

Reflecting on the Obstacles to Uses of Colonizing Species ('Weeds') as Bio-resources

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Abstract

Ecology, *Weed Science*, Restoration Ecology Conservation science and related disciplines are now well-developed. These disciplines have the knowledge, capacity and tools, firstly, to recommend the prevention of potentially risky plant introductions; and secondly, to develop methods to eradicate, contain or manage problematic species and reduce any harmful effects, either to food systems, human health, or the environment. However, in all of these 'sciences', the ideas for the *utilization of colonizing taxa* are not well articulated; nor are the opportunities adequately pursued. Why? we may ask.

The utilization of 'weedy' colonizing species for direct human benefits and other practical applications is a much-neglected area within *Weed Science*. It is the result of an inadequate ecological understanding of weeds, which I call 'weed-illiteracy'. Most weed scientists and even some ecologists and conservation scientists have been brought up hearing a flawed myth that '*all weedy species are bad all the time*' and some may even engulf the world!

A change in attitude and a shift of focus are required to redress the issue. Weedy taxa have been blamed and used as a scapegoat for too long to hide human follies (related to disturbances caused by land-clearing, deforestation, inappropriate forms of agriculture, and excessive urban population growth). Changing our perceptions of colonizing species will allow weed scientists to explore the benefits of a positive relationship with a vast array of such taxa and their unique capabilities. Faced with the uncertainties of a changing climate, not to change our attitude towards weedy species appears another human folly in the making.

Keywords: Colonizing species, weeds, utilization of weeds

'Responsibility' – a Virtue

Unfortunately, most weed scientists are trained from their early careers to fight weeds, not to utilize them. The '*war on weeds*', is an attitude that has been around for more than 70 years (Evans, 2002; Larson, 2005; Falck, 2010; Davis et al., 2011; Dwyer, 2012). The war metaphor believes *humans could win a war against weedy enemies*. This misguided and unhealthy attitude has been a bane of weed science.

The primary 'weapons' of war (herbicides) were mostly discovered and developed as commercial products in the 1940s and 50s decades. Weed science, as a discipline, was also founded in the 1950s decade. Even in those decades, the slogan

'*war with weeds*' has been like a *mantra*, repeatedly heard at various symposia and weed conferences.

After the first synthetic, organic herbicide, 2,4-D was discovered and developed in the late 1940s, many others followed. Herbicides, especially selective chemicals, initially provided highly effective weed control across agriculture and many other areas where colonizing taxa posed problems, such as in the management of golf courses, infrastructure, public spaces and rights-of-way.

Early in the development herbicides were saviours, not problems. However, within two decades, the overuse of herbicides for weed control in agriculture and in other situations presented a major difficulty in the USA, UK and Western Europe.

More than six decades ago, ecologists warned that weeds would most likely evolve resistance to the repeated use of herbicides on the same land (Harper, 1956). The incredible success of herbicides in killing weeds and the profits that could be made by technological and scientific breakthroughs led to these warnings being largely unheeded.

The echo of the misinformation – that humans can actually win a war against weeds - reverberated through the discipline in the 1960s, 70s and 80s decades. The message was heard loud and clear by public officials, land managers and volunteers, who enthusiastically joined the ‘forces’ against weeds.

More ecological understanding, and even common sense, should have alerted ecologists, weed scientists and environmental scientists that it is foolish to believe in such a myth just because we have in our possession an arsenal of herbicides. As a result of believing the pervasive myth, most weed scientists have become wary of evaluating the ecological roles that weedy taxa play in Nature and exploring the opportunities to integrate them into our lives.

These days, most, (but not all i.e. Organic agriculture) media stories blare out the sensational message: *All weeds are bad news*. Disappointingly, thousands of weed research articles, even in recognized weed journals also give the same negative message. Many weed scientists are still too busy ‘*battling*’ the evolving weedy taxa to think about concepts and practical applications of utilization that weedy taxa offer. A major obstacle is simply the shallowness of the discourse and prevailing ‘*weed-illiteracy*’. Ideas regarding ‘*beneficial*’ or ‘*tolerable*’ weeds run contrary to killing weeds. Any ideas about utilization are thwarted by the ‘*fear*’ created in people’s minds regarding weedy species, presented as ‘*aliens*’ ready to engulf the world.

Given the entrenched view that *weeds are bad news*, most weed scientists, perhaps with some justification, stop short of recommending that these colonizing taxa can actually be useful for societal benefits. For some weed scientists, the utilization of weedy taxa seems like an *idealistic position* rather than a realistic and attainable goal. A few, surprisingly, have gone even further, believing that the *utilization of colonizing taxa is the future!*

Hiding the positive attributes of the accused is part of this story. The ease with which proponents spread mis-information about colonizing taxa inhibits

a better relationship with them. *Our societies are poorer for this mistake.*

Regrettably, ecological knowledge about plants, animals, microbes and how complex biological systems work on this fragile earth is not a high priority for most people. As a result, making people understand the virtues of weeds is a huge challenge and the uses and opportunities remain under-explored (Chandrasena, 2008; 2014).

With some species, such as water hyacinth [*Eichhornia crassipes* (Mart.) Solms.] that can be exploited for various uses, and arundo (*Arundo donax* L.) and jatropha (*Jatropha curcas* L.) that can potentially be expanded as a biofuel crop, utilization may present modest but manageable risks. ‘*Good observers*’ do not miss such possibilities ¹.

The frameworks and concepts for managing a potential risk posed by a specific species are well-developed within weed science and related disciplines. Given this, as I have previously discussed (Chandrasena, 2014), we have a moral responsibility to change our attitude towards colonizing taxa so that suitably targeted action to manage them can be taken on a *case-by-case* basis, *where, when and if required*. The experience of ecological restoration projects is that it is often unnecessary and futile to carry out drastic and lethal action against any widespread species in most habitats.

The resolution of most environmental conflicts lies in the power people have over issues that concern them. The vexed issue of *colonizing taxa*, which are regularly accused of being a problem in agricultural land, home gardens, public spaces or nature reserves, falls into this category.

There can be no doubt that sustainable solutions need to be found for a myriad of problems weedy taxa present by their sheer abundance, in specific situations. But solutions can only be found by people themselves, with a sympathetic attitude combined with an enlightened ecological understanding. Developing effective solutions will require balancing the negative effects of colonizing taxa in specific situations with their positive effects, i.e. the values of goods and ecosystem services the taxa provide.

As Devine-Wright et al. (2022) argued: ‘*The learnings from Social Sciences prove that placing people at the centre of solving the problems that they have created is essential*. Additionally, actions by both individuals and society, as a whole, are crucial,

what they are looking for when it is there, does not see what they are looking for when it is not there and sees what they are not looking for when it is there”.

¹ Robert Zimdahl, Emeritus Professor of Weed Science at Colorado State University recently stated (*personal communication*, Nov, 2020: “*What we need are good observers. A good observer sees*

as humans face a precarious future under a changing climate. In ethics, *responsibility* is counted as an environmental virtue and often expressed as a good-trait of character. A '*good human being*', with compassion and benevolence, will take responsibility for behaving appropriately towards the environment, including all other species (Thompson, 2011).

Extending from such ideas, both individuals and a collective society *must* take *responsibility* to obtain an enhanced ecological understanding of the interactions between humans, other species and the environment. This awareness is critical in dealing with colonizing taxa. When and where the excessive growth of a weedy species becomes a problem, whether it be in agricultural or non-agricultural settings, we must manage them using well-developed tools and tactics and strategic approaches. We must also do so without harming the environment or other organisms that rely on the colonizing taxa. This is being good environmental stewards.

Zimdahl and Holtzer (2021) have argued that in all our activities, we should worry about the *ethics* of what we do. All of humanity has a moral responsibility to '*do no harm*' to the environment, biodiversity and the planet. In their view, in agriculture, or all other productive endeavours, profits alone must not be the key driver. The environmentally-responsible person will be disposed to acquire the knowledge to achieve this and also execute that know-how.

It is also important to note that as climate change adaptations show, science and technology alone cannot solve complex societal problems. All our actions should be undertaken with an eye on protecting the earth and sharing resources with billions of other animals and plants. A priority must be to conserve what *Mother Earth* has endowed us with, but we must allay our fears of the so-called '*Aliens*' or '*Invasive Alien Species*'.

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Should weeds be treated '*guilty, until proven innocent*'? Some people have taken this phrase to unjustified depths, maligning weeds. The view is repeated but hardly questioned in agricultural and related vocational courses in Australia, such as horticulture, landscape ecology or rural development. It is often heard at weed conferences. Thankfully, the false assumptions in this viewpoint have been questioned by many prominent people²⁰

The initial objections came from a philosopher - Mark Sagoff (Sagoff, 2002; 2009) and a group of ecologists - Mark Davis and Ken Thompson (Davis, 2005; Davis and Thomson, 2000; 2001), Curtis Daehler (2001) and Brendon Larson (2005). These

were followed by strong criticisms by historians - Matthew Chew (Chew and Carroll, 2011; Chew, 2015) and John Dwyer (2012), who expounded the opposite view. Writing to the prestigious *Nature Magazine*, in 2011, Mark Davis and 18 others (Davis et al., 2011) also voiced their strong objection to the nebulous concepts and questionable narratives that blamed introduced species for human follies. Recently, Guiaşu and Tindale (2018) added their voice, objecting strongly against the use of fear-invoking terms in public discourses.

The simple ecological process of '*colonization*' by which some highly adaptive taxa establish in new areas, where opportunities exist, has been misconstrued with a fear-invoking term '*invasion*'. Despite the lack of consensus, over several past decades (Davis and Thompson, 2001; Colautti and MacIsaac, 2004; Rejmánek et al., 2005; Davis, 2005), many such species have continued to be branded as '*Invasive Alien Species*' (IAS).

This flawed narrative and disagreement are obstacles to the prospects of the utilization of many species with unique capabilities. The '*native*' versus '*aliens*' debate, which was ignited in the 1990s (Sagoff, 2002; 2009; SCB, 2007; Davis, 2005; Chew, 2015; Shackelford et al., 2013) also continues unabated, often clouding weed-related discourses.

A large number of species, including some humble '*farmer-friendly*' weeds have been branded as IAS deserving to be punished with death for merely occupying human spaces. The term '*alien*', used correctly, should not disparage species in any sense.

As the pioneer users, who popularized the term (i.e. British botanists - Hewett Cottrell Watson (1847) and Stephen Troyte Dunn (1905) have so clearly explained, it should only apply, if ever, to species '*introduced*' to new areas (Chandrasena, 2021). The terms "*alien*" and "*native*", used by Watson, Dunn and other traditional botanists, along with phyto-geographers in the mid-19th Century, gained *moral force* with the rise of environmentalism, more than a century later (Chew and Carroll, 2011; Chew, 2015).

'Natives' were natural, innocent and untainted by any human association; 'Aliens', like their human enablers, had detrimental "impacts", not effects.

As Larson (2005) and Dwyer (2012) stressed, terms, such as '*alien*', '*feral*', '*invader*' and '*invasion*' are designed to exaggerate and create fear in the public's mind. In my view, the reversal of the universally accepted concept, that everyone is '*innocent until proven guilty*', so clearly enunciated for the public good, is intellectually dishonest. The quicker we stop using such divisive language, the better we will be as a society.

To say that: '*all weeds must be guilty until proven innocent*' is a form of populism at its worst. Unfortunately, despite objections, this trend is still continuing, especially in the USA, Australia, New Zealand and some Western European countries.

The current trend of presenting the negative effect of colonizing taxa as an imminent '*invasion*' is a mess that *Weed Science* would do well to address as a matter of urgency. It has nothing to do with a genuine interest in saving the world from '*invaders*', who, it is alleged, commit crimes against humanity! Disturbingly, in my experience, the claim is hyperbole to get more funding. Ken Thompson (2014) went further and called it a deliberate lie!

"...The assertion that alien species constitute the second greatest global threat to biodiversity has been debunked so often (yet is endlessly repeated) that it no longer deserves the status of a myth and is best described merely as a straightforward lie..."

These emotive and highly subjective adjectives still continue to thrive within the discipline of *Invasion Biology* (Binggeli, 1994; Chew and Laubichler, 2003; Colautti and MacIsaac, 2004). Without a doubt, these powerful terms also influence the public's thinking and prevent positive relationships with weedy taxa.

Defense against "*biological invasions*" became a prominent goal of conservation biologists, who decided, by acclamation, that the '*impacts*' of IAS present a dire threat to biodiversity, thus creating a myth. In this mythology, any form of *colonization* of a new location by plants or animals became viewed as a problem (Chew and Laubichler, 2003).

Historical usage of the terms shows that the concept of '*nativeness*' lacks any reliable ecological content. It simply means that a species under scrutiny has no *known* history of human-mediated dispersal and may have been a resident of a given biogeographical area for centuries (Chew and Carroll, 2011; Hill and Hadley, 2017). Moreover, there are many global examples, which indicate that not all species introductions to new areas, regions or continents are so dramatically detrimental as claimed by conservationists and the media

My view is that the industrious plant collectors and phyto-geographers of the past, such as Watson (1847) and Dunn (1905), knew more than a century ago that *not all 'introduced' plants can be successful in their new environments*. When moved across geographical barriers and continents only a mere handful can successfully establish on their own without help from humans. Also, only a very few grew in such abundance that they caused problems for humans and natural ecosystems.

Ecology teaches us that given the variety of life cycles, reproductive strategies, and the dispersal means that plants and animals have, many species can indeed move about and spread on their own crossing even geographical boundaries. They would receive some assistance for spread, establishment and eventual '*colonization success*' from natural vectors (such as wind, water, and animals) and also benefit greatly from the relentless disturbances that humans and other animals cause. However, not all species, being moved about by humans or other vectors, can be successful in all types of habitats (Parker et al., 2013).

The combination of two powerful adjectives - '*invasive alien species*' (IAS) - has confused many scientists, including weed researchers and the public. Regrettably, nowadays, one could find large numbers of journal articles using the term IAS interchangeably with weeds. At conferences, symposia, workshops and other fora also the fear-invoking terms IAS, '*alien invaders*' and '*invasion*' are widely used in an *ad hoc* manner with no real understanding.

Statements, such as '*weeds are guilty until proven innocent*' using disparaging adjectives like '*feral*' and '*evil*' in referring to colonizing taxa are not worthy of the people who make them. As with all bad news (or *fake news*), this *untruth* about weeds has travelled farther, faster and deeper, across the globe. In most well-documented cases, the term IAS exaggerates the likely longer-term ecological impacts of organisms in new environments.

In most countries, the IAS lists include some valuable species from which societies can benefit. In the confusion created by the IAS branding, one can excuse the public, scientists and policymakers for being misled. Many have been brainwashed by this narrative to think that all '*weedy*' species are plunderers of our resources, moving across geographical barriers to engulf continents.

Changes to such irresponsible typecasting will come with time, as attitudes change, but it can be expedited by a better understanding of weedy taxa. *Weed Science, Ecology, Plant Biology and related disciplines have a responsibility to better understand what colonizing taxa really are, their worth for humanity, and what they can offer to our Planet Mother, presently crying in distress.*

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Regardless of our capacity to kill weeds in most situations, by their sheer tenacity, and abundance, colonizing species gives us several messages. The paramount message they give is the *challenge* they pose with the capacity to adapt rapidly to climate change, as well as to the selection pressure applied

by humans through the use of herbicides. A relevant question would be - *Despite our ingenuity, do humans have that adaptive capacity? The answer is no.*

Notwithstanding the inconveniences weeds may cause humans, they will always be there, now and in the future, as part of the earth's rich biodiversity. *We should be thankful that these pioneer species exist and are unlikely to go extinct.* The time is upon us to enter into a peaceful co-existence with colonizing taxa and learn how to live with them.

Contrary to the alarmists' view, colonizing taxa *will not take over the world.* It should hardly be necessary to point out that *the Earth does not have a feral future!* The distortions of what science has taught us are driven by the feeding frenzy of the twenty-four-hour news cycles. Sensational messages consume us day-in-day-out. Science writers, looking for attention-grabbing stories, put their own spin and most of the time, get the message wrong.

The echo chambers of negative messages on weeds are largely designed to obtain more funding to manage the *invasion* threats. But they skew our thinking; make people feel powerless; and often debilitate our rational thought processes concerning the true nature and virtues of colonizing species.

Public servants, who deal with policies on weeds and natural resources, feeling the need to protect their jobs, prefer not to be too vocal in support of weedy taxa and their uses (Harper and Chandrasena, 2018). Some are convinced that what they do is right and the alternate view - promoting the utilization of weedy taxa for any ecological, environmental or societal benefit - *will go against the grain.*

In Australia, funding has never been available to investigate the positive contributions of colonizing taxa to the environment or to society. All government funding goes towards killing weeds, *presumed as guilty* and harming the environment or human interests. For instance, even the last round of weed research funding, announced in June 2021, sought *'off-the-shelf', 'farm-ready'* easy fix solutions that hold out *'silver bullet'* promises for managing a *prioritised* list of taxa (DAFF, 2022). Sadly, this was despite the lack of evidence that these generic solutions have had much of an effect on weed management in Australia (Harper and Chandrasena, 2018).

Since the mid-1990s, substantial weed research funding has been spent in Australia, unimaginatively, to manage, more or less the same list of species, with limited success. The absence of any concern or funding for exploring potential uses of colonizing taxa in such calls for research reflects how the discourses

have been hijacked by the more powerful (negative) voices. *Use-inspired, utilization research funding, whether it be basic (pure) science or applied science, will only come with determined campaigning by concerned citizens seeking better solutions.*

This situation, however, is not unique to Australia. In dealing with weedy taxa, often, governments take a *'we-know-it-all'* attitude, which leads to *'top-down'* enforced approaches. Such an approach fails because it does not adequately foster collaborations and community-based weed management. The availability of funding for on-ground weed management is also influenced by privileged stakeholder groups whose voice is more powerful than that of environmental groups and advocates of conservationist agendas.

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Compared to countries with diverse and mature cultures, the European mindset on weeds in the relatively newly-colonized Australian continent is an impediment to exploring the utilization of colonizing taxa as bio-resources. The fear of weeds, stealing resources from crops and drawing energy out of human endeavours, is deeply ingrained in the population. Unfortunately, the knowledge of the extensive use of weeds as biological resources, within Australia, or by other traditional cultures, extending to nearby Oceania, has not penetrated deeply into the society's worldview.

The low population density in most regional areas of this large and mostly arid continent does not help. Generally, low-density regional communities are too sparse and small to economically utilize the relatively large biomasses of colonizing taxa, which are spread across vast, arid landscapes.

Another powerful reason is the relative affluence of the population, given Australia's rich mining-based economy. Most people are wealthy, deriving income from manufactured goods and services rather than from raw materials in the environment. The affluence creates little incentive for people to utilize natural resources for their livelihoods. This is especially true for plant resources unless that use is directly related to profitable pastoralism (i.e. fast-growing grasses and nitrogen-fixing ground-covers and trees, or shade trees) or animal farming (i.e. fodder species).

A large portion of the wealthy have no reason to develop sympathetic attitudes toward Nature, which they believe, is there to be exploited. *In this social milieu, weedy taxa are cast aside as unimportant, or worse still, to be killed off, at every opportunity.* The disconnect between sectors in the community and the environment is also a contributory factor, which creates conflicts with species.

For example, primary producers, large agribusinesses and others- Nursery Industry, and even consumers, often initially experience positive effects from a new plant species. However, when the same colonizing taxa become naturalized over time and then begin to spread, they become the objects of a visceral dislike of the same landowners because of the problems the species may cause.

In Australia, pastoralists derived enormous benefits from N₂-fixing legume trees and leguminous cover crops, which were introduced over a century ago to improve grazing lands and fodder for the animals. But it did not take long for the same farmers to despise these species, as they spread across vast, arid rangelands. Although the judgements of wealthy landowners and pastoralists, with vested interests, are flawed, they form strong political constituencies, and their voices drown those of others with opposite views on specific species.

To answer the question of whether we can ever co-exist with weeds, *science is not enough*. Value judgements, societal considerations and democratic decisions are involved, but these should be underpinned by both scientific and non-scientific knowledge and a commitment to Nature ². Weed scientists have a *responsibility* to engage more with people working on 'weed policies' or focus on the *social ecology* of weeds.

Armed with scientifically testable ideas, more 'policy-related' research is the only way forward to finding sustainable solutions to managing vast landscapes, agriculture, and soil and water resources. Trade-offs and compromises will have to be made with a commitment to do *no further harm* to the environment. In that regard, the potential for utilization of colonizing species *must* be a serious candidate for funding in the future.

Weed scientists, across the globe, must also take *responsibility* to better understand colonizing taxa before embarking on developing unsustainable and lethal solutions. We must learn lessons from the way weedy taxa rapidly evolved resistance to the continuous use of herbicides (Heap, 2014; 2022).

² Non-scientific knowledge comes from traditional knowledge, as well as the personal experiences, intuition, logic, and authority of individuals in a society. Scientific knowledge, on the other hand, relies on hypothesis-testing and research findings obtained by following the scientific method.

³ E O Wilson's 1992 book (Wilson, 1992) popularized the flawed notion that 'invasive species' including weeds, are the '*second greatest threat in the world*', following '*habitat loss*'. The idea was attractive to some who had to do something, and it got embedded in the *Convention on Biological*

If our genuine desire is to protect the environment from the ravages allegedly caused by 'colonizing taxa, blamed as the '*second greatest threat to biodiversity*' ³, we must find more funding to prove this claim more convincingly. We also need better measures and ecological data to inform our understanding of the effects of colonizing species across varied landscapes and time scales. My view is, in the longer term most weedy species will *co-exist* with the so-called 'natives' without completely displacing the latter or causing irreparable harm.

The idea that the world needs to be 'conserved' or 'restored' is fraught with difficulties, as Matthew Chew (2015) argues so eloquently:

"...Evolving as a 'crisis discipline' with a 'call-to-arms' mandate to 'save the world', the Invasion Biology narrative presumes that the earth is 'pristine', as well as rather static and the changes that have occurred or currently happening, could be reversed with direct action. Man's culpability is quite explicit in the conservationists' agenda; however, in the same breadth, most conservation ecologists are ready to blame weeds as a primary cause of biodiversity losses, without much empirical evidence, which is a shame..."

By writing large numbers of articles on weeds, one should not expect the public to understand weeds or weed-related issues of concern. If researchers really care about how their findings will influence public opinion and government policies, they must redress this '*communication gap*' and '*translational deficit*'. This deficit, obvious in the majority of *weed science* publications, is possibly due to inadequate *ecological literacy*, and often, poorly-selected research topics that have only an academic interest but little practical value to society.

The *translational deficit* regarding the practical applications of specific research findings and scientific insights can only be remedied by balancing scientific evidence with the priorities of societies. Perhaps, weed researchers themselves should better understand colonizing taxa and moderate their

Diversity (CBD, 1992). without much challenge. The repercussions are felt even today, in that it inhibited people to think more positively about colonizing species and the advantages they may offer to society (Chew, 2015).

Since the first claim, E O Wilson (1997) has written that "*...Extinction by habitat destruction is like death in an automobile accident: easy to see and assess. Extinction by the invasion of exotic species is like death by disease: gradual, insidious, requiring scientific methods to diagnose...*"

own views regarding the objects they are dealing with. This will help many researchers not start every article by presuming that all weeds should be controlled, at all costs and that they are among the greatest threats to the planet's biological diversity.

Only cross-disciplinary research, integrating weed research with other disciplines, including *Social Science* and *Ethnobotany*, will allow weed scientists to better appreciate the values of weedy taxa. Weed scientists must realize that they also have a *responsibility* to form hypotheses regarding the potential uses of colonizing taxa that can be carefully tested. Presenting a convincing research agenda is the only way to attract funding from governments or civil societies and change the discourses to favour these resourceful taxa.

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The prevailing *minority view* that weeds are not the enemy of humans, not liabilities, but are useful resources – for now, and for the future, is not a radical idea or a misleading notion. Although the message is somewhat muted in the discourses, most people, farmers, biologists, and even politicians, who care for the environment, will have to agree.

Colonizing taxa have clearly staked claims on disturbed habitats, over large landscapes, which are increasing around human habitations. This is inevitable as the vast human population disturbs the planet's natural ecosystems. Hardly any areas on the planet now exist untouched by the human hand.

The sheer abundance and persistence of many weedy taxa get our attention. They meet our wrath because they will not yield to control easily. These experiences often cloud our judgements and in this confusion, it is easy to overlook the redeeming values of colonizing species. They provide vegetative cover over barren areas, stabilizing soil, anchoring nutrient cycles, producing food for animals and humans, and providing pollen and nectar for bees. They enrich Nature by adding variety, richness, abundance and biological diversity to any landscape.

If we *listen* carefully and also observe carefully, we will hear the silent story that weedy, pioneering species tell us – *of their resilience in the face of adversity and capacity to adapt* – serious lessons that humans can and should learn. The species are also spotlighting a spectrum of human follies in damaging the very environments that we should be preserving.

Learning from Nature

Instead of demonizing species, we must learn from each other and learn from Nature, as well as from pioneering plants and animals. Our ancestors, notably, *pioneers themselves*, did so admirably. Our

existence today is a testament to the adaptability and survival skills of our pioneer ancestors.

Unfortunately, survival is now precarious for many human cultures and societies across the globe. As climate change poses the greatest threat to humankind's survival (), our future existence as a species depends on how well we integrate with Nature's wonders, as well as the challenges the natural world throws at us. Humility, combined with a fundamental understanding that we are merely a species passing through a specific period in the Planet's life, would be a definite advantage as we continue our struggles to survive on the earth.

We must also do our best to mitigate human impacts on the environment. Some of the most destructive human activities include the excessive use of fossil fuels (related to global warming), over-exploitation of natural resources (such as caused by mining for oil, gas and minerals), habitat destruction, large-scale deforestation, expanding animal farming, monocultures and other forms of unsustainable agriculture. One must add to this list soil, air and water pollution, damages caused by the globally-rampant wildlife trade and poaching, and also the environmental pollution caused by the human waste created by a burgeoning population.

An emerging idea – of *Nature's Contributions to People* (NCP) – was recently highlighted by Pascual and co-workers (2017). It is a conceptual framework that fits the world of colonizing taxa and how we may strive to create a sustainable future for the present and future generations. As the authors explain:

"...Nature's contributions to a good quality of life are often perceived and valued by people in starkly different and often conflicting ways. People perceive and judge reality, truth, and knowledge in ways that may differ from the mainstream scientific lens..."

"...Hence, it is critical to acknowledge that the diversity of values of nature and its contributions to people's good quality of life are associated with different cultural and institutional contexts and are hard to compare on the same yardstick..." (Pascual et al., 2017).

The NCP concept has been developed within the context of the *Intergovernmental Platform on Biodiversity and Ecosystem Services* (IPBES). It is proposed as a pluralistic approach, widely applicable to knowledge-based policy initiatives.

The NCP platform recognizes the benefits of embracing the diversity and power relationships across stakeholder groups that hold different values on human-nature relationships. Resonating with the

term *Ecosystem Services*, the NCP concept includes all of the positive benefits and occasionally negative contributions, losses, or detriments, that people obtain from Nature (*anthropocentric values*). It also captures a *non-anthropocentric value* as a value centred on something other than human beings. These values can be *non-instrumental* (e.g. a value ascribed to the existence of a specific species for their own sake), or *instrumental* to non-human ends (for example, the instrumental value a particular habitat type may have for a species that is well-adapted to it).

Other knowledge systems, such as '*Nature's Gifts*', prevalent in many indigenous and traditional cultures, are recognized within the NCP concept. In a sympathetic worldview, colonizing taxa, which are accused of causing adverse effects on biodiversity and people, fall within the milieu of NCP and are most certainly, '*Nature's Gifts*'. *A flexible mind will allow us to seek clarification on this viewpoint.*

Conservation of biodiversity

I sometimes wonder how many people actually appreciate that the most unique feature of the earth is its biological life, and the most amazing feature of life on earth is its biological diversity. Innovative messaging and a greater emphasis on '*ecological literacy*' are required in discourses to hammer this message to some sections of society.

Approximately 9 million types of plants, animals, protists and fungi inhabit the Earth. So, too, do more than eight billion people. Human actions have been continually dismantling the Earth's ecosystems, eliminating genes, species and biological traits at an alarming rate, as highlighted at the 1992 *Rio Earth Summit* (Hooper et al., 2012; Cardinale et al., 2012).

Most people push global biodiversity losses and their link to human activities to the margins of their consciousness because they cannot quite comprehend the complexities of understanding '*causes and effects*'. Some people (such as climate change denialists) vehemently refute the linkages altogether, mainly for their own benefit.

There is still a great deal of money to be made by continuing destructive activities, such as large-scale logging of the tropical forests in Borneo or the Amazon and relentless extraction of oil and gas in the fossil fuel industry. Despite the overwhelming evidence (IPCC, 2022), it is too risky for many parties to accept that climate change is occurring. *And it is the poor who will suffer most from inaction by the rich.*

Nevertheless, a clear message emerging from innumerable ecological studies is that increased biodiversity often leads to greater, and less variable, levels of ecosystem functioning. That means, the

richer the biodiversity, the lesser the threat of extinction of plant and animal species.

As argued by Cardinale et al. (2012) and Hooper et al. (2012), diversity-driven increases in function can boost rates at which nutrients, energy and organic matter flow through an ecosystem, as well as increase their overall multi-functionality and stability. Therefore, in the conservation efforts of global species and ecosystems, maintaining high levels of overall biodiversity across landscapes is a must to even reduce the extinction risks of specific species.

As critical components of biodiversity in any biogeographical area, assemblages of pioneer taxa would collectively exploit the resources of particular environments in ways that maximise the cycling of energy and nutrients through those ecosystems. Along with all other life forms of plants, pioneer species will fill a variety of roles in ecosystems. Of their very unique nature, they will withstand disturbances and bounce back, responding to environmental changes. Although frugal in the way they consume resources, these highly adaptive species will share those resources with others.

Humans clearly present the greatest threat to biodiversity, of which both people and colonizing species are constituent parts. However unpalatable this message is, it needs to be given much more publicity, to achieve a better balance between human greed, the development aspirations of nations, and global biological diversity.

Concluding Comment

Hill and Hadley (2017) recently wrote: '*As the world stumbles deeper into the Anthropocene, the novel biogeographic dynamics (globalization, mass disturbance, and climate change) will progressively warp habitats*'. Under such disturbances, colonizing taxa will thrive and also change the habitats, which they occupy. However, I must emphasize that *weedy species are no more alien or villainous than we humans have been.* With or without humans on the planet, colonizing species will play vital roles in stabilizing the earth's damaged ecosystems. *They will survive catastrophes on Earth. We may not.*

Science helps us approach the '*world of weeds*' with both wonder and humility. Scientific ethics call for us to have an honest dialogue with Nature and what we find in life. Science will also help us fight fake news and mis-information and navigate the troubled waters and find a more resilient and reasonable position concerning weedy taxa. What we must all strive for is to '*rethink Nature*' (Hill. and Hadly, 2018) and attempt to find the '*middle ground*' in the discourses (Shackelford, et al., 2013) instead of blaming colonizing taxa for human follies.

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