Native and Non-Native In the Anthropocene

by

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Introduction what to care about and why?

A. Anthropogenic Disturbances

Anthropogenic, human caused, impacts on the environment are not just widespread but are also always interacting and synergizing off of each other. Global temperature rise, which has its own immediate effects, causes species ranges to shift both across a map and vertically in elevation. It additionally causes a type of range shift temporarily where the phenology, timing of life events, of certain species drift from other species within their ecosystem as well as causing dramatic population changes. Deforestation's effects are felt across the world, as well as the effects of habitat fragmentation and the increasing prevalence of edge effects. All of these disturbances combine to worsen the effect of and/or facilitate the spread of pest species. Many of these pest species are non-native and invasive, although the distinctions in categories can be blurry, inconsistent and economically driven rather than scientifically. Although humans (*homo sapien)* have altered ecosystems and species composition throughout history, the modern form of this takes on a new level. As we grapple with understanding the scope of anthropogenic impact on the world in the present, future and past, the standards of invasion must be altered considering the severity of anthropogenic modification to the planet.

Climate Change, shifting ranges, and Phylogeny

Climate is one of the biggest factors in the distribution of species and their shifting ranges on Earth across all biomes. Climate change, combined with land use causes ranges to grow and shrink, not just across a map but in elevation on a local level.

This creates a global increased risk of extinction across both plants and animals, and at the local level causes introduction of otherwise native species into novel ecosystems. This also creates opportunity for new, unforeseen, biological interactions , including Harbor Seals (*Phoca vitulina*) acting as a vector in the spread of a disease found in the Atlantic to California Sea Lions (*Zalophus californianus*). Although in the history of life ranges are frequently flux we are facing unprecedented shifts (Phillips 2010). The concerns around these growing ranges aren't exclusively ecological as human health concerns are relevant. Mosquito species *(Aedes aegypti)* and deer ticks *(Ixodes scapularis)* have been spreading further and further north within the continental US and increasing in concentration within their established range, introducing more people to these biological hazards. (CDC 2017)

This shifting temperature and range has caused normally native and ecologically important species to become considered invasive and pests as they spread to novel areas. The Mountain Pine Beetle (*Dendroctonus ponderosae),* a tree boring beetle, is native to British Columbia and invasive in Alberta. Although its temperature driven shift in range is cause enough for concern, the changes to its phenology are a further one. Historically, MPB populations have been bi-voltinist, with a new generation forming every other year. Populations were controlled by the winter which would wipe out as many as 92% of beetles. As a pine tree can withstand a certain number of beetles without suffering dramatically, the effects on tree populations have had an equilibrium. However with the increase in temperatures, beetle populations have not only avoided the effect of winter, but most populations mating cycles have switched from semi-voltinism, spawning a new generation every other year, to voltinism, spawning a new generation every year. (Bentz et al. 2014)

The phenological changes in plants include blooming, seeding, budburst, curling leaves and more happening at different times than normal, while other plants or animals that somehow or another depend on the traditional timing of these events are left arriving either late or early. This leads to an ecological desynchronization that impacts different trophic levels, levels of the food web, in different ways. For example caterpillars hatching earlier than normal with budburst happening later, leaving some caterpillars without their primary early life food source (Thackeray 2013). Another example includes birds breeding earlier while their offspring's primary food source does not. In a laboratory setting as few as 6 days desynchronization between solitary bees and blooming showed a dramatic decrease in fitness (Schenk et al. 2017). Some models for the future ranges of certain *agave* species and their primary pollinator the Mexican Long Eared Bat (*Leptonycteris nivalis*), which is already endangered, show the bats migration no longer overlapping with the flowering *agave* (Thackeray et al. 2016)

Habitat destruction

Habitat fragmentation is one of the largest impacts to biodiversity in the world in which a large expanse of habitat is transformed into several smaller patches of habitat isolated from each other by a different form of habitat. Although this can happen naturally it has become a major anthropogenic threat to biodiversity, with common causes being residential or agricultural development, and primary resource extraction. The effects to biodiversity are habitat loss, the largest factor due to straightforward destruction of habitat, increase in isolation, limiting gene flow between local populations among other things, and a reconfiguration of habitat, which is more of a complex interaction that has both positive and negative effects on different species. Some of the establishing research for this concept focused on oceanic islands, likening the isolated patches of "habitat" to islands separated by human "ocean." A major factor in the restructuring of habitats associated with forest fragments are edge effects, the microbiome changes in biochemistry that occur at a forest edge compared to a forest core. 70% of forest on the earth is within 1km of non-forest, 50% within 500m and 20% within 100m, making edge habitat a significant portion of forest.(Haddad et al. 2015) Some of the common effects of edge effects are decreased humidity, increased solar radiation and increased wind exposure. Consequences of edge effect include altered species composition, of plants, animals, microorganisms and fungal mycelium. This altering has positive effects for certain species that favor edge habitat, including many brood parasitic birds. (Patten 2016) Another consequence of habitat fragmentation the opportunity provided for invasive plants to spread. Although some invasive plants can invade resilient, undisturbed forest core, the majority prefer the microbiome created by edge habitat, as well as benefiting from the disturbance of edge effects to a forest (Holway 2005).

Invasive Species

A simple description of invasive species is that they evolved in one location, have ended up in another location and certain traits have allowed them to outcompete, predate, or reduce fitness of native species. They impair their encountered environment's structure and function, for plants often modifying soil biochemistry. One of the major factors in their success is novelness to the area. Non-native animals benefit from both predator release and prey naivety, their natural predators aren't around to eat them (predator release), and their encountered prey do not know to and/or are not given traits that allow them to avoid predation (prey naivety). Characteristics common for invasive plants include rhizomal regrowth, which allows them to sprout from tiny portions of root material, fast growth, high dispersal ability, tolerance of a wide range of conditions, phenotypic plasticity, the ability to adapt phenotypic traits rapidly and flexibly, and association with humans or human activity.

Despite evidence of anthropogenically introduced species as far back as the neolithic (Webb, 1985), the rapid change in land use associated with the spread of colonialism, industrial revolution and modern day global supply chain, have contributed to a world in which invasion distance, frequency and severity has increased. Over a third of all introductions for the past 200 have happened since 1970 (IUCN 2017). Climate change reduces the resilience of forests to invasion, and could allow regularly introduced species that have previously not established themselves in an encountered ecosystem to do so. The invaders' broader tolerances, rapid growth and far dispersal facilitate their shifting ranges overtaking native plants that shift slower. Although many plants are having earlier than normal budburst, many invasive species have been shifting faster (Colautti 2017). The anthropogenic effects previously discussed all make the threat of invasives to biodiversity greater, and more dramatic.

Distinct Distinctions:

Native species that evolved in the environment and niche they're in, specific to not just regions or biomes but microbiomes, localities and niches.

Alien species have either naturally or anthropogenically found itself someplace other than where it had evolved. They often don't live as the encountered environment is outside their climate requirements. Very rarely are they able to reproduce, and even rarer are they able to establish a population.

Naturalized species are alien species that have able to establish populations in encountered ecosystems. They are able to reproduce and have yet to be observed impacting local biodiversity negatively.

Invasives are naturalized species that, due to certain traits and characteristics have grown in population to the point where they're negatively impacting local biodiversity.

Vague Variations:

The details of what makes a species "native" are not consistent, ecologically or sometimes culturally based. Often, to simplify the process a year is chosen, however since different federal and sub-federal nation states choose different years, a species status shifts as it crosses a border. Norway uses the year 1800 and everything in Finland before that year is native (Helsinki 2001). In the UK, rabbits can be considered non-native despite being what many locals would consider quintessential. Species that are shifting due to climate change to new locations and elevations can have negative impacts on encountered ecosystems despite being native. Predator release is experienced in many human modified ecosystems as predators are not just chased out of residential areas but most primary predators require a wide range of intact ecosystems, and have a low tolerance to fragmentation. This makes certain species harmfully abundant, like deer in Westchester, causing damage to both the ecosystem and human infrastructure, just like invasive plants do. There have also been many species with negative impacts on their ecosystems determined as invasive that are native including the sea lamprey (*Petromyzon marinus*) in lake champlain and a bush in the lesotho which pollen records show have been on the island for at least 10,000 years (Fitchett et al. 2007).

Alien species are constantly introduced to novel ecosystems especially around cities and docks that receive heavy global traffic. Very rarely does an alien species encounter an ecosystem it can survive in and even rarer does it encounter one it can reproduce in. The climate is outside their tolerances, they are consumed by encountered species, and unable to find food or nutrients. But one of the predicted effects of climate change is species previously unable to establish themselves are as minimum temperatures enter into their range, resilience of local ecosystems is lowered, and large local predators and herbivores become less common. There is similar fear around naturalized species being largely invasive waiting-to-happen.(Hill 1994)

Invasive species are, in many heavily anthropomorphized ecosystems such as heavily populated urban areas, invasive plant species may be the alternative to no plants at all. Non-native trees in an urban setting still help to counteract urban heat sink. There are endangered birds who use invasive plants as essential nesting leaving a strange limbo where a plant is protected because it's being used by a protected species, but invasive and being attempted to eradicate. With time there also comes the question of prey species losing the prey naivety that makes them so vulnerable to predation by non-native species. When early human migration brought dogs with them to Australia those dogs contributed to loss of native biodiversity as no prey species were adapted to them. After thousands of years those dogs became Dingos (*Canis familiaris dingo)* which are now a protected and endangered species in Australia. A study in the backyard of an Australian suburb showed that wombats (*vombatus ursinus*), are less likely to visit the backyards in which a dog has been present than the ones it hasn't. This indicates that they no longer have prey naivety to dogs. (Carthey et al. 2012) Oftentimes the declaration of invasive is for policy and economic reasons rather than scientific, a simplified version of good vs. bad species.

Anthromes as a factor:

As humans have become the most prevalent geological force modifying ecosystems, many researchers have categorized regions by their anthropogenic modification, similar to how biomes are categorized by climate. These human biomes, or anthromes, can indicate current land use or historic. Dividing the surface of the earth into 6 categories depending on population density and land use. Dense settlements, villages, croplands, rangelands, forested and wildlands, which includes barren land. On average the percentage of invasive species increases as population density increases, with urban areas being the most modified and wildlands the least. Additionally land use and anthromes have been evaluated historically as far back as 1700, when more than half the earth was considered wild and 45% semi-wild lightly used for agriculture. As Climate change progresses however, more and more of human modification to the environment is not through direct land use, but through global effects. (Ellis 2010)

Conclusion:

The dichotomy of invasive/native, useful as it may be for the sake of policy, has historically been less relevant in heavily anthropogenic regions, where soil biochemistry, climate, food webs and microbiomes are heavily modified. The negative effects to the environment of a region cannot be determined by endomnocity, which in itself can often be disproven. In the coming century the extent of effects of these same modifications on sparsely or even unpopulated areas will produce the same issue which will require naturalists to find a more consistent standard for judgement of impact that considers the extent of disturbance within our ecosystems.

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