Transportation of Invasive Species: A Management Framework

Sinclair, J. S., Lockwood, J. L., Hasnain, S., Cassey, P. & Arnott, S. E. (2020) A framework for predicting which non-native individuals and species will enter, survive, and exit human-mediated transport. Biological Invasions, 22(2), 217-231.

Invasive species management traditionally focuses on post-introduction, meaning when the species has already entered a new environment. Human activities, movements and trades both intentionally and unintentionally transport species outside of their usual ranges, and thus there are many factors that can prevent the spread of species even before the species enters into a new place. In fact, research focusing on pre-introduction management strategies, in order to prepare for the impact of invasive species before they even arrive and become invasive, is becoming increasingly popular.

These researchers were interested in combining this research and creating a framework that will help scientists, organizations and governing bodies consider each factor within the journey of the species travelling to a new place. This will then also help them determine the invasiveness of the non-native species that is being transported.

In the study, the researchers refer to the object that transports a species as a vector. In regard to biology, a vector is an agent that helps something get from one place to another. In terms of this study, a vector would be a human, car, train, plane, etc. After combining and reviewing pre-existing research and frameworks, the researchers created a new, all-encompassing framework that attempts to consider the many different factors of a species' introduction into a new environment. The framework considers the biological processes and the vector's characteristics through the different points of the transportation including where it came from, the entrance of the species into/onto the transportation object (human, clothing, train, car, boat, etc.), the survival on the transportation object, the exit from the transportation object and into the new environment (Figure 1).

The Framework...

Biological Characteristics

Entering the Vector

Many biological processes will affect the probability of a species latching onto or entering into/onto a transportation object, such as:

- If a species range overlaps human ranges (in same area)
- If a species is rare or abundant
- If a species (or reproductive structures of that species (ex. seed)) can easily latch onto a transportation object (like seeds on clothing) or if species is parasitic and requires a host
- If a species is associated with intentional value assigned by humans (aesthetic, cultural value, conservation)

Surviving the Vector

Once on the transportation vector, scientists can determine if the species will survive, by looking at:

- If a species is insensitive to stress of movement, handling and captivity
- If a species is insensitive to environmental stress such as temperature, water availability, toxins
- If a species has characteristics that are good for these conditions (dormancy, flexible behaviour, heat-shock proteins, energy reserves through body mass, moisture retention)
- The possibility of shared transportation (vectors carrying different species) presents an impact on survival (predation, crowding, disease or even mutualism)

Leaving the Vector

The exit from the vector is the last step that the species needs to take to enter a new environment, which is dependent on:

- If the species is explorative and will leave the vector (unless in captivity) or timid and will stay in the vector
- If a species leaves with no behavioural choice (seed movement)
- If a species escapes or can no longer be kept due to size/behaviour

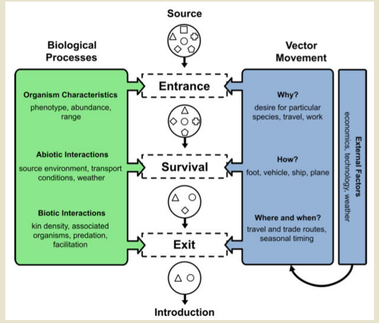

Figure 1.

Vector Characteristics

Entering the Vector

The possibility of a species getting onto a vector also depends on the vector characteristics, such as:

- The type (ex. vehicles designed to carry fish might capture some unwanted aquatic microorganisms)
- When and wear the vehicle operates, as the more times a certain vehicle enters into the same place, the higher possibility that a species could enter into or onto it
- All factors affecting the direction and travel of the vector (location, weather, technology, errors)

Surviving the Vector

A species survival on the vector is also dependent on the conditions inside or outside the vector, which include:

- The duration of the travel
- Intention of travel and preparation of travel (unintentional pick-up of species means that there will likely be no preparation for the species, whereas intentional pick-up of the species most likely means that appropriate conditions for the species is provided)
- Climate of the area travelled within, laws and policies of the area travelling to
- Human awareness and education of species travel (washing shoes, washing boats, security while crossing borders)

Leaving the Vector

As the last step of the transportation, the exit from the vector is also dependent on the vector itself, and these factors:

- If intentional pick-up of the species, the species could be set-free or in captivity and cannot exit
- If unintentional pick-up of the species, the species could be killed during regulation policies and procedures, especially if the vector is travelling long distances
- The distance from source to new environment

Emeral Ash Borer: Case Study

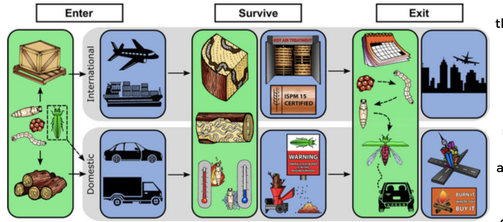

Figure 2.

The researchers applied their new framework to the Emerald Ash Borer issue, which determined a multi-faceted assumption for understanding how the beetle entered into a vector, survived the vector, and exited the vector to interact in a new environment (Figure 2). The green sections in each stage represents the biological processes such as development stages and timing, and resistance to hot and cold temperatures. The blue sections represent vector characteristics such as the vehicle type, conditions of the vector both inside and out, and management strategies put in place that affect the species throughout the process such as warning signs, sorting, and education. Lastly, the grey sections represent different pathways that the beetle could have taken.

Overall, this study presents a reason as to why many factors even before the non-native species has entered a new place, should be considered for invasive species management. Sinclair et al. (2020) state, that "in summary, the reasons why people move, how they move, where/when they move, and the external factors that affect each, combine to drive patterns and behaviours of human movements. By questioning the motivations, methods, directionality, and timing of human movements, we can improve predictions of which subset of species and individuals are likely to be moved, the conditions they experience during transport, and their probability of exit." And lastly, "the pre-introduction process is an integral driver of invasion and a deeper understanding of it is also valuable for identifying effective targets for control and prevention. Our framework can be similarly applied to understudied, new or potential invaders both to better elucidate what is happening prior to introduction that could be driving invasion, and for identifying key mechanisms upon which to focus regulatory efforts" (Sinclair et al., 2020).

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