

# Invasion Ecology: Expanding Trade and the Dispersal of Alien Species

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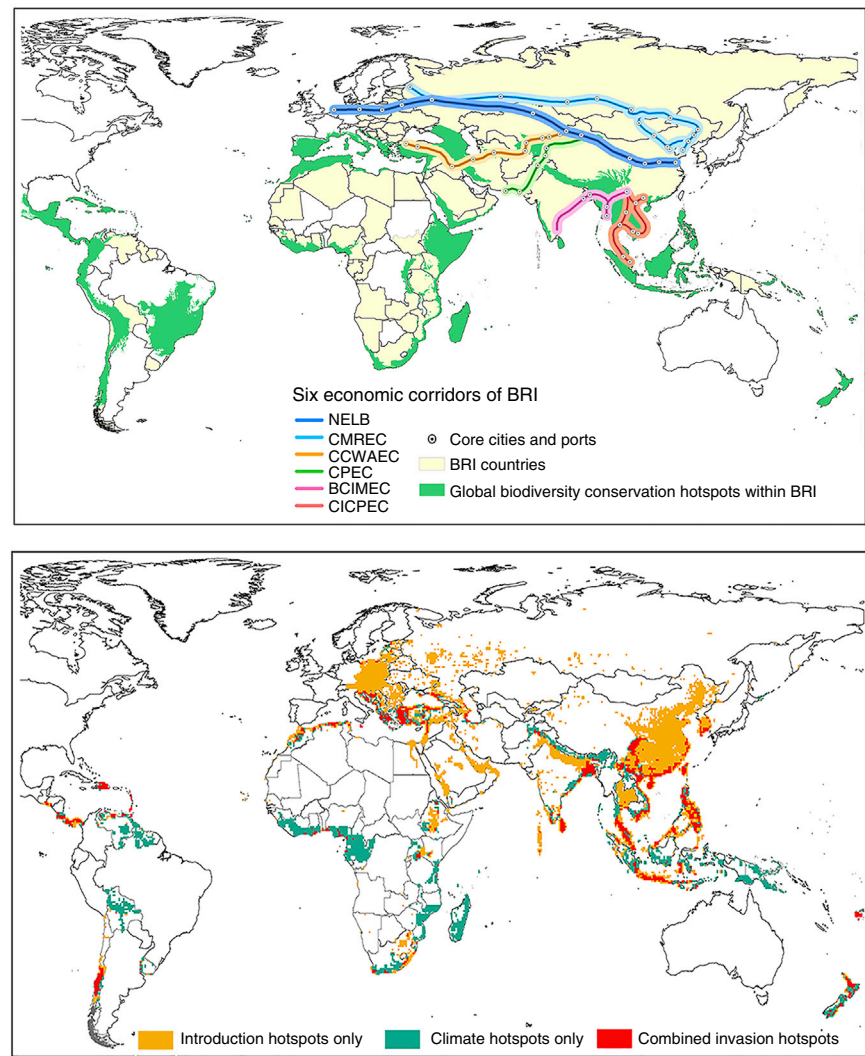
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China's ambitious aspirations to build a modern Silk Road will open new avenues for species to spread into regions outside their native range. A new study identifies 14 hot spots of biological invasions falling along the planned economic corridors.

Alien species are species which have been introduced by humans to regions outside their native range, and they are currently spreading around the world at the highest rate ever [1]. This is probably not surprising, as the dispersal of alien species is tightly coupled to socio-economic activity of humans such as trade and transport [2], which has increased considerably during recent decades. By moving cargo, people or — more generally — vehicles, humans also move species either intentionally or accidentally. To some degree, the dispersal of species is a natural process, which is essential for the survival of species. But the expansion and intensification of trade have increased the spread of species to unprecedented levels and has connected regions which have never been connected before [3]. New infrastructure projects, such as China's Belt and Road Initiative, may lead to yet more biological invasions. In a recent issue of *Current Biology*, Xuan Liu, Yiming Li and colleagues [4] provide a first comprehensive assessment of the potential influences of China's Belt and Road Initiative on the introduction and establishment of alien species.

The spread of species as a consequence of trade is nothing new. With the diaspora of European explorers and traders around the year 1500, the first global trade network was established, spanning nearly all continents [5]. This caused a first wave of introductions of alien species, many of them still present in the alien region such as rats, cats and mice [6]. During the following centuries, increasing demand and technological advances have accelerated and intensified traffic, thus increasing the probability of invasion. Local alterations,

such as the opening of the large shipping canals in Panama and Egypt, had distinct effects on the spread and distribution of species with worldwide impacts [7,8]. The



**Figure 1. Invasion risks and the New Silk Road.**

Economic corridors considered in China's Belt and Road Initiative (BRI; upper panel) and invasion hotspots identified by Liu and colleagues [4] (lower panel). Figure after [4].

current wave of new species introductions was caused by a further intensification of trade triggered by the invention of containerized transport [9].

China's Belt and Road Initiative is a very ambitious development strategy adopted by the Chinese government to connect international and domestic markets (Figure 1). With a planned expenditure of eight trillion US dollars and investments in nearly all Asian countries, as well as Africa, Australasia and Europe, it is one of the most ambitious infrastructure projects ever conceived. In their study, Liu and colleagues [4] first estimated likely introduction hotspots based on current data for trade, passenger numbers and cargo volumes across the 73 countries considered in China's strategy plan. The obtained introduction measures were combined with suitability maps of 816 known alien vertebrate species (mammals, birds, amphibians and reptiles) to identify potential invasion hotspots.

Liu and colleagues [4] identified 14 invasion hotspots with both a high likelihood of introduction of new alien species due to trading dynamics and a high suitability of habitats (Figure 1). In many cases, the planned economic corridors of China's Belt and Road Initiative will fall along areas with high habitat suitability. That is, these regions provide both high probabilities of receiving new alien species and high probabilities of their successful establishment. Most of the predicted invasion hotspots are located in South-East Asia, South-East Europe and the Near East, often within regions of high native biodiversity. According to the new study, species from all over the world may arrive and establish in these areas (Figure 2). Liu and colleagues [4] propose the implementation of comprehensive biosecurity precautions to mitigate the spread of alien species and their potential impacts.

Predicting alien species richness on large geographical scales is challenging mostly due to the lack of data and the stochastic nature of biological invasions. This is particularly true when high uncertainty surrounds the underlying assumptions. China's Belt and Road Initiative lacks forecasts of how economic development will unfold in the future. Thus, absolute numbers of predicted alien



**Figure 2. Future invader?**

The American mink is identified as one of the species with a high potential to expand its range into countries considered in the Belt and Road Initiative (photo: Tim M. Blackburn).

species may be questionable. Nonetheless, the value of the study by Liu and colleagues [4] is that it is the first assessment of the consequences of the planned infrastructure project for biological invasions and identifies likely invasion hotspots. The authors clearly show that even under current levels of trade the potential for introducing and establishing new species is high, particularly in regions close to the planned economic corridors. The likely increase in traffic due to China's economic ambitions will certainly increase the probability of invasion considerably.

Numerous studies have shown how infrastructure facilitates the spread of alien species in the past [10,11]. One of the most prominent examples is the opening of the Suez Canal connecting the Mediterranean and the Red Sea [8]. More than half of 573 assessed alien species in the Mediterranean entered directly via the Suez Canal [12]. This massive event is still ongoing even after 150 years. In contrast, fairly few species migrated through the Panama Canal showing that such projects need not necessarily lead to a massive exchange of species, but this is usually due to coincidental circumstances, such as natural dispersal barriers, rather than cautious planning [8].

China's Belt and Road Initiative has the potential to be as influential for the spread of alien species as the shipping canals with many new alien species emerging for the decades to come. The new infrastructure will expand into regions which have not been fully incorporated into the global trade networks, such as the Near East, South and South-East Asia, and parts of Africa. Many of these countries have a comparatively low number of alien species so far [13], but are predicted to receive most alien species in the future even without considering the new infrastructure [14]. In addition, the new corridors will mostly expand latitudinally, connecting regions of similar environments, which increases the chance of success for alien species establishments. Finally, the envisioned emerging markets will attract trade partners from all over the world, thereby increasing the pool of potential alien species and their probability of arrival [15].

China's Belt and Road Initiative has the potential to pose huge environmental impacts beyond biological invasions [16]. Liu and colleagues [4] clearly pointed out that there is a high potential for the creation of new invasion hot spots, and the authors provide a first step for an in-depth analysis of the consequences for

biological invasions. China and all its partners have the opportunity to address environmental impacts before the actual start of the project, which is crucial particularly for biological invasions as the removal of alien species after populations are established is nearly impossible. China has the unique chance to take a lead in the development of sustainable infrastructure projects and to build a 'green Silk Road' as promised by the Chinese government.

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## Neuroscience: Sex Hormones at Work in the Neocortex

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Sex hormones have easy access to the brain and their receptors are expressed by cortical neurons. Until recently, little was known about what impact, if any, they have on cortical processing. New data reveal that estradiol potentially alters inhibitory neurotransmission in the neocortex.

The neocortex is considered the seat of higher cognition and is often placed at the top of the hierarchy of brain structures due to its late appearance in evolution and its capacity for complex computation. Steroid sex hormones, in contrast, are associated with ancient 'instinctive'

behaviors like fighting, mating and parental care. Given the perceived gap between the elevated functions of the neocortex and the base functions of the gonads, it is not surprising that few studies have examined the effects of gonadal hormones on neocortical circuits.

Emerging work suggests we have underestimated the influence of gonadal hormones.

Steroid hormones released by the gonads (ovaries and testes) circulate throughout the body and can diffuse through lipid membranes including those of cells that form the blood–brain barrier.

