Overview - Background

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Successful long distance dispersal
Successful dispersal of organisms by wind has three phases: uplift, movement and survival within the wind column, and deposition and subsequent establishment.

![Wind dispersion diagram]

Biosecurity and wind dispersal

* Biosecurity is broadly defined as the protection of the economy, environment and society from negative impacts associated with the entry, establishment and spread of exotic organisms. Organisms include weeds, pests, diseases and disease-vectors. It might also include entry of new genotypes of organisms that are already in the country, such as pathotypes or insecticide-resistant genes.

* Biosecurity activities occur along a continuum, from pre-border, at-border to post-border, and from preparing for potential incursions through to responding and ultimately adjusting to new incursions and endemic pests.

* Organisms can enter a country, and subsequently spread, by a range of pathways including human-assisted dispersal and natural dispersal by wind and water.

* Understanding pathways is an important step to preparing for and responding to potential incursions. For wind this includes:
  - Knowing whether entry through a particular pathway is inevitable. In some cases the right preparations can be made, for example by ensuring crop cultivars are available that are resistant to the anticipated pest.
  - Knowing where source regions are geographically if pests are to arrive by wind, and then where and when they would arrive. This can guide surveillance activities. In some cases it may also be possible to manage source populations of the pest (such as through biocontrol) to minimise the risk of wind-borne spread, or to minimise the risk of establishment (such as avoiding extensive planting of susceptible hosts).
  - Understanding the consequences of large-scale changes in land use patterns. For example, what are the biosecurity implications of the proposed intensification of agriculture in northern Australia? Would the establishment of niche grain industries increase the risks to major grain-growing regions in other parts of Australia?
  - When a new pest incursion has been detected within a jurisdiction, test whether wind was a likely pathway, and determine the potential source. Understanding the history of incursions through “back-casting” can help prevent or prepare for new incursions.
  - When a new incursion has been recorded, determine where else it could already be, and identify new areas that are most at risk. Mapping at-risk areas are critical for guiding incursion responses, including surveillance, monitoring and delimiting response areas.
Many endemic pests are wind-dispersed, so anticipating seasonal dispersal can help prevent or manage subsequent impacts. Wind dispersal remains a relatively poorly understood pathway. Improved understanding of wind dispersal more generally will better equip the biosecurity system for dealing with wind-borne threats into the future.

Application of wind modelling approaches to study and help respond to wind-borne biosecurity threats has had a long history, but prior to TAPPAS has required considerable resources in terms of time, computing and expertise.

Biosecurity and wind dispersal: history

- Computer modelling of wind dispersal of pests and diseases commenced with the advent of atmospheric circulation models and particle dispersal models in the 1970’s. HYSPLIT was one of the early models developed. It was first released in 1982.

- Exponentially increasing computing power, increasing sophistication in atmospheric circulation models and more empirical data against which to fit and tests these models, means that precision and accuracy is continually improving.

- Very recent biosecurity applications of wind dispersion modelling are starting to consider diffuse source populations, survival in the air column, and to incorporate biology of the organism.

- TAPPAS is the first web-based platform to allow main-stream users to conduct such analyses and for those analyses to be done fast enough (hours and days) to inform incursion responses in real time.

TAPPAS Architecture

The basics:

- TAPPAS is a web application that provides a visual interface to simulate passive wind dispersal of organisms.

- It allows users to access the power of the high performance computing needed to undertake complex scenarios.

- When conducting a scenario the user enters values or accepts default values for various attributes that are specific to that simulation. These attributes are then transformed into a JSON string that is parsed to the Australian Bureau of Meteorology HYSPLIT API (Application Programming Interface) and starts the running of HYSPLIT on a high-performance computer located at the National Computing Infrastructure (Canberra, Australia).

- HYSPLIT output is created initially in a binary file which is then transformed to a NetCDF and a zipped KML. Data is retrieved by TAPPAS, and linked to a PostgreSQL database for later retrieval.

- Within TAPPAS users can retrieve previously run simulations and view these within an OpenLayers map window. Results can also be overlaid on other spatial data layers (such as land use) to help visualise and interpret outputs. These extra layers are stored within PostgreSQL and are also accessible via a WMS published using Geoserver.

Where possible we have used open source software as the framework to TAPPAS.