Specious Claims?

Radu Cornel Guiașu

Conservation biologist Radu Guiașu looks beyond the alarming headlines to assess the true impact of "invasive" species. Barbarian invaders? Or just a case of species xenophobia?

SURREALIS_UK

RALPH PRESGRAVE

As I was reading the paper one Sunday morning, a rather alarming front-page headline ...

... caught my eye: "Attack of the killer worms—foreign invaders threaten saplings and trilliums."

Reading further, I discovered that the article was referring to some inconspicuous non-native earthworm species introduced into Ontario hundreds of years ago whose only apparent crime is eating leaf litter. A harmless activity. The article was vague about the threat but appeared to suggest that these worms have a negative impact on soil, although in the fourth paragraph the author confessed that no formal studies have been conducted in Ontario. Mere "anecdotal reports" of the earthworm invasion were circulating. So much for grabbing readers' attention.

Introduced earthworms—whose aeration of soil and recycling of nutrients are generally good for plant life—are not the only non-native species to receive negative press coverage lately. In recent years, many of the nature articles I've read have mentioned one threat or another from "invasive" species said to be poised to take over our water, soil, and forests, destroying everything in their path. The fact that a species may have originated elsewhere—even if it arrived in North America centuries ago and has had no discernible, scientifically proven negative impact on its new surroundings—seems to be enough to generate this type of bad publicity. Even worse, often, the proposed solution for getting rid of these non-native species is a controversial control program. These programs, which can be expensive and unnecessary, sometimes also create problems for innocent bystander species.

Such news articles have not arisen out of nowhere. They mirror a trend begun among some conservation biologists within the last two decades. This trend, which has intensified in the last few years, is called invasion biology, a new branch of conservation biology. Through my teaching of conservation biology at York University's Glendon College and the fieldwork I have conducted in ecology for the past 16 years, I have become very much aware of the growing popularity of invasion biology.

Rapid growth in the young field of conservation biology since the 1980s has generally been a positive development. It has led to increased awareness of human threats to the natural world. Many good researchers are working hard to learn more about a variety of species and ecosystems, and the valuable knowledge gained through such vital research is essential for protecting countless endangered animals and plants and preserving many vulnerable natural environments.

And indeed, sensationalism aside, some invasive species can, under certain circumstances, threaten human health, undermine human economic interests, and sometimes add to the risks that vulnerable local species face. The recent arrival in Ontario of the notorious West Nile virus—which is known to infect and kill humans as well as other mammals and many types of birds—is decidedly unwelcome.

But when it comes to the overall impact of many other non-native, or exotic, species the situation is usually more complex. To begin with, it is often quite difficult to ascertain whether a particular species is native to a given area. In many cases, we just don't know exactly where a particular species originated and when or how it reached a certain region. As well, the various definitions for the terms "native" and "non-native" as they are applied to biological species can be more or less arbitrary. Some authors consider introduced species to be those that have arrived in a particular area since the beginning of recorded human history, and native species those that have either evolved in the region or moved there during prehistoric times. In other studies, species are classified according to their presence or absence at an arbitrary point in time. The year 1500, for example, is often used in Europe to assess whether plant species are native or not.

Because of the uncertainty surrounding the terms native and non-native, in 1996 American biologist James Carlton proposed a third category—cryptogenic species. These are species whose native or exotic status simply cannot be determined based on the available evidence by using any of the standard criteria. A recent example of a difficult-to-assess conservation situation is that of the pool frog (*Rana lessonae*) in the UK. We know that this frog was introduced in the early 1800s from southern Europe, so it was assumed this species was non-native in the British Isles. But a major 2005 study reported that some pool frogs were in fact native to the UK. A team of researchers arrived at this conclusion based on various sources of evidence—among them, examining historical records, DNA data showing that these frogs were not directly descended from the introduced frogs, and the discovery of pool frog remains in the UK dating back 1000 years or so, long before the southern European frogs were introduced. These native pool frogs were more closely related to conspecifics (members of the same species) from

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Opening spread: Recent research reveals that zebra mussels and purple loosestrife, two of Ontario's most notorious invasive species, may not be as harmful as previously believed. This Page, Top: The introduced black locust tree may have been native in Ontario prior to the Ice Age. Middle: The non-native mute swan is a target of control programs in some US states. Bottom left: Some pool frog populations are considered native to Britain while others are not. Bottom right: Seeds of the introduced bull thistle are a favourite food of some native North American birds.

Sweden and Norway than to the southern European frogs. Since there is no evidence of any historical introductions from Scandinavia, for now at least, some *R. lessonae* frog populations in the UK are considered native while others are considered exotic.

The difference between the two may seem purely academic, but it is not a trivial matter. Native status may afford a certain level of protection for a species, whereas an "introduced" designation may label it, in the words of the study's authors, "an undesirable alien." Should some ancient historical records come to light one day indicating that a Viking warrior carried a pool frog or two to Britain more than 1,000 years ago, the conservation status of this species may be revised yet again.

Species distributions are not frozen in time and space. They change continuously in response to changing environmental conditions—with or without human interference. In my own studies of crayfish, for example (see sidebar "The Reviled Rusty Crayfish"), the species *Cambarus robustus* has expanded its range in central Ontario, possibly at the expense of another crayfish, *C. bartonii*. But scientists were not concerned about this and never considered intervening because the process was deemed "natural"—both species are considered native to Ontario. But when the crayfish *Orconectes rusticus*, assumed to be an introduced species in the province, expands its range, as it has in various places in the province, some biologists feel compelled to intervene and stop the range expansion or remove this crayfish altogether.

One problem that arises with this kind of intervention is that identifying a species is not as straightforward as it may seem. Other crayfish species, such as *O. luteus*, found in parts of the US, are sometimes mistaken for *O. rusticus,* as are hybrids between different species—*O. rusticus* and *O. limosus*, for instance. There are also regional variations among populations of the same species. Thus, control programs targeting a certain species can backfire, destroying similar-looking species in the process, particularly when experts are not involved.

Another problem with control programs is that they often attempt to eradicate unwanted species by a variety of unsavoury means, such as poisons. These methods can unintentionally kill non-target species as well. In New Zealand, for example, poisons used to eradicate mice also killed the North Island saddleback, a rare native forest bird. Such programs can also be unpopular. In the US, concerned citizens have led legal challenges to stop wildlife management organizations from killing the graceful mute swan, a species introduced from Eurasia in the mid-1800s. The control programs, which took place in states such as Rhode Island and Maryland, involved destroying eggs and removing adult birds. Advocates of such programs say the swans sometimes attack people, but fail to mention that such attacks typically occur when the birds are protecting their nests from intruders. Mute swans have been a beautiful presence in some of our urban ponds and marshes—including those along the Toronto waterfront—for well over a century.

In Ontario, all the species that live here now arrived relatively recently (compared to the 3.5 billion years of life on Earth)—within the last 10,000 years or so. About 12,000 years ago, towards the end of the last Ice Age, Ontario was covered by huge ice sheets hundreds of metres thick. As the ice retreated northward, species from ice-free regions to the south began moving gradually into the province to occupy newly available habitats. Crayfish species such as *Cambarus robustus*, which presumably reached Ontario on its own after the last glaciation, are considered native, while species such as *Orconectes rusticus*, which arrived as recently as several decades ago, perhaps initially with some human help, are assumed to be introduced.

For other species, such as the black locust tree (*Robinia pseudoacacia*), there is evidence that they lived in Ontario before the last Ice Age but haven't had time to get back here again naturally just yet. To date, this tree species has expanded its range northward on its own only as far as Pennsylvania. But human reintroduction programs have brought the species back to Ontario to reforest polluted habitats where few other trees can survive. This very useful ability allows the black locust to prosper in urban and industrial areas and it is a boon in many of Toronto's wooded ravines because its roots are also particularly good at preventing erosion. Yet despite its usefulness and history of being native to the province, the black locust tree is still referred to in several field guides as an aggressive invader in Ontario—simply because it was reintroduced by humans. The same field guides advise readers to pick introduced flowers freely but not to touch native ones. This kind of advice can encourage the mistreatment of certain species and perhaps even interfere with the public's enjoyment of the beauty and diversity of nature. It may be more difficult to enjoy a walk in the woods if you are constantly on the lookout for species that are not allowed to be there.

Although only a small percentage of introduced species become invasive and cause widespread and well-documented harm to the environment, certain biologists

The Reviled Rusty Crayfish: Hated Invader or Native Son?

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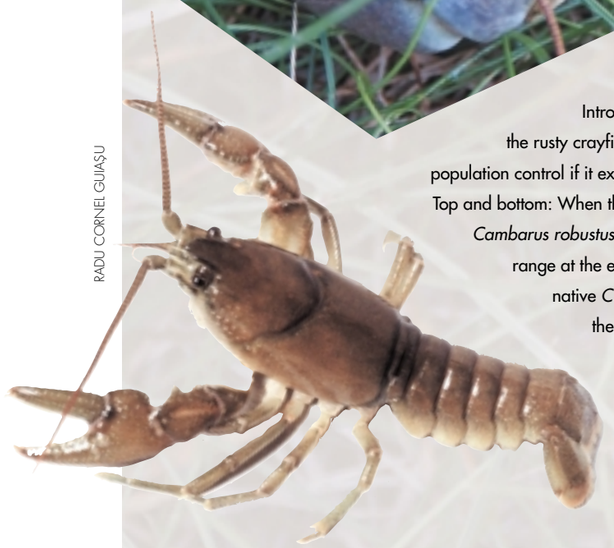
PHIL MYERS, ANIMAL DIVERSITY WEB



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Middle: Introduced in Ontario, the rusty crayfish is subject to population control if it expands its range. Top and bottom: When the native crayfish *Cambarus robustus* (top) expands its range at the expense of another native *C. bartonii* (bottom) the process is considered natural.

Most of my work as a conservation biology instructor at York University and a field researcher in ecology for the last 16 years focuses on the conservation, ecology, and behaviour of Ontario's crayfish species. I have tracked the changing distributions of several of these crayfishes by analyzing specimens and records stored in the collections of the Royal Ontario Museum. In the field, I have studied current crayfish habitats and locations. What I've learned reveals much about invasive and native species.

Orconectes rusticus, the rusty crayfish, is the most reviled crayfish in North America today. Considered invasive in many parts of the continent, including Ontario, it is currently the target of a number of control programs that aim to eradicate it from certain lakes and streams. But the exact initial native range of the rusty crayfish is unclear. According to some experts, this crayfish might well have lived in Ontario originally. Biologists know that the species is native to nearby Michigan and Ohio. And we know that this resourceful crayfish can survive in a variety of aquatic habitats, from small ponds to fast streams. So it is able to spread quite well naturally.

Often, biologists assume the rusty crayfish was introduced into Ontario by US fishermen who used it as bait. But for the most part, we are just not sure how the crayfish arrived here. It is very likely that some of the range expansions into Ontario were natural—in other words, they increased their range without human help.

The rusty crayfish is disliked because it is accused of outcompeting other crayfish of its genus, such as *O. virilis* and *O. propinquus*, in parts of the US and Ontario. But it should be noted that while *O. rusticus* does seem to replace species such as *O. virilis* at certain locations, the phenomenon is highly variable and influenced by local conditions. Both *O. virilis* and *O. propinquus* remain quite abundant and very widespread in North America in general, and in Ontario in particular. In fact, *O. virilis* is the most widely dispersed crayfish in Canada. Not one of Ontario's lake and river crayfish species is currently threatened. The only vulnerable crayfishes in this province are the semi-terrestrial burrowing ones (see *Rotunda* Summer/Fall 2002), but their plight has nothing to do with the rusty crayfish.

So, branding species with native or non-native status is not straightforward. Such labels are often dependent on individual local jurisdictions in charge of species management. The crayfish *O. virilis* is considered native in places such as Wisconsin and Ontario, but invasive in North Carolina, while *O. propinquus* is listed as native in southern Wisconsin, but invasive in the northern part of that state. Following this line of reasoning further, we can envisage a scenario in which a species can be native on one side of a road, but invasive if it ever crosses over to the other side. — RCG

and wildlife managers continue to consider virtually all non-native species as potentially harmful. Dividing the natural world into "good" and "bad" species is a highly subjective exercise, one often based more on current human needs or preferences than solid ecological principles. Our epic struggle against harmless introduced dandelions in order to "save" lawns and golf courses is one such example of a current double standard. Lawns are essentially monocultures of usually introduced grass species (such as Kentucky bluegrass), which, due to frequent mowing, are not even allowed to complete their life cycles. As a result, lawns are not exactly as "natural" as we might assume.

But even well-known invasive species, such as zebra mussels, can have positive effects on some local species and ecosystems. These mussels arrived in the Great Lakes region from Europe in the mid-1980s in the ballast water of ships. After their initial rapid expansion, there is now evidence that in some Ontario locations zebra mussel populations are stabilizing or even declining. At many locations along the Canadian shoreline of Lake Ontario, the newly introduced quagga mussels have largely replaced zebra mussels. Both zebra and quagga mussels have become important food sources for several local species in Ontario, including various crayfishes and fish, as well as waterfowl, such as the lesser scaup, the greater scaup, and the bufflehead. At Long Point, on the shore of Lake Erie, for example, these waterfowl eat large quantities of introduced mussels, keeping mussel populations in check naturally.

Another oft-heard complaint about non-native species is that they reduce our biodiversity. But the evidence for such statements is often controversial or lacking. In a major recent study on purple loosestrife, researchers Heather Hager and Karen McCoy reviewed all available information and found no solid evidence in support of the idea that this much-maligned introduced plant has a negative effect on our wetlands. On the contrary, it seems that many insect species, including native ones, feed on the plant. Yet textbooks and brochures continue to label purple loosestrife as a marauding invader that should be controlled by drastic means.

In the Greater Toronto Area the vascular plant biodiversity has actually increased within the last century or two because of the addition of exotic species. According to recent estimates, approximately 750 of the 1000 or so native plants initially found in the GTA before rapid urbanization began are still present in the city, and about 500 exotic plants have become established there. Hundreds of introduced plants coexist with native ones in the city's ravines, creating a unique urban ecosystem. These exotics contribute to our environment in many ways—they generate oxygen, store carbon dioxide, and provide food and shelter for a variety of native and non-native animal species. The seeds of the introduced bull thistle are a favourite food of the native American goldfinch, introduced honeybees pollinate a variety of flowers, and non-native city pigeons are the main prey of the native endangered peregrine falcon, to list just a few of the many cases of vital native-exotic interactions. Trying to pull apart the complex ecological strands that currently tie all these species together, and removing plants and animals simply because they may not have been here at some arbitrary point in the past, could actually make our fragile urban ecosystems less functional and less diverse.

Recently, for example, volunteers in Toronto's High Park undertook a targeted removal of non-native plants, including honeysuckle and buckthorn. Such programs may be well intentioned, but their ecological value is questionable. These shrubs, which are among the first to have been introduced into Ontario from Britain centuries ago, seem to thrive in our urban parks and offer valuable habitat for a variety of bird species. And, as with crayfish, because introduced shrub species can look quite similar to native shrubs, mistaken species identity is always a concern. The aim of this removal program was the preservation of a few oak trees, which are particularly vulnerable to pollution and are therefore unlikely to do well in the city. Before engaging in such control programs, we should ask ourselves what we are trying to accomplish. Are we trying to restore the local environment to the way it was in, say, 1850? Why not 1790 or 1640? Is this a realistic goal in today's cities, and are they more "natural" places because these shrubs have been removed?

As urban areas continue their rapid expansion and new subdivisions swallow up more and more land, I, for one, am grateful for every little woodlot that survives, even if it hosts such exotic species as Norway maple and Austrian pine, which are particularly well adjusted to city conditions.

We know that deliberate species introductions can have unpredictable consequences and they should never be attempted casually. But the same is true of control programs against targeted species. Neither should be undertaken without conclusive scientific research and careful consideration. Perhaps the best thing we can do for many wilderness areas, and the species they shelter, is to leave them alone as much as possible and allow them to continue to exist and evolve on their own. ROM

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Top: The native North American apple maggot fly became a parasite of this fruit only after the apple tree was introduced from Europe. Middle: The cane toad, an introduced species in Australia, has adapted its size and toxicity in its new homeland. Bottom: The seeds of the introduced bull thistle are a favourite food of the native North American goldfinch.

Adaptation — Darwin Style

Key concepts in evolutionary biology, such as natural selection, adaptation, and speciation, as set out by Charles Darwin in his classic book *On the Origin of Species* and his other writings, are essential to understanding the long-term impact of introduced species.

Adaptation to new environments for example is often a hallmark of successful introduced species. The marine, or cane, toad (*Bufo marinus*), which is native to South America but has been introduced into several other parts of the world, is one example. The world's largest toad, it was brought to Australia in 1935 to control beetles that were devastating sugarcane crops. It spread quickly and now occupies a large area of the country. The toad's two large poison glands can kill a predator within 15 minutes of an attempted attack on the toad. Predators that survive may learn to avoid the toads. But recent studies have shown that the cane toads themselves have changed morphologically since their arrival in Australia. With far fewer predators than in their homeland, and therefore under less pressure to out-adapt their enemies, Australian cane toads have been getting progressively smaller over time—in overall body size and in the relative size of their poison glands. The toads are now less toxic than they used to be, and their impact on native predators is therefore decreasing.

Some of the toad's main predators in Australia, native snakes, are in turn adapting to the presence of their lethal prey. Over the decades, the snakes have increased in body size, which makes them more able to withstand toad poison. And they have developed smaller mouths, which make them less able to ingest a deadly toad. Both adaptations enhance the snakes' ability to survive a cane toad encounter. Significantly, these changes have not occurred in all native snakes but only in those species that interact with the cane toad. So, sometimes, the impact of invasive species is minimized naturally over time, thanks to adaptive changes in both the exotic and the native species.

Occasionally, the introduction of non-native species even leads to speciation events—the formation of new species from older ones. The apple maggot fly (*Rhagoletis pomonella*), is one possible example of speciation in progress. This native North American fly species is a fruit parasite and at one time laid its eggs exclusively in the fruit of hawthorn trees, which are also native to North America. But after apple trees were introduced from Europe about 300 years ago, some flies started laying their eggs in the apples instead. This phenomenon was first observed in 1864. Today, some *R. pomonella* populations have adjusted to life as apple parasites, while other populations of this fly species have remained hawthorn parasites. Over time, genetic differences have emerged between these distinct fly populations, as each becomes increasingly specialized in response to its particular plant host. Although flies from the two populations can still interbreed if they are brought together in the laboratory, they do not usually do so in the field, since each prefers to complete its life cycle on a different tree species. — RCG