

**THE CHALLENGE SAVING AND RESTORING NATIVE VERSUS INTRODUCED, NATURALIZED AND INVASIVE
FLORA IN OUR
PARKS, GARDENS AND NATURE RESERVES:
HOW TO RESOLVE THE PROBLEMS WITH A
MINIMUM OF EFFORT**

David B. Wingate

INTRODUCTION

Those of us who are now in our eighties have witnessed a greater change in Bermuda's floral landscape since 1948 than in all the previous 350 years of our history. It all began with the loss of our dominant Bermuda cedar forest to introduced insect pests in the late 1940's. It accelerated with the introduction of a host of introduced ornamentals to replace the cedar in subsequent decades and was exacerbated further in a series of landscape transforming hurricane events at the end of the 20th century.

The whole issue of what is happening to our wild growing flora as a result of man-induced changes since Bermuda was colonized is very complex, but the bottom line is an economic one, in that we have gradually shifted, over the centuries, from a natural (unmanaged) landscape which provided a self-renewing and economically valuable source of timber and other useful products, to one in which there are now very few harvestable resources, but lots of invasive pest plants that are very labour intensive to control. In order to explain how this came about, it is necessary to retrace the history of changes in our flora from the time of settlement.

HISTORIC SUMMARY OF FLORAL CHANGES ON BERMUDA

Before human settlement, Bermuda had a relatively impoverished flora, i.e. of low biological diversity, typical of remote oceanic islands, but one which was characterized by relatively uniform height, low stature trees, which were dense foliated and rigid in growth form (ideal for withstanding powerful windstorms), but which formed a somewhat open canopied forest. Most were also salt spray tolerant, remaining green after storms. The dominant trees in that self-renewing forest provided extremely valuable timber or other useful products. The four most important *trees* were the cedar, *Juniperus bermudiana*, which provided high quality timber for all purposes; The palmetto, *Sabal bermudana*, which had multiple uses ranging from roof thatching, basket and hat making with the leaves, to making an alcoholic drink called Bibby; the Yellow-wood, *Zanthoxylum flavum*, which had a sweet smelling yellow coloured hard wood timber of such value that it was profitably shipped back home to England in the first few years of settlement; and the Bermuda olivewood, *Elaeodendron laneanum*, the bark of which was used for tanning leather.

This flora lacked the range of edible crops or fruiting trees which man had co-evolved with, however, so not surprisingly the early settlers emphasized the edible in their initial introductions. For some time, things went remarkably well, and we had the best of both worlds with useful self-renewing forests that now even included introduced and wild growing citrus and other fruit crops that had little trouble competing with the few natives. Ultimately, however, and usually by accident rather than design, our introductions began to include more and more pest insects and diseases, and pest plants, that had no economic or aesthetic value from our perspective but began to out-compete both the useful natives and the useful introductions until some were no longer self-sustaining in the wild. This was a slow process at first, with people gradually becoming aware

that the endemic olivewood and the native yellow wood tree were no longer self-seeding, and the introduced citrus no longer viable in the wild because introduced insect pests weakened them while faster growing, but less useful *introduced* plants began to out compete them.

The one exception was the relatively fast-growing Bermuda cedar, which had all the characteristics of an invasive species because it is what ecologists call a pioneer tree. i.e. one which thrives in disturbed or frequently cleared land. (Cedars self-seed and grow fast enough to produce millable timber in 25 years and because this time period matched the marriageable age of daughters of larger land holders, it became customary to give them a dowery of mature cedar forested land to start the marriage.

Ecologists have coined a term: r-selected for species of short life expectancy and high reproductivity, (but in pre-colonial Bermuda the cedar had a relatively long-life expectancy as well, killed early only by the occasional fire event or hurricane blowdown). Cedars supported a ship building industry and most of our house timber, furniture and even cooking fuel requirements for over three centuries). The strong scent emanating from cedar chests was very effective at deterring cockroaches. Indeed, the Bermuda cedar thrived so well in the man-modified landscape, that it became a virtual monoculture by the mid 19th century. Bermuda cedar canopy, with three species of invasive (possibly introduced) sage-bush (*Lantana*) understorey, became the definitive natural forest cover of Bermuda for over a century. Some of our other native plants were what ecologists call K-selected, (meaning that they have slow growth and a long-life expectancy, but a low reproductive capacity) and didn't survive as well: trees like the yellow-wood and Bermuda olivewood. With frequent land clearing they gradually became scarcer, resulting in a lower biodiversity; but this was compensated for by a higher biodiversity of introduced species, (many of which were also r-selected). Most of these were first planted in our formal gardens.

It was only with the accidental introduction of two cedar scale insects in the mid 1940's, (one of which, ironically, was imported on some ornamental junipers from California), that the tables turned completely against the dominance of native flora in the latter half of the 20th century. With the sudden death of approximately 95% of our cedar forest by 1950, the unmanaged landscape was left wide open to those potentially invasive introductions which were already here, notably the three Lantana bushes; the Pride of India or Chinaberry tree; the Fiddlewood tree; the Allspice tree; the Surinam cherry bush, and the Yaupan bush (locally called Bermuda Holly).

Then, in the frantic effort by Government and commercial horticulturists to fill the void and re-vegetate the landscape again, a host of new tree and shrub species were introduced in the 1950's through the 1980's with emphasis on fast growing and showy ornamentals like the Poinciana tree, (which was already long established). While most of these have been useful in beautifying and diversifying our *managed* parks and gardens (many have colourful flowers, while most of the native species don't), a few inevitably joined the growing list of species which have become invasive and cause a problem primarily in our unmanaged natural woodlands. The most notable of these, and the specific problems that they pose, are discussed in greater detail later in this treatise.

WHY INTRODUCED INVASIVES, IN GENERAL, ARE PROBLEMATIC

Conservationists and gardeners are not against our introduced ornamentals and crop plants *per se*, but only against those few which have become aggressively invasive or even monopolistic.

But why even against them, you might ask? Don't we want plants that can self-seed and grow quickly without human aid, especially after a hurricane? Well, once again, the answer is complex, but with the bottom line

being economics and the preservation of biodiversity, which latter we all seem to agree is desirable as a stabilizing factor in preserving the natural environment.

Before trying to explain why introduced invasives are undesirable, generally, and some of them also a major problem for specific reasons, it is first necessary to explain what we mean by invasive. The term is generally applied to those introductions by man that become so aggressively self-propagating in the wild that they ultimately out-compete or over-shade everything else and become *monopolistic*; and monopolies mean loss of biodiversity. But that is exactly what happened with the Bermuda cedar, too, before the scale epidemic. So again, what is the difference?

Well, for one thing the cedar was a valuable timber resource for us and an excellent windbreak tree that resisted blow down in storms, while nearly all the naturalized invasives happen to have no presently perceived economic value or are even regarded as down right pests for one practical reason or another, requiring a lot of money and effort to control. But the difference goes much deeper than this. The cedar is endemic, i.e., uniquely evolved in, and adapted to Bermuda, while the introduced invasives are endemic to other parts of the world. If we are looking at the issue of loss of biodiversity from a global perspective, then the introduction of a species from elsewhere, which becomes invasive and threatens a localized endemic with extinction, has the ultimate effect of cosmopolitanizing the world and reducing global biodiversity.

One of the sad facts of life today is that wherever we travel in the tropics, the flora in the hotel gardens, roadsides and even in un-managed areas is beginning to be more and more the same! (We are suffering the same kind of problem in preserving the cultural diversity of our own species as the global economy swamps out locally evolved societies).

Invasive species, then, are a problem generally because they result in loss of biodiversity at the global level.

Before looking more specifically at the deleterious effects of invasive plants in Bermuda, it is necessary to draw a distinction between our managed and our unmanaged lands, because what has happened in these two categories over the years is totally different.

THE DIFFERENTIAL IMPACT OF INVASIVES ON OUR MANAGED AND UN-MANAGED LANDSCAPES

Given the high human population density that has been attained on Bermuda, approximately two thirds to three quarters of our un-paved or un-built landscape is now *intensely managed* in terms of its vegetation cover in our parks, private gardens, arable fields, playing fields and waysides. This means lawn mowing, weed whacking, hedge trimming, tree, shrub and crop planting; nurturing with fertilizers, and ultimately, clearing and replacement with new nursery stock after major storms. The more pernicious invasive species are not an *obvious* problem in these intensely managed landscapes because our constant management keeps them under control, but gardeners and park or nature reserve managers are acutely aware of the high costs of doing so! Just look at the number of landscaping and garden management firms listed in the telephone directory!

The other one quarter to one third of our landscape is unmanaged with respect to vegetation, and it is here that the problems caused by introduced invasives have become manifested to the extreme.

Bermuda has always tended towards a forested landscape because of its rich soil, adequate rainfall and semi-tropical climate, but as already mentioned, the character of this un-managed woodland has changed over the centuries from a low-diversity but mixed species open-canopied native forest in pre-colonial time, through a lower diversity, Bermuda cedar dominated forest in historic time up until 1950, and finally to a still low-diversity invasive dominated broadleaf forest between 1950 and the present. The two consistent trends throughout this period have been continuing low diversity, but a gradual reduction in the proportion of native species from 100% of the biomass in pre-colonial time, to 5% or less, today.

As already explained, the continuing low biodiversity despite many new introductions is an end result of invasive species monopolies, but why have the natives and endemics been so relentlessly displaced by these introductions? Again, the reasons are complex and sometimes hard to unravel. One explanation is the difference in growth rates, height at maturity, and growth form of most invasives: The introduced and invasive tree species on Bermuda not only tend to grow much faster than the natives, but some mature at a much greater stature, up to two or even three times as high like the casuarina and Indian laurel. Rapid growth and high stature is usually associated with more flexible or more brittle timber, prone to breakage or easy up-rooting in storms. While the low stature and rigid growth form of the natives protects them from storms, they cannot survive the over-shading, abrasion and smashing from wind-whipped or uprooted invasive trees once they are overgrown by them. Add to this the fact that most of the invasives are broadleaved species, which cast a *deeper* shade (to which the native species in the open canopied native forest were not adapted), and we have displacement by shading-out as well. Another, more subtle explanation for the steady decline of natives is that they were isolated on this relatively pest free and competitor free pre-colonial paradise for so long that they lost their defenses against them. Then, when man colonized Bermuda and began importing new pests and competitors from the continents the native and endemic species suddenly found themselves at a disadvantage. (The disaster that overtook the cedar is a classic example of this).

A third reason is that Bermuda had no mammals at all before colonization by man, so our endemics had lost their adaptations to cope with grazing animals and seed eating rodents too. (This was probably a major factor in the decline of the Bermuda olivewood and the yellow-wood, which no longer self-seed in the wild because their seed is eaten by introduced rats). On the other hand, most of the introduced invasives were first imported as seed or cuttings *without* their co-evolved complement of pests: (these days we try to ensure this by quarantine measures); or they came from continental and tropical environments where they had to evolve defenses against just about everything, so are inherently tougher to begin with. Their sudden release into an environment without their co-evolved pests and with fewer competitors gives them the edge that enables them to thrive better than they ever could in their home range. It is beginning to become apparent to ecologists that this is the fundamental reason why transplanted species tend to become invasive outside their native range, especially on species - impoverished oceanic islands.

Let us now examine the kind of woodland the invasive species have created on our *un-managed* landscapes, and ask ourselves the question: Are we really better off today? The short answer is that we have the kind of problem that we experienced after category 3 hurricane Fabian in 2003. The quicker they grow, the easier they up-root, or break. Most of the invasives dominating our unmanaged woodlands today have no timber value or other economically useful attributes and they are neither salt spray resistant or hurricane adapted. Consequently, we have a temporary situation after hurricanes or major winter storms in which these woodlands are burnt brown and defoliated, and a more permanent situation in which a high percentage of the trees have at some time been up-rooted, leaving the under-storey so cluttered with fallen trunks and branches in various stages of decay that human access is impossible without costly and time consuming opening of trails with a machete, chainsaw or even a bulldozer!

This is a relatively new phenomenon on Bermuda. Up until hurricane Emily in 1987, I can distinctly remember that most of our fiddlewood dominated woodlands were upright and open under the canopy, allowing easy access in any direction. The main thing that maintained this character, surprisingly, was the rigid support provided by the dead Bermuda cedar forest!! Yes, even in death the cedar continued to provide a valuable

windbreak and rigid support framework for other trees. (most of those which have not been deliberately cut down are still standing!).

Today, most of those dead cedars have been removed for their timber – a good portion of them harvested illegally by timber thieves - resulting in a progressive collapse of the forest canopy in each successive hurricane. Even worse, this has opened the canopy for the invasion and eventual dominance of even less desirable invasives like the Chinese fan palm, Brazil pepper, *Schinus terebinthefolius*, (which is naturally sprawling in growth habit anyway); and monopolistic vines like morning glory, *Ipomoea villosa*, and the more recently introduced giant balloon vine, *Cardiospermum* spp, which completely overgrow and smother trees and can kill them.

Indeed, the situation in our unmanaged woodlands is so chaotically bad today that it is not surprising that many people feel the only thing to do is clear all the vegetation and start all over with new, preferably native plantings.

Yet, ironically it is the unmanaged invasive dominated woodlands that comprise the bulk of our Woodland Reserve zonings in all the development plans for Bermuda since 1983.

SPECIFIC EXAMPLES OF INVASIVE SPECIES PROBLEMS

Looking more specifically now at the invasive species comprising our unmanaged woodlands, there are a few, mainly post cedar scale introductions, that pose some particularly intractable problems for us. I will discuss only the most significant of these here.

The Casuarina, *Casuarina equisetifolia*

Originally regarded as the quick solution for re-greening Bermuda after the cedar scale disaster, this Australian tree was heavily planted in parks and gardens during the 1950s, 60s and 70s. Its rapid growth, salt spray resistance and evergreen foliage seemed to make it the ideal replacement for the cedar. Moreover, it does not readily self-seed in Bermuda soil, so nobody expected it to get out of control. Casuarina groves became ideal feeding habitat for local and migratory birds, especially the local European goldfinch and the migratory Indigo bunting, (which feed on the tiny seed in the seed cones); and 20 species of migratory wood warblers (which feed mainly on the accidentally introduced spittle bug that feeds on the foliage).

The first real sign that the casuarina might become a problem was when people saw how incredibly tall they grow in comparison with the native trees. This combined with their relatively sparse and open foliage not only diminished their value as a windbreak, but aggravated the problem by creating wind turbulence and mini twisters in their lee. It was not until we had our first big windstorm in hurricane Emily (1987), after a long period with no hurricanes, that we discovered that they up-root in droves and destroy everything in their path as they fall. But this was not all. Soon after hurricane Dean in 1989, we began to note that aggressive self-seeding was beginning along our coastline. It seemed that hurricane waves washing high up the cliffs helped to trigger this self-seeding event. This was subsequently confirmed after hurricanes Felix in 1995 and Gert in 1999. By 2000 it had become apparent that the casuarina now threatens to become dominant on the coastline including even our back-beach dunes! Unlike our still dominant native coastal flora, which grows prostrate and doesn't obscure the vistas of the sea, the casuarina continues to grow tall and straight even in this harsh environment. Where they are rooted in soft rock the levering effect of strong winds causes them to break off large sections of cliff, thus hastening coastal erosion. With sea-level rising due to global warming, waves from hurricane Fabian in 2003 extended the rocky coastal zone along the south shore at least 12 feet further inland by stripping off the soil cover to bedrock. Many of these freshly exposed areas have become a

dense forest of view-blocking casuarinas since, and nearly all our native coast flora is now threatened with degradation by over-shading.

The only way of preventing this would be to place a ban on the casuarina and remove all the seed producing adult trees, followed by culling out of all seedlings. As this is un-enforceable, let alone feasible, we face the prospect of having to cull out casuarinas along the coastline at regular intervals; a hugely time consuming, dangerous and possibly insurmountable task if we want to save our coastal flora and views of the sea.

The Indian laurel, *Ficus microcarpa*

Indian laurels were just one of several large-growing *Ficus* trees promoted for park and garden planting after the cedar scale disaster. Unlike the others, though, the species-specific pollinating wasp for this particular species somehow got to Bermuda a decade or so later. Before that, it grew only where we wanted it (although a few gardeners discovered to their regret that they had not allowed for its huge stature at maturity and had planted them much too close to their houses!). After the pollinating wasp arrived, the tiny seeds began dispersing and germinating in rot hollows of other trees, rotting wood on the ground, and in cracks and crevices of house walls and natural rock outcrops. Today it is self-seeding everywhere and given its huge size at maturity it threatens to become monopolistic in rocky habitats like the Walsingham formation, which up until now have been the

last haven for our native upland flora. The Indian laurel's threat to house walls and drystone walls requires constant vigilance.

Indian laurels pose a particularly serious threat to those many ancient Bermuda cedars that survived the scale epidemic, by germinating in their rot hollows and ultimately overgrowing and strangling them. Nearly all of the ancient cedars in the Paget marsh nature reserve, that survived so well up until 1980, have since been strangled and killed! Once again, we are locked into a situation where constant vigilance and culling is required. The only alternative to this would be to try and eliminate the tree completely from Bermuda, but as with the casuarina, its total removal, even assuming that it was possible, would be highly controversial. The ripe figs are an enormously important food source for all fruit eating birds and its tiny seeds are now a major food for Ground doves.

The Brazil Pepper, *Schinus terebinthefolia*

This umbrella-shaped ornamental with the red berries that ripen about Christmas time and make a poor substitute for holly, was supposedly introduced on the Southlands estate in Warwick in the early 1950s. Its spread was slow at first, but beginning in the 1960s it began an explosive increase coincident with the colonization and rapid increase of the Starling, *Sturnus vulgaris*, its main seed disseminator. The germination and growth rate of Brazil pepper is nothing short of phenomenal. On the Nonsuch Island Living Museum nature reserve, where a concerted effort is made to cull out all introduced species, Starling dispersed seed germinates at the rate of tens of thousands a year, an order of magnitude greater than any other species, and those that are over-looked can be four feet high in two years, and self-seeding by the third year!

By the 1970s it became apparent that any cleared land that was subsequently left fallow soon became a monoculture of Brazil pepper, but pre-existing woodlands of other broad-leaved trees like allspice or fiddlewood were not readily invaded. However, hurricane Emily in 1987 changed all that. By shattering or up-rooting much of the pre-existing woodland, Emily opened the canopy to invasion by the lower stature Brazil pepper, and once established, its unique growth habit of horizontally sagging side stems, which flex in windstorms and lay over the top of other vegetation, ensured that it held its place against any future over-shading. Even before Fabian the Brazil pepper was becoming universal, but now it has become overwhelmingly dominant in most unmanaged woodlands. There could hardly be a worse candidate. Its extremely rapid dispersal and growth rate and its flexible, horizontally sprawling habit blocks access to all of

Bermuda's woodlands today and make trail maintenance through woodlands an endless and labour intensive task.

While the greenish flowers are attractive to bees, *this is only for one month of the year in October. It overshadows and out-competes all other bee attracting plants for the rest of the year.* While the red berries are the current substitute for the old "Bermuda holly", an earlier introduced invasive, which has since been displaced by the pepper, it is a poor substitute due to rapid wilting after cutting. The dried berries are used by some as peppercorns for spicing food, but are in fact poisonous if used in quantity. Some unfortunate people are allergic to the sap in the same manner as poison ivy, because Brazil pepper is a close relative in the Sumac family.

Chinese fan palm, *Livistona chinensis*

This aggressively naturalized palm is so similar in appearance to the Bermuda palmetto that most people don't recognize the difference. So you might well ask: why it is perceived by conservationists and some gardeners to be a problem species? There are two reasons, in fact. One is purely practical from a gardener's perspective. The fan palm has nasty spines on the leaf stems which make handling and disposal of the fallen or cut leaves a hazardous business. Moreover, this species germinates everywhere in gardens, most often under flowering hedges where we don't want it, so we are all too often in the business of having to cut and handle the spiny leaves.

The second and more pertinent reason is that without human intervention it threatens eventually to replace the endemic Bermuda palmetto thanks to the introduced Great Kiskadee and American crow, which are its main dispersal agents. Again, some may say "so what", it looks just like our palmetto! The bottom line is that once Chinese fan palms form a monoculture the dense groves become inaccessible to man and almost sterile for native birds. Palmetto groves on the other hand are accessible to walk under without management as in Paget Marsh and provide feeding habitat for cardinals, catbirds and the native White-eyed vireo. As the proportion of fan palms increases in our woodland the prevalence of *all* bird species, especially migrant wood warblers, has declined.

Most significant of all, the fan palm can germinate and grow in deep shade under other broadleaf trees and once the first to establish in a new area reach maturity and begin to shed seed, the resulting seedlings spreading out from that nucleus are so close-spaced that their interlocking spiny leaves and persistent leaf litter block access and prevent anything else from growing or feeding under or between them except rats. If I were to try and guess what the new monoculture forest might be on future Bermuda, I would say Chinese fan palm generally, but even they might be displaced by huge Indian laurel trees in the rocky Walsingham district.

The 'fern' Asparagus, *Asparagus densiflorus sprengeri* (commonly known as "Asparagus fern").

Unlike the preceding invasives, this is not a tree or woody shrub and does not contribute to the canopy of our invasive woodlands, but it does become totally dominant as a ground cover in shrubby openings near the coast (where the native St. Augustine grass formerly dominated) and inhibits the growth of most other species of ground cover. It has also become common under the canopy of low stature, scrubby thickets elsewhere on Bermuda. As another Starling dispersed invasive it is second only to the Brazil pepper in abundance. Why is it a problem, apart from its obvious displacement of native ground cover? After all, we use the vines of this and the even more attractive shade-loving *A. plumosus* ideal for making wreaths for flower arrangements. Well, for those of us who can remember walking along the coastline through lush greenswards of St. Augustine grass, which were cool, soft and comfortable to sit down in, the answer is obvious. Try even walking through those knee-high, barbwire like and foot tripping mats of Asparagus that have replaced the grass today and you will understand. This is just one other invasive that has made our formerly accessible open spaces almost impossible to enjoy without labour intensive management.

I could continue with other examples of even more recent invasives, like the giant Balloon vine, which are just beginning to be recognized as posing potential future problems, but the point is already made: Outside of our managed gardens the invasive flora has clearly had a negative impact both on the native flora and on the quality of our natural open spaces, a quality that we previously took for granted because it was self-sustaining.

THE CHALLENGE OF MANAGING OUR INVASIVE PLANT PROBLEMS

Now that I have reviewed the history of changes in our local flora and described some of the problems that have arisen due to the deliberate or accidental introduction of species that have become aggressively invasive, I want to devote the second half of this article to a more constructive approach by offering some practical advice on what we can do about it. In so doing I am drawing upon a lifetime of experience trying to preserve and/or restore nature reserves for native flora and fauna, notably the Nonsuch island 'living museum'; the Paget Marsh Nature Reserve, and the Walsingham Trust native forest restoration experiment.

The bad news from this experience is that native flora or high-quality woodlands are no longer viable, let alone self-sustaining, without human intervention with on-going management. By opening the Pandora's box of alien species introductions, we have become permanently enslaved to dealing with the problems that they brought with them, and *all* of Bermuda will now have to be managed in some way or another to keep the problems at bay.

The good news, however, is that there *are* ways of managing these problems that are better and cheaper in terms of labour costs, than what most people have been practicing up until now.

At this point it is appropriate to distinguish once again between what we have been doing, or could be doing, in our managed parks and gardens and what we have *not* been doing, but could do, in the presently unmanaged, woodland areas.

MANAGING INVASIVES IN PARKS AND GARDENS

One of the ironies already alluded to earlier in this treatise is that much of the endemic and native flora, and most of the better-quality naturalized trees, do better in our *managed* areas than in the Woodland Reserve zoned areas that were intended to protect them, but this is more by default than design. They do better in managed areas simply because we are (often quite unwittingly) keeping the more aggressive invasive species that would otherwise out-compete them under control. The best example of this that I can think of is the number of healthy Bermuda cedars that survive in manicured cemeteries like those of St. James church, St. John's church and the Old Devonshire church, or close to houses in the more urbanized areas of the island where there is little else except lawns or low hedges to compete with them. Being a pioneer tree, the cedar thrives in clearings where there is nothing to over-shade it. Elsewhere in the unmanaged areas - and ironically in our Woodland Reserve zoned areas - they are being shaded out by taller-growing, invasive trees like Fiddlewood and Allspice, or strangled by Indian laurels that germinate in their rot hollows.

Likewise, Bermuda Olivewood trees and other lower stature native species and ornamentals, which would quickly become over-shaded by Brazil pepper, Fiddlewood, or invasive vines in the wild, are routinely protected in our gardens by culling.

The point I wish to make here is that many, if not most garden owners and their hired labour, are doing this without any conscious awareness that they are favouring native flora, because they probably do not know which trees and shrubs are native and which are introduced, or which are ultimately going to be beneficial and appreciated in the garden and which are going to prove to be a nuisance. Imagine, then, how much more effective they could be if they *were* fully aware of such distinctions.

This is where a good working knowledge of the Bermuda flora becomes invaluable. Knowing that Ficus trees mature at a huge size and have roots that can penetrate water tanks from a long distance away, for example, can save one the folly of planting them too near a house. Knowing that certain trees like casuarinas can grow very tall, and shed needles or leaves constantly on roofs, or are prone to up-root in major windstorms, can likewise avoid the folly of planting them too near to a house or under utility wires. I am certainly not against the use of large stature or tall growing trees in our gardens, because this is one of the things that adds variety and interest to a garden, but we ought to anticipate, and be prepared to deal with potential consequences. Periodically topping casuarinas to the natural mature height of the original cedar forest can make them virtually immune to blow down, and as it re-foliates its foliage is much denser, providing a better windbreak, so that they even look like a cedar for a while, but anyone who has tried to do this on their own, or paid to have it done professionally, knows just how incredibly dangerous or expensive it can be!

I would encourage greater use of native trees and shrubs in our parks and gardens, not just because these *managed* areas offer the best hope for their survival as a part of our unique natural heritage, but because collectively they have features in common which make them ideal candidates for use in our typical small lot subdivisions, especially considering our unique system of water catchment on roofs and storage in cisterns under the houses. Here are their main benefits:

1. They are more in scale at maturity with the small size of our average building lots and less likely to over-shade roofs, or to pose a problem to utility wires.
2. They withstand windstorms better in the typically more exposed environment of small lot subdivisions where the wind tends to funnel between houses or across lawns.
3. Most do not shed leaves seasonally or after windstorms, so that leaf accumulation in roof gutters is much less of a problem
4. By remaining foliated, and usually green after major windstorms they help to protect the more fragile exotics in the garden.
5. They may not have showy flowers (although Turnera, Turkey berry, Coast Sophora and Prickly pear are exceptions), but they offer a wide range of sizes, growth forms, leaf colours and textures to diversify the garden.

The Bermuda olivewood is a classic example of an endemic tree with all of the above benefits, absolutely ideal for the small lot garden where the owner wants a manicured appearance without the constant need for pruning or leaf raking. (Olivewoods grow naturally into a dense foliated, rounded growth-form and always look as if they have been managed by topiary): and they mature at a manageable height. It is pertinent to comment here that before its ornamental value for small lot gardens was recognized this endemic tree survived only in the Walsingham area and was in danger of extinction!

Other native woody shrubs ideal for use in gardens are Bermuda Snowberry, Forestiera, Jamaica dogwood, Doc bush and Wax myrtle, or nearer the coast, Buttonwood, Tassel plant and Iodine bush. The endemic Darrell's fleabane, and the native Coast sophora, Prickly pear and Spanish bayonet make attractive and

distinctive additions to rock gardens, flower beds and borders, but only if we can avoid that obsessive compulsion to mow, or weed whack into every corner of the garden. There are even some distinctive native grasses and sedges, which can be grown in shaded woodlands, (like wood grass, *Oplismenus hirtillus*, and Bermuda sedge *Carex bermudia*).

Happily, there is a growing interest in the propagation of natives, not only by the Government nursery at Tulo Valley, but also by such organizations as the Bermuda National Trust, the Save Open Spaces (SOS) nursery, and private individuals like Robin Marirea and (formerly) Evan Morbey, now deceased, who created a native garden demonstration area and nursery at Cluster cottage in Warwick.

I only wish that some of the larger commercial nurseries would make a greater effort in this regard.

What I am recommending, then, is that we get back to a more even balance between native and exotic flora in our parks and gardens. Just as in the old days, when the cedar and palmetto were still dominant, and provided the evergreen backdrop and windbreak within which we expressed our individual tastes in garden development, we should try to use the dominant pre-colonial native trees, (Cedar, Palmetto, Olivewood, and yellow-wood, or the winter deciduous Southern Hackberry, *Celtis laevigata* and red mulberry, *Morus rubra*), to create a sturdy framework or backdrop for our modern gardens. All of the preceding are the best trees to plant adjacent to, (but not directly under) utility wires along our property boundaries and are the best to use for windbreaks generally. The hackberry is ideal for a garden sitting area where you want sun in winter and shade in summer. The red mulberry has delicious fruit in spring and attracts our resident fruit eating birds as well as a number of showy migrant species like the Scarlet and Summer tanagers, the Baltimore oriole, and the Rose-breasted grosbeak, but beware of the tendency of these birds to eat them on your clothes lines and stain your clothes! Some people have actually cut mature mulberries down simply for this reason. Wouldn't it be better to get a clothes dryer?

One final word on garden management: Too many of us, and certainly too many of our garden maintenance firms, adopt a "Blitzkrieg" approach to garden maintenance, attacking everything that grows indiscriminately with an arsenal of noisy, motorized weapons of destruction. Weed whackers are probably the worst thing that ever happened in Bermuda because they girdle and kill new tree and shrub plantings almost as fast as nurseries can provide them. I couldn't count the number of times I have been asked by garden owners why their seedling tree plantings never seem to grow, or keep dying! I have seen this mindless cycle of propagation and planting followed by girdling and killing repeated over and over in parks and gardens by people who never seem to learn that you should *NEVER, EVER USE A WEED-WHACKER AROUND THE BASE OF A PLANT*. Perhaps if they were to give themselves a lesson, by using the machine around their own ankles first, they would understand the reason why! Plants have fragile skin too. We call it bark.! Human nature being what it is, however, the best guarantee to protect young tree plantings is to install plastic tree guards around them.

By weed whacking and mowing excessively into every corner of our gardens, or by using herbicides, or anything other than regulation lawn grasses, we are not only increasing our workload and pesticide pollution unnecessarily but impoverishing the biodiversity of our gardens as well.

Undoubtedly, the greatest loss of floral diversity on Bermuda during my lifetime has been in the realm of perennial forbs, annuals and grasses: the sort of plants that used to thrive along our waysides and in our cow, horse and goat grazed meadows and pasturelands, which support many small showy flowers that children like to pick for bouquets.

By adjusting our mowing regimes to create a spring season meadow, rather than a permanent lawn, we can encourage the endemic Bermudiana, *Sisyrinchium bermudiana*, (our national flower), to proliferate along with many other spring flowering forbs and save a lot of unnecessary labour, fuel and noise pollution as well!. My recommended strategy is to reduce the mowing to 4' wide pathways within the lawn between the most commonly accessed areas of the garden, from about November, when grass growth slows greatly anyway, until the beginning of June when the annual Bermudiana has set seed and dries up. Grass growth is so rapid in the hot months that it has to be mown, but the cessation of mowing for the cooler half of the year is not long enough for the grass to grow too tall to walk in, or for seedlings of woody shrubs like brazil pepper to establish beyond the seedling stage. They can easily be weeded out by hand at this stage and this should be done before mowing is resumed anyway. This annual regime saves a huge amount of effort, fuel waste, noise pollution from mowers and loss of biodiversity. How sad and idiotic that many owners of large properties still maintain large sterile lawns, especially on coastal hillsides where Bermudiana grows best.

A much more gentle choice of tools for the culling of seedlings of invasive woody shrubs like the aggressive saplings of Brazil pepper, while sparing the harmless annuals and perennials, is the mattock and the weed wrench. The latter is a tool with a clamp and a levered handle, which is fitted around the base of a plant stem and then levered over, effectively up-rooting the plant without any back strain for the operator. Weed wrenches come in various sizes from small versions with 2 foot handles, ideal for pulling 2-4 foot tall saplings, to giant versions capable of up-rooting bushes with 1" diameter stems. They are ideal for selective culling in brushy areas or woodland understorey, where swinging a mattock is difficult and causes root damage to more desirable adjacent species.

Knowing how to recognize the saplings of the most aggressive woody invasives and culling them out selectively in this way before they become too large, can save an awful lot of trouble and labour later on. Failure to cull them early on can, for example, result in an attractive Oleander or Hibiscus hedge being gradually replaced by Brazil pepper or Chinese fan palm, despite regular maintenance in other ways, such as hedge clipping! Many gardeners and employees of Garden Maintenance firms hardly notice that this is happening and go on merrily hedge clipping until the former hedge is just a hodge podge of invasive shrubs!

I have one further example of totally unnecessary labour which actually does more harm than good: This is the all too common habit, particularly of landscaping firms, of pruning the living basal leaves off Palmetto palms, often to the point of leaving only one or two central leaves remaining. I guess this is misguidedly done in the interest of tidiness because some people don't like the appearance of dead leaves hanging on the palm, and rationise that the more of the live leaves they cut off the longer it will be before the remaining leaves will die and need pruning again! In fact, all they are doing is uglifying and weakening the palm, because in the natural cycle of leaf growth and death the dying leaves actually feed their nutrient content back into the newly sprouting leaves.

Palmettoes, in any case, look most attractive when all their leaves are left uncut and form a perfect globe shape. So why go to all that unnecessary effort when the growth habit of every palm is to shed its dead leaves naturally at the end of their usefulness. It is so much easier and cost effective just to pick up the dead leaves when they fall to the ground!

I cannot end this section without offering what I hope will be perceived as constructive criticism for the benefit of our electric utility tree trimming crews and Works and engineering roadside hedge maintenance crews. There have been many comments in the press about the poor standard of tree pruning from an aesthetic perspective and our roadsides are not only the first, but the primary vistas of Bermuda that our tourist visitors are exposed to. It is the practical disadvantages, rather than the aesthetic disadvantages,

though, that I want to emphasize here, because it could save those crews so much unnecessary labour in the future. Let me cite some specific examples: I have frequently seen perfectly fine Japanese Pittosporum and Surinam cherry bushes cut off at the base under utility wires even though their maximum growth height falls short of the wires. By removing these dense-foliaged and slow growing bushes the way is opened for the much faster and taller growing Fiddlewood and Brazil pepper to invade, thereby increasing the workload on future pruning cycles.

Likewise, some particularly sturdy and healthy Bermuda cedars growing adjacent to, or *around* utility wires can actually help to protect them from other more brittle or flexible trees in storms. Yet I have seen live cedars quite unnecessarily cut back so that they no longer provide this protection, once again opening the door for the more problematical trees like Fiddlewood to take over. Belco could avoid a huge amount of unnecessary damage to utility wires in storms if it were to employ just one qualified horticulturalist/tree surgeon who knows the growth characteristics of all Bermuda's trees and shrubs and could distinguish the difference between those that predictably pose a threat to wires and those that might actually help to protect them. Likewise, Parks maintenance crews responsible for roadside hedge trimming and for maintaining trails through woodlands or nature reserves could find their workload reduced by more than 50%, merely by *selectively culling out* all the fast growing and fast sagging Brazil pepper bushes *and their seedlings*; and all Chinese fan palms *and their seedlings*, growing adjacent to those trails; The former are best cut off at the stump with a chain saw, killing the stump with a systemic herbicide and then chipping the whole with a chipper. The latter are best culled by cutting off the adults with a chainsaw at the base (which kills them) and digging out the seedlings and juveniles (the ones which don't yet have a stem) with a mattock, after cutting off the spiny leaves with a machete.

If the gaps resulting from brazil pepper and fan palm removal are large enough, this is the perfect opportunity to replace them with trees and shrubs that are more attractive and wind resistant; and not tall enough at maturity to reach the height of utility wires. Bermuda cedars, Bermuda palmettoes and olivewoods are the best three candidates., but there are many others.

THE ULTIMATE CHALLENGE: CONTROLLING INVASIVES AND RESTORING NATIVE FLORA IN OUR PRESENTLY UN-MANAGED NATURE RESERVES AND WOODLAND RESERVE ZONED LANDS

Having described better ways of managing our gardens and parklands to favour native flora and higher quality introduced species, while also saving on labour, noise pollution from mowers and strimmers, and less use of herbicides and pesticides, I will now address the ultimate challenge: what we might be able to do about those *unmanaged woodlands, mostly zoned 'Woodland Reserve'*, which have been taken over completely by invasive pest plants.

Many people who own property zoned as Woodland Reserve express frustration that the zoning regulations do not permit them to do any management that involves vegetation clearing. While this is a legal tool intended to prevent people from clearing woodland *for other development purposes*, there is a procedure, albeit cumbersome and bureaucratic, for getting around this and preserving the intent of the law, which is to protect, and enhance the quality of the woodland.

Landowners can apply to the Planning Department for a permit for "woodland management" which is then vetted by Conservation Services, who decide whether the management technique proposed will in fact work and enhance the woodland in the long run, and if not, will recommend a better way of doing it. There can be great flexibility in this regard. No one is trying to dictate exactly what can or cannot be planted, provided the end-result is a higher quality and more diverse woodland. Some people, for example, might wish to emphasize fruit bearing trees in their woodland, such as Tamarinds, Mulberries, Avocados or Loquats, but the general

advice is to strive for a compatible balance between native trees like the cedar and Palmetto and the best of the introduced trees that are not too invasive, such as the poinciana, black ebony, Indian almond and Japanese pittosporum.

Woodland management was an area in which I did a lot of research during my tenure as Conservation officer, and what I found out was both discouraging and encouraging. The discouraging part was that in certain situations, notably inland valley localities which have been totally overgrown with Fiddlewood, allspice or Brazil pepper and then trashed by a hurricane, there is little choice but to get a permit for what I call a “block clearing” – an opening in the canopy large enough to permit new plantings without the risk that they will be over shaded or damaged by further tree fall in storms. In other words starting from scratch again with a patchwork of small clearings rather than one wholesale clear-cut, so that at least some woodland is retained through the transition. In a sense this is emulating the shifting cultivation of Indian Milpas gardens in tropical forests, whose small clearings in the larger forest context tend to maximize biodiversity while preserving the forest as a whole. Of course, this system only works effectively if the woodlands are large enough, but unfortunately most “woodland reserve” zoned areas on Bermuda are barely more than woodlots or screening hedgerows!

But here is the good news: in other more exposed areas of Bermuda with a lower stature and scrubby vegetative cover, notably coastal hillsides and some hilltops, all that is necessary is to cut a grid of access trails at 25 foot spacing through the invasive scrub, while sparing any native or high quality introduced species encountered, and then planting the other desired trees at the intersection of the trails. Subsequent maintenance via the grid trails can usually be accomplished with weed wrenches and/or machete. Native trees, with their better tolerance of wind and salt spray, do exceptionally well in such un-managed areas, and indeed the Bermuda cedar is already beginning to re-colonize them naturally, but the process could be greatly speeded up in this way, with the result being a Bermuda cedar dominated forest of much higher stature than the surrounding scrub in which it was started. The lower stature native bushes, like Jamaica dogwood, Rhacoma, Doc-bush and Wax-myrtle can *only* survive in the stunted vegetation of windswept and thin soiled hilltops, but the latter two can also compete well in peat marshes.

The fact that some natural regeneration of Bermuda cedars is already taking place in areas like Ferry point and Smith’s island in St. Georges, and the Vesey Nature Reserve in Southampton, where the invasives are lower in stature and less competitive, is very encouraging, because it suggests that the cedar is now largely resistant to the scale, and invasive tree competitors are the *only* thing preventing it from making a complete come back.

The other good news about woodland management is that once the initial selective clearing and replanting has been done, subsequent maintenance, although necessary on an occasional basis, is vastly less labour intensive than that normally associated with a formal park or garden and continues to lessen as the new woodland matures.

I was able to restore and maintain quality woodland with a high proportion of native species on nature reserves with a total area roughly equivalent to the Botanical gardens with only two to four field staff who worked on them only part of the time, whereas the Botanical gardens employs at least twice as many staff, working full time.

I termed the technique of woodland restoration that I developed “Restoration by culling” because once the initial clearing and re-planting is done, all subsequent effort is limited to selective culling of invasive species re-growth at regular intervals. The key to minimizing labour costs lay in determining the optimum time between

cullings and not allowing the regrowth to get to a size that hand-weeding, mattocks, or weed wrenches could not handle. In practice this worked out at about once a year for any given area and at this frequency a four-man crew was able to cover one quarter of an acre a day. All that is required by way of training for woodland owners, or volunteers, is the ability to distinguish the *seedlings* of the aggressive invasive species to be culled from the seedlings of those more benign or quality species to be spared.

The insight leading to my development of this technique came from my discovery back in the early 1960's of a few remote corners on Bermuda, notably in the heart of the Walsingham tract; in Paget marsh; on Morgan's island, Ely's harbor; and on Abbots cliff, where the virgin native forest cover had never been significantly disturbed by man and was so robust that it actually resisted invasion by the introduced and naturalized species up until the time of the cedar scale epidemic and the naturalization of the Brazil pepper. I rationalized, therefore, that if an effort was made to replant all the components of the native forest and protect them from invasives until they were mature, they should ultimately require very little effort to maintain.

The first full trial of this technique was carried out on isolated Nonsuch island and was so successful that I followed up with two other major trials on Bermudas mainland in Paget marsh and within the Walsingham trust. In general, the taller growing trees like cedar, palmetto and hackberry did better in valleys, and the lower stature species like Bermuda olivewood, forestiera, rhacoma, doc-bush and Jamaica dogwood did better on hilltops.

All three sites now provide living testimony that the technique works.

A key factor in the success of these projects was to emulate the mix, spacing, and habitat placement of the plantings, (Viz: coastal, hilltop, valley and peat marsh) as closely as possible to the way they were in those relic stands of *native* woodland. (Some people trying to restore natives in their gardens or woodlands have made the mistake of planting the trees too close to each other, or in groupings of one species or another, rather than mixing them, and not choosing the right species for the particular habitat).

My successful woodland restoration experiments have provided another insight: Introduced plant pests and diseases, while they may stress and weaken the native flora, rarely, if ever, exterminate their host plants for the simple reason that they are dependent on them for their own survival. What happens is that natural selection ultimately restores a balance by weakening the pest and strengthening the host – the so called “balance of nature”.

The longer-term survival and recovery of the Bermuda cedar after the initial knockdown of the scale epidemic is a classic illustration of this. Outright extermination requires a second factor, and that is the presence of competing plant species. The invasives are the bigger of the two problems because they do not depend on the natives for their own survival. On the contrary they are better off without them because they can then occupy the space that the natives formerly commanded. The steady decline of native flora in the landscape from 100% to 5% is a result of this “double whammy” effect. Introduced pests and diseases weaken the native flora, then over-shading and displacement by invasives finishes them off.

This is why removing the invasives by culling is vastly more effective than trying to control the pests and diseases that may be attacking and weakening the natives. Broadcast use of pesticides only lowers the biodiversity, by killing the insects on which birds and other wildlife depend. In any case, once the invasives are removed pesticide use becomes entirely unnecessary.

OTHER GENERAL STRATEGIES FOR TRANSITIONING FROM AN ALL NATURALISED INVASIVE WOODLAND BACK TO AN ALL NATIVE WOODLAND

When I first started experimenting with native woodland restoration on Nonsuch island it was shortly after the cedar scale epidemic and all but one cedar on the island had died. The ground cover was almost exclusively St Augustine grass because a herd of goats had browsed most understory shrubbery to extirpation, and many had not yet been introduced to Bermuda at that time. Thus, all I had to do was remove the goats, dig the tree holes and plant the natives and endemics in their proper habitat and mix. I did not have to remove the overstorey of dead cedars because they weren't in the way, and in death did not shade out the new plantings. Indeed, they proved to be beneficial because even in death they provided a valuable windbreak and most are still standing 60 years later!

The situation is very different today because of the very tall and dense replacement forest of invasive trees, which has taken over on the rest of Bermuda, casting too deep a shade and too much competition for new native planting to germinate and grow naturally. It is essential, therefore, to remove that invasive woodland first, or at least thin it out radically to initiate the transition. But doing so creates two additional problems. Firstly, it is incredibly labour intensive and creates enormous piles of cut vegetation that block the ground and pose a fire hazard. This cut vegetation is valuable for recycling on site as compost, however, so it makes no sense to truck it to the dump at huge expense.

THIS IS WHY I CONSIDER A CHIPPING MACHINE ESSENTIAL FOR WOODLAND RESTORATION: THE LARGER THE BETTER!

The second problem encountered is that by opening up our secondary invasive dominated woodland, most of those typically taller, naturalized trees become more vulnerable to blow down in storms. When this happens, they can damage or even kill the new native plantings.

There are three ways of getting around this, and they differ, depending on the type of invasive cover.

If it is a sheltered inland location with fast growing and tall trees like fiddlewood, which are very vulnerable to breakage or blow down, it is best to remove or top them to create a block clearing big enough so that blow down along the edge of the clearing won't occur or can't reach most of the new native plantings.

If it is an inland location with a monoculture of allspice (most common in Warwick parish) that species is much more resistant to blow down, so a less labour intensive strategy is to create a sunny opening by just girdling the trees rather than removing them. The dead trees let in enough light to allow the new native plantings to establish underneath, and they should stand long enough to enable those new plantings to establish before they fall or get harvested for their hard and durable timber, (useful for making fish pots or rustic fencing).

If the invasive cover is predominantly low stature dense shrubbery like Surinam cherry, which does not blow down in windstorms, the clearings need only be big enough to accommodate a mosaic of individual native tree plantings. Also, as I said earlier in this treatise, in some coastal areas or hilltops the invasive cover peaks in height lower than the most robust native trees, so all that is necessary is so make small openings for the new native plantings in a grid pattern.

One last strategy, which applies particularly to windy and salt spray prone coastal hillsides, is to start the transition process on the inland side and work gradually towards the coast as the new plantings become established and begin to provide cover for each other. This way the windbreak benefit of any existing invasive dominated coastal vegetation cover can be retained right up to the final stage of the restoration. Fortuitously, the native vegetation, like buttonwood and bay grape, generally dominates near the coast anyway.

Note that all this advice implies a gradual approach to restoration.

In many cases it is not possible or advisable to do it all at once. It is often best to let the new native plantings in a block clearing grow large enough to provide wind protection for each other, and for bird habitat, before clearing the next block.

In conclusion, given that forest management can be so much less labour intensive than formal garden maintenance; and given the crucial need to maintain Woodland Reserve zoned areas on Bermuda for the preservation of the Bermuda image, floral diversity, wildlife, windbreak, shade, carbon sequestration, and all the other free services that woodlands can provide, would it not make sense for Government and some of the local landscaping firms to train and employ some woodland management crews who could begin the daunting task of restoring our invasive dominated “Woodland Reserve” zoned areas to something more useful, diverse and attractive? We may soon have to establish such a crew anyway, just to control casuarina invasion blocking views along the coastline.

Small as our woodlands are, there is even the prospect that some of them could be restored and managed for cedar timber production again, given the incredibly high value that Bermuda cedar has attained on the open market in recent years. One experimental cedar planting that I did on arable fields within Great Head park, St. David's, in 1974, grew trees that could have been cut for 4" x 6" roof beams of 12' length within 35 years. Indeed, a few enterprising thieves actually did harvest a few!

There is a growing need for educating and field training of landowners, or the landscaping firm employees that they hire, on the labour saving and environment enhancing techniques that I have outlined in this treatise. Thus I am especially pleased that the Bermuda Zoological Society, (the volunteer support charity for the Bermuda Government Aquarium) has undertaken to copy the Living Museum project that I started on Nonsuch island on 7acre Trunk Island in Harrington Sound. BZS is now using that project as a training site, and hundreds of students and adult volunteers are benefiting from the opportunity to learn the techniques involved. Better yet, they are beginning to apply that knowledge in their own gardens, or as volunteers on other Nature Reserves.

Considering that each able-bodied Bermudian citizen would only have to restore and manage less than half an acre, it is not unreasonable to suggest that if *they could all* be persuaded to implement the procedures described here on their own properties, and by volunteering on nature reserves, it would be possible to restore *all* of our woodlands back to a high-quality condition in four or five decades.

(29 Dec. 2020 edit)