Biosecurity frameworks for cross-border movement of invasive alien species

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Abstract

This article examines the policy background and legislative frameworks underlying the regulation of transboundary movement of potentially invasive alien species (IAS). The starting point is the examination of the fundamental regulatory concepts for IAS that are found in (1) the International Plant Protection Convention (IPPC) (in accordance with the World Trade Organisation's *Agreement on the Application of Sanitary and Phytosanitary Measures*, 'SPS Agreement') and (2) the Convention on Biological Diversity (CBD), together with a discussion on whether IAS are legally regarded as 'pests'. How these concepts are applied in different transboundary situations is then examined with examples from within federal jurisdictions (USA, Australia) and across external and internal boundaries in transnational jurisdictions (European Union and Eurasian Economic Union). Special attention is paid to IAS in aquatic environments and the question of naturalisation of once alien species. The article concludes with suggestions for development of future policy on IAS taking into account the degree of effectiveness of present regulatory frameworks and the need to consider the impact of climate change on future threats from invasives. *173 words*

Keywords
Invasive alien species, pests, transboundary, regulation

1. Introduction and background

This paper, based on a review of the literature and relevant legislation, explores the background to current concern about alien invasive species and explores six related questions that inform the developing narrative on their regulation and the future development of policy:

(i) Is there sufficient political imperative to implement biosecurity effectively to regulate trade in plants that are potentially invasive;

(ii) can the authorities respond quickly enough to limit the spread of IAS once reported in their territories;

(iii) can invasive 'plants as pests' be effectively regulated as quarantine pests or should there be a third new *sui generis* category of regulated pest under the IPPC, that of 'invasive organism';

(iv) to what extent can plant health measures deal with invasive species that are not plants, such as vertebrate and invertebrate species grazing on plants; and

(v) to what extent will species currently regarded as invasive adapt to their new home and naturalise without permanent environmental degradation (but still be subject themselves to introduced pests);

(vi) to what extent can IAS be predicted in the face of changing environmental conditions from climate change?

The overall aim is to comment on the policy development needed to address these scientific and technical issues.

Following Copp *et al*. (2005) we have adopted the following definitions: invasive organisms means native or alien species that spread, with or without the aid of humans, in natural or semi- natural habitats, producing a significant change in composition, structure, or ecosystem processes, or cause severe economic losses to human activities; alien (synonymous with non-native, non-indigenous, exotic) refers to a species, sub-species, race or variety that does not occur naturally in a geographical area. The definition of (plant) pest is taken from the 'Glossary of Phytosanitary Terms' (FAO, 2017): any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products. Copp *et al*. 2005 have discussed how invasive species and pest are mutually exclusive concepts.

Starting with an exploration of the status of alien organisms and the risk assessment of invasiveness, the article then examines problems arising from deliberate introductions of alien organisms. This part of the article is supported by supplementary material in boxes on these topics.

The main body of the article will then examine the extent to which biosecurity frameworks have been successful in the regulation of plant pests including invasive

species in trade across continents. This includes movement of goods across national borders and across internal borders in federal jurisdictions (USA, Australia) as well as within transnational entities (European Union, Eurasian Economic Union). (Figure 1.) Recourse will be had to information on the regulation of quarantine pests in the narrow sense in border transactions where no action specifically on invasive species has been taken. The article concludes by offering answers to the questions posed above in order to facilitate policy development on IAS regulation.

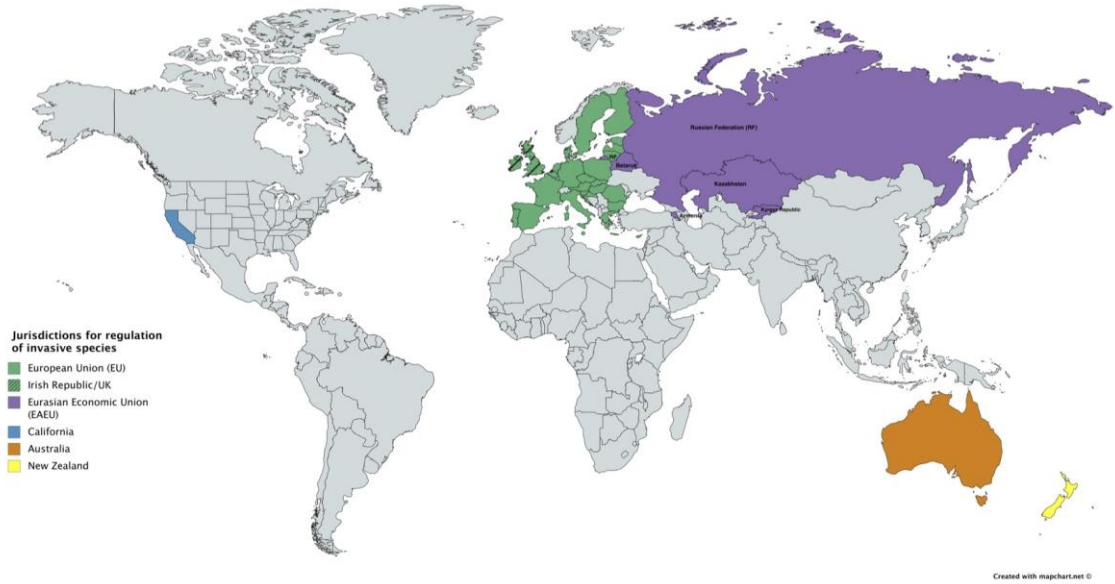

Figure 1. Jurisdictions for regulation of invasive species considered in this article.

1.1 Alien status and risk assessment

This article examines the development of policy and legislation in biosecurity frameworks regulating transboundary movement of invasive alien species (IAS). The context is national and state boundaries within federal jurisdictions (USA and Australia), and boundaries between members of a transnational economic union (European Union, Eurasian Economic Union). The regulations pertaining to these matters have their origin in two different approaches to the designation of potentially alien status. First, there is the World Trade Organisation's Agreement on the Application of Sanitary and Phytosanitary

Measures ('SPS Agreement') and its trade-related 'sister' the International Plant Protection Convention (IPPC). The basis in the SPS Agreement is the requirement that sanitary and phytosanitary (SPS) measures to regulate imports of goods in international trade must be based on international standards or be justified by 'scientific evidence' (Article 2 of *SPS Agreement*) and risk assessment (Article 5). In this approach, organisms that are potentially invasive are regarded as pests and the status of 'regulated pest' requires risk assessment. Correspondingly, the 1997 version of the *International Plant Protection Convention* (IPPC) currently in force was a revision for consistency with the *SPS Agreement* and adopted pest risk analysis (PRA) to meet the requirements of Article 5 of the SPS Agreement. By concordance between the IPPC and the Convention on Biological Diversity (CBD), there is a unified approach to pest risk analysis (PRA) in the International Standard for Phytosanitary Measures (ISPM) no. 11 covering 'quarantine pests', organisms that are considered as 'environmental risks' and genetically modified organisms (see Box 1).

Plant health differs from food safety and animal health in the biosecurity/SPS sphere in that there are no 'standard' organisms that are universally recognised as harmful to plants in contrast to harmful food-borne microorganisms like *Salmonella* or animal pathogens like foot and mouth disease virus. Instead, each national territory or supranational biosecurity area like the European Union has, or should have, its own list of *regulated pests* that are the only plant pests that may be regulated by SPS measures (see Box 1). This follows from the virtually countless number of plant species that are the potential target of an even greater number of potential pests. By contrast only a defined and relatively limited number of species of harmful organisms are subject to feed, feed safety and veterinary provisions to protect humans, livestock and related wild animals. (Only terrestrial animal diseases are being considered at this point. The situation is more complicated with aquaculture and aquatic wildlife, to be considered later.)

Link to Box 1

By contrast, in many jurisdictions invasive alien species are not regarded as 'pests' in the IPPC sense but assigned a risk status in their own right. In this context, the CBD does not require sovereign states to do risk analysis to demonstrate that a given alien species poses a threat to its biological diversity before imposing restrictions. Rather, the CBD in the

Preamble adopts a precautionary approach to threats to biological diversity rather than adopting the risk assessment approach according to the SPS Agreement. The difference between the WTO's risk approach to trade regulation and the precautionary approach to introductions of organisms into a national territory adopted in the CBD remains largely unresolved.

Link to Box 2

1.2 Problems arising from deliberate introductions

In this section, two further aspects of these contrasting concepts are emphasised while providing examples of problematic introductions of alien species. First, whereas plant pests in the original narrow sense of pests of cultivated plants are almost always introduced into a new territory unintentionally (even in the case of smuggled commodities), invasive plants are usually introduced by deliberate human actions. This also applies to vertebrate and invertebrate animals that were introduced deliberately as pets, livestock or for commercial benefit but that subsequently damaged habitats or reduced biodiversity (Black and Kireeva 2009). Second, that plants may be pathways for other plants as pests, as in the case of weed seeds contaminating food grains and seeds for sowing, as well as pests in the narrow sense (Bryson and Carter, 2004).

Certainly, the taxonomically wide range of alien organisms that have had severe environmental impact, catalogued by Black and Kireeva (2009), were introduced without precaution or consideration of risk. Further information is provided in Box 3.

Link to Box

However, in the wider context it is necessary to consider the impact of naturalised plants that have become part of our landscape or adopted in cultivation practices. In some cases, these plants have become subject to pests that were introduced simultaneously or later as illustrated by two examples: sweet chestnut (*Castanea sativa*), native to southern Europe and Turkey and the Caucasus, is now at risk from chestnut blight (Forestry Commission 2017a) and oriental chestnut gall wasp (*Dryocosmus kuriphilus*) (Forestry Commission 2017b); and horse chestnut (*Aesculus hippocstanum*) from horse chestnut leaf miner (*Cameraria ohridella*) (Forestry Commission 2017c). Further information on the march

of diseases of trees and shrubs (native and introduced) across Europe is available from Black (2013) while information on three specific tree diseases is given in Box 4.

Link to Box 4

So far the discussion has focused on terrestrial environments but special consideration should be given to fresh water and marine habitats because of the ease by which animals and plants can spread through water, applying both to intentionally introduced species that become invasive, and pests and diseases of native organisms. Examples of the former include zander (*Sander lucioperca*) introduced into many countries, including the UK, (NNSS 2018a); the red signal crayfish (*Pacifastacus leniusculus*), introduced into the UK but out-competing the native crayfish (NNSS 2018b; and the Pacific oyster (*Magallana gigas*, formerly known as *Crassostrea gigas*) introduced to replace declining native oysters but with reproduction boosted unexpectedly by climate change, it has naturalised and become a threat to marine habitats (NNSS 2018c).

Link to Box 5

What is clear from the application of PRA is that invasive species (at least those that are plants) are being categorised as pests under the IPPC and accordingly subject to trade regulation. The question remains as to whether biosecurity frameworks that address invasive species can actually be implemented in practice in face of pressure to import plants for intensification and expansion of cultivation with new varieties or higher quality planting material, enhance the landscape and offer greater variety for our gardens. In face of all this is environmental change, with shifting zones of cultivation increasing demand for novel crops and new varieties of existing ones better suited to the changing climate. Also to be taken into account is informal cross-border exchange of plants between communities that are divided artificially by borders. This has certainly led to the spread of quarantine pests, particularly viruses in vegetative propagation material (Akinbade *et al.* 2010; Legg 1999).

2. Border controls in Eurasia between different jurisdictions

2.1 Eurasia as phytosanitary region – European and Mediterranean Plant Protection Organisation (EPPO)

Receiving increased prominence/attention in the 1997 version of IPPC was the role of Regional Plant Protection Organisations (RPPO), intermediate between the Secretariat of the IPPC and official national bodies responsible for plant health (National Plant Protection Organisations in IPPC). RPPOs have no official regulatory function but serve to coordinate activities of the national bodies, provide information and, with some RPPOs, training and other support. One of the most active RPPOs is the European and Mediterranean Plant Protection Organisation (EPPO) covering all of Western and Eastern Europe except Iceland and Montenegro, three countries in North Africa, Turkey, Israel Jordan and, since the collapse of the Soviet Union, five countries Central Asia (Georgia, Azerbaijan, Kazakhstan, Kyrgyz Republic and Uzbekistan). Belarus, Russian Federation, Kazakhstan and Kyrgyz Republic are also members of the Eurasian Economic Union (EAEU, 3.2) along with Armenia (not an EPPO member). EPPO is not to be confused with the phytosanitary activities of the European Union mediated through the latter's various institutions including the European Commission and the European Food Safety Authority (EFSA).

From the early 2000s, EPPO has embraced alien invasive plants as a separate category of potentially harmful organisms and now recommends measures to prevent their introduction and spread via international trade. As well as the EPPO list of invasive alien plants, there is a separate shorter alert list for invasive plants alongside pests in the traditional sense while the monthly newsletter (EPPO Reporting Service) has a separate section for invasive plants alongside 'pests' and diseases. Finally, there is the EPPO Observation List of invasive alien plants that are held to be of lesser risk than the fully established alien species.

The outputs from EPPO demonstrate the benefits of information exchange on pests and invasive species across jurisdictional boundaries. However, this is not to say that the state of information on pest distribution is equally advanced across EPPO. Lack of information may impede trade as will be seen in the case of the EAEU (3.2)

2.2 Phytosanitary measures on imports into the European Union

The foundation of phytosanitary controls of the EU, and all aspects of the EU's farm-to-fork strategy is the single market (‘internal market’ in EU legislation). At present the governing legislation is the 'Plant Health Directive' 2000/29/EC. However, with effect from 14 December 2019, this will be repealed by Regulation (EU) 2016/2031 on protective measures against pests of plants that for the first time adopts the IPPC concepts and terminology of quarantine pest and non-regulated quarantine pest rather than ‘harmful organisms’. In addition, however, and in force already there is Regulation (EU) 1143/2014 on the prevention and management of the introduction and spread of invasive alien species.

As well the exclusions from the definition of invasive alien species (IAS) given in Article 3.2 of Regulation (EU) 1143/2014, the respective scope of the two Regulations is given in Article 1.1 of Regulation (EU) 2016/2031:

> Where there is evidence that non-parasitic plants, other than those regulated under Article 4(1) of Regulation (EU) No 1143/2014, pose phytosanitary risks which would have a severe economic, social and environmental impact on the Union territory, those non-parasitic plants may be considered as pests for the purposes of this Regulation.

Regulation (EU) 1143/2014 derives from the Convention on Biological Diversity (see Introduction) rather than the IPPC, the object being to protect species and habitats from the adverse impact of IAS. This is evident from EFSA's introduction to IAS (EFSA, 2019).

Regulation (EU) 2016/2031 makes distinction between Union quarantine pests/Union regulated non-quarantine pests requiring action at EU level and protected zone quarantine pests whose movement into a protected zone from another area of the EU is to be prevented. Further consideration of protected zones is given in 3.1.

On the other hand, Regulation (EU) 1143/2014 distinguishes [IAS] of Union concern and [IAS] of Member State concern (to be listed according to Article 12) where an individual Member State needs to take action because of the potentially adverse impact on its

territory. Union IAS (European Commission, 2019) are banned from importation unless a permit is issued as a derogation for research or ex-situ conservation or there is 'authorisation for research in exceptional circumstances'. There is no overall ban for IAS of Member State concern, but Member States may place restrictions on these organisms according to Articles 7, 8, 13-17, 19 and 20 provided they are compatible with the Treaty of the European Union. More stringent national rules are also permitted under Article 23. Also of note, however, is the category of [IAS] of regional concern and species native to the Union (Article 11) that Member States may identify from their national lists as requiring 'enhanced regional cooperation'

Apart from the ban on importation into the EU through its external borders, there is a ban on sales, cultivation, propagation, and keeping in aquaria or ponds, where appropriate. Noted, however, is that movement within the EU as such is not prohibited, either for personal or commercial purposes; neither does Regulation (EU) 1143/2014 invoke plant passports or protected zones that feature in Regulation (EU) 2016/2031 (3.1).

Eastern European countries formerly under communist rule that are not already EU member states, including the former Yugoslav countries have been aligning relevant legislation with the EU. Therefore, it is not considered necessary to make special reference to these jurisdictions. This does not apply to countries of the Former Soviet Union (FSU) discussed in the next section.

2.3 Imports into the Eurasian Economic Union (EAEU)

The Eurasian Economic Union (EAEU) is at present developing moves to facilitate trade between third countries that were members of the Former Soviet Union (FSU). However, unlike the former colonies of Western European nations, the newly independent nations of the FSU did not benefit from any consistent post-independence development assistance. Most of these countries joined the Commonwealth of Independent States (CIS) that began to develop common trade rules and standards. Various trade-related groups developed within the CIS but the most significant of these was the Eurasian Customs Union (Black & Kireeva, 2015). The latter evolved into Eurasian Economic Union (EAEU), currently consisting of Armenia, Belarus, Kazakhstan, Kyrgyz Republic and the Russian Federation. The Common Rules and Standards to Ensure Plant Quarantine on the Customs Territory of the Eurasian Economic Union set the union-wide framework for

phytosanitary measures along with common phytosanitary requirements and a Common List of Plant Quarantine Objects of the Eurasian Economic Union (ADB, 2019). These are Technical Regulations (see below) that implement national phytosanitary laws of the EAEU members. However, the EAEU still resembles more of a customs union than a single market like the EU or even Mercosur (Southern Common Market, members Argentina, Brazil, Paraguay and Uruguay).

Arrangements for biosecurity/SPS measures in general and plant health in particular are predicated on the negotiations over the accession of the Russian Federation to WTO. The Russian Federation insisted on adopting Technical Regulations for SPS measures in its post-accession legal frameworks despite the fact that TRs, as per the Agreement on Technical Barriers to Trade, and SPS measures are mutually exclusive (Black & Kireeva, 2015; ADB, 2019). Hence for processed food compliance with TRs is required on matters that are food safety rather than composition and nutritional quality as a legacy of the non-risk-based GOST State Standards (государственный стандарт – gosudarstvennii standart) system. Phytosanitary controls applying to fresh plant produce were never part of the GOST. However, EUAU TRs on common list of quarantine objects common phytosanitary requirements implement national law of the EAEU members while neither national or TRs are necessarily and overtly risk-based (ADB, 2019). The primary concept of quarantine object resembles the EU concept of 'harmful organism' more than the IPPC definition of quarantine pest (Kireeva & Black, 2010). The major technical issue is incomplete and out-of-date information on the distribution of listed quarantine objects; this causes trade problems between third countries and in intra-EUAU trade (see 3.3).

In the Common List of Pests referred to above, 12 plants are listed as pests absent from the territory of the EAEU including parasitic *Striga*. Seven plants are listed as having limited distribution in the EAEU with some of these regarded as naturalised in some countries, indicating they would not be under control, although it is not clear whether any risk assessment was done before according this status.

- *Acroptilon repens* (invasive, but native or naturalised Eurasia), three *Ambrosia* spp. (invasive), *Cenchrus longispinus*, and two *Solanum* spp. as invasive species
- *Cuscuta* spp. (parasitic)

However, there is a much longer list of 'quarantine weeds' in the Common Phytosanitary Requirements, the seeds or planting material of which are not permitted to enter the territory of the EUAU or move within it.

From December 2013, Kazakhstan has been operating 'Green Channels' for import of fresh fruit and vegetables from the People's Republic of China across designated border crossings, in conjunction with other trade facilitation initiatives including the single window. A decision is pending on clearance until the goods arrive at a customs warehouse in the destination city for processing. The “green channel” approach is expected to speed up border processing but aspects of traceability (due to reloading requirements), phytosanitary scrutiny, and food safety controls are not fully settled (ADB, 2019).

3. Border controls within transnational and federal jurisdictions

3.1 EU

With the single market in operation according to the Maastricht Treaty, phytosanitary border controls between Member States were abolished in 1997 and thus phytosanitary certificates are no longer issued for movement of plants and plant products, as required in international trade. To manage the risks of the spread of harmful organisms that are partially distributed within the EU, protected zones have been set up originally by a Directive but now according to Regulation (EC) 690/2008 (as amended) for specified harmful organisms ('protected zone quarantine pests' in new Plant Health Regulation). Certain plants or plant products are prohibited from movement into a protected zone. In other cases, a 'plant passport issued' by an authorised operator (e.g. plant nursery) may be required for movement into a protected zone. Under the new Regulation, the authorised operator is responsible for ensuring absence of quarantine pests, but also non-quarantine regulated pests. Depending on the pest risk, 'movement' may include all movement or commercial operations. (It should also be noted that plant passports may be required generally for movement of specified plant material within the EU, not just in the case of protected zones; Article 79 of Regulation (EU) 2016/2031; Defra, 2019a).

It should be recalled, however, that IAS in the EU are not regarded as harmful organisms in the context of Directive 2000/29/EC or as pests in the context of Regulation (EU) 2016/2031. Plant passports are not required for movement of IAS within the EU. The

prohibition of sale, keeping, etc. is in force but for plants, for example, botanic gardens were required to check whether they hold any collections of listed species. Each national authority (e.g. the Non-native Species Secretariat in the UK) is responsible for monitoring IAS in its territory and issuing appropriate alerts (NNSS, 2019.)

3.2 Protected zones, IAS and Brexit

The island of the Republic of Ireland and Northern Ireland may be considered an area of special plant health significance, particularly in the context of 'Brexit' (the UK leaving the EU on 31 October 2019). An initial approach to the risk assessment of IAS in Europe is detailed in Mumford *et al.* (2010). The governing plant health laws for the United Kingdom of Great Britain and Northern Ireland are the Plant Health (Great Britain) Act 1967 and the Plant Health (Ireland) Act 1967. This separation of statutory authority long preceded devolution in the UK but reflected the geographical isolation of the island of Ireland from Great Britain that was in turn separate from continental Europe. The Island of Ireland as a whole is a protected zone for some pests e.g. *Lyriomyza bryoniae* (a leaf miner affecting tomatoes) without Great Britain being so protected, but there are also protected zones for Ireland and UK as a whole (with or without the Isle of Man and the Channel Islands coming under UK protection). Until 2006 the whole island was a protected zone for *Erwinia amylovora* (fireblight), but with its eradication from the Republic of Ireland in 2006 (EPPO, 2016), this was then applied to some parts of Northern Ireland. However, protected zone status has been removed from Northern Ireland because the disease is now widespread in the province. (Defra, 2018). Individual enterprises may now apply for buffer zone status (Defra, 2019b).

The Plant Health Directive (2000/29/EC) was implemented under the dual authority of s.2. of the European Communities Act 1972 and either the Plant Health Act 1967 (covering Great Britain) or the Plant Health (Northern Ireland) Act 1967. Consistency with the IPPC is actually provided by the Directive's implementation in UK Regulations, not by the 1967 Acts that predate WTO. Defra indicated that the UK would implement Regulation (EU) 2016/2031, already retained law in the EU Withdrawal Bill but not due to be implemented until December 2019, originally after Brexit (UK Parliament, 2018). However, with Brexit delayed until January 2020, the Regulation automatically came into force in the UK. This would ensure consistency of UK plant health legislation with the

IPPC post-Brexit. The Invasive Species Regulation (1143/2014) is already in force and is retained legislation of direct effect.

Many questions remain about the UK's plant health regimes post-Brexit depending on the outcome of departure negotiations. On the assumption that the UK will leave the single market and the Customs Union the most important questions are:

- Will the use of plant passports be entirely abolished for movement of plants between the UK and the EU, to be replaced by phytosanitary certificates (placing an extra burden on the national plant health services of both UK and EU member states)?
- What arrangements will apply to the transfer of plant material between the Republic of Ireland and Northern Ireland?
- Will customs checks be applied for these cross-border transactions?
- What is the future of devolved responsibility for plant health currently held by the agricultural administrations of Wales, Scotland and Northern Ireland?

3.3 Movement within EAEU

The EAEU does not function as a fully integrated single market for the trade in goods between members. Some members of the Union have issued notices of non-compliance with phytosanitary regulations against other members. In June 2017, Kazakhstan announced it was ready to introduce restrictions on the export and transit of plant products from the Kyrgyz Republic because of violation on prohibition against Comstock's mealy bug (*Pseudococcus comstocki*, a citrus pest), oriental fruit moth (*Cydia molesta*) and an unspecified fruit fly (AKIpress 2017. Although there have been only a 'minimal number' of non-compliances with phytosanitary requirements, the Kazakhstan SPS authorities have confirmed their interest in improving effectiveness of movement control of commodities through the Russia-Kazakhstan border in 'order to provide epizootic, phytosanitary and food safety in the countries' (Federal Service for Veterinary and Phytosanitary Surveillance, 2017). It is assumed that these movement controls will mirror the EU's risk-based plant passport system although in the Former Soviet Union and Communist Eastern Europe, movement controls of plant products were as much for economic as for strict phytosanitary control; and they were official controls whereas plant passports are issued by the enterprise under official supervision (co-regulation).

4. Border controls within Federal jurisdictions

4.1 California, USA

Within the USA, California presents an interesting case study on control of pests and invasive species entering from other states because it is surrounded by geographical barriers to the to the north, east, west and an international border to the south. There are strict controls on the import of plants and animals into the state, either as invasives or pathways for pests. This includes rules and guidance for house plants and trees (California Department of Food and Agriculture, 2019). There are border protection stations along highways that bring traffic from neighbouring states. There are powers of inspection for prohibited species but there is no permit system.

However, California is most concerned about aquatic invasives, present in sediment and spread by water and therefore with border measures having limited effect. The most active responses are against sponge plant (*Hydrilla verticillata*) giant salvinia (*Salvinia molesta*), alligator weed (*Alternathera philoxeroides*) and water primroses (*Ludwigia* spp.). Other less serious threats recognised included African elodea (*Lagarosiphon major*), water chestnut (*Trapa natans*) and Miramar weed (*Hygrophila polysperma*). These are not present in California in part or all of USA or under localised eradication. (DiTomasso, 2013; US Fish and Wildlife Service, 2018).

An intriguing case of a terrestrial invasive is highway iceplant (*Carprobrotus edulis*) that was actually brought to California to stabilise soil along railway tracks and was also promoted as a garden plant. It is now regarded as a threat because of dense mat formation. It should be noted, however, that California has a much longer list of noxious plants native or already naturalised in the state (DiTomasso, 2013). Finally, invasive plants are thought to increase the intensity and frequency of wildfires.

California is also concerned about marine invasive species (California State Lands Commission, 2019), although not an issue directly for border controls within a federal jurisdiction. These species include some crustaceans, molluscs and fish, mostly introduced intentionally, but there some algae officially regarded as invasive. *Caulerpa taxifolia,* known as 'killer algae', a strain of green seaweed believed to have been released from an aquarium either directly into a water body or through a storm drain. The fact that

C. taxifolia was apparently released from an aquarium indicates the potential for dispersal of freshwater aquatic species that are used in aquaria or garden ponds for ornamental purposes or for purifying water.

Asian kelp *(Undaria pinnatifida*) is an invasive alga that is native to Japan, northern China, and Korea. This was first observed in Southern California and has since spread to San Francisco and Half Moon Bay, it most likely came to the California coast by means of hull fouling. Asian kelp can out-compete native species by monopolizing resources, resulting in ecosystem alteration (Zabin *et al*. 2009). This continues to spread throughout California, and in 2009 it was found in San Francisco Bay. The potential high cost and technical challenges have prevented any eradication efforts.

4.2 Australia

Australia's efforts to control the internal spread of invasive plants began with *Mimosa pigra* (giant sensitive tree) that was introduced to the continent at the Darwin Botanic Gardens in 1891. The first major infestation was reported in 1952 100 km south of Darwin. Seed was transmitted in sand, but the main pathway was the extraction of sand from rivers for building operations. There is a national control strategy based on the necessity to control transport of building sand but also recognising that tyres and wheels are important pathways (CRC Weed Management, 2003).

More than 3000 naturalised plants are cited in Federal environmental regulations covering invasive species with more than 1000 invasives recognised as having environmental impact. (Invasive Species Council, 2019). These impacts are estimated to cost the agricultural and other economic sectors is more than AUS$4 billion per year.
The Federal approach exemplifies the permitted list (‘White List’) approach to managing invasives under the Environmental Protection and Biological Conservation Act 1999 (Invasive Species Council, 2009). From 1998, originally under the Quarantine Proclamation of 1998, all plant species were prohibited from entering Australia until they were formally assessed and/or appeared on the Permitted Seeds List. Within the country, White-list restrictions apply only to the sale or movement of plants, not their possession. Thus, owners or occupiers of land with non-permitted plants would not be breaking the law 'except if the plants were on a prohibited list with conditions requiring landholders to remove those species or if they were breaching a duty of care'. This approach is used at

the national border (and in New Zealand) and for movement into Western Australia, but is not generally applied at the borders of other states. However, the White list approach is used in the Northern Territory for aquatic plants and also by state and territory governments for some categories of exotic animals. Apart from Western Australia applying the White list, other states have a variable number of prohibited species (87-223). Western Australia rejected 7% of cases in assessments totalling 5869 over the period 1998-2004. At Federal level the rejection rate was 24% over the period 1977-2004. In terms of a means for effective governance, the White list approach is considered to be cost effective in Australia with priority accorded to public interests. By contrast, the prohibited list approach is held to favour private interests.

4. Concluding remarks on recommended policy initiatives

Six questions were posed at the end of section 1 which can now be answered in the light of evidence gathered from the jurisdictions examined; but some of these questions are best answered together.

Taking first and third questions (regulatory issues), in mature systems invasive species are generally considered as a category distinct from pests whereas under the IPPC they are regarded as 'plants as pests'. However, the emphasis of control systems is prevention of introduction, or movement across borders in a federal jurisdiction, rather than restrictions on internal trade. This is in contrast to restrictions imposed within the EU on plants at risk from pests by the plant passport system. Phytosanitary border controls under the SPS Agreement are now considered to fall under agendas for trade facilitation (ADB, 2019) so there is a case still to be made for considering plants as pests potentially invasive. Therefore, having a third category of regulated pest as 'invasive plants' might be helpful for trade facilitation. How to treat invasive animals is considered below.

In the emerging national jurisdictions of the FSU and the EAEU, invasive plants are included in pest lists with either reference to invasiveness or as 'quarantine weeds'. However, plant quarantine-related law in these countries almost invariably uses the rather ambiguous concept of 'quarantine object' rather than the IPPC concepts of 'regulated pest' which includes 'quarantine pest' and 'regulated non-quarantine pest'. Phytosanitary laws and regulations in this region lack full alignment with the IPPC and the adoption of IPPC concepts and definitions in these respects is needed.

The effectiveness of plant health measures against plant and non-plant pests (second and fourth questions) depends on accurate assessment of risk, prediction of likely future risk (particularly those arising from climate change) and identification and implementation of measures to minimise it (Outhwaite, 2017). The following are examples of situations in which this approach has not been possible.

- Unintended consequences; examples could be rabbits (*Oryctolagus cuniculus*) (Australia) and deer (UK) with fallow (*Dama dama*) introduced by William the Conqueror for hunting and grey squirrel (*Sciurus carolinensis*)/Muntjac (*Muntiacus reevesi*) escapes from Woburn wildlife park; changes in public attitude to hunting and pest control
- Despite measures to prevent exotic bark beetles entering the UK by requiring de-barking of coniferous timber prior to shipping, the great spruce bark beetle (*Dendroctonus micans*) is now well established in the west causing damage to commercial spruce plantations (Forest Research, 2019).
- Dealing with the unexpected – the Asian gall wasp *(Dryocosmus kuriphilus),* established in northern Italy as a result of importing graft material for nut orchards from China appeared in Kent in 2015. Route of entry is still unclear and it is in these unpredicted cases where it is difficult to see how the standard risk-based approach to plant health measures can be effective.
- Host plant plasticity – it is increasingly recognised that, in the current rapidly changing environment, previously benign herbivores can – and are – changing their preferred host plants.

It will be seen from the above examples, that apart from invertebrate pests and plant pathogens, non-plant invasive species may spread far too quickly for regulatory action to be taken to prevent their spread even if the regulatory infrastructure is in place (question ii). This applies particularly to aquatic organisms.

On the remaining questions, while invasive alien species are universally recognised as a threat to native biodiversity, there is an emerging debate regarding exactly what is meant by 'native species'. While some conservationists promote re-wilding the landscape, with the most extreme favouring de-extinction of species such as the woolly mammoth, (*Mammuthus primigenius)* others consider sweet chestnut, established to have been naturalised in England for at least two thousand years, should be removed from nature reserves as it is not a native plant. While this has prompted some to argue that, acknowledging the currently rapidly changing environment, the definition of 'native' needs to be reconsidered this is seen as highly controversial. This is important in the context of climate change. Experience has shown that pests are likely to move with their hosts when cultivated plants, (either herbaceous or woody) are grown in non-traditional zones, a consequence of accidental introduction. Generally, introduced crops do not become invasive because they are managed. However, introduced forests species for timber purposes to replace denuded natural forest may provide an alien environment with lower biodiversity (Black and Kireeva, 2009). Another well publicised environmentally damaging introduction is oil palm (*Elaeis guineensis*).

Thomas and Parmer (2015) argued that high diversities of native and non-native plant species are compatible and further that "*The negative effects of non-native plants on British biodiversity have been exaggerated and may also have been exaggerated in other parts of the world*". This view was promptly refuted by Hulme *et al*. (2015) with a reminder that it had long been recognised that not all non-native species pose a threat to biodiversity. Clearly this is the case, but it is also true that, as environmental conditions change, then the plants more suited to ambient conditions are also likely to alter, with consequential effects on plant communities. There is emerging literature on the species vs community vs ecosystem service perspective with books such as 'The aliens among us' (Anthony, 2017) and 'Inheritors of the Earth: How Nature Is Thriving in an Age of Extinction' (Thomas, 2017) highlighting the need to reconsider conservation objectives and, while taking a risk assessment approach to minimise future introductions, accept change in plant – and animal – communities as part of the ongoing evolutionary process.

To conclude, three aspects of policy towards regulation of IAS require development. First, is the means to determine the status of organism as pests *sensu stricto*, invasives or

naturalised species. Second is the need to distinguish the requirements for protecting targets of invasiveness – protecting agriculture and horticulture or protecting habitats and biodiversity with commercial forestry somewhat intermediate. Third is the need for clarity on a requirement for risk assessment when predicting future invasions as a consequence of climate change.

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