recruitment responses were incorporated into a simple stochastic demographic model to predict likelihoods of localized extinction of natural species populations from their current densities listed as 0.2 km² point locality records in a Protea Atlas Database. Seven of the eight Proteaceae species tested exhibited diminished seedling recruitment, both in absolute amounts (total germination) and rate (germination vigour), under the experimentally enhanced soil temperatures. However, seedling masses were increased, an outcome of less intense intra-specific competition between individual seedlings resulting from smaller population densities linked to the diminished seedling recruitment with experimental warming. The demographic model predicted comparatively less severe climate warming impacts on Proteaceae species distributions and a different perspective on these than those projected by bioclimatic models encompassing the entire plant life cycle. It forecast the disappearance over 5 fire cycles spanning an approximate 50 to 100 year period of predominantly low density populations currently occurring in relatively consistent though mostly small fractions (≥17% of total populations) throughout species distributions ranges. The consequences of which would be increased fragmentation of already disjointed Proteaceae species populations with only minor (≥5%) contraction in their overall distribution ranges. It is concluded that the demographic model applied could supplement the bioclimatic model approach by providing an empirically based means of identifying which Proteaceae species populations at precisely specified locations are at greatest risk of disappearing with climate warming so appropriate mitigation measures can be considered.

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Molecular phylogeny supports model of bulb evolution in southern African Oxalis: Morphological and taxonomic implications

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Oxalis is virtually unique amongst the non-monocot angiosperms in exhibiting a true bulbous growth form; both southern African and South American members of the genus display this trait. Bulbs of the southern African taxa differ from their South American counterparts in that their leaf bases have lost petiolar and laminar extensions, and their above-ground plant organs are borne on a seasonal rhizome. Recent morphological and anatomical studies focusing on the bulbs of the southern African taxa have clarified the identities of many underground structures, and have allowed a model of bulb evolution to be proposed. This model allows for the typical angiosperm stem and leaf architecture of oxalidaceous relatives to be successively transformed into the bulb structures present in South American and southern African species. It successfully explains the major differences between these bulb types and utilizes a diversity of extant underground structures as putative intermediates. Moreover, patterns of relationships evident in recent DNA-based phylogenetic reconstructions of the genus Oxalis are highly congruent with the steps implied by the model. These patterns support a single origin for the bulbous growth form in the genus, and a close relationship between the South American and southern African taxa. The proposed model has important implications for the tremendous morphological diversity present in the southern African species, where the above-ground architecture between closely-related (and even within) species can be radically different. Numerous species have an above-ground stem—leaf arrangement analogous to that of the bulb, and several taxa bear bulbils in the axils of the leaves. These characters are considered evidence for the co-opting of the typical bulb architecture onto above-ground structures. Such a mechanism would also explain the

From jelly beans to jumping genes — Application of biotechnology in conifers

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Conifer biotechnology has been implemented in many of the most commercially important forest tree species worldwide using techniques such as in vitro clonal propagation, microarray technology, synthetic seed technology through to genetic modification. South Africa is classified as a water-scarce country due to an average annual rainfall of approximately 450 mm/annum. Intensive forestry requires 800 mm/annum or more. This has directed the attention of the South African forestry industry towards quality product-based selection rather than exploitation of natural resources and indigenous forests. The integration of biotechnology has the potential for molecular tree improvement; as well as assisting in plantation site constraints, and in making milling processes more efficient and environmentally-friendly. This paper will serve to review recent advances in forest biotechnology, which have culminated in progress relevant to the South African forestry industry.

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variability and unreliability of stem–leaf arrangements in elucidating phylogenetic placement in *Oxalis*.

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**Effects of climate warming on the distributions of invasive European annual grasses: A southern African perspective**

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Threats posed by invasive European annual grasses to ecosystem function have received little attention with protocols for prioritising these invasive species and likely future dimensions of their spread urgently required. Here we modelled their potential distributions and shifts in distribution ranges in southern Africa under current and future climate scenarios applying BIOMOD which integrated a variety of parametric statistical and non-parametric rule based models. These were applied to digitised point distribution records of 29 invasive grass species to predict their current and future distributions applying six environmental variables relevant to their physiological function and survival. Correspondence between modelled and recorded distributions was excellent in 12 C3 species, good in 11 C3 species and fair in 4 C3 and 4 C4 species. Mean temperature of the coldest month was the main environmental constraint for C3 species, which concurred with floristic analyses of large-scale patterns of grass distributions in South Africa and other countries. Mean annual temperature, mean temperature of the warmest month and mean annual precipitation were of comparatively equal importance as environmental constraints for C4 species. Modelled future distributions of the invasive grasses under A2-High (4.5 °C increase) and B2-Mid (2.5 °C increase) climate scenarios indicated range contractions in all C3 species, except Briza minor. These were accompanied by shifts in species distribution ranges into higher altitudes, those of greater than 20% in magnitude apparent only in *Avena sativa* and *Lagarus ovatus*. All C4 species displayed habitat loss of relatively similar magnitude with climate warming and shifts in their distribution ranges into higher elevations also. These findings infer that climate change will hinder the spread of invasive European grasses in southern Africa, though shifts in their distributions into pristine areas at higher elevations could pose a threat to the natural vegetation by altering fire regimes.

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**Co-differentiation of pollinator and plant populations in a long-tongued fly pollination system (*Moegistorhynchus longirostris*: Nemestrinidae)**

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The co-divergence of pollinating insects and flowering plants is thought to have been a key process driving the diversification of insects and angiosperms, but there is very little evidence for this process at the level of populations. While many studies have demonstrated how plant populations diverge through adaptation to different pollinator species, data on the reciprocal adaptation of pollinators to plants is lacking, leaving the diversity evident in clades of specialized flower visiting animals unexplained. Here we show that the geographical pattern of variation in proboscis length in the long-tongued fly *M. longirostris* matches the pattern of infraspecific variation in the nectar tube lengths of its host plants, suggesting that pollinator and plant are in the early stages of co-differentiation. This evidence of population level co-differentiation complements larger scale phylogenetic studies which suggest that plants and their pollinators might be radiating together.

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**Pollination of southern African species of *Plectranthus* (Lamiaceae) by flies with moderate proboscis lengths (Acroceridae, Tabanidae and Nemestrinidae)**

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Recent work on the pollination of southern African species of the genus *Plectranthus* revealed specialised lines of pollination of straight, long-tubed species by long-proboscid nemestrinid flies (proboscides up to 30 mm long), and sigmoid-tubed species by long-proboscid bees and nemestrinid flies with moderate proboscis lengths (up to 10 mm long). The remaining species of *Plectranthus* consist of a group with shorter, straight tubes that are pollinated by more generalist bees and flies, with proboscis lengths that generally vary according to the tube length of each species. The flies are of particular interest, since three families, the Acroceridae, Tabanidae and Nemestrinidae, are involved. These flies have proboscis lengths that match those of pollinating bees in certain cases, and there is some overlap with flies associated with long-tubed and sigmoid lines of floral specialisation. This paper aims to explain some of the patterns observed in proboscis length in this