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Plant biosecurity policy-making modelled on the human immune system: What would it look like?

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ABSTRACT

This paper takes inspiration from the field of bio-mimicry to suggest what a plant biosecurity system might look like if it was modelled on the human immune system. We suggest structural and institutional changes to current biosecurity systems that would facilitate adaptive preparation and response policies, focusing particularly on the Australian plant biosecurity system. By improving information exchanges, interpretation and managing overlapping complementary response capabilities of this system, novel policies emerge that increase resilience to harmful weeds, pests and diseases. This is achieved by adding an element of flexibility in invasion response to cope with different circumstances and contexts, rather than a 'one size fits all' approach. While we find bio-mimicry to be a potentially useful system design tool, there are key differences between the immune and biosecurity systems that the analogy makes clear. Perhaps the most important of these stems from the inability of immune systems to imagine future threats.

1. Introduction

Analogies and metaphors provide an invitation to view objects as if they were something more familiar, and through the resonance of possible connotations new contextual meaning is created (Lissack, 1999). While past use of the analogy between social ecological systems like biosecurity systems and human immune systems has been made to point out similarities and differences between systems (Janssen, 2001; National Invasive Species Council, 2001), little insight into new and improved biosecurity governance structures has been forthcoming. The term biosecurity is used here to describe systems that prevent the spread of invasive alien species (IAS) throughout the world, where IAS are species with a perceived or measured net negative effect on social welfare (Cook et al., 2010). Like the immune system, a biosecurity system is a constellation of responses to external attacks comprising of

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many facets, a number of which can change to optimise the response to these unwanted intrusions. When the wrong target is hit, or a response is excessive or inhibited somehow, the consequences for the body or the economy can be dire.

There is a lot to like about the analogy. While the immune system is a network of cells, tissues and organs that work together to defend the body against invasion, a biosecurity system relies on networks of *components* to defend land areas from IAS. The components range from individual land managers and communities to large institutions and governments which represent and govern the behaviour of large numbers of individuals. The human body provides an ideal environment for many microbes, and it is the job of the immune system to keep them out or, failing that, to seek out and destroy them. In fulfilling these functions, both systems must maintain reactive and adaptive capacities to minimize the damage caused by invaders, while at the same time providing the highest levels of protection to other areas of the body or the economy.

In this paper we take a step beyond analogy towards the science of bio-mimicry which analyses natural structures and adapts them for human applications (Benyus, 1997). Given the complex environment in which IAS prevention and response policies are formulated, we discuss how the study of immune system design and function suggests institutional features that might deliver improved plant biosecurity policies. Firstly, we provide a description of the current linear, or 'top-down' Australian plant biosecurity system in relation to plant pests and diseases. We then discuss what changes would be required to change this to a more adaptive system with components resembling those of the human immune system. Finally, we point out key differences between the immune and biosecurity systems that are made abundantly clear when we use bio-mimicry as a plant biosecurity system design tool.

2. The current Australia biosecurity system

The Australian biosecurity system involves the coordination of actions across a continuum of pre-border, border and post-border quarantine components that attempt to achieve the largest trade and societal benefits for the least IAS cost. That is, it must manage the potential risks of IAS incursions and spread while at the same time acknowledging the benefits of trade in IAS-host commodities. This is increasingly difficult with continued improvements in freight and passenger transport technologies and the expansion of world trade. Indeed, natural and agricultural ecosystems throughout the world are being invaded by a growing number of destructive IAS, many introduced as a result of trade (Levine and D'Antonio, 2003; Waage et al., 2005). It has been estimated that Australia accumulates 20 new species of arthropods, weeds and diseases every year despite a reputation for diligence in IAS risk management (Lonsdale et al., 2001).

Economists regard IAS incursions as 'negative externalities' of trade. An externality is a particular form of *market failure* where the full cost of an activity is not incurred by those undertaking it. So, while consumer society may benefit from relatively cheap imported food products, they unintentionally create a pathway for IAS to enter and cause damage to domestic industries and ecosystems. The market 'fails' because the value of this (potential) damage is not reflected in the price of imported goods. Importers are not liable for damages incurred and so are not obliged to recover compensatory costs from consumers via price increases despite the potential for severe economic, environmental and social consequences of IAS incursions.

The impacts IAS have on *market* goods, such as host agricultural commodities with known prices, are the most readily quantified invasion consequences. They include direct effects like yield loss and cost increases, as well as indirect effects such as lost export market access. *Non-market* consequences of IAS are more difficult to value. Environmental, social and cultural assets, for instance, have no price information from which to infer impact value. If there were a price for these type of assets, it would need to reflect both use values (such as recreation values) and non-use values (such as existence, bequest and moral values transferred between generations) (Mumford, 2001). To make matters more complicated, unlike agricultural IAS impacts that tend to increase in an obvious fashion (incrementally or exponentially) within production systems, non-market effects may go unnoticed for long periods of time before exploding into the social consciousness. By this time the damage may be irreversible (Cook et al., 2011).

Despite the complications of IAS impact measurement, the notion of risk management underpinning the pre-border and border biosecurity system components is to ensure the expected level of avoided damage does not exceed an agreed standard. This standard, known as the acceptable level of protection (ALOP), is not set at zero. Even in a perfectly self-sufficient system where no trade takes place at all, a biosecurity system cannot possibly guarantee that zero IAS incursions will occur. Fungal spores, insects and even some vertebrate pest species can be transported vast distances on wind and ocean currents. Moreover, even if trade pathways were the sole determinant of IAS risk closing off all trade pathways would have large consequences for the economy. The modern economic system increasingly relies on consumption goods and production inputs being sourced from relatively cheap producers from around the world who have a comparative advantage in their production. Hence, the ALOP involves a positive amount of IAS damage deemed 'acceptable'.

Australia's ALOP has been ambiguously described as 'very low', or 'very conservative' (Kahn et al., 1999; Tanner, 2001), meaning that there only needs to be a very low likelihood a prospective import contains an IAS for it to be refused entry. This vague interpretation allows some flexibility in the measures that may be imposed on imported products before they are declared safe to enter the country by the Australian Government's Department of Agriculture (DoA), which conducts import risk assessments (IRAs) in response to applications from overseas countries wanting to export products to Australia. It then recommends entry conditions in accordance with the World Trade Organization's (WTO) agreement on the application of sanitary and phytosanitary measures, or SPS agreement (GATT, 1994), that lower the risk of IAS entry and establishment to a level corresponding to Australia's ALOP. Once these conditions have been established a separate part of