How do germination responses to smoke relate to phylogeny, growth form, fire response strategies and vegetation type? A focus on eastern Australia

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Background

It has been known since the 1990's that exposure to smoke promotes seed germination in some species. Smoke has been shown to affect timing and success of germination, as well as seedling vigour, in native, weed and commercial species. In contrast, smoke can also inhibit germination in some species. An understanding of regeneration responses to smoke is critical for the management of threatened plant species and vegetation communities under changing climate, including increased fire frequency.

How widespread are germination responses to smoke?

Most of the research on germination responses to smoke has been conducted in Western Australian, South African fynbos, Californian chaparral, and Mediterranean matorral ecosystems. In comparison, very little is known about germination responses to smoke for eastern Australian species. Additionally, we know almost nothing about patterns of smoke-promoted germination in relation to phylogeny, growth form, vegetation type and fire response strategies (obligate seeders vs resprouters). We are also interested in the effectiveness of different smoke treatments in eliciting germination responses. Common treatments include aerosol smoke, smoke water (made by bubbling aerosol smoke through water), and karrikinolide (KAR1, a chemical compound identified by Flematti *et al.* 2004 as an important component of smoke that plants are responding to). Less frequently used smoke treatments include ash/charate and glyceronitrile. Understanding some of these broad-scale patterns in germination responses to smoke would enable conservation practitioners to incorporate knowledge about smoke-responsive germination into their management practice.

Aims of this project

This project investigates patterns of smoke-promoted germination both internationally and with a focus on eastern Australian flora, to examine relationships between smoke response and phylogeny, growth form, fire response strategies and vegetation type.

Approach

Seed banks associated with botanic gardens are untapped resources of germination trial data that often include smoke treatments. Working together with the Australian Seed Bank at the Australian Botanic Garden Mount Annan, we organised access to this hard copy data to inform our study. We have now compiled and digitised these data.

We have also obtained data on smoke-responsive germination from a recent review of the global smoke germination literature (Jefferson, Pennacchio & Havens-Young, 2014). A subset of this global dataset pertaining to south-eastern Australia has been created, and combined with the Seed Bank data. This larger dataset will be used to investigate how smoke-promoted germination relates to the variables previously mentioned, with a south-eastern Australian focus. At a later stage we will also investigate how these variables relate to smoke-responsive germination in the global flora.

The dataset

The dataset made up of the Mount Annan Seed Bank data and the south-eastern Australian subset of the Jefferson, Penacchio & Havens-Young (2014) dataset contains 377 entries from 46 sources (journal articles, or seed bank germination trial data), comprising 298 species from 60 families and 173 genera. Of the 298 species in the dataset, 138 have more than one entry, meaning that it will be possible to investigate different factors that might result in a positive or negative response to smoke (different types of smoke treatment, different pre-treatments, different incubation temperatures and so on).

Of the different types of smoke treatment, 132 entries record responses to smoke water, 220 to aerosol smoke, 11 to karrikinolide, and 5 to ash/charate. No studies in this dataset used glyceronitrile.

The majority of the dataset comprises entries from woody (169 entries) and herbaceous (116 entries) species, followed by graminoids (77 entries), with one succulent and one climber.

The best represented habitats in the dataset are "Woodland/forest/shrubland/heath" with 250 entries, followed by "Aquatic/wet" with 31 entries, "Rainforest" with 18 entries, "Arid/dry/rocky/sandy" with 11 entries, "Diverse/widespread" with 7 entries, and "Grassland/herbfield" with 3 entries.

Of the 377 entries, 181 record a germination response to smoke treatment. Of these, 13 entries recorded reduced germination in response to smoke, and 168 entries recorded a positive germination response to smoke.

A first look at smoke germination responses according to the type of smoke treatment suggests that, within our south-eastern Australian dataset, more species may respond to aerosol smoke than to smoke water (Figure 1). Other types of smoke treatment (karrikinolide, ash/charate, smoked filter paper and glyceronitrile) have been much less commonly used (Figure 1).

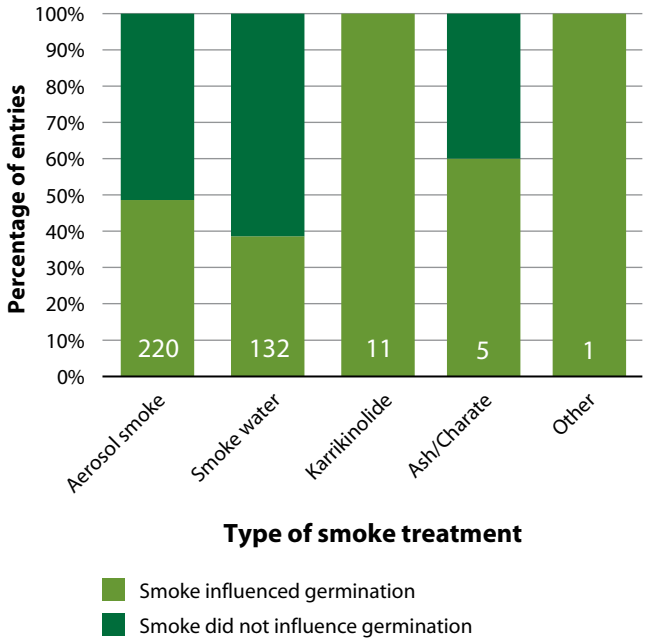

Figure 1. Percentage of dataset entries showing germination responses to smoke (grey bars), according to smoke treatment applied. Germination responses to smoke could be either positive or negative, although by far the majority (168 out of 181) were positive. Numbers at bottom of bars show the number of entries in each smoke treatment category. The Other smoke treatment was smoked filter paper.

Next steps

Detailed data analysis aimed at answering our research questions, and looking for the patterns that best predict smoke-responsive germination in eastern Australian flora is currently underway.

Outcomes

The research outputs will be published as peer reviewed journal articles, and the dataset associated with this project will be made freely available to the public through a web-based portal at https://pirel.wordpress.com/datasets/. We intend that anyone interested in the conservation and management of natural areas can access and use this dataset to inform their work.

We hope it enables the incorporation of smoke-promoted regeneration into vegetation management in eastern Australia, and helps to promote the cultivation of eastern Australian plants.

References

Flematti, G.R., Ghisalberti, E.L., Dixon, K.W. and Trengove, R.D. (2004). A compound from smoke that promotes seed germination. *Science* **305**, 977-977.

Jefferson, L., Pennacchio M. and Havens-Young, K. (2014). *Ecology of plant-derived smoke: its use in seed germination.* Oxford University Press.