

asked to predict what happens next. The contest was more than a game; it provided a vehicle for evaluating the consistency of different approaches to risk assessment (<http://www.nceas.ucsb.edu/~mccarthy/Complntro.htm>). Each contestant's score was an accuracy index, averaged over 24 different predictions that were requested (six different types of risk predictions for each of four species).

This contest is one facet of an Extinction Risk Working Group that is funded by NCEAS (National Center for Ecological Analysis and Synthesis) in Santa Barbara. The contest is being reopened for a second round, presumably to give the rest of the world a chance to overturn the Australians' dominance. Winners get their expenses paid to NCEAS to participate in follow-up analyses of the contest results, as well as in broader discussions of extinction risk assessment. *PK*

Putting cutting-edge science into conservation practice

David Smith, who invented a bacterial meningitis vaccine and then founded a company to distribute this vaccine (Praxis Biologics), donated funds a few years ago to establish a unique postdoctoral fellowship program with The Nature Conservancy. This program, now in its third year, has just announced a call for new applicants (<http://www.smithfellows.org>), with an application deadline of 1 February 2002. The Smith Fellows Program is looking for recent PhDs who are committed to improving the connection between basic biological research and on-the-ground conservation. At least five new fellows will

be selected this year, with an emphasis on 'conservation by design'.

The guiding vision of conservation by design (<http://www.nature.org/cbd>) is the recognition that environmental groups have typically focused on opportunism, advocacy and reaction, with little attention paid to developing a thoughtful strategy that could direct conservation efforts in the most effective manner possible. In a world of limits, it is irresponsible to pursue conservation as though money does not matter, and as though difficult decisions about priorities can be avoided. Whereas it is relatively easy to point out the many risks and threats to biodiversity, there are tremendous scientific challenges associated with using basic ecology to help set conservation priorities and identify effective strategies. *PK*

Swedish Government funds major research into reproductive ecotoxicology

Scientists have increasingly cautioned that chemical exposures that appear safe in terms of mortality studies could severely impair human and wildlife reproduction. For example, low doses of common chemicals, such as plasticizers (e.g. phthalates), disrupt spermatogenesis in laboratory rodents. In the wild, biologists have seen profound gonadal abnormalities among alligators hatched from eggs containing DDT metabolites. Even humans could have some cause for concern, because some

researchers hypothesize that the well-documented recent declines in male sperm production (such as in Denmark) could be due to widely distributed reproductive toxins. Unfortunately, most chemicals on the market have not been tested for their potential impacts on animal reproduction.

Recognizing the need for broad testing of possible chemical reproductive toxicity, the Swedish Environmental Protection Agency (EPA) has awarded US\$3.3 million to the Centre for Reproductive Biology in Uppsala (<http://www.cru.slu.se/>). The scientific goals of the newly established ReproSafe program include the development of test systems for assessing reproductive toxicity, as well as sensitive indicators of alterations

in the reproductive performance of wildlife. In addition, the ReproSafe program intends to provide advice to the Swedish EPA and to serve more broadly the European Union as governments attempt to develop policies that address the insidious risks of reproductive toxins. *PK*



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Letters

All mycorrhizas are not equal

In a recent Opinion in *TREE*¹, Van der Putten *et al.* present a thought-provoking critique of the interactions between aboveground and belowground organisms, highlighting the complexity of the interactions involved. However, for mycorrhizal fungi, we believe that the complexity is far greater than that described. Appreciating the complexity of these interactions is crucial if the paper is

to be successful in one of its aims, namely identifying areas for future research.

First, it is important to distinguish between different types of mycorrhiza. For example, ectomycorrhizal and arbuscular mycorrhizal (AM) fungi might have different effects on plant morphology and physiology² and, as a consequence, their interactions with insect herbivores might also differ³. Effects of AM fungi on host plants might not always be positive, as Van der Putten *et al.* seem to imply, and there are many examples of AM fungi acting as plant antagonists⁴.

Second, we believe that a problem with many previous mycorrhizal-higher trophic-level organism experiments is that the system studied might not have been representative of field conditions. Indeed, most AM-collembola experiments have simply selected organisms that are easy to culture⁵. A crucial point, which is not stressed by Van der Putten *et al.*, is that future experiments must involve combinations of organisms that are known to co-occur in the field. Few such experiments exist and many more are needed⁶.

Third, it is imperative that we recognize that different mycorrhizal species can have different effects on insects and plants and also that herbivores can have different effects on different mycorrhizal species. Herbivory can dramatically change the species composition of ectomycorrhizal communities, even that of nondefoliated neighbouring plants⁷. If such effects also occur with AM fungi, then herbivores could indirectly alter the species richness of plants in natural communities, because plant species diversity is linked to AM fungal diversity⁸.

Fourth, although agreeing that mycorrhizal effects might be mediated through plant defence, we believe that AM effects on pathogens are better known than Van der Putten *et al.* suggest⁹. These effects are likely to result from changes in the availability of carbon and it has been shown that AM effects on insects can be explained by the mycorrhizal-induced production of carbon-based defences¹⁰.

In summary, we completely agree that there are important gaps in our understanding of multitrophic interactions. However, we urge future workers to use realistic experimental systems, so that these gaps are filled by meaningful information.

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All mycorrhizas are not equal

Response from Van der Putten, Vet, Harvey and Wäckers

Gange and Brown¹ argue that, in our recent Opinion in *TREE*² on aboveground–belowground multitrophic interactions of plants, herbivores, pathogens, and their antagonists, we did not completely address future research issues or explicitly advocate the use of real species assemblages in research on multitrophic interactions.

Current exciting developments on above- and belowground interactions involve various groups of organisms (nematodes, plant pathogens, insects, parasitoids, mycorrhizal fungi, etc.) and our paper² had two aims. The first was to bring the approach as outlined by Price *et al.* (1980)³ below ground. Price *et al.*³ argued that including predators would improve our understanding of interactions between plants and their herbivores. This approach has become successful above ground, but has rarely been adopted by soil ecologists. The second aim was to provide a conceptual framework with which to understand how plant species might interact with aboveground and belowground herbivores, plant pathogens, and their antagonists throughout their life history. We argued that this leads to interaction strengths and selection pressures that might vary in space and time.

Information on the effects of arbuscular mycorrhizal fungi on plant defence is indeed increasing rapidly⁴; however, this

is also the case in, for example, free-living rhizosphere bacteria (e.g. *Pseudomonas* spp.)⁵ and endophytes (e.g. the genus *Neotyphodium*)⁶, and an exhaustive review was not the purpose of the article². Nevertheless, for natural ecosystems, the number of examples of antagonists against soil pathogens is still very limited⁷ and mechanistic explanations are only provided as an exception to this⁸.

Gange and Brown¹ emphasize that multitrophic interaction studies should involve combinations of organisms that are known to co-occur in the field and we fully agree with this. Investigations often begin with occasional combinations of species, or from cultures purchased from commercial suppliers⁹. Nevertheless, the use of real species combinations is actually an inherent part of the conceptual framework as advocated in our paper². In addition, we have also stressed the importance of considering the sequential occurrence of the different species involved². For example, the outcome of interspecific interactions between root-feeding nematodes is known to be highly determined by the order of appearance of the individual species¹⁰.

In conclusion, we concur with Gange and Brown¹ about the importance of using natural systems for multitrophic interaction studies, but our aim was not to provide a detailed overview of each species or interaction involved. Instead, we have provided a workable framework for understanding aboveground–belowground linkages of multitrophic interactions[†].

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