Strategies for successful biodiversity conservation and restoration on small oceanic islands: some examples from Bermuda

David Wingate

(Bermuda National Trust & Bermuda Audubon Society) PO Box HM834, Hamilton HMCX, Bermuda
Email: wingate@bbsr.edu


(David Wingate at Spittal Pond Nature Reserve)

I do not need to remind this audience that small remote oceanic islands are the most vulnerable to ecological disruption and have suffered the highest extinction rates on the planet. This is mainly because they have never been connected to the continents and typically lack all those portions of the continental floras and faunas which are incapable of dispersing across the ocean on their own without man's aid.


Satellite view

The extremely recent colonization of most of the world's remote islands by man broke down this barrier of isolation so that now it is possible for any species from anywhere in the world to be introduced via ships or now aircraft.

Apart from man himself, other mammals in particular have had a catastrophic effect.


In Bermuda it began with the pig about 1560, followed by rats, cats, dogs and ungulate herbivores after British settlement in 1612.


As this 1616 map showing the subdivision by the Bermuda Company into settlement shares shows, no part of Bermuda was spared from immediate exploitation, and the result was immediate catastrophe. There are two classic examples of man's catastrophic impact on oceanic islands from Bermuda.

Cahow *Pterodroma cahow*

The cahow or Bermuda petrel is a gadfly petrel with no inherent defences against mammal predators. It nested in superabundance throughout the island, digging its nesting burrows in soil under the forest.

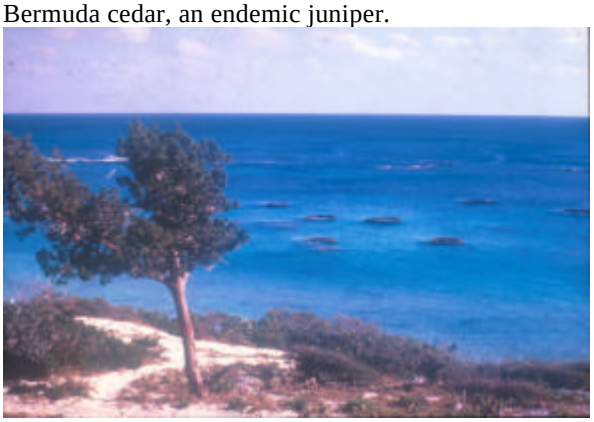

Cahow fledgling

Despite a proclamation to protect it as early as 1616, the Cahow was considered to have become extinct as early as 1630, a mere 20 years after settlement!

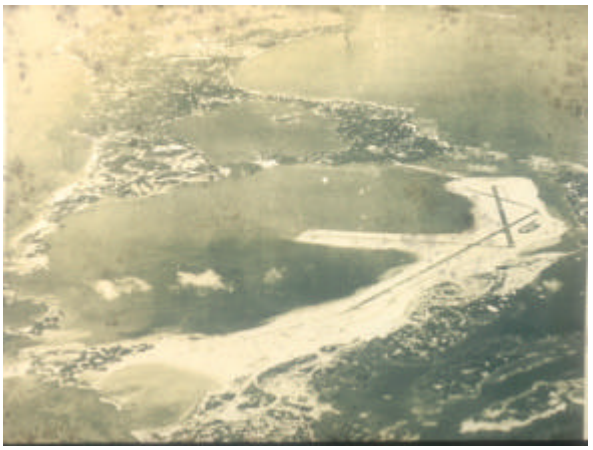

Scattered feathers of slaughtered seabirds (tropicbird killed by cat)

Bermuda cedar *Juniperus bermudiana*

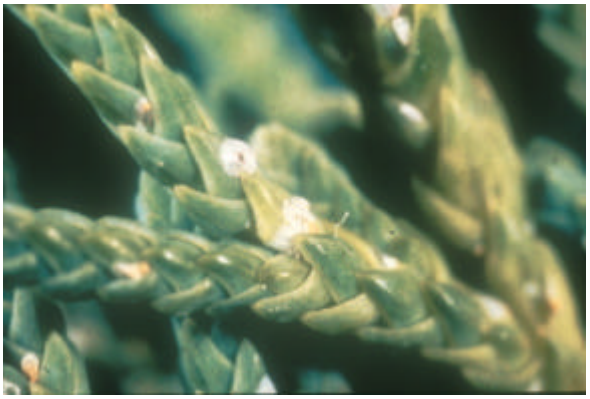
The other classic example, which interestingly was much more recent in time, was the demise of the Bermuda cedar, an endemic juniper.



This probably resulted from the construction of an airport on Bermuda in 1941-43, which greatly accelerated the introduction of invasive species to Bermuda.



Up until 1945, this endemic juniper thrived on man's influence in Bermuda, because it is an "r-selected" early successional tree and valued for its timber, which sustained a thriving ship building industry. Indeed, it had become a virtual monoculture forest by the 20th century!


Close up of cedar scale

But a scale insect pest *Carulaspis minima* accidentally imported by aircraft on ornamental juniper from California about 1946 found it a perfect host with no biochemical defences and no native biological controls.


Dead cedars

Within 10 years 96% of the trees were dead, leaving Bermuda virtually unforested! The broadleaf

woodlands which have since replaced it are now 95% introduced species by biomass!

The loss of the cedar starkly revealed another frightening truth. Bermuda is today probably the most densely populated isolated oceanic island in the world!

Bermuda aerial view showing white roofed houses

The issue now is more whether any vegetation will be able to survive in our urban future, let alone any of the native species!

Bulldozer and endemic palmetto

Our largest remaining open spaces are like small islands completely surrounded by development!

Paget Marsh from the air

A third of Bermuda is now totally urban, and the mean density of houses is two per acre for the island, with a mean human population density of five per acre!

Prospects

In the face of such facts it seems reasonable to wonder how any native biodiversity is going to be able to survive at all. It is also easy for conservationists to become pessimistic and to feel like giving up in despair.

I have recently read two highly relevant essays on this issue in *Biological Conservation*, and their message to conservationists and restorationists is very important. The first essay by Eric Beever is on the importance of maintaining realistic optimism in our work in order to be effective. He makes the point that the worst enemy of conservation is negativism, pessimism or scare tactics. It simply causes our potential allies to turn off.

The second essay by David Erhenfeld makes the other important point that merely conducting endless surveys or carrying out sophisticated scientific research on the problems is not enough. His appraisal of all of the published papers in the first three issues of *Conservation Biology* indicated that the majority yielded more descriptions of problems than actual conservation achievements. We must not permit our surveys and research to become ends in themselves, with the selfish goal of keeping us employed with endless grants. Rather it should be a means to an end by revealing how to develop workable strategies and then actually to implement them.

I have devoted most of my career on Bermuda to the researching and implementation of workable strategies, and in the process I am pleased to report that nature's extraordinary resilience, if we will only stop beating on it and work with it instead, has turned me back into an optimist – even in the seemingly hopeless case of Bermuda!

So how is any restoration possible on small oceanic islands? The frank answer is not much and not easily, for they truly are only "fragments of the paradise" that they were. So much has been completely lost to extinction and so many of the invasive introductions on to them are hopelessly irreversible. Nevertheless, restoration ecology has been aptly described as "the art of the possible" and some amazing things are indeed still possible!

The key to success is clearly understanding the root causes of problems and looking for exploitable options for reversing the causes rather than merely trying to treat the symptoms.

In the case of small oceanic islands we can actually capitalize on the circumstances that made them vulnerable to disruption in the first place by turning them to our advantage:

- Small size means that we can exert a more intense and total control. Eliminating undesirable invasives like rats is more feasible on small islands for example.

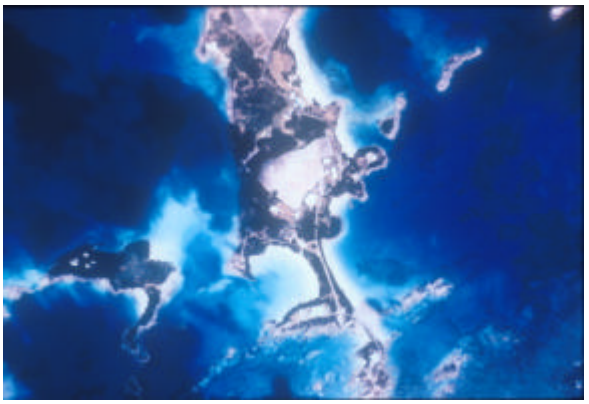
- Isolation means that we can exert better control against unwanted invasives by implementing quarantine measures against re-introductions and new introductions

Fortuitously, islands often have satellite islands where the foregoing advantages can be applied even better. Restoration may be possible on a satellite island where it is impossible on the main island if, for example, the satellite island does not have a resident human population with a conflicting agenda, so that it becomes possible to manage it exclusively for conservation or restoration. Also, an islet which lacks certain introduced species already present on the main island may have enabled a threatened endemic species to cling on in that smaller fragment of its former range.

Examples of oceanic islands with important satellite islets like this are Round Island off Mauritius, Cousine Island and others off the Seychelles, Bosun Bird Island off Ascension, numerous islands off New Zealand, and the Castle Harbour Islets off Bermuda.

Rediscovery and conservation of the cahow

The cahow is a classic example of an endemic species which managed to cling on because the mammal predators which exterminated it on the main island did not reach the offshore islets. It was rediscovered in 1951 by Dr Robert C. Murphy and Louis S. Mowbray (picture above), surviving on five of the tiniest Castle Harbour islets shown on the aerial view (following). Their combined area totalled less than three acres.



But the breeding habitat was so marginal that the islets lacked soil cover sufficient for burrowing, forcing the birds to use deep natural erosion crevices in the cliffs for the deep dark burrows that they require.

But these were the obligate nesting places for the still common white-tailed tropicbird *Phaeton lepturus*, or longtail as Bermudians call it.

When first surveyed in the 1950s, two-thirds of the 18 surviving pairs were subject to nest-site competition with longtails. This resulted in the death of the cahow chicks every year! The population was still declining after three centuries of presumed extinction but we were in the nick of time to help.

Because the only significant problems facing the cahow were on its breeding grounds and not on its vast ocean range, once we understood the sequence of causes causing its decline we were able to devise a strategy to reverse the situation.

First we developed an artificial doorway or baffler for the crevice entrances which took advantage of the size differences between the two species by excluding the larger tropicbird.

By this simple device installed at all nests we were able to treble the breeding success and turn the population decline around in 10 years.

Next we created artificial burrows for the birds on the level tops of the islets where tropicbirds would not nest and cahows could not for lack of soil cover for burrowing. This recreated in part, the original breeding niche separation between the two species.

Digging artificial burrow.

Partly completed concrete burrow

Completed burrow

The beauty of the artificial burrow was that it could be placed in optimal sites for discovery and colonization by the cahows, closely adjacent to already occupied sites. Also, they could be built as closely together as possible in order to maximize the very limited space on the tiny islets. By this second step we created the potential for about 300 pairs eventually to be housed on the existing nesting islet. The breeding population has already trebled to 55 nesting pairs in the 50 years since rediscovery - remarkable progress considering the slow maturation rate and extremely low reproduction potential of procellariiform birds in general.

Next, we persuaded government to declare the larger adjacent island of Nonsuch (15 acres) as a nature reserve in 1961. We eliminated rats from it and made sure by quarantine that it would remain free of potential predators in future. Although not yet colonized by cahows, Nonsuch has deep soil cover where the birds could excavate their own burrows. I estimate that it would be capable of supporting 10,000 pairs!

Nonsuch Island and Cahow Islet

But there is a 'Catch-22' in persuading cahows to colonize, because new pairs normally settle on islets where cahows are already nesting. We will have to trick them into believing Nonsuch is the hottest nightclub in town by putting out models and playing tapes of their aerial courtship calls via 'ghetto blasters' set up on the island. The technique has already been proven with petrels elsewhere. And the need to go ahead with this soon is urgent because of global warming and sea-level rise.

Erosion by Hurricane Felix on one of the cahow islets

Before Hurricane Dean in 1989 I never had a serious sea-flooding incident on the nesting islets, but in 1995 and again last year (1999), two of the four islets were completely over-washed and the others seriously reduced by erosion. This was caused by groundswell from hurricanes Felix and Gert. Luckily the cahows were not nesting at those seasons. 40% of the nest-sites were trashed both times, and we really had to scramble to repair the damage before the birds returned for their next nesting season.

An holistic approach

Preparing Nonsuch for the cahows was the beginning of a much more ambitious "living museum " project, an attempt to restore holistically all that remains of Bermuda's original precolonial heritage.

Three things made Nonsuch absolutely ideal for such a project:

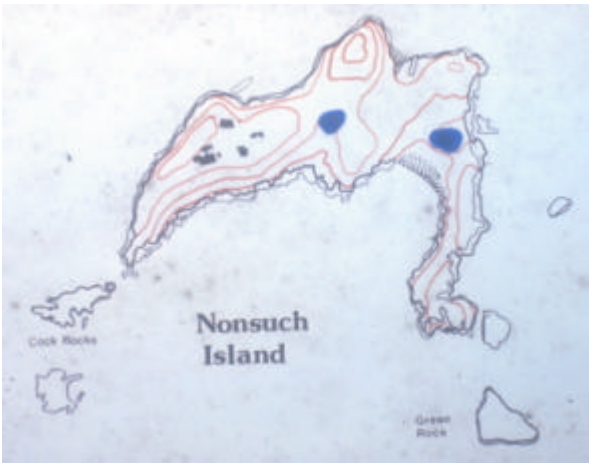
- Its relative isolation made it possible to quarantine against most of the invasive species already on Bermuda.
- Its relatively large size for a Bermuda satellite islet (one thousandth of Bermuda's total area), and topographical diversity, enabled it to represent most of the habitats that occur on the main island
- and yet it was small enough to be totally manageable, for the most part by one person.

It even proved possible to create the missing wetland habitats artificially!

Freshwater pond excavation

Placing liner

Finished marsh



Nonsuch map showing ponds

Small as these ponds are, they are very important in Bermuda's diminutive wetland context. Both now support healthy populations of an endangered endemic brackish-water killifish *Fundulus bermudianus*, threatened by pollution on mainland Bermuda.

The species which most inspired my holistic approach to restoration was the endemic Bermuda skink which had a population on Nonsuch (lacking in predators) that was 40 times as dense as on the mainland when I began the project.

But my holistic approach was not limited to fauna alone.

Unfortunately the dominant cedar forest and other flora on Nonsuch had been devastated (picture

following) by the cedar scale epidemic and a herd of goats, so that when I moved to the island in 1962 it was like starting with a clean slate

The goats and rats were easily removed, setting the stage for restoring the flora in its original context of no mammal herbivores

My strategy was to restore only with known endemics and natives, while culling out as thoroughly as possible all those introduced invasive plant species that were already established on the island, keeping them off by quarantine, and on-going culling in the case of bird-dispersed species.

Guidelines for planting and sources of seedlings were provided by small relict stands of native forest which survived almost intact in a few remote or inaccessible corners of mainland Bermuda. On Abbots Cliff, for example, now a protected nature reserve, the flora was still 70% native in the 1960s (picture below) before the establishment of the pernicious Brazil pepper *Schinus terebinthefolius*.

Planting began in earnest in 1963. By 1974 more than 8000 seedlings of canopy species had been established (following picture). Growth was slow at first because of extreme exposure to wind and salt spray occasioned by the loss of the cedar as a windbreak.

By 1974, however, it was becoming apparent that the 4% of cedars that survived the cedar scale (due evidently to some genetic trait for resistance that barely survived in the population), with help from

selectively introduced biological controls specific to the scale, were beginning to reproduce and re-populate Bermuda again under the intense new selective pressure resulting from the pest. I began planting cedars in earnest on Nonsuch in that year, in the belief that the species was becoming viable again.

It is worth pointing out here the context in which I made that decision. At that time all of my colleagues in the Government were convinced that my project would never work. The native flora and fauna were finished, they said: one only had to consider what had happened to the Cahow and the cedar to see that it was hopeless! The emphasis for reforestation on the main island of Bermuda, therefore, was on exotic trees and shrubs from all over the world, a decision which was ultimately to result in even more invasive species problems like the Brazil pepper and the Indian laurel *Ficus microcarpa* and new problems for my own project on Nonsuch!

My rationale for the eventual success of my project was as follows. Even though the native and endemic flora was sickly and declining on the main island due to weakening by a host of new introduced insect pests and diseases, and by competition from other invasive plant introductions, the problem of insect pests and diseases alone should not be the decisive factor in their ultimate extermination. Parasites and diseases need their hosts and must eventually reach an accommodation with them in order to survive themselves. Indeed, we could already see this happening with the cedar's rapidly evolving resistance to the scale. The real enemy of my project were the introduced competitors, because they do not have any need for the natives and are in fact much better off without them!

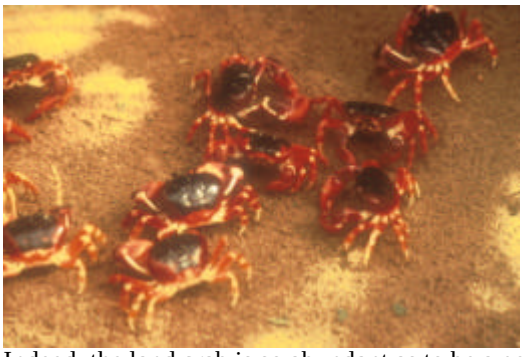
Extirpation of the native flora had been a double-whammy process. The introduced (and native) predators, parasites and diseases can only weaken their hosts, but the introduced competitors (which man usually introduces without their co-evolved predators, parasites and diseases) do much better as a consequence and perform the *coup de grâce* by shading the natives out and replacing them.

Fortunately, it did prove possible to keep the plant competitors at bay on Nonsuch. The long-term result after 38 years has been nothing short of spectacular. I currently estimate that we have been able to restore the native flora on Nonsuch to within 90% of the precolonial, within the limits of what we know about it from early records and palynological work on fossil pollen. Indeed in the absence of rodents, the forest (picture below) is restoring itself so vigorously that I have almost had to leap out of the way.

There have been many unanticipated surprises too. On mainland, the endemic olive wood no longer self-seeds due to competition from introduced Surinam cherry and rats eating the seed. On Nonsuch, however, seeding is superabundant (picture below), again illustrating the advantages of the holistic approach – restoring everything within its original context as far as possible.

But this was just a beginning. I now want to describe a couple of other successful restorations, both of which have had wholly unanticipated ecological and economic spin-off benefits. And both involve species which had been exterminated completely from Bermuda during early settlement, but survive elsewhere in their native range.

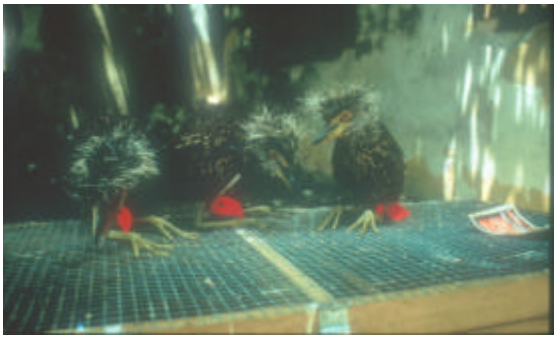
The first was a crustacean-eating heron *Nyctanassa violacea* which, I concluded, would establish on Bermuda again if introduced. This is because circumstances have changed, with good bird protection law, as at present, and because its main prey is still abundant (the common land crab *Gecarcinus lateralis*).



Indeed, the land crab is so abundant as to be a pest, particularly on golf courses, lawns and agricultural land, by riddling the ground with burrows and stripping the ground vegetation.

In fact, the original Bermuda night heron was an endemic derived from the yellow-crowned night heron, as revealed in our fossil record, so I settled on the nominate species which is a migrant in Bermuda, and eats land crabs in transit. If you believe in punctuated evolution, a re-introduced population might rapidly evolve into an endemic again like the first, which had short legs and a heavy bill.

But the migrants leave again. To get around this, we introduced hatchlings from a non-migratory population in Florida, and weaned them into the wild on a diet of land crabs in Bermuda.



The project was funded by government on the basis that they might effect some biological control, desperately needed on golf courses which represent about 8 percent of Bermuda's land area. It was the easiest and most successful restoration project I ever did. 44 chicks were hand-reared and weaned between 1976 and 1978.

Nesting began in 1980 in a main-island nature reserve. But the main nesting rookery is now on Nonsuch, in trees that I planted out of gallon cans 25 years before. And that's not all. It turns out that they do achieve virtually 100 percent control of crabs on golf courses and lawns where the crabs have no hiding places, and where control is most desired. Elsewhere the necessary predator-prey balance is beautifully maintained.

Crab remains eaten by heron

This project provided an interesting retrospective insight as well. The Bermuda sedge *Carex bermudiana* (above) is our rarest endemic, barely replacing itself on a few relict locations on the mainland. It is now thriving on Nonsuch in the absence of rodents. However, had we introduced it there before we re-introduced the heron, a crab-predator, our transplants were eaten off by crabs on the very first night after their planting. I would like to know of any ecologist who could have predicted that the survival of this sedge would depend on a heron that eats land crabs – yet another illustration of the benefits of a holistic approach to restoration.

My final example of a successful restoration with both ecological and economic benefits is the West Indian topshell *Cittarium pica* that was harvested to extinction for food by the early settlers under the tough circumstances of a subsistence existence. Again I rationalised that circumstances are very different today, with our higher standard of living and better conservation laws. So we tried it in 1982, and it worked. From 86 shells released into the inter-tidal of Nonsuch, I found my first evidence of reproduction in 1986 and, as of a thorough survey conducted in 2000, the topshell is now island-wide in appropriate habitat and already abundant again.

West Indian topshell

Land hermit crab

The economic significance of this success is that the species is second in importance to the conch as a shellfish resource, with future harvestable potential if carefully regulated. Interestingly, however, there have been some local incidents of illegal harvesting since the re-introduction. This decimated it in some areas, thus confirming the hypothesis of its original extirpation. A potential ecological spin-off benefit of this successful restoration is that it may eventually lead to a like recovery of the land hermit crab which depends on the empty topshell for its home and is presently in danger of extinction because of its increasing dependence on empty topshells from the pre-colonial population.

I have been the architect of several other equally successful restoration projects, specifically on Bermuda's main island. The most notable of these is the eastern bluebird *Sialia sialis* recovery project, using nest-boxes (below) and involving school parties, and several other native forest restoration projects – but there is no time left to detail them here.

I hope these examples are enough to restore your faith in the resilience of nature, and the restoration successes that await us if we only work with, rather than against, it.