

1 **China must revise its regulation for managing non-native invasive species**

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## 40 **Abstract**

41 Biological invasions are a leading contributor to the global biodiversity crisis, yet existing regulatory  
42 frameworks are challenged by definitions of ‘non-native’ species that are based on geopolitical rather  
43 than ecological boundaries. This perspective highlights the critical disconnect between administrative  
44 jurisdictions and biogeographic units, with focus on China’s biosecurity laws. These laws, centered on  
45 national borders, render the country vulnerable to ‘domestic’ invasions, some of which may have  
46 pronounced ecological or economic consequences. We posit that China should recalibrate its legal  
47 definition of invasive species and a shift from a ‘territory-based’ to an ‘ecosystem-based’ model, under  
48 which human-mediated intra-country translocations of species across ecosystems or other  
49 biogeographical units are redefined as non-native introductions rather than treated as movements of  
50 nationally native species. Then, we link this revised legal definition to risk assessment, inter-ecosystem  
51 infrastructure management, and stricter regulation of intra-country species translocations, to better  
52 safeguard ecosystem integrity.

53

## 54 **Main text**

### 55 **The Geopolitical Trap in Invasion Science**

56 Biological invasions incur enormous impacts to global ecosystems and significant costs to economies,  
57 with China among the most impacted countries (Diagne et al., 2021; Haubrock et al., 2025). Despite  
58 this widespread acknowledgement, a fundamental challenge persists at the intersection of science and  
59 policy related to how ‘non-native’ species are defined and thus considered in regulatory and  
60 management practices. In China and many other countries, biosecurity is closely associated with  
61 border security. In the ‘*Ecological and Environmental Code of the People's Republic of China* (中华人民  
62 共和国生态环境法典)’ (Adopted at the Fourth Session of the Fourteenth National People’s Congress on  
63 March 12, 2026), invasive non-native species (外来入侵物种) refer to species that have been  
64 introduced from outside the territory, have established populations, and pose threats or cause harm to  
65 ecosystems, species, and their habitats or growth environments (National People’s Congress of the  
66 People’s Republic of China, 2026). In addition, the foundational regulatory document, ‘*Measures for the  
67 Administration of Invasive Alien Species* (外来入侵物种管理办法)’ (hereafter ‘*the Measures*’), defines  
68 ‘alien species (外来物种)’ as those with ‘no natural distribution within the territory of the People's  
69 Republic of China’ (Ministry of Agriculture and Rural Affairs of the People’s Republic of China, 2022).  
70 While this definition facilitates customs enforcement at international ports of entry, it overlooks the vast  
71 biogeographic diversity within a single nation-state. This is particularly true for a large country like  
72 China, spanning multiple physiographic and climate zones as well as complex hydrological systems. As

73 such, a species native to the tropical south can be non-native to the temperate north, thus offering new  
74 opportunities for species interactions with native species and potential ecosystem impacts. Under the  
75 current territory-based definition, the human-mediated movement of species across internal  
76 biogeographic barriers within a country's territory is legally invisible, often classified as a mere species  
77 'translocation' rather than a potentially catastrophic non-native introduction (Sun et al., 2026). This  
78 classification generally does not trigger the regulatory scrutiny, risk assessment, or enforcement  
79 measures reserved for legally recognized non-native species under current law. Legal inconsistency  
80 hinders effective biosecurity management because species moved across ecological boundaries within  
81 China may escape formal recognition, risk assessment, and regulatory control, and limits China's  
82 capacity to protect its ecosystems from internal invasions (Li et al., 2021).

83

84 An additional regulatory-technical disconnect exists: although China possesses a broader scientific  
85 framework for ecological risk assessment of non-native species, it is not legally triggered for intra-  
86 country translocations because the species involved are classified as native under territory-based law.  
87 The Chinese Ministry of Ecology and Environment's formulation of the '*Technical guideline for*  
88 *assessment on environmental risk of alien species* (外来物种环境风险评估技术导则)' clearly defines  
89 'alien species (外来物种)' as those occurring outside their historical or potential distribution range  
90 (Ministry of Ecology and Environment of People's Republic of China, 2011), which provides a scientific  
91 framework for risk assessment, the applicability and target species definition of these technical  
92 standards are fundamentally constrained by the legally binding higher-level laws. However, the  
93 applicability of this technical standard and its definition of target species are fundamentally constrained  
94 by the legally binding, higher-level definition adopted in *the Code* and *the Measures*. As a subordinate  
95 operational standard, the *Technical Guidelines* must strictly adhere to this legal definition in both design  
96 and application. Consequently, risk assessment is only triggered once a species is recognized as  
97 legally non-native, which effectively limits formal assessment to species crossing national borders and  
98 overlooks those introduced across ecological boundaries within China. While it does not amount to a  
99 formal legal conflict, it does create a regulatory-technical disconnect. The *Guideline* provides a broader  
100 scientific framework for ecological risk assessment, but its application is not legally required for intra-  
101 country translocations when those species remain classified as native under *the Code* and *the*  
102 *Measures*. As a result, the scientific tool is not fully utilized in cases of ecologically consequential  
103 domestic species translocation.

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### 105 **Comparative Jurisprudence: The US Ecosystem Model**

106 The United States recognized this dilemma as early as 1999 with the issuance of Executive Order

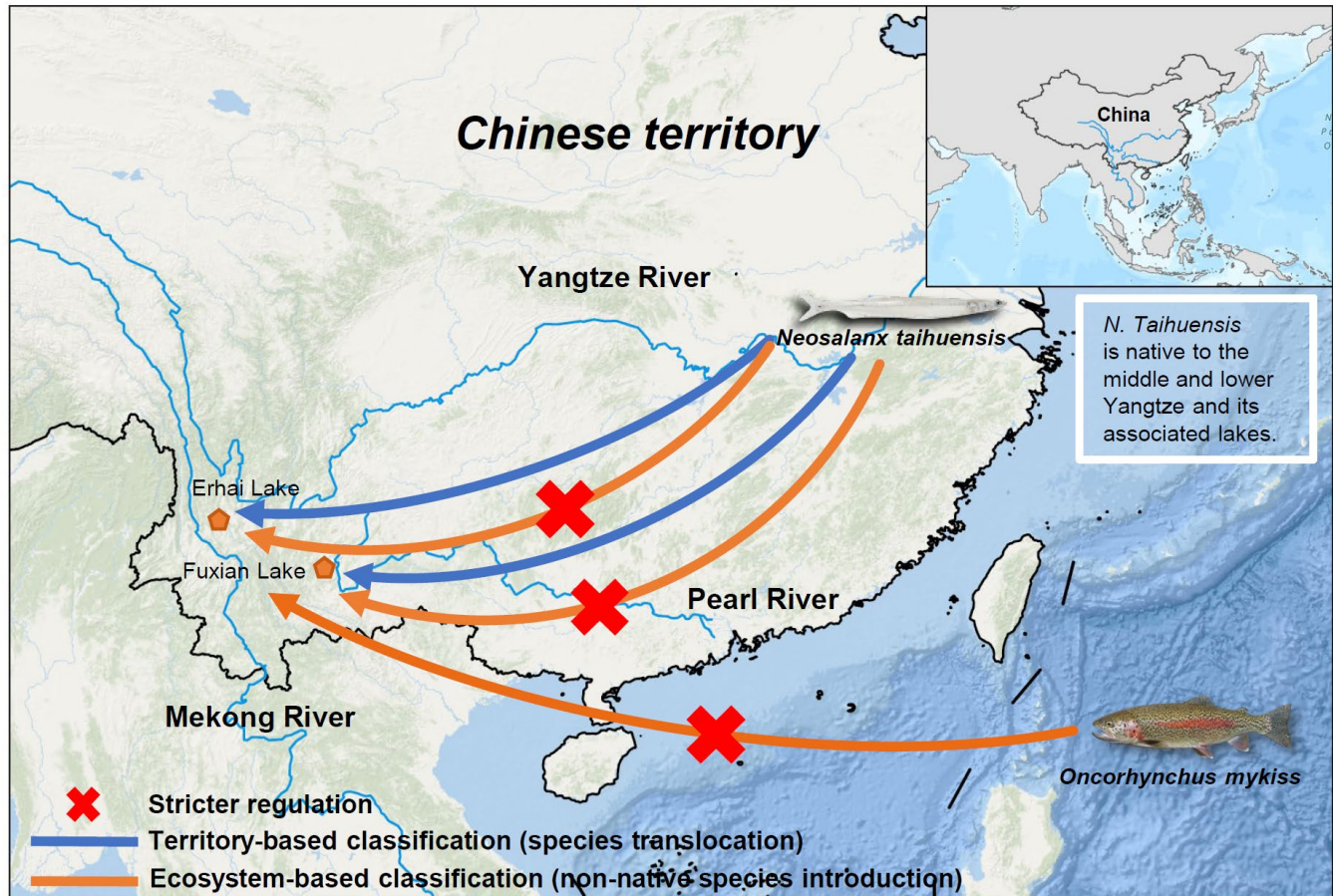
107 13112. Unlike the Chinese territory-based definition, the US order defines a ‘non-native species’ as one  
108 that is not native to a particular ecosystem (Executive Office of the President, 1999). This shift anchors  
109 the policy in in species geography rather than political boundaries, acknowledging that a species may  
110 be native to one part of the country but non-native in another if it disrupts the receiving ecosystem. The  
111 2016 revision of Executive Order 13751 further expands the mandate to consider the effects of climate  
112 change, recognizing that species may naturally move across political lines but still require management  
113 when they threaten new ecosystems (Executive Office of the President, 2016). Adopting an ecosystem-  
114 first approach across China's diverse ecosystems would not only enhance policy coherence but also  
115 create a more scientifically-informed legal structure to better manage non-native species.

### 116 117 **The Scientific Imperative: The ‘Ecosystem-Based’ Rule**

118 Recent advances in invasion science recognize population-level differences and the obscurity of  
119 human-made borders, thus offering a robust alternative to territory-based definitions. In China, the  
120 spread of species beyond their natural ecological range is increasingly facilitated by multiple human-  
121 mediated pathways, including artificial waterways, inter-basin water transfer, the transport of wood  
122 products and food commodities, recreational and religious releases, and the intentional movement of  
123 horticultural and aquaculture species. Sun et al. (2026) propose a ‘basin-first’ rule for managing non-  
124 native species in freshwater systems, arguing that the hydrological basin is the only scientifically valid  
125 unit for managing aquatic nativity. For instance, the freshwater sleeper *Odontobutis potamophila* is a  
126 small predatory fish native to the lower Yangtze in southern China, but in recent years it has spread to  
127 river basins in Beijing in northern China. According to ‘*the Measures*’, this species would be defined as  
128 native, since its range lies within China’s borders. However, if applying the ‘basin-first’ rule, it would be  
129 considered a non-native invader in northern basins, where it likely traverses artificial water transport  
130 channels.

131  
132 The deliberate translocation of economically significant species to boost regional aquaculture  
133 production has institutionalized a pervasive threat to regional biodiversity. To date, at least 91 fish  
134 species have since been moved within the country, with the Yangtze River basin receiving the greatest  
135 number of translocated fishes (Li et al., 2021). Among these, the widespread introduction of icefish  
136 (*Salangidae*) across China for its high economic value represents a significant ecological threat (Figure  
137 1). These internal translocations have frequently triggered the collapse of indigenous fish communities  
138 and led to severe species decline or local extinctions in recipient ecosystems, most notably within the  
139 vulnerable highland lakes of the Yunnan Plateau (Kang et al., 2015). This logic is not limited to  
140 freshwater fishes. In terrestrial systems, the emerald ash borer (*Agrilus planipennis*) is native to

141 northern China, but following the widespread planting of susceptible ash trees, it has also been  
142 recorded as invading southern China (Sun et al., 2024). This case shows that invasion risk can arise  
143 within national borders when human activities facilitate expansion beyond a species' natural ecological  
144 context.



145  
146 **Figure 1.** Conceptual comparison of territory-based and ecosystem-based classification of species introductions  
147 in China. In the current territory-based framework, under which species moved within China are generally treated  
148 as domestic translocations rather than non-native introductions, even when they cross major ecological  
149 boundaries such as river basins. Under this approach, transfers of icefish (*Neosalanx taihuensis*) from its native  
150 range (Lower Yangtze) to Erhai Lake and Fuxian Lake are not recognized as non-native introductions, whereas  
151 the introduction of rainbow trout (*Oncorhynchus mykiss*) from outside China is classified as non-native. For the  
152 ecosystem-based framework, under which species are assessed relative to their natural ecological or  
153 biogeographic range rather than national territory alone. In this case, transfers of *N. taihuensis* across basin  
154 boundaries are also recognized as non-native introductions and would trigger stricter regulation, alongside  
155 introductions of species originating from outside China.

156  
157 Intra-country species translocations are typically not regulated by law because the species involved are  
158 often considered 'native to China'. However, these species are entering new ecosystems, and much

159 like invasive species have the opportunity to establish populations and cause harm. In freshwater  
160 systems, the 'basin-first' rule offers a useful framework for distinguishing native from non-native  
161 introductions across hydrological boundaries. For terrestrial and marine systems, the same principle  
162 can be generalized through an ecosystem-based definition, whereby species are assessed relative to  
163 their natural ecological or biogeographic range rather than national territory alone. This broader  
164 framework would improve the regulation of species introductions and better align management with the  
165 realities made clear from decades of invasion science. Had an ecosystem-based framework been in  
166 place, these intra-country translocations would have triggered risk screening and region-specific  
167 regulation before release, rather than being treated as routine movements of nationally native taxa.  
168

### 169 **Infrastructure as an Ecological Bypass**

170 China's massive infrastructure projects, such as the South-to-North Water Transfer Project (SNWTP)  
171 and the Dianzhong Water Diversion Project, provide access to shipping or critical water supplies,  
172 though they also inadvertently create ecological highways that bypass natural barriers. The SNWTP  
173 functionally merges previously isolated basins, facilitating the movement and invasion of plankton,  
174 bivalves and fish across basins (Zhang et al., 2026). For example, the golden mussel *Limnoperna*  
175 *fortunei*, which is native to the Pearl River basin in southern China but has spread northward across the  
176 Yangtze, Huai, Yellow, and Hai River basins, with artificial waterways and the SNWTP likely facilitating  
177 its expansion within China (Boltovskoy et al., 2025). However, under the territory-based rule, the  
178 environmental impact assessments for these projects often focus on water quality and volume,  
179 neglecting the 'internal' invasion risk of such species.  
180

181 The US Water Resources Development Act of 2007 was developed specifically to address the spread  
182 of species via artificial connections, like the Chicago Sanitary and Ship Canal, which connects and  
183 potentially allows species movements between the Great Lakes and Mississippi River basins. This type  
184 of legislation has been crucial in mitigating invasive species spread in the US. China would benefit from  
185 adoption of similar regulations that require mandatory ecological isolation technologies for any  
186 infrastructure project that connects distinct biogeographic regions. Comparable measures would help  
187 prevent the unintended spread of non-native species across ecosystems, which otherwise remain  
188 ecologically isolated.

### 189 **Societal and Cultural Drivers: The 'Life-Release' Challenge**

191 The intersection of biosecurity and society in China is further complicated by cultural practices such as  
192 *Fang Sheng* (ritualistic life-release), where individuals release animals such as fish, turtles, and birds

193 into local ecosystems, due to deep cultural and religious traditions, particularly within Buddhist and  
194 Taoist communities. This practice, driven by the desire to accumulate merit and good karma, is  
195 widespread and often performed without full consideration of its ecological impacts (Du et al., 2024).  
196 Although many of these released species are considered 'native to China' in a broad sense, their  
197 release into specific ecosystems may result in ecological disruption. A shift in legal definition would also  
198 provide a pedagogical tool for society. If the law explicitly states that a species is non-native once it  
199 crosses its ecosystem boundary, the government can more effectively regulate the trade and release of  
200 such species.

201

202 **Recommendations for Policy Revision**

203 First, to enhance its biosecurity framework, China should consider revising *the Code* and *the Measures*  
204 to align with ecosystem-based definitions and ecological realities. A critical first step would be to amend  
205 the current legal definition of 'non-nativeness' by redefining non-native species in reference to specific  
206 hydrological basins, biogeographical regions, or ecosystems. In doing so, China will align its regulatory  
207 framework with the reality that species are often native to one ecosystem but non-native to another.  
208 This would allow for more precise management of species that are moved by human activities across  
209 ecological boundaries but remain within national borders.

210

211 Second, the current regulatory approach should evolve from a static national list into a dynamic system  
212 that accounts for regional needs, using the smallest ecologically meaningful and operationally  
213 manageable unit (i.e., a hydrological basin in freshwater systems, or an equivalent biogeographic unit  
214 in terrestrial and marine contexts) as the basis for assessment and regulation. Between 2003 and 2016,  
215 China published four installments of the List of Invasive Non-native Species in China's Natural  
216 Ecosystems. However, a critical limitation is that these lists only included species originating from  
217 outside of China. Regulatory lists would be more ecologically meaningful if they were developed  
218 according to ecosystem-specific conditions, thereby allowing the recognition of species that are 'native  
219 at the national scale' but non-native and potentially harmful in particular domestic regions. A regional  
220 management system would allow authorities to tailor their efforts based on specific ecological contexts,  
221 offering greater flexibility and responsiveness to local biosecurity concerns. Focus should be directed  
222 towards species with a documented history of significant invasive impacts in other regions or countries  
223 (Tarkan et al., 2024). For these taxa with high-risk potential, the absence of a national-level listing  
224 should not preclude regional-scale preventive measures, as their proven capacity for ecological  
225 disruption makes them prime candidates for 'native to country' invasions when translocated across  
226 domestic ecological barriers. Rather, standardized risk screening and assessment tools should be

227 applied to identify species that are ‘native to the country’ but may become ecologically disruptive when  
228 introduced across domestic ecological barriers.

229  
230 Third, while China’s existing legal framework has made substantial progress in advancing national  
231 biosecurity and reflects a strong commitment to ecological protection, additional measures are needed  
232 to address the overlooked risks associated with artificial connections among previously isolated  
233 ecosystems. We recommend that China’s legal and regulatory system incorporate a more  
234 comprehensive approach to impact assessments for large-scale infrastructure projects. With the  
235 growing number of projects that link previously isolated ecosystems—such as the SNWTP—there  
236 exists an urgent need to mandate inter-ecosystem biosecurity risk assessments. These assessments  
237 would evaluate the potential risks of species spreading, both invasive and native, when distinct  
238 ecological units are artificially connected. The implementation of biological isolation technologies, such  
239 as filtration systems or physical barriers, should be required for all infrastructure projects that facilitate  
240 inter-basin or inter-ecosystem species movement. This proactive approach would help mitigate the  
241 ecological risks associated with such large-scale projects and prevent inadvertent species  
242 introductions.

243  
244 Fourth, there exists a need to expand regulatory authority to include transport of live organisms across  
245 internal administrative and ecological boundaries. Currently, many live organisms are transported  
246 without sufficient regulation within China, despite the potential ecological risks associated with their  
247 movement. Empowering agricultural and environmental departments to regulate these internal  
248 movements with the same rigor applied to international imports would close the gap in biosecurity  
249 oversight. This expanded authority would ensure that species translocations within the country are  
250 subject to the same risk assessments, quarantine procedures, and containment measures as  
251 international trade, preventing the internal spread of invasive species.

252  
253 These recommendations, if implemented, would significantly strengthen China’s biosecurity framework,  
254 allowing for a more responsive, scientifically-grounded and ecosystem-based approach to managing  
255 non-native species. By transitioning to an ecosystem-first model, China can better protect its diverse  
256 ecosystems from invasive species and safeguard its ecological integrity in an increasingly  
257 interconnected world.

### 258 259 **Towards Ecological Jurisprudence**

260 The current ‘territory-based’ approach to biosecurity is an outdated framework rooted in 20th-century  
261 geopolitical thinking, which does not address the dynamic nature of biological movement in the 21st

262 century. By adopting an ecosystem-first model, China can close the domestic blind spot that currently  
263 leaves its diverse regions vulnerable to internal invasions. This shift would help in protecting China's  
264 unique biodiversity - from high-altitude plateaus to tropical river basins - while providing a strong global  
265 example for countries with high biogeographical complexity and biodiversity. The goal is to establish  
266 'ecological jurisprudence,' where legal boundaries align with the natural boundaries of life.

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321

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### 328 **Competing interests**

329 The authors declare no competing interests.

330