As invasions slow down, biosecurity must move inward

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Highlights

- Recent evidence indicates that rates of new non-native-species records and establishment are slowing.
- As external establishments decline, heterogeneous non-native-species pools within connected regions become increasingly important sources of future preventable invasions.
- Free-trade regions combine intense internal movement with potential compositionally distinct non-native pools and comparatively weak internal biosecurity.
- Deglobalization provides a timely opportunity to incorporate intra-regional biosecurity into reorganised and emerging trade networks.
- Meeting biodiversity targets requires nested prevention: maintain external-border control while extending surveillance and pathway management inward.

Abstract

Rates of non-native-species first records and establishment are slowing. This is encouraging, but it changes rather than resolves the biosecurity problem imposed by biological invasions. As external establishments decline while national non-native-species pools remain compositionally distinct, a growing share of remaining invasion opportunity should lie in redistribution among connected jurisdictions and subsequent within-country spread. Free-trade regions are particularly susceptible because internal movement is intense, whereas biosecurity remains concentrated at external borders. Simultaneously, deglobalization and consequent reshoring and economic regionalisation are reorganising trade towards shorter and more spatially concentrated transport corridors. We argue that this creates a timely policy opportunity: maintain external prevention while extending biosecurity systematically to intra-regional pathways and within-country spread. Successful prevention should make biosecurity move inward, not retreat.

Keywords: *biological invasions; biosecurity; invasion credit; secondary introductions; deglobalization*

Acknowledgements

P.J.H. was supported by the Marie Skłodowska-Curie Postdoctoral Fellowship HORIZON-MSCA-2024-PF-01 (Project DIRECT; Grant No. 101203662).

Declaration of interests

The author declares no competing interests.

A slowdown changes the management problem

For much of the past two decades, invasion science has operated under the apparently simple framework that globalisation was exposing increasingly large source pools to increasingly connected recipient regions, and non-native species (see Glossary) were showing little evidence of saturating (Seebens et al., 2017, 2018, 2021). Reiterated postulations of continued non-native-species accumulation and increasing transport connectivity concomitantly reinforced expectations that introduction pressure would remain high or increase (Sardain et al., 2019; Essl et al., 2020; IPBES, 2023; Roy et al., 2024).

Evidence that this trajectory may be changing first emerged from analyses of first records across the European Union (EU), where cumulative non-native-species richness expectedly continues to increase, but the number of annually recorded non-native species peaked in the 1990s and declined thereafter, without corresponding saturation of the cumulative non-native-species stock (Haubrock et al., 2023). Despite being inherently good news for conservation and global biodiversity, first records can substantially post-date introduction or establishment, and recent records are particularly susceptible to detection and reporting delays (Solow & Costello, 2004; Buba et al., 2024; Brock & Daehler, 2025; Haubrock et al., 2025a). Evidence of trajectory change was already embedded within the literature underpinning the no-saturation paradigm, with Seebens et al. (2017) reporting declining first-record rates for several taxonomic and regional subsets, despite demonstrating continued accumulation globally. A paradigmatic example includes a pronounced decline in non-native vascular-plant records in New Zealand associated with strengthened biosecurity (Seebens et al., 2017). Similarly, primary detections across 49 aquatic ecosystems peaked in 2005–2010 and declined thereafter (Bailey et al., 2020), while Antarctic introduction rates have recently slowed or remained static despite increasing human activity (Leihy et al., 2025). Thus, although saturation is not universal, neither is continued acceleration: marginal additions have plateaued or declined across several well-studied systems and taxonomic groups.

Importantly, a recent analysis by McGeoch et al. (2026) suggests these patterns may extend beyond observed first records to the underlying establishment process. By explicitly separating establishment from observation, they estimated that annual rates of non-native species establishment across countries declined by approximately 35% between 1970 and 2020, a period when biodiversity-recording effort increased rather than decreased, suggesting this slowdown is not just an artefact of declining observation. These results are encouraging as they suggest decades of pathway management, quarantine, legislation, and surveillance may have successfully bent a curve that was projected to continue rising exponentially (McGeoch et al., 2026). However, these observations also indicate that the remaining species source pools are also changing geographically. As novel establishments from distant source regions become less frequent, an increasing proportion of future establishments should derive from non-native species already present in geographically and economically connected jurisdictions, rather than from previously distant source pools (**Figure 1**).

Although the factors leading to these changes (e.g. shifts in trade, source-pool accessibility, and other socioeconomic drivers) are highly intertwined and establishing their relative importance remains an important empirical question, the management implication is that a lower rate of non-native species establishment does not mean that invasion risk disappears. Instead, it changes the spatial scale at which invasion risk must increasingly be considered. Biosecurity has traditionally emphasised primary introductions across major biogeographic boundaries, but the accumulation of large and compositionally

heterogeneous non-native-species pools within continents creates increasing opportunities for secondary introductions among countries, regions, catchments and other connected jurisdictions. Because human-mediated introductions operate across nested spatial scales (Blackburn et al., 2011; Robertson et al., 2020), declining rates of external establishment do not reduce the importance of sources, pathways and propagule pressure. Instead, it requires that these same questions should be asked at finer spatial scales. The emerging management challenge is consequently not only to prevent the next species from reaching a specific continent, but also to prevent species already established there from reaching the many jurisdictions and ecosystems they have yet to invade.

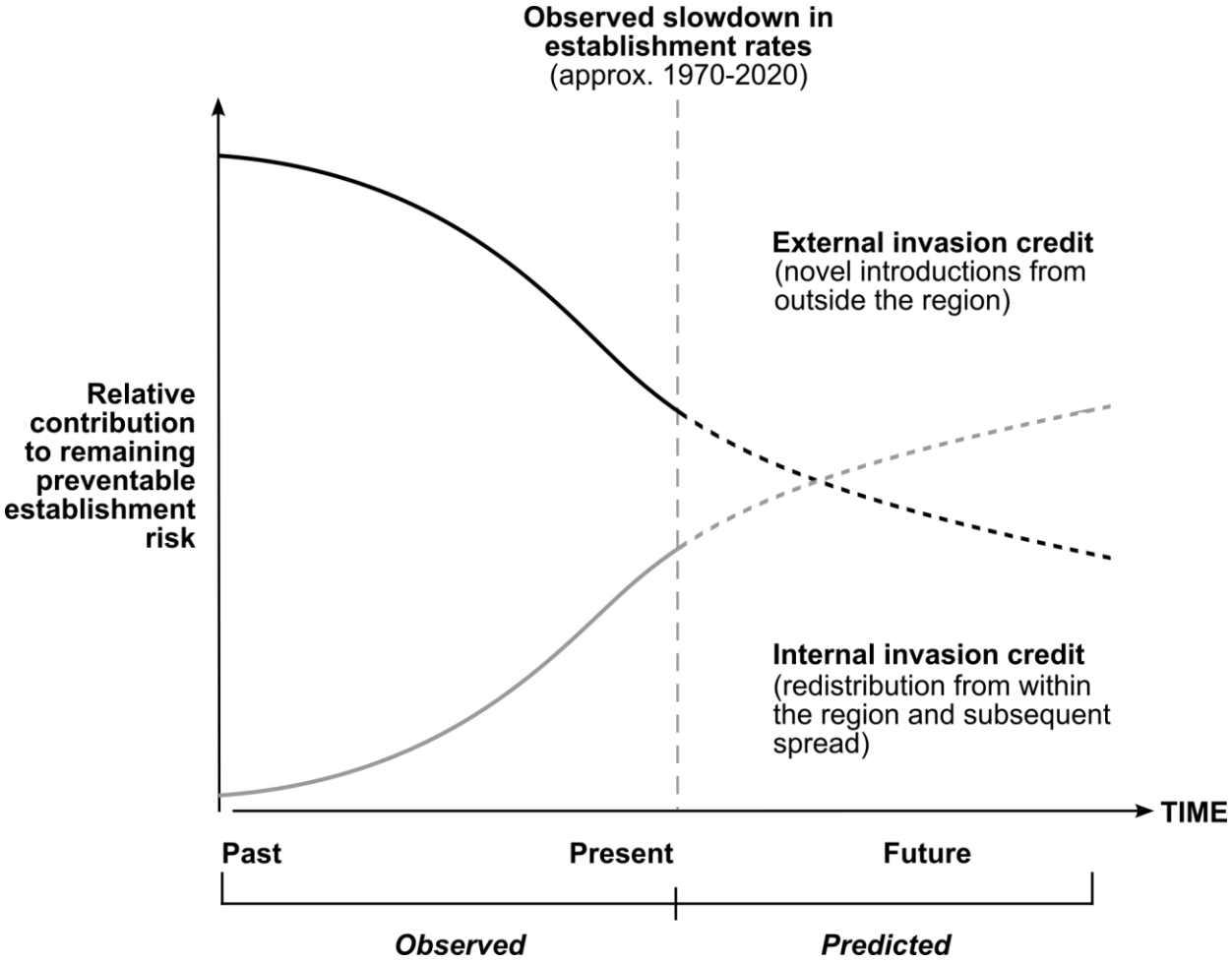

Figure 1. Declining external establishment increases the relative importance of internal invasion credit. Conceptual temporal hypothesis linking the observed slowdown in non-native species establishment to a predicted shift in the spatial distribution of remaining preventable invasion risk. The decline in establishment rates over approximately 1970–2020 is based on the detection-corrected global inference of McGeoch et al. (2026), with comparable declines or plateaus in first records or detections reported in several systems (Seebens et al., 2017; Bailey et al., 2020; Haubrock et al., 2023; Leihy et al., 2025). If external establishments continue to decline while non-native species pools within economically connected regions remain heterogeneous, external invasion credit should contribute progressively less, and internal invasion credit progressively more, to remaining preventable establishment risk. Solid lines represent the empirically supported historical pattern and dashed lines the hypothesised future trajectory; the crossover is conceptual rather than a quantitative prediction.

Single markets are not single biotas

Political and economic integration across vast regions, such as North America and Europe, does not erase ecological heterogeneity. For example, the European Union (EU) is a single market economy, but its Member States do not host the same single non-native species pool due to spatial variation in climate, differing introduction histories, trade, land use, research effort, and national policies (Turbelin et al., 2017; Haubrock et al., 2023; Hudgins et al., 2023). This creates an asymmetry between regional economic integration and biotic homogenisation, as economically integrated jurisdictions can remain compositionally distinct for prolonged periods. For instance, when considering two neighbouring EU Member States with similar or overlapping environmental conditions (Beck et al., 2018), species A may have been established for decades in one country but remain absent from the other, while species B shows the opposite distribution. Neither represents a novel introduction to the wider trade *bloc*, but each remains a potential invader in the country where it is absent owing to dense transport connections linking compositionally distinct species pools.

McGeoch et al. (2026) describe the broader unrealised potential for future invasions as invasion credit since most globally recognised non-native species remain established in relatively few countries, leaving substantial scope for further inter-country spread. Globally, preserving this "credit" is an opportunity for prevention, but regionally, the same pattern reveals a reservoir of species already present within a connected economic system despite their absence from many of its constituent jurisdictions. This preserves the importance of prevention in still-uninvaded jurisdictions, while increasing the importance of control and containment in already invaded jurisdictions to reduce their role as sources of secondary introductions. Distinguishing two spatial components of invasion credit (**Box 1**) is thus crucial: external invasion credit, comprising potential invaders still absent from a focal region, and internal invasion credit, comprising species already established somewhere within that region but absent from connected jurisdictions or subregions where they could establish (**Figure 2**). Moreover, this distinction becomes increasingly consequential as external establishments decline. For instance, a species transported directly from East Asia to Poland in Central Europe would represent a biosecurity event. If that species establishes and becomes the source of a subsequent introduction to France (which already has a notable pool of non-native species; Haubrock et al., 2023) then it might produce the same new national establishment, albeit via a different introduction pathway. If a species were present in both countries, neither repeated movement between them nor subsequent within-country expansion would generate additional national first records. Country-level first records thus capture progressively less of the invasion process as spread proceeds within already invaded jurisdictions. They may remain essential for detecting invasions of new countries (Seebens et al., 2017; McGeoch et al., 2026), but cannot measure subsequent range filling, repeated propagule transfer among already invaded jurisdictions, or human-mediated movement among catchments and ecological regions (Haubrock et al., 2026). This is because first records, establishments, occupied area, and reported impacts describe very different stages of an invasion that must be considered in parallel (Essl et al., 2011; Rouget et al., 2016; Diagne et al., 2021; Soto et al., 2023a; Haubrock et al., 2025b).

Box 1. From invasion credit to internalization and externalization of invasion credit

Invasion credit describes the potential for currently unrealised future invasions, i.e. non-native species that have not yet been introduced or established in locations where establishment remains possible (McGeoch et al., 2026). At the global scale, the large number of non-native species currently restricted to relatively few countries represents substantial unrealised invasion credit. This credit should be separated spatially because external invasion credit comprises species absent from an entire focal region or trade *bloc* but capable of future introduction and establishment there. In contrast, internal invasion credit comprises species already established somewhere within the region but absent from particular countries, states, provinces, islands, catchments, or ecological subregions where establishment remains possible. The distinction becomes increasingly relevant as external establishment declines and external invasion credit may contract, while internal invasion credit remains substantial because biotic homogenisation lags behind economic integration. Different jurisdictions within larger regions that are connected by intensive commodity flows can therefore remain sources of novel establishments for one another long after the species concerned has ceased to be novel to the wider region.

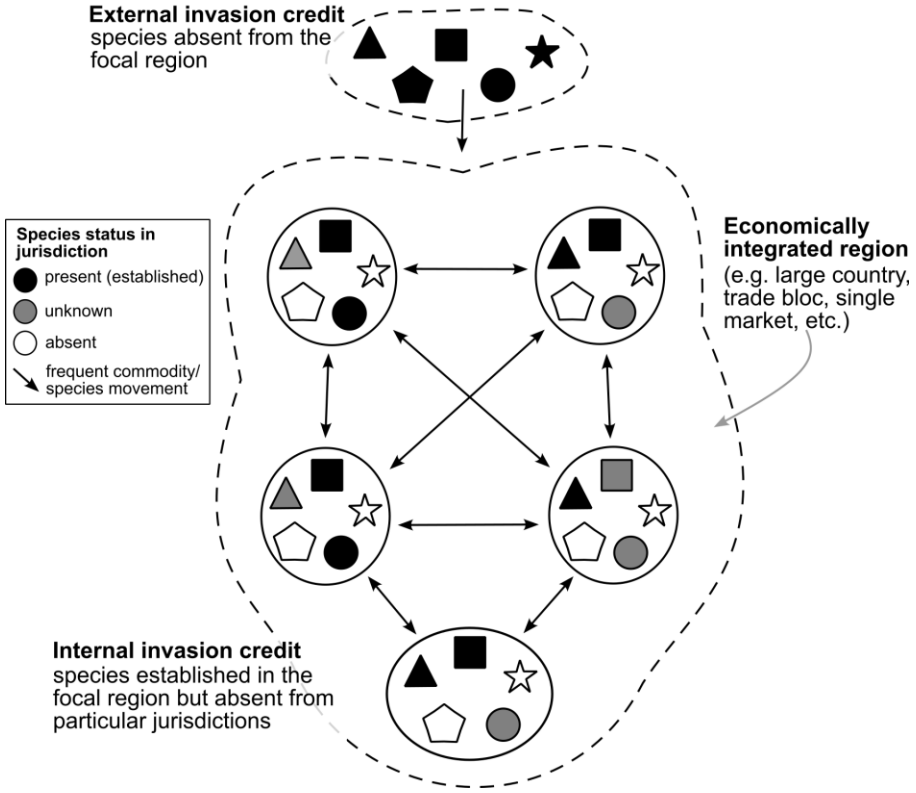

Figure 2. Economic integration connects heterogeneous non-native species pools. Conceptual representation of external and internal invasion credit within an economically integrated region. Member jurisdictions contain overlapping but non-identical non-native species pools because of differences in introduction history, pathways, climate, management, and observation (Turbelin et al., 2017; Haubrock et al., 2023). External invasion credit comprises potential invaders absent from the focal region, whereas internal invasion credit comprises species already established within the region but absent from one or more constituent jurisdictions. Frequent movement of commodities and organisms connects these heterogeneous pools, creating opportunities for secondary introductions among jurisdictions even when no novel species enters the wider region. Filled, grey, and open symbols indicate species recorded as present, of unknown status, or absent, respectively.

The neglected middle of an invasion

Biosecurity is spatially asymmetric because external borders concentrate customs controls, phytosanitary inspections, ballast-water regulation, import restrictions, and other mechanisms intended to prevent introduction. Inside integrated market economies (e.g. EU, among US states) and large countries (e.g. China, Russia, Brazil), the movement of commodities is deliberately facilitated despite these areas encompassing different biogeographic realms, leaving comparatively weakly managed middle layers between international introduction and local spread. Within the EU single market, most goods move between Member States without routine border inspection comparable to that applied at the Union's external frontier, although sector-specific phytosanitary and non-native species controls remain. Regulation (EU) No 1143/2014 and the associated list of non-native species of 'Union concern' should provide important safeguards (European Union, 2014, 2022; Tollington et al., 2017). This list, however, deliberately prioritises a small subset of high-concern taxa and is not designed to intercept the much larger pool of unlisted non-native species that may be redistributed internally (Haubrock et al., 2023).

The pathways responsible for introductions (e.g. horticultural and live animal supply chains, aquaculture, road and rail freight, and logistics hubs) act similarly by consolidating and then redistributing species as commodities (Hulme, 2009; Floerl et al., 2009; Tricarico, 2012). Thus, the novelty is not their existence, but their changing relative importance when the contribution of new external establishments declines. An example is the Ponto-Caspian amphipod *Dikerogammarus villosus*, for which an initial long-distance translocation was followed by extensive dispersal through connected European waterways and recreational vectors (Soto et al., 2023a). Once *D. villosus* is established somewhere within a region, preventing another intercontinental crossing addresses only one component of subsequent risk and may not prevent its spread and subsequent introductions. If external establishments decline while regional non-native pools remain heterogeneous and strongly connected, internal invasion credit should account for an increasing share of remaining preventable invasions, generating the direct empirical prediction that the proportion of new jurisdictional establishments (whose likely source population is already present within the same economically integrated region) should increase through time.

Importantly, however, this argument distinguishes between observation, inference, and prediction because the recent slowdown in first records and estimated establishment is empirical (Haubrock et al., 2023; McGeoch et al., 2026). The increasing relative importance of internal invasion credit follows if connected regional species pools remain heterogeneous while external establishments decline. Whether internal redistribution is itself increasing in absolute terms, and whether changing trade geography accelerates it, thus becomes a testable prediction, not an established global trend.

Deglobalization creates a policy window

A spatial shift in source pools of biological invasions coincides with a broader reorganisation of the global economy because continuously deepening global integration is giving way to greater protectionism, geopolitical fragmentation, supply-chain security, industrial policy, nearshoring, reshoring, and stronger regional trading relationships (Witt, 2019; Wiebe et al., 2025; Haubrock et al., in press). Although international trade is not disappearing, its geography is changing as national interests promote reshoring and regionalisation. Non-native species introductions might shift accordingly as reduced dependence on long supply chains could reduce some opportunities for novel intercontinental introductions, while reinforcing the slowdown in invasion records. Regionalisation may simultaneously

intensify movements among geographically or politically closer partners because (*i*) manufacturing relocated nearer to consumer markets can generate additional freight movements, (*ii*) agricultural trade redirected towards regional partners still transports organisms, and (*iii*) regional logistics hubs, roads, railways, inland waterways, and short-sea shipping may increase in importance as long-distance supply chains are reorganised (Haubrock et al., *in press*). This means that propagule pressure may be rerouted rather than reduced, providing opportunities to embed biosecurity into regionalising supply chains before new pathways become entrenched. Emerging trade architectures, such as the EU–Mercosur agreement (Everts et al. *in press*), may simultaneously reconfigure extra-regional introductions and strengthen connectivity among already connected species pools, while existing sanitary and phytosanitary provisions continue to fail in addressing the full spectrum of biological invasions (European Commission, 2026; Ng et al., 2020). This creates a strong case for maintaining external prevention while extending biosecurity inward, particularly as countries implement Target 6 of the Kunming–Montreal Global Biodiversity Framework that aims to halve introduction and establishment rates by 2030 (Convention on Biological Diversity, 2022). The estimated 35% decline since 1970 may therefore represent substantial progress, but persistent invasion credit means that declining country-level establishment does not necessarily imply declining intra-regional redistribution or within-country spread (McGeoch et al., 2026).

Biosecurity must become nested

The management of biological invasions should not, however, shift entirely from prevention to post-establishment control and containment, nor weaken external borders just because establishment rates are declining. Prevention remains central to invasion management and is generally more effective than intervention after widespread establishment (Robertson et al., 2020; Roy et al., 2024). Instead, biosecurity should operate at three nested scales (**Figure 3**). External prevention (the outer layer) must continue to target movement between major biogeographic regions and economic *blocs*. New source pools may therefore remain accessible despite changes in transport pathways, climatic barriers, and emerging trade arrangements generating new donor–recipient combinations (Sardain et al., 2019; Essl et al., 2020). Then, trade blocs and federations (the middle layers) should explicitly treat internal transport networks as invasion pathways. Accordingly, management should identify non-native species present in some member jurisdictions but absent from others, combine these distribution differences with environmental suitability and commodity-flow information, and direct surveillance towards the internal nodes most capable of realising internal invasion credit (Floerl et al., 2009; McGeoch et al., 2016; van Rees et al., 2022). This shift raises questions of responsibility and financing: if containment in an invaded jurisdiction reduces the probability of secondary introduction into neighbouring jurisdictions, the benefits of control extend beyond the country bearing its costs. In integrated *blocs* such as the EU, internal invasion credit could justify greater cost-sharing of containment, analogous to other policy areas in which investments within one Member State generate collective benefits across the Union. Finally, biosecurity (the inner layer) should continue after a non-native species is introduced and enters a national checklist, making the occupied area, its connectivity at catchment and landscape scales, repeated human-mediated translocations, and expansion into previously unaffected regions routine components of monitoring efforts for preventing catchment- or region-level translocations when eradication is unachievable (Reaser et al., 2020; Robertson et al., 2020).

Importantly, national establishment rates or country-level first records cannot distinguish prevention of an extra-regional introduction from prevention of spread out of a neighbouring invaded

jurisdiction, nor can such indicators measure continued expansion within a country. Reporting under Target 6 should therefore retain country-level establishment trends while complementing them with new-to-region occurrences and, where suitable data exist, changes in occupied area to interpret progress across invasion stages (McGeoch et al., 2023; Gonzalez et al., 2023). Indeed, a substantial reduction in new country-level establishments can coexist with continuing biotic homogenisation within countries and among jurisdictions that already share the same non-native species, but measuring only the outer stages of an invasion would risk declaring success while pressure has shifted to a finer spatial scale. Trade governance could provide an immediate mechanism to address this gap, as sanitary and phytosanitary systems already have the institutional machinery to manage harmful organisms. Furthermore, emerging and revised regional agreements could extend this architecture through shared watch lists, interoperable notification of *new-to-jurisdiction* records, commodity-specific surveillance, and minimum standards for non-native-species occurrence data (Latombe et al., 2017; Groom et al., 2017; Pagad et al., 2018). Because nested biosecurity does not replace prevention, regional biosecurity should follow commodities and pathways rather than depend exclusively on lists of already recognised high-impact species.

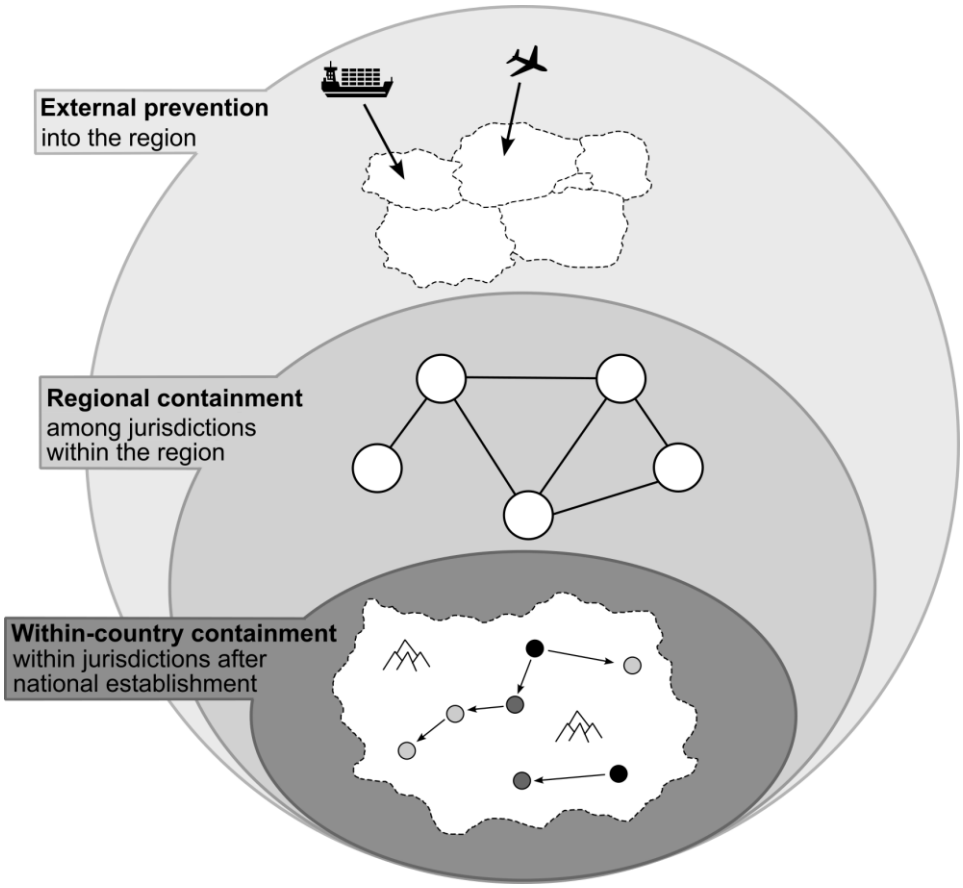

Figure 3. Nested biosecurity across spatial scales. Conceptual representation of three complementary layers of biosecurity. External prevention targets introductions into a focal region through long-distance transport and entry pathways (Hulme, 2009). Regional containment targets secondary introductions among connected jurisdictions within that region (Floerl et al., 2009; Tricarico, 2012). Within-country containment targets subsequent range expansion and human-mediated translocation among localities, catchments, landscapes, or other subnational units following national establishment (Robertson et al., 2020). Effective biosecurity therefore extends from preventing entry into a region to limiting redistribution among jurisdictions and subsequent spread within them.

Conclusion

For decades, invasion science confronted evidence that introductions were continuing to accumulate without saturation (Seebens et al., 2017, 2018). Now, regional first record and introduction dynamics are alreadying showing plateaus or declines across several well-studied systems, including Europe, New Zealand, global aquatic ecosystems, and the Antarctic, while detection-corrected global establishment models now suggest that the underlying establishment rate itself may also have declined (Seebens et al., 2017; Bailey et al., 2020; Haubrock et al., 2023; Leihy et al., 2025; McGeoch et al., 2026). Successful prevention, however, changes the invasion problem before it solves it, because non-native-species pools remain large, unevenly distributed, and incompletely mixed. Many non-native species may not have been reported or remain absent from jurisdictions in which they could establish, leaving substantial invasion credit (McGeoch et al., 2026). At the same time, reshoring and regionalisation may strengthen the shorter transport networks connecting these heterogeneous pools (Haubrock et al., in press). The next phase of large-scale invasion biosecurity should therefore follow these networks inward: external-border prevention must be maintained but complemented by systematic management of internal invasion credit to identify non-native species already present elsewhere within connected regions, identify the pathways capable of redistributing them, and contain spread after national establishment. Indicators must follow the same spatial hierarchy, distinguishing new external establishments from redistribution among jurisdictions and subsequent within-country expansion.

Glossary

Non-native species: a species transported by human activity beyond its historical native range (*sensu* Soto et al., 2024).

Deglobalization: a relative retreat from globally integrated production and trade towards protectionism, reshoring, regionalisation and shorter or politically aligned supply chains.

Establishment: formation of a self-sustaining population after introduction.

External invasion credit: potential future invaders absent from an entire focal region but capable of introduction and establishment there.

External establishments: the establishment of a non-native species within a focal region following its introduction from a source population outside that region.

First record: the earliest documented occurrence of a non-native species within a defined jurisdiction; it can substantially post-date introduction or establishment.

Free-trade region: an economically integrated set of jurisdictions within which goods and services move with reduced customs or regulatory barriers.

Internal invasion credit: species already present somewhere within a focal region but absent from connected jurisdictions or subregions where establishment remains possible.

Invasive non-native species: spreading non-native species for which negative impacts on biodiversity or ecosystems may or may not have been demonstrated.

Pathway: the process, route and vector through which organisms are transported beyond their previous distribution.

Propagule pressure: the number, frequency, and quality of individuals introduced into a recipient location.

Regionalisation: increasing concentration of economic activity and trade within geographically or geopolitically aligned regions.

Reshoring: relocation of production or supply chains back to the importing country; related nearshoring relocates production to geographically closer countries.

Secondary spread: expansion following initial establishment, including human-mediated movement between jurisdictions or within a country.

Target 6: the Kunming–Montreal Global Biodiversity Framework target addressing invasive non-native species, including pathway management and reduction of introduction and establishment rates.

Outstanding Questions

Is the source of new non-native-species establishments shifting from outside to inside regional trade blocs? Reconstructing likely source populations for successive first records and linking them to changing transport networks could reveal whether intra-regional redistribution contributes an increasing share of new jurisdictional establishments.

How large is internal invasion credit within major economic regions? Combining differences among jurisdictional non-native-species pools with environmental suitability and transport connectivity could quantify the pool of species available for secondary establishment.

Does greater economic integration accelerate biotic homogenisation among member jurisdictions? Before–after analyses of trade liberalisation and transport connectivity could test whether increasing internal commodity flows reduce compositional differences among non-native-species pools.

Which internal transport nodes contribute most strongly to new establishments? Freight and horticultural hubs, inland waterways, road and rail corridors, marinas, and recreational vectors could be compared directly with external entry points to identify where surveillance produces the greatest benefit.

Does regionalisation increase the absolute importance of internal invasion credit? Linking changing trade networks with reconstructed invasion histories could distinguish the relative increase predicted from declining external establishment from an absolute increase driven by stronger intra-regional connectivity.

How should Target 6 distinguish introduction, redistribution and subsequent spread? Combining establishment rates with new-to-region occurrences and occupied-area indicators could reveal whether progress at one spatial scale coincides with continuing invasion at another.

References

Bailey, S.A. et al. (2020) Trends in the detection of aquatic non-indigenous species across global marine, estuarine and freshwater ecosystems: a 50-year perspective. *Divers. Distrib.* **26**, 1780–1797

Beck, H.E. et al. (2018) Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Sci. Data* **5**, 180214

Blackburn, T.M. et al. (2011) A proposed unified framework for biological invasions. *Trends Ecol. Evol.* **26**, 333–339

Brock, K.C. and Daehler, C.C. (2025) Time lags in biodiversity data processing create the illusion of an invasion slowdown. *Glob. Ecol. Biogeogr.* **34**, e70168

Buba, Y. et al. (2024) Evaluating models for estimating introduction rates of alien species from discovery records. *Glob. Ecol. Biogeogr.* **33**, e13859

Convention on Biological Diversity (2022) *Kunming–Montreal Global Biodiversity Framework*. Decision 15/4, Target 6. Convention on Biological Diversity

Diagne, C. et al. (2021) High and rising economic costs of biological invasions worldwide. *Nature* **592**, 571–576

Essl, F. et al. (2011) Socioeconomic legacy yields an invasion debt. *Proc. Natl. Acad. Sci. U. S. A.* **108**, 203–207

Essl, F. et al. (2020) Drivers of future alien species impacts: an expert-based assessment. *Glob. Change Biol.* **26**, 4880–4893

European Commission (2026) *EU–Mercosur Partnership Agreement and Interim Trade Agreement: Texts and Application*. European Commission

European Union (2014) Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species. *Off. J. Eur. Union* **L315**, 35–55

European Union (2022) Commission Implementing Regulation (EU) 2022/1203 updating the list of invasive alien species of Union concern. *Off. J. Eur. Union* **L186**, 10–13

Everts, T. et al. (in press) Could the EU–Mercosur trade agreement catalyze biological invasions? *Biol. Conserv.*

Floerl, O. et al. (2009) The importance of transport hubs in stepping-stone invasions. *J. Appl. Ecol.* **46**, 37–45

Gonzalez, A. et al. (2023) A global biodiversity observing system to unite monitoring and guide action. *Nat. Ecol. Evol.* **7**, 1947–1952

Groom, Q.J. et al. (2017) Seven recommendations to make your invasive alien species data more useful. *Front. Appl. Math. Stat.* **3**, 13

Haubrock, P.J. et al. (2023) Is the number of non-native species in the European Union saturating? *Environ. Sci. Eur.* **35**, 48

Haubrock, P.J. et al. (2025a) Analysing factors underlying the reporting of established non-native species. *Sci. Rep.* **15**, 12337

Haubrock, P.J. et al. (2025b) The impacts of biological invasions. *Biol. Rev.* **101**, 1255–1310

Haubrock, P.J. et al. (2026) The spread of non-native species. *Biol. Rev.* **101**, 1197–1234

Haubrock, P.J. et al. (in press) Conservation risks and opportunities from deglobalization in a fragmenting world. *Nat. Rev. Biodivers.*

Hudgins, E.J. et al. (2023) Unevenly distributed biological invasion costs among origin and recipient regions. *Nat. Sustain.* **6**, 1113–1124

Hulme, P.E. (2009) Trade, transport and trouble: managing invasive species pathways in an era of globalization. *J. Appl. Ecol.* **46**, 10–18

IPBES (2023) *Thematic Assessment Report on Invasive Alien Species and Their Control*. IPBES Secretariat

Latombe, G. et al. (2017) A vision for global monitoring of biological invasions. *Biol. Conserv.* **213**, 295–308

Leihy, R.I. et al. (2025) Antarctic biosecurity policy effectively manages the rates of alien introductions. *Earth's Future* **13**, e2024EF005405

McGeoch, M.A. et al. (2016) Prioritizing species, pathways, and sites to achieve conservation targets for biological invasion. *Biol. Invasions* **18**, 299–314

McGeoch, M.A. et al. (2023) Invasion trends: an interpretable measure of change is needed to support policy targets. *Conserv. Lett.* **16**, e12943

McGeoch, M.A. et al. (2026) Global slowdown in the rate of invasive alien species establishment. *bioRxiv*. Published online August 24, 2026. https://doi.org/10.64898/2026.08.21.746256

Ng, L.S. et al. (2020) The scale of biodiversity impacts of the Belt and Road Initiative in Southeast Asia. *Biol. Conserv.* **248**, 108691

Pagad, S. et al. (2018) Introducing the global register of introduced and invasive species. *Sci. Data* **5**, 170202

Reaser, J.K. et al. (2020) The early detection of and rapid response (EDRR) to invasive species: a conceptual framework and federal capacities assessment. *Biol. Invasions* **22**, 1–19

Robertson, P.A. et al. (2020) A proposed unified framework to describe the management of biological invasions. *Biol. Invasions* **22**, 2633–2645
Rouget, M. et al. (2016) Invasion debt – quantifying future biological invasions. *Divers. Distrib.* **22**, 445–456
Roy, H.E. et al. (2024) Curbing the major and growing threats from invasive alien species is urgent and achievable. *Nat. Ecol. Evol.* **8**, 1216–1223
Sardain, A. et al. (2019) Global forecasts of shipping traffic and biological invasions to 2050. *Nat. Sustain.* **2**, 274–282
Seebens, H. et al. (2017) No saturation in the accumulation of alien species worldwide. *Nat. Commun.* **8**, 14435
Seebens, H. et al. (2018) Global rise in emerging alien species results from increased accessibility of new source pools. *Proc. Natl. Acad. Sci. U. S. A.* **115**, E2264–E2273
Seebens, H. et al. (2021) Projecting the continental accumulation of alien species through to 2050. *Glob. Change Biol.* **27**, 970–982
Solow, A.R. and Costello, C.J. (2004) Estimating the rate of species introductions from the discovery record. *Ecology* **85**, 1822–1825
Soto, I. et al. (2023a) Tracking a killer shrimp: *Dikerogammarus villosus* invasion dynamics across Europe. *Divers. Distrib.* **29**, 157–172
Tollington, S. et al. (2017) Making the EU legislation on invasive species a conservation success. *Conserv. Lett.* **10**, 112–120
Tricarico, E. (2012) A review on pathways and drivers of use regarding non-native freshwater fish introductions in the Mediterranean region. *Fish. Manag. Ecol.* **19**, 133–141
Turbelin, A.J. et al. (2017) Mapping the global state of invasive alien species: patterns of invasion and policy responses. *Glob. Ecol. Biogeogr.* **26**, 78–92
van Rees, C.B. et al. (2022) A framework to integrate innovations in invasion science for proactive management. *Biol. Rev.* **97**, 1712–1735
Wiebe, R.A. et al. (2025) Trajectories of biodiversity loss and extinction from trade globalization. *Curr. Biol.* **35**, 4096–4105
Witt, M.A. (2019) De-globalization: theories, predictions, and opportunities for international business research. *J. Int. Bus. Stud.* **50**, 1053–1077