

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

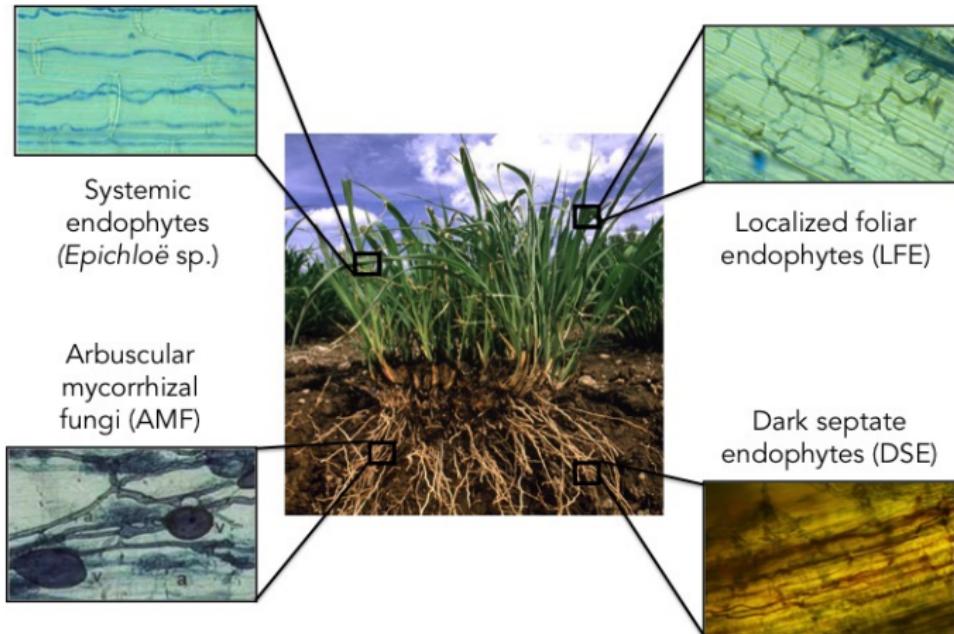
Melanie Kazenel  
7 April 2016





How will climate change alter plant-symbiont interactions?

# Plants and Fungal Symbionts



# Symbionts can mediate plant responses to climate change



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

SPECIAL INVITED PAPER—GLOBAL BIOLOGICAL CHANGE

## FUNGAL Symbionts ALTER PLANT RESPONSES TO GLOBAL CHANGE<sup>1</sup>

STEPHANIE N. KIVLIN<sup>2,5</sup>, SARAH M. EMERY<sup>3</sup>, AND JENNIFER A. RUDGERS<sup>4</sup>

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,<sup>2\*</sup> Michael Gottfried,<sup>2†</sup> Stefan Dullinger,<sup>2,3\*</sup> Otari Abdaladze,<sup>4</sup> Maia Akhalkatsi,<sup>4</sup> José Luis Benito Alonso,<sup>5</sup> Gheorghe Coldea,<sup>6</sup> Jan Dick,<sup>7</sup> Brigitte Erschbamer,<sup>8</sup> Rosa Fernández Calzado,<sup>7</sup> Dany Ghosh,<sup>10</sup> Jarle I. Holten,<sup>11</sup> Robert Kanka,<sup>12</sup> George Kazakis,<sup>10</sup> Jozef Kollár,<sup>12</sup> Per Larsson,<sup>13</sup> Pavel Moiseev,<sup>14</sup> Dmitry Moiseev,<sup>14</sup> Ulf Molau,<sup>13</sup> Joaquín Molero Mesa,<sup>9</sup> László Nagy,<sup>15,16</sup> Giovanni Pelino,<sup>17</sup> Mihai Puscas,<sup>18</sup> Graziano Rossi,<sup>19</sup> Angela Stanisci,<sup>27</sup> Anne O. Syverhuset,<sup>11</sup> Jean-Paul Theurillat,<sup>20,21</sup> Marcello Tomaselli,<sup>22</sup> Peter Unterluggauer,<sup>8</sup> Luis Villar,<sup>23</sup> Pascal Vittoz,<sup>25</sup> Georg Grabbherr<sup>1</sup>

nature  
climate change

LETTERS

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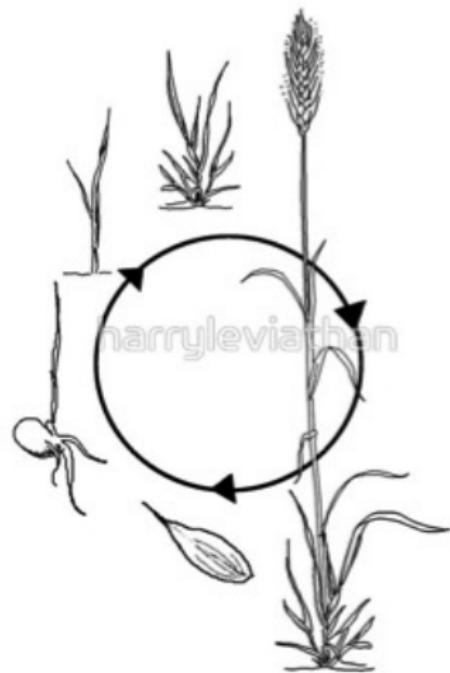
## Continent-wide response of mountain vegetation to climate change

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

# Mechanisms for disruption of plant-symbiont interactions

Plants and symbionts may have different:

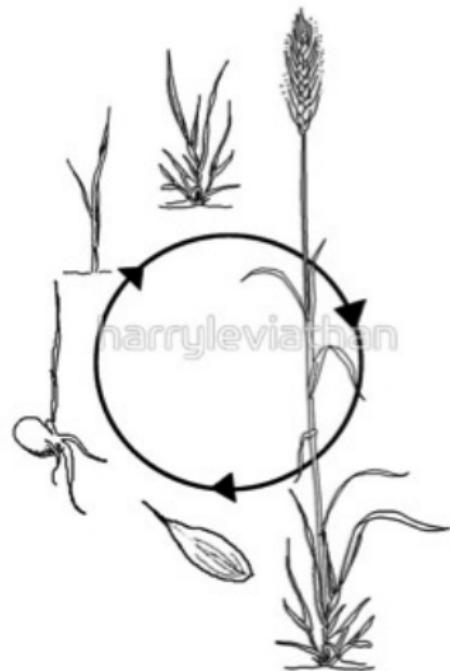
- ▶ Physiological tolerances



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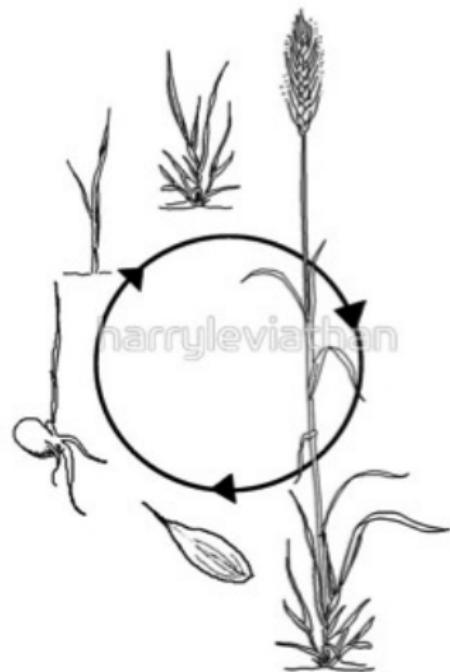
- ▶ Physiological tolerances
- ▶ Dispersal rates



# Mechanisms for disruption of plant-symbiont interactions

Plants and symbionts may have different:

- ▶ Physiological tolerances
- ▶ Dispersal rates
- ▶ Phenological responses



# Study System



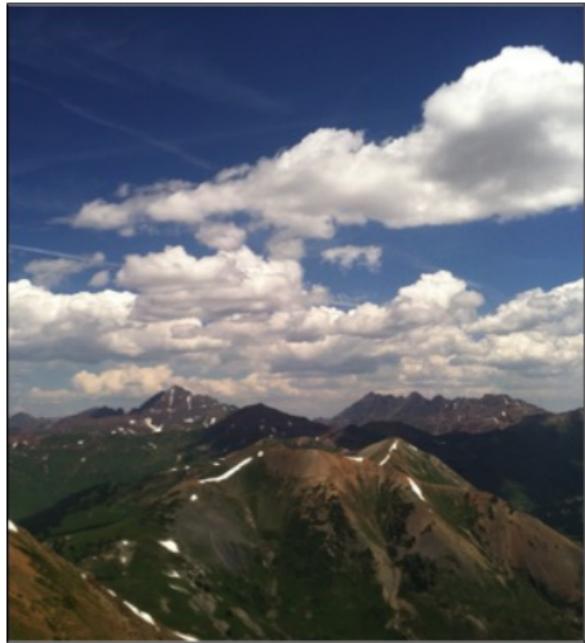
## Mountains

- ~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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- ▶ Altitude response?

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# Warming Experiment

Rocky Mountain Biological Laboratory

- ▶ Established in 1991



Photo: Mary Ellen  
Harte

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Harte

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- ▶ Dries soil by 10-20%



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Rocky Mountain Biological Laboratory

- ▶ Established in 1991
- ▶ Warms top 15 cm of soil by ~2°C
- ▶ Dries soil by 10-20%
- ▶ Extends growing season by ~12 days on each end



Photo: Mary Ellen  
Harte

# Study Species

*Achnatherum  
lettermanii*  
(ACLE)



*Festuca  
thurberi*  
(FETH)

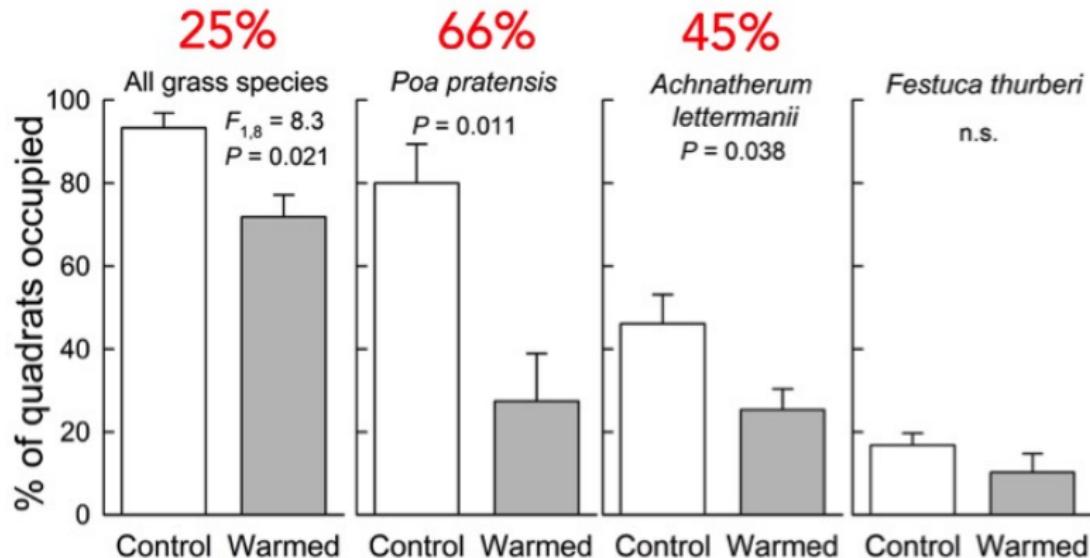


*Poa  
pratensis*  
(POPR)



ÅNGSTRÖM, POA PRATENSIS L.

# Experimental warming reduced grasses (1991 – 2011)



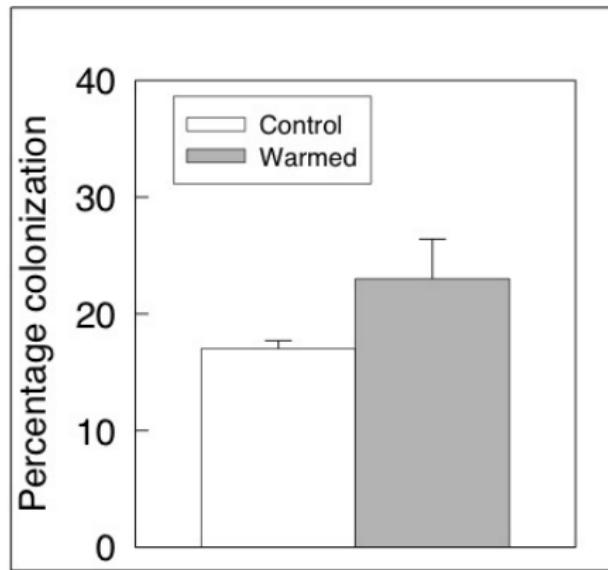
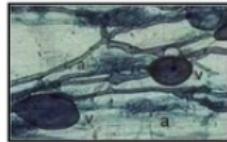
Mean %  $\pm$  s.e. of 49 (0.2m $\times$ 0.2m) quadrats surveyed per plot.  $n = 5$  plots per warming treatment. Rudgers et al. *Ecology* (2014).

# Experimental warming increased mycorrhizal colonization of roots



*A. lettermanii*

Arbuscular  
mycorrhizal fungi



Rudgers et al. *Ecology* (2014).

## Field collection methods

- ▶ 3 focal grass species:



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Photo: Noah Whiteman

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  - ▶ *Festuca thuerberi*



Photo: Noah Whiteman

## Field collection methods

- ▶ 3 focal grass species:
  - ▶ *Achnatherum lettermanii*
  - ▶ *Festuca thuerberi*
  - ▶ *Poa pratensis*



Photo: Noah Whiteman

## Field collection methods

- ▶ 3 focal grass species:
  - ▶ *Achnatherum lettermanii*
  - ▶ *Festuca thuerberi*
  - ▶ *Poa pratensis*
- ▶ 6 individual plants collected per species per plot



Photo: Noah Whiteman

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- ▶ 6 individual plants collected per species per plot
- ▶ Roots and leaves (2014)



Photo: Noah Whiteman

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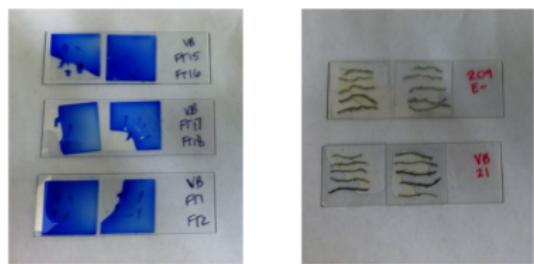
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  - ▶ *Festuca thuerberi*
  - ▶ *Poa pratensis*
- ▶ 6 individual plants collected per species per plot
- ▶ Roots and leaves (2014)
- ▶ Phenology: June and September



Photo: Noah Whiteman

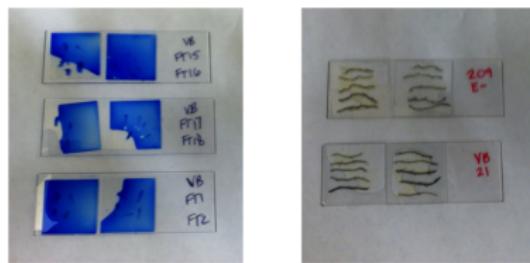
# Laboratory methods

- ▶ Staining and microscopy → colonization



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- ▶ Illumina MiSeq DNA sequencing → composition



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