Strategies for Plant Survival:
How do plants avoid getting sunburnt?

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Introduction:

Plants have evolved to optimize their own survival and reproduction in the niche to which they are adapted. To do this they have to optimally capture resources from the environment, including light energy from the sun and inorganic nutrients from the soil. In the case of light however, excessive supply can cause harm, a process analogous to sunburn. Specifically light in excess of that which can be used for photosynthesis can induce damage to the photosynthetic apparatus, called *photoinhibition*. Plants can protect themselves from such damage via two pathway: in the short term they use protective mechanisms, in particular a process called *non photochemical quenching* (NPQ) which acts as a safety valve, dissipating excess energy as heat (Kulheim et al., 2002; Kromdijk et al., 2016); in the long term, plants can adjust the relative composition of their leaves to suit their environment, in a process of *photoacclimation* (Athanasiou et al., 2010; Dyson et al., 2014; Dyson et al., 2015; Dyson et al., 2016). Both mechanisms have disadvantages – NPQ is inefficient, as light energy is wasted. Photoacclimation can be costly, requiring investment of inorganic nutrients, especially nitrogen. Loss of either mechanism has been shown to be costly to plants, reducing overall fitness. The cost-benefit relationship between these different strategies is poorly understood but is likely to depend on the nutrient status of the soil in which plants grow.

Project Summary:

The aim of this project is to examine the relative importance of NPQ and photoacclimation in plants from different soils, varying in nitrogen availability. You will test the hypothesis that NPQ is favoured by plant adapted to nutrient poor environments, whilst photoacclimation is favoured in nutrient rich soils. Training will be provided in plant physiology and ecology. You will receive training in the latest techniques in gas exchange and *in vivo* spectropscopy to measure photosynthesis. You will perform growth analysis of study species and undertake chemical and biochemical analysis of plant material, including using mass-spectrometry based proteomic approaches. Using a selection of species from different ecological niches, exposed to different soil conditions, you will develop models to understand the relative importance of NPQ vs photoacclimation as a function of ecological strategy. You will be supervised in this project by Dr Giles Johnson, an environmental plant physiologist with an interest in plant stress (Athanasiou et al., 2010; Dyson et al., 2014; Dyson et al., 2015; Dyson et al., 2016), and Dr Franciska de Vries, a soil ecologist interested in plant:soil interactions (de Vries and Bardgett, 2016; de Vries et al., 2016). Both lead active research groups, providing a vibrant multidisciplinary research environment. Additionally, you will have the opportunity to collaborate with colleagues interested in mathematical modelling of biological processes. Work will be based in state of the art new labs at the University of Manchester and in our extensive greenhouse facilities nearby.

Work on this project will contribute to our overall understanding of plant ecology, especially plant adaptations to the environment. This is important not only to contribute to our general knowledge of plant biology but also to efforts to improve our future food security, in the face of changing climates. The

processes to be studied are known to be important determinants of plant yields and have the potential for improvement in crop species.

Image 1 Caption – An alpine meadow, near Gmund, Austrian. Plants are competing in this habitat for both light and nutrients

References:

Athanasiou K, Dyson BC, Webster RE, Johnson GN (2010) Dynamic acclimation of photosynthesis increases plant fitness in changing environments. Plant Physiology **152:** 366-373

de Vries FT, Bardgett RD (2016) Plant community controls on short-term ecosystem nitrogen retention. New Phytologist **210:** 861-874

de Vries FT, Brown C, Stevens CJ (2016) Grassland species root response to drought: consequences for soil carbon and nitrogen availability. Plant and Soil **409:** 297-312

Dyson BC, Allwood JW, Feil R, Xu YUN, Miller M, Bowsher CG, Goodacre R, Lunn JE, Johnson GN (2015) Acclimation of metabolism to light in Arabidopsis thaliana: the glucose 6-phosphate/phosphate translocator GPT2 directs metabolic acclimation. Plant, Cell & Environment **38:** 1404-1417

Dyson BC, Miller MAE, Feil R, Rattray N, Bowsher CG, Goodacre R, Lunn JE, Johnson GN (2016) FUM2, a Cytosolic Fumarase, Is Essential for Acclimation to Low Temperature in <em>Arabidopsis thaliana</em&gt. Plant Physiology **172:** 118

Dyson BC, Webster RE, Johnson GN (2014) GPT2: a glucose 6-phosphate/phosphate translocator with a novel role in the regulation of sugar signalling during seedling development. Annals of Botany **113:** 643-652

Kromdijk J, Glowacka K, Leonelli L, Gabilly ST, Iwai M, Niyogi KK, Long SP (2016) Improving photosynthesis and crop productivity by accelerating recovery from photoprotection. Science **354:** 857-861

Kulheim C, Agren J, Jansson S (2002) Rapid regulation of light harvesting and plant fitness in the field. Science **297:** 91-93