may have different:

- Physiological tolerances



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Plants and symbionts may have different:

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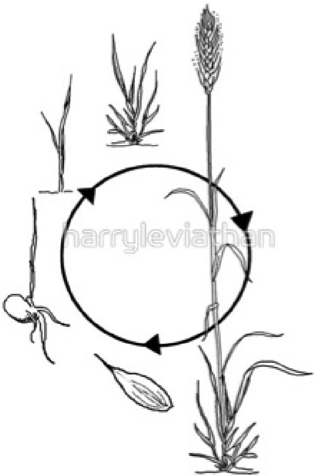
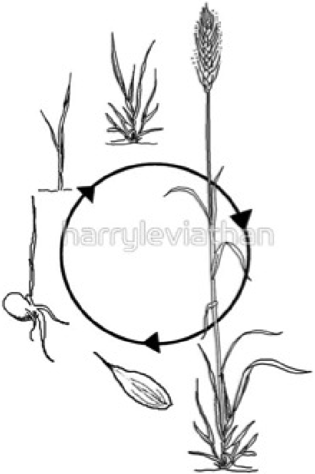


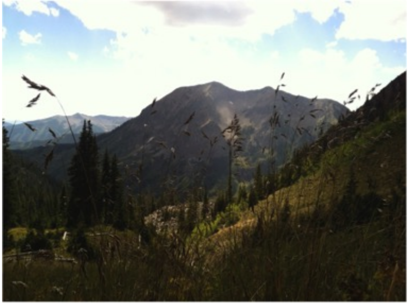
# Mechanisms for disruption of plant-symbiont interactions

Plants and symbionts may have different:

- Physiological tolerances
- Dispersal rates
- Phenological responses



# Study System



Mountains

- $\sim$25% of land area on Earth
- 50% of the human water supply
- 1/3 of terrestrial plant diversity

Grasses

- Cover 1/3 of land area ($>$10,000 species)
- Provide the majority of food for humans and domesticated animals
- All have mycorrhizal fungi in roots and fungi in leaves

# Altitudinal Gradients and Experimental Warming

# Focal Questions

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- Extends growing season by ~12 days on each end

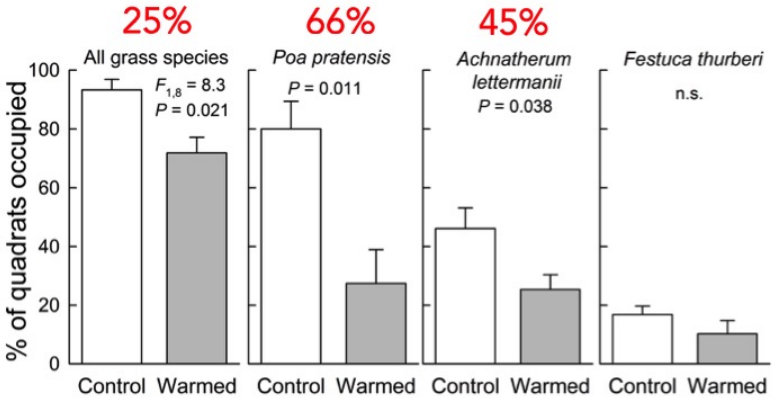
# Study Species

*Achnatherum lettermanii* (ACLE)

*Festuca thurberi* (FETH)

*Poa pratensis* (POPR)

# Experimental warming reduced grasses (1991 – 2011)

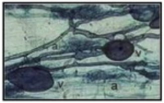


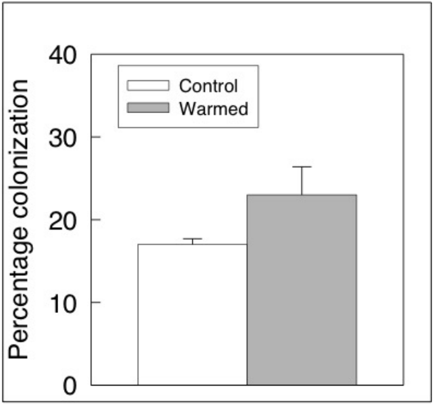

Mean % ± s.e. of 49 (0.2mx0.2m) quadrats surveyed per plot. n = 5 plots per warming treatment. Rudgers et al. *Ecology* (2014).

# Experimental warming increased mycorrhizal colonization of roots

*A. lettermanii*

Arbuscular mycorrhizal fungi

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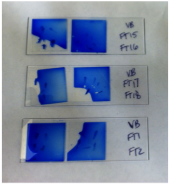
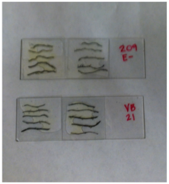
- Roots and leaves (2014)
- Phenology: June and September

# Laboratory methods

- Staining and microscopy $\rightarrow$ colonization

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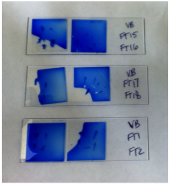
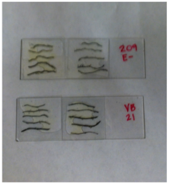
- Illumina MiSeq DNA sequencing $\rightarrow$ composition




illumina®

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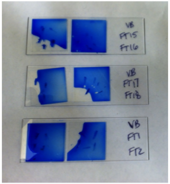

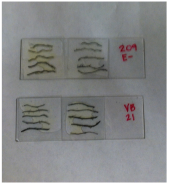

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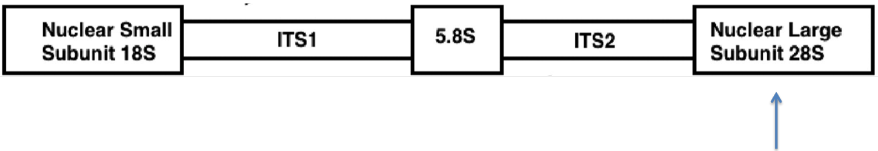
Paired-end sequencing of fungal nuclear ribosomal DNA using primers targeting:

- ITS2 region (for VTE, LFE, and DSE)



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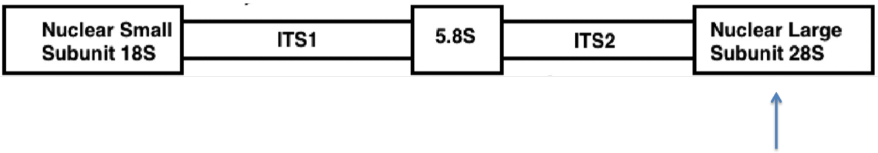

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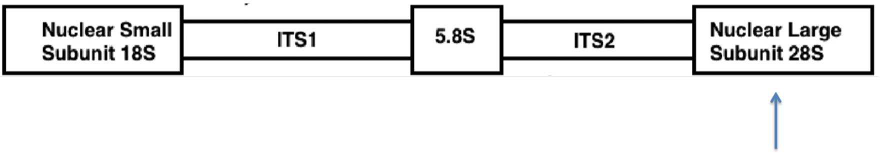

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- Conducted analyses on 802 OTUs

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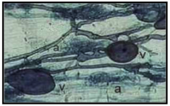
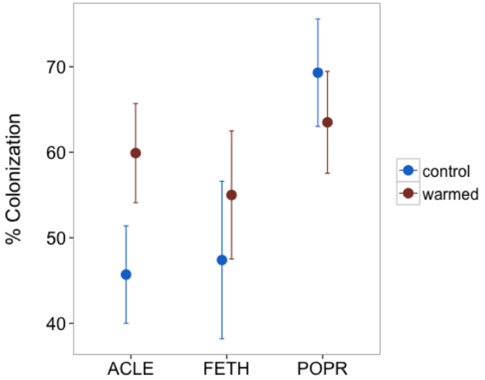
- PERMDISP: to test for dispersion within groups
- Indicator species analysis (SIMPER): to identify OTUs that contributed strongly to differences among groups

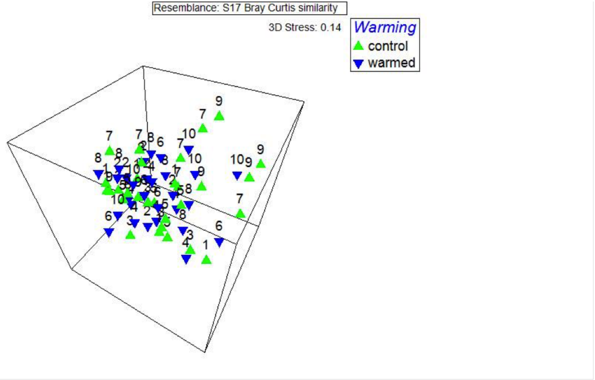
Arbuscular
mycorrhizal
fungi






# Results: All Species

- OTU composition did not differ between warming treatments (df = 1, pseudo-F = 1.361, P = 0.1391)



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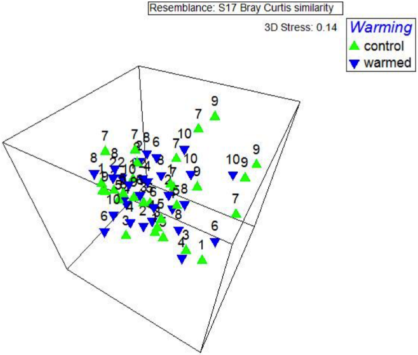

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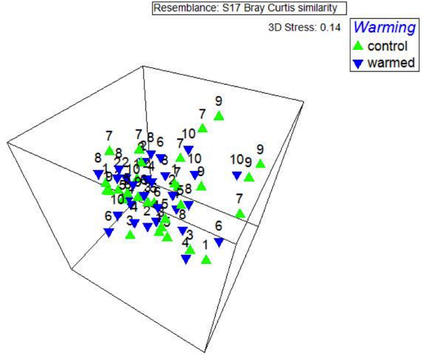
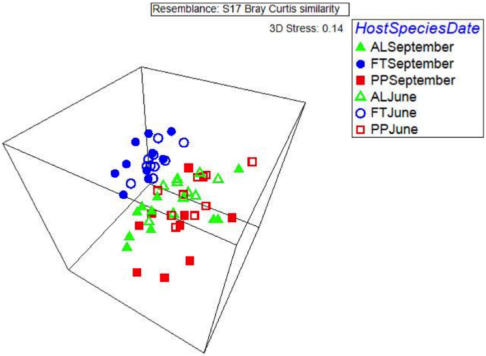
- OTU composition did not differ between warming treatments (df = 1, pseudo-F = 1.361, P = 0.1391)
- High stress value
- Spatial heterogeneity (significant effect of block)



- OTU composition differed between sampling dates (df = 1, pseudo-F = 2.9483, P = 0.0009) and among host species (df = 2, pseudo-F = 5.4469, P = 0.0001)



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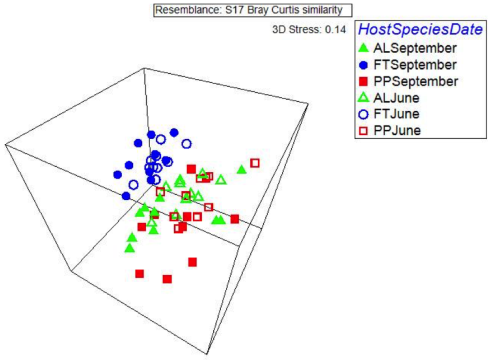
  - FT differed from AL and PP



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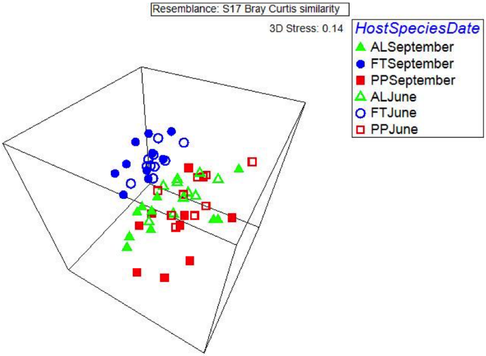
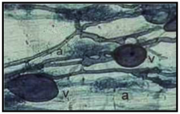
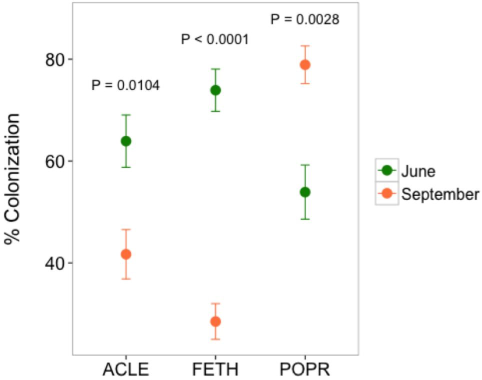
  - FT differed from AL and PP
  - Communities of AL and PP were significantly more dispersed relative to communities of FT (PERMDISP)



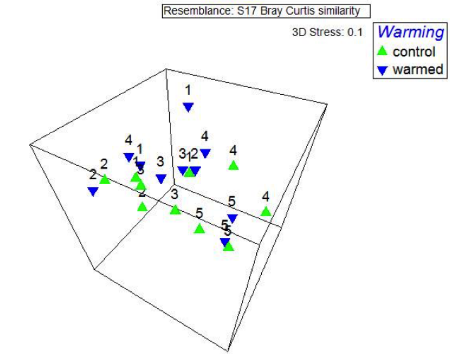
# Changes in AMF colonization between June and September for all three grasses

Arbuscular mycorrhizal fungi

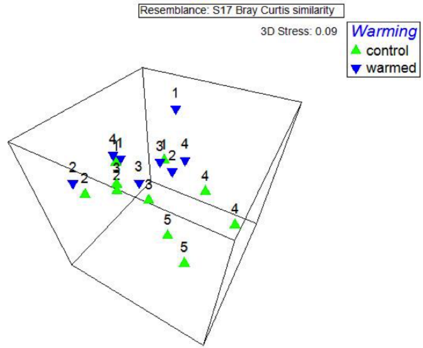





# Results: *A. lettermanii*

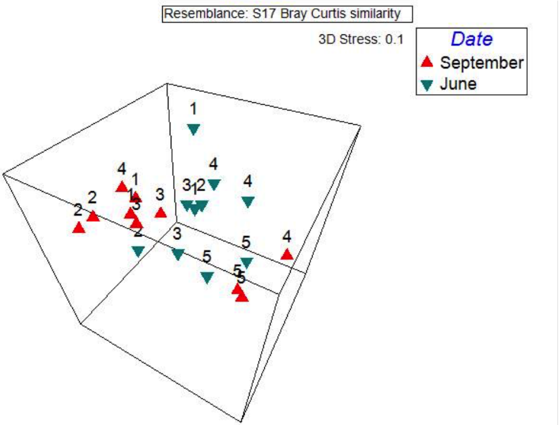



All data

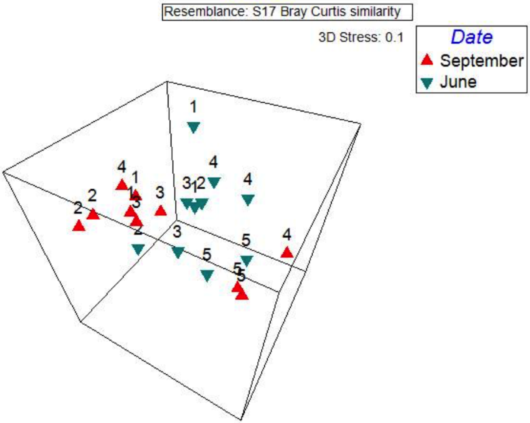



Plot 10 data removed

- Sampling date affected OTU composition (df = 1, psuedo-F = 3.1274, P = 0.0024



- Sampling date affected OTU composition (df = 1, psuedo-F = 3.1274, P = 0.0024
- No difference in dispersion between two dates



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- Grouping by plot