# Refining plant functional classifications for Earth System Modelling

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**State of the art**

Plant functional classifications were proposed by GCTE in the early-mid 1990's as a tool to model vegetation dynamics and ecosystem functioning (esp. biogeochemical cycles) in response to climate and $CO_2$ (Woodward & Cramer 1996, Smith et al. 1997). Since then, plant functional type (PFT) research has been a flourishing field, well beyond the realm of global change research (see Lavorel et al. 2006 for a synthesis). However a disconnect remains between modellers, working at the regional scale or beyond, who still tend to use rather coarse classifications, with few PFTs that are based on a small number of plant traits (e.g. life form, phenology, photosynthetic pathway), and experimental scientists who focus on a greater range of plant traits, and nowadays tend to prefer continuous descriptions ratuer than classifications into discrete PFTs. Major findings from this experimental work have included the identification of a suite of leaf traits that capture plant nutrient economy. They can be used as markers of both the response of plant communities to nutrient (and to some extent water) availability, and of plant effects on key ecosystem processes such as ANPP, litter decomposition and herbivore consumption through their effects on photosynthesis or tissue quality. The characterization of plant response to climate (esp. cold extremes) and $CO_2$ through traits that are easy to measure for large floras remains elusive, but *a priori* PFTs such as those used by large-scale models are clearly insufficient to represent the diversity of responses in natural communities. Likewise, more complex ecosystem processes such as those involved in the N cycle (including emissions) are more difficult to link to simple plant traits because of the complex interactions with soil biota.

From the modelling perspective, some of the current needs are the refinement of processes that govern community assembly, such as dispersal (to represent migration) and disturbances (fire, herbivory including grazing and pests). This again requires that PFT classifications be re-examined, and new empirical knowledge from plant functional trait research can significantly contribute here too. Significant progress has been made in the understanding of traits that influence recruitment and response to disturbance, though this is not complete yet. In any case, these traits are independent of leaf and other adult traits (e.g. morphological), requiring that plant functional classifications consider a hierarchy from adult to regeneration traits. Classifications would also need to be tailored regionally, depending on the evolutionary history of the flora. This could result in simplifications of the classification within each region (Díaz et al. submitted).

New perspectives on classifications to appropriately capture vegetation dynamics through time, e.g. based on palaeo-data, indicate that up to 100 PFTs may be required. How to design them in a comprehensive manner, and how to link them with existing data bases is a key challenge.

During 2005, several independent workshops started bringing together the range of scientists who helped formulating this challenge and started outlining the key scientific and technical issues (e.g. constraints on model structure). These were sponsored by Diversitas (Dourdan, France, May 2005; Borneo, September 2005, jointly with the NSF Biocomplexity programme), the Australian Research Council (Sydney, October 2005) and QUEST (Exeter, October 2005).

**Objectives for the FTI**

A proposed IGBP-Diversitas Fast Track Initiative on Plant Functional Types would aim to:

1. design a new basis for plant functional classifications to be used in the new generation of large-scale dynamic vegetation models
2. identify existing data and data gaps for its implementation
3. conduct a first test, at least for one or a few regions where suitable data and models are currently available

**Products**

1. an outline (structure, rules for implementation and data needs) for new plant functional classifications for large-scale dynamic vegetation models, published in a high-visibility journal
2. at least one paper presenting a test of the classification, e.g. in Global Change Biology
3. a compilation of links to data bases and other sources for the regional implementation of classifications, to be made available on the internet
4. a strategy to fill data gaps, to be made available on the internet and published in an international journals

**Timelines**

- last quarter 2006: workshop to lay out a first draft of the classification. Choice of region(s) and model(s) for test application.
- first semester 2007: data synthesis for a first test on one or a few target regions and model parameterization; identification of a validation data set(s)
- last quarter 2007: workshop to discuss and write up the results from the test exercise; design final version of the classification and strategy for implementation and validation (based on the AIMES experience in model comparison)
- first semester 2008: synthesize data sources, identify major gaps (types of traits and geographic and develop guidelines for filling data gaps
- second semester 2008: writing of papers, presentation at major international conferences.

**Interactions with stakeholders/user community**

This FTI will deliver an improved plant functional classification scheme for the improvement of the large-scale vegetation models that are needed for global and regional assessments (e.g. IPCC and future biodiversity assessments). These models are also those needed for improved earth system modelling.

**Key scientific areas that need to be represented to achieve the goals**

Plant functional ecology, biodiversity, biogeochemistry, biogeography, large-scale vegetation modelling, palaeo-ecology.

**Draft list of participants**

| Name | Country | Expertise | Affiliation |
|---|---|---|---|
| *Sandra Lavorel* | *France* | Plant functional ecology<br>Landscape modelling<br>Biodiversity<br>Land use change, disturbances | *IGBP (GLP)* |
| *Colin Prentice* | *UK* | Biogeography<br>Biogeochemistry<br>Large scale vegetation modelling<br>Paleao-ecology | *IGBP, AIMES* |
| *Sandra Díaz* | *Argentina* | Plant functional ecology<br>Biodiversity<br>Comparative plant ecology | *GLP* |
| *Paul Leadley* | *France* | Biodiversity<br>Biogeochemistry<br>Ecosystem modelling | *Diversitas* |
| Guy Midgley | South Africa | Plant functional ecology<br>Biodiversity<br>Biogeography | NA |
| William Bond | South Africa | Plant functional ecology<br>Biodiversity<br>Biogeography | NA |
| Juli Pausas | Spain | Plant functional ecology<br>Landscape modelling<br>Fire<br>Mediterranean ecosystems | NA |
| Mark Westoby | Australia | Plant functional ecology<br>Biodiversity | NA |
| Ian Wright | Australia | Plant functional ecology<br>Biodiversity | NA |
| Stephen Roxburgh or Damian Barrett | Australia / New Zealand | Plant functional ecology<br>Biogeochemistry<br>Regional-scale modelling | (GCP) |
| Andrew Gillieson | Australia | Plant functional ecology<br>Biodiversity<br>Biogeography | |
| Wilfried Thuiller | France | Plant functional ecology<br>Biodiversity<br>Biogeography<br>Modelling (landscape to region) | (Diversitas) |
| Doris Barboni | France | Paleao-ecology<br>Biogeography<br>Plant functional ecology | NA |
| Sandy Harrison | UK | Paleao-ecology<br>Biogeography<br>Large scale vegetation modelling | |
| Ian Woodward | UK | Plant functional ecology<br>Large scale vegetation modelling | |
| Hans Cornelissen | Netherlands | Plant functional ecology<br>Biogeochemistry | |
| Howard Epstein | USA | Plant functional ecology<br>Biogeochemistry<br>Ecosystem modelling | |
| Dominique Bachelet | USA | Large scale vegetation modelling<br>Disturbance (fire, grazing) | |
| Victor Brovkin | Russia | Paleao-ecology<br>Ecosystem ecology | |
| TBA | China | Ecosystem ecology / modelling? | |