EDITORIAL

Seeing 'Weeds' with new Eyes

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Introduction

Marcel Proust, once said: "*The real voyage of discovery consists not in seeking new lands but seeing with new eyes.*" I suggest we look at weeds in this way in this 21st Century.

In this Editorial for the second issue of the new journal - *Weeds* - I reflect upon some ideas that have shaped our recent discourses on weeds. It seems to me that the emerging generation of weed scientists may benefit from a dip into this history. As someone said: '*without history, man is nothing*'.

> *"…One longs for a weed, here and there, for variety; though a weed is no more than a flower in disguise, which is seen through at once, if love gives a man eyes..."* James Russell Lowell (c. 1890)

> *"…It is time for us to eliminate weeds from our cultivated lands. But we should understand why we do it, and what we're doing. Nature has a reason for allowing weeds to grow where we do not want them. If this reason becomes clear to us, we will have learned from Nature how to deprive weeds from their 'weedy' character; that is, how to eradicate them from cultivated land, or rather, how to improve our methods of cultivation so that weeds are no longer a problem…" Ehrenfried Pfeiffer* (c. 1950)

The first quote pleads for people to 'open their eyes' and appreciate Nature, in which weeds are an essential part. Poetic freedom allowed James Russell Lowell to promote a profoundly sympathetic view of weeds, instead of looking at them negatively, as always causing problems to humans. The second quote, from a soil scientist, who pioneered organic agriculture in the USA, recognized that some plants might become a nuisance when they interfere with the growth of crops or man's other activities. Dr. Pfeiffer suggested that such 'weeds' need to be eliminated from arable land, but we should do so with a good understanding of why they are there in the first place.

Both viewpoints are essential in looking at weeds with new eyes, as intended by our Society's new journal - '*Weeds*'. Many weed scientists and other ecologists would agree that weeds have been poorly understood for the past two centuries. These plants have also been subject to excessive malign, primarily driven by misconceptions and perhaps, even influenced by the prevalent worldview that everything on earth has been created to be subdued and exploited to satisfy man's selfish interests.

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The relationship between weeds and men is an old one; however, it is changing fast. There have been increasing public concerns about the effects of land-clearing, over-development, overuse of herbicides, and other destructive farming practices, as part of our goal of assuring human food security. Such concerns have encouraged some to think critically about whether we ought to and need to continue maximum control programs against plant taxa that only pose problems under certain sets of conditions.

A critical issue for *Weed Science* is the persistent and uninformed slandering of colonizing plants (weeds) by some people, which inhibits others from admiring them and appreciating their redeeming values and thereby welcoming them into our lives and environment. As discussed by Zimdahl (1999), common definitions of a weed include: "*a plant, which has a detrimental effect on economic, conservation, or social values*" and, "*an undesirable plant, which is out of place*". Such definitions are inappropriate in a scientific discipline, because they are anthropocentric and culturally-biased. They mislead by creating a negative perception that all weeds are bad, under all circumstances. Addressing this anomaly requires recognition of the beneficial effects and values of weeds, as part of the Earth's rich bio-diversity.

Are Weeds 'Plants Out of Place'?

In the 1960s, our founding fathers steered the discipline well clear of ludicrous ideas, such as 'plants out of place'. In articulating the scientific and ecological basis for explaining weeds, they pointed out that these organisms are no more than taxa with strong colonizing abilities adapted to natural or human-disturbed habitat (Baker, 1965; Bunting, 1965; Harlan and De Wet, 1965; De Wet, 1966). They are the first occupiers of newly cleared land. The more you disturb the land, the more you create opportunities for these highly successful "*pioneers of secondary succession*" — nothing more; nothing less.

When moved by natural dispersal agents (e.g., wind, water, animals) or by the human agency, and introduced into new environments, 'pioneering' taxa can successfully establish populations and increase in abundance within a short period. Attributes that allow them to do so (see Baker's List of '*The Ideal Weed*', Baker, 1965) include their innate genetic systems and reproductive capacity to produce seeds or other propagules under most conditions, and fast growth to reproductive maturity. Colonizer taxa are also capable of stress tolerance and plasticity, which allow them to adapt quickly to unfavourable biotic or abiotic environments. The absence of natural enemies in the new environment, at least initially, also helps these taxa to colonize a new habitat.

Mis-information is rife on the negative impacts weeds have on the environment or on biodiversity. The negative publicity has been increasing. It is rare to find a biology lecturer, teacher, or an ecologist, who would has the courage to mention the virtues of weeds. They are either scared; or unsure, because there are powerful voices advocating the opposite view. These negative viewpoints also have taken deep root, over a long period. At weed conferences, one often hears speakers flippantly indulge in the use of pejorative terms like "*damned weeds*"; "*bloody weeds*" drawing approval from audiences. It is a fashion, although such words are not in the lexicon of enlightened ecologists or weed scientists.

The overwhelming negative attitudes towards weeds, rampant in some Western countries, including Australia, the USA and Canada, appears to be a form of xenophobia (dislike of anything strange or foreign). The notion, that weeds are plants '*out of place*', is very American, as the historian Zachary Falck (2010) noted. It arose in the 1850s out of the aspirational dream of the American middle-class in creating cities, which needed to look 'sanitary' and 'orderly'. The early American cities, mostly in the East coast, had been influenced by the streetscapes of European cities, from which the ancestors of the settlers had come. As opposed to the attractive and colourful wildflowers, which beautify parks, sidewalks and median strips, untamed growth of weeds was blamed for 'disfiguring' open spaces and for the 'imperfections' of urban life in the cities. Tim Creswell (1996; 1997) explains how inherently flawed the '*out of place*' idea is, as follows:

> *"…the notion that everything has its "place" and that things (people, actions) can be "in-place" or "out-of-place" is deeply engrained in the way we think and act. Such is our acceptance of these ideas that they've achieved the status of common sense or become second nature to us. Common sense produces the strongest adherence to an established order..."*
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> *"…People act as they think they are supposed to; they do what they think is appropriate in places that are also appropriate. It is therefore essential for powerful groups in any given context to define 'common sense' and that which goes unquestioned. When individuals or groups ignore this socially-produced common sense, they are said to be "out-of-place" and defined as deviant..."*

We brand some plants '*out of place*', because, we have firstly ourselves defined in some abstract way, elements of our immediate environment as '*proper places*', and these would demand '*appropriate behaviour*'. Such a notion may be satisfactory for some of our living spaces, such as home gardens, flower beds, and turfed lawns, kept neat and tidy, in which weeds may be accused of de-spoiling the tidiness. One may also call agricultural fields '*proper places*', because we use them to produce our food and fibre. By the same argument, one may call natural or pristine areas, with little human interference, as '*proper places*' from a human point of view. But it is a stretch to call all wilderness landscapes with we interact '*proper places*'? Such places, being part of nature, often not interfered by man's activities, pose many challenges to humans, unless you are a skilled survivor in the wilderness. Teeming with life, including wildlife, wilderness areas are not likely to respond in the way we perceive the world to be.

What is "*out of place*" depends on the context and who is making this subjective assessment, based on personal experiences. Thus, within our discipline, we create lists of plants labelling them as 'environmental weeds', 'horticultural weeds', 'agricultural weeds', 'ruderal weeds', 'urban weeds', 'sleeper weeds', and so on. Many of these categories

have no scientific basis. They are just descriptors. From an environmental perspective, crops could also be viewed as weeds. From a farmer's perspective, native plants growing in fields could potentially be weeds, particularly if they produce large numbers of offspring and are hard-to-kill. As Radosevich and Holt (1967) said: "*Any plant can be a weed, and no plant is always a weed. As a consequence, some plants may be considered weeds, and hence, undesirable to have at particular places and at specific times*".

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To appreciate weeds, one must look at them through 'new eyes', an ecological lens, and frame of mind. The fact that weeds are colonizers with extraordinary abilities is the accepted wisdom in ecology. Nevertheless, as a group, these plants have been subjected to relentless attacks through negative publicity and the liberal use of militaristic metaphors e.g., ''invasions'. The public can be excused for being scared out of their wits and common sense. Attitudes towards weeds must change, and this will happen only if weed scientists *open their eyes* and look closely at the organisms we have learned to despise.

The resilience of weeds, their tenacity, and the capacity to adapt to environmental disturbances need to be recognized not only as harmful but also as potentially beneficial. I suggest that *the very success of these plant taxa in the environment is also their weakness.* Their verdant growth and abundant presence, in some situations, conflict with human objectives, and this is why they have become targets for our technology. Perhaps, this understanding would help modify our attitudes allowing us to avoid creating conflicts with potentially useful plant taxa and getting into situations from which we cannot win.

It is necessary and good for all scientific disciplines to realign their focus and objectives from time to time. *Weed Science* has reached that stage. While there is a vast amount of disparate literature, the future requires a convincing 'body of knowledge' of the utilization of colonizing species to be established, so that present and future generations will benefit from that knowledge.

Humans - the 'weediest' of all species

> *"…The word weed is taken to mean a species or race, which is adapted to conditions of human disturbance. By this definition weeds are not confined to plants. Animals such as the English sparrow, the starling, the "statuary" pigeon, the house mouse, Drosophila melanogaster, and others are especially fitted to environments provided by human disturbance. Indeed, perhaps no species thrives under human disturbance more than Homo sapiens himself. In this ecological sense, man is a weed…" Harlan and De Wet* (1965).

The reason I cite Harlan and De Wet is to remind the new generation of weed scientists that because we 'thrive on human-modified landscapes' humans are clearly '*weeds par excellence*'.

We are the only species that does not have to adapt to the environment. We change and/or modify our environment to suit our needs. For example: we heat our homes, air-condition them, wear clothes, drive cars, etc. On the other hand, colonizing species have the inherent capacity to adapt fast to any new environment. Often introduced to different continents deliberately or accidentally by humans, weeds are trekking the globe as the' *shadows of men'*.

The same attributes that make a plant highly successful in getting established in new environments (vaguely called 'invasive') will be sought after under a different set of circumstances. The way forward is to broaden our understanding of colonizing plant taxa and their crucial ecological role in biological communities. To achieve this objective, our journal will promote more in-depth ecological studies and critical analyses of weeds, instead of just publishing papers on pure and straightforward weed control.

A '*War with Weeds'* is untenable

The fact that weeds cost farmers more than any other major pest category has engendered a 'war mentality' in dealing with weeds, which is unfortunate. Given that cropped fields are continually-disturbed for production reasons, the occurrence of colonizing taxa is inevitable. But to say that we should deal with weeds like a military campaign is an idea fraught with danger. It is also an inappropriate strategy that includes an unattainable goal – 100% weed control forever.

Developed over centuries, agriculture has ample strategies and tactical tools to deal with weeds, which include tillage, hoeing and other methods of land preparation, active cover cropping, crop rotation, inter-cropping, and maintaining organic residues of even pioneer species to cover the soil and add organic matter, but not to set seed. Declaring 'all-out war' on weeds, mainly with chemicals, may yield 'clean' and 'weed free' fields and good harvests, but *for how long will these last?* Overuse of herbicides has

already backfired with the widespread development of herbicide resistance in weeds on a large-scale, across the globe, threatening agriculture in many countries (Heap, 2019).

Biologists need to continuously reflect upon the ethical dimensions of the language they use when communicating with the public on weeds and other species, often derided as 'invasive'. As Larson (2005) questioned: "*Is the language of 'war' likely to promote social cohesion and, consequently, effective and appropriate action towards weeds?*"

The militaristic and combative metaphors used within 'invasion biology' are unsuitable because: (1) they lead to a narrow perception of weeds and certain animals as marauding armies of 'invaders'; the idea is far from the truth! (2) they contribute to a profound social misunderstanding of weeds as nothing but plunderers of our resources, leading to xenophobia, and loss of scientific credibility; and (3) they reinforce militaristic patterns of a 'winnable war' against all weeds, an attitude that is counter-productive for both conservation and restoration of native vegetation.

While 'war' and 'invasion' metaphors may motivate some people into action against weeds in the short term, they are likely to fail in the long term. Alternatives to militarism will better promote realistic weed management and conservation goals in a multicultural context (Larson, 2005). I add that removing such jargon from the *Weed Science* lexicon will allow people to be optimistic about having a better relationship with weeds (Chandrasena, 2015).

'*War with Weeds*'- is the wrong choice of words to describe how we should manage weeds. This phrase is often bandied around in TV, radio, books, and magazines. The attraction is clearly in the alliteration, the repetition of the letter 'w', which makes a snappy phrase. Evans (2002), in his historical analysis of weeds in Canada, used it as his book's title, but to convey a wholly different message.

The 'war' analogy probably got entrenched in the mid-1940s, following the military successes of the Western-allied forces in 1945 in finally annihilating Nazi Germany's war machine. The end of World War II coincided with the discovery of the first synthetic herbicide, 2,4-D in 1944, which then began to be used widely for weed control. Much of the work was done during the war, but the research was not allowed to be published until the war was over. Pest control, those days, was also seen as a requirement for the total annihilation of the target pest, so that the pest populations may not ever recover. The basis for the obliteration mentality was the undisputed success of the large-scale use of the first-ever synthetic insecticide, DDT in 1939, in controlling the malarial mosquitoes and typhus (spread by body lice) among the Allied forces in various battlefronts.

The total annihilation of a pest organism was the main goal, but it was an unachievable one, both scientifically and practically. The possibility of large-scale heavy hitting with synthetic chemicals may have adverse effects on humans, and non-target animals were not generally realized until Rachel Carson's *Silent Spring* (Carson, 1962).

In the early-1960s, Rachel Carson raised the issue of excessive losses of birds, creating a heart-rendering image of a 'silent spring', directly pointing the finger at the overuse of pesticides. Residues of some pesticides persisted in the food chain, reaching higher concentrations (bio-accumulation), which resulted in more severe effects at successively higher trophic levels. Worryingly, pesticide residues were identified as the cause of rapid population decline, particularly in birds of prey, such as the peregrine falcon and sparrow hawk, through the thinning of eggshells. The offending chemicals, mainly organochlorine (OC) pesticides, including DDT (dichloro-diphenyl-trichloroethane), have now been banned in many countries, but they are still used in some poorer countries of the world.

Rachel Carson's observations were quite controversial at that time; she was ridiculed, and her predictions dismissed. The corporate world paid millions to have her silenced. But, eventually, the love of bird songs won out. People read her book, grieved at the prospect of a 'silent spring', spoke up, and insisted on regulations that eventually brought a ban on DDT and strict legislative controls on the uses of all pesticides. Nevertheless, this was a period during which powerful chemicals, insecticides, fungicides and herbicides, were being discovered, and the idea that an *all-out war* would solve pest problems became further entrenched in the minds of the proponents. In the post-war USA, it was common to talk about obliteration or annihilation of the enemy. With a bit more common sense, phrases like '*war*' might have been left out from the lexicon used in communicating weed or pest control messages to the public.

To presents a largely human-caused problem as a confrontation between humans and weeds in a way that alienates each other is ethically wrong. The human culpability (humans, as a major cause of the global spread of weeds) is mostly removed in this narrative. It reflects the flawed prevalent thinking in our modern societies that *all ills are someone else's faults and never ours*.

From a pragmatic viewpoint, this mentality, foolishly describes a situation from which there are no true winners. Humans may *subdue* some colonizing species here and there, but surely, it is unlikely, ever, to eradicate problematic species without causing other types of environmental harm. Hence, instead of pursuing the delusion of winning a war with weeds, we ought to aim for a negotiated peace; a multi-faceted co-operation between weeds and us; and a peaceful *co-existence* (Chandrasena, 2007; 2017). Not to do so would be counter-productive in the long-run. To successfully negotiate peace, a deeper ecological understanding of the strengths and weaknesses of the 'potential foe' is a must. The history of *Weed Science* records that our founding fathers, decades ago, argued most persuasively for such an understanding with more in-depth ecological studies on weeds (Harper, 1960; Bunting, 1960; Baker, 1965; Baker and Stebbins, 1965). They were, of course, motivated by common sense and scientific rigour alone and unburdened with the need for hyperbole.

Speaking at the 22rd Asian-Pacific Weed Science Society Conference, in 2011, David Low challenged the notion of a 'war economy' for weeds. He explained that the primary reason for using this analogy in Australia is that it allows the protagonists (bureaucrats) who control budgets, to shift spending in preferred directions. I agree with him.

> *"…As is the case in any real ''war' situation, "War!" effectively shreds our normal investment priorities, and such a situation can be used to create the urgency needed to bulldoze away the messy contingencies that support future life. One of the most overlooked consequences of this manipulation is that it disconnects the trajectories and social priorities that give rise to weeds from the costs (social and ecological) of controlling or preventing them.*
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> *As such, the taxation imposed by government to prevent and/or control weeds is no longer transparently connected to the dislocating human activities that give rise to weeds. The disconnecting social activities are therefore not subject to social critique. Put in economic terms, we might say that there is a "persistent market failure''. The analysis undertaken here, however, suggests that what is really persistent is a lack of ecological literacy…"*
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> *"…The centrality of the "war'' analogy in the weed discourse largely explains why weed preventing and/or controlling, presently attracts mass market support and commands the allocation of significant social resources. For example, the wholesale value of herbicide sales in Australia for 2008-09, a drought year, was $1.1 billion. As this figure demonstrates, not only do humans invest a great deal of their time and money extracting victories "over'' nature, but they are also willing to spend a great deal of time and money "protecting'' their preferences for a limited range of life – after all, the purpose of herbicides is to efface future life that "threatens" prevailing human priorities. What perhaps needs to be understood clearly, therefore, is how partial the understanding underpinning the "war on weeds'' analogy really is. Circumspection is required….."*
> David, Low (2011)

Are weeds *Alien*?

Edward Salisbury, a Professor of Botany at University College, London, popularized the use of the term '*alien*' in his book on "*Weeds & Aliens*", published in 1961. He was also the Director of Kew Gardens in London during 1943-56 and someone who had considerable interest in weeds. The term, of course, had been used much earlier by renowned botanists in the mid-19th Century who dealt with extensive collections of plants sent to the Kew Herbarium from various parts of the British Empire. The word *alien* (from Latin, "*alienus*") means belonging to another, not one's own, strange, or foreign. The term first appears among annotations and notes on the side panels of old herbarium specimens of some species that the 19th Century botanists were examining.

Of course, those botanists knew they were studying common species and not aliens from another planet. Their purpose was not to slander plant species, but to draw attention of other botanists on the risks of introducing plants across the continents, particularly with the exchanges of live specimens among botanic gardens. Likely, they were also aware of spreading plant species along with movements of livestock, fodder, people, and military equipment, at that time. It is most likely that Salisbury followed this practice and used the term '*alien*' interchangeably with the term '*introduced*'. Some authors use the term to refer to plants becoming weedy when transferred from their native to an *alien* environment, meaning a new environment. Here, while the emphasis is on the new environment, the organism is also regrettably branded as an *alien foreigner*.

This term 'alien' is now often directly attributed to Salisbury's book as if it is original. Inadvertently, he

has indeed, given those who dislike weeds and want 100% control of colonizing species the perfect weapon! Taking the cue from him, other senior botanists also used the term, as Hiram Wild, a renowned botanist from South Africa did in discussing *Weeds and Aliens in Africa* and their origin, as potentially *'American Immigrants'* (Wild, 1967). Peter Kloot (1983), an Australian botanist, also borrowed the term for discussing naturalized plants that had been introduced to South Australia from overseas. The term '*alien*' is superfluous in both these historical publications for their key botanical messages.

I often wonder why I hadn't heard these phrases while studying in the School of Plant Biology, University of North Wales in Bangor, U.K. One explanation is that John Harper (see Harper, 1960) and other leaders of the relatively new Plant Biology School those days, considered it an unnecessary embellishment and consciously kept such words out of the discussions in the nurturing of their students.

'*Invasive Aliens*' – a misleading narrative

The concept of 'invasive species' was first raised by the British Ecologist Charles Elton (Elton, 1958). His landmark treatise prophetically suggested that some animal and plant species may spread widely across continents, and potentially "invade" (he really meant, 'colonize') other bio-geographical regions, which are non-native to the original populations.

This term '*invasive*' only became common in *Weed Science* in the late-1980s and it was primarily in the USA (Davis, 2011). I can safely vouch that in the early-1980s, in the UK, it was sufficient to refer to the plants with colonizing abilities just as 'weeds', until the narrative changed. The proceedings of two of the most influential milestone events in the evolution of *Weed Science* as a discipline, put more emphasis on understanding the global spread of weeds and other animals as part of ecological phenomena of plant succession, adaptations and colonization. These books rarely mention 'invasions' in the sense that the term is used nowadays (see the edited books - Harper, 1960 and Baker and Stebbins, 1965).

Following everything American as good is a well-known populist trend, partly due to America's overwhelming economic success and its flow-on effects on the rest of the world. It is undeniable that other countries try to emulate the economic success of the USA and, at the same time, follow American trends without too much thought on their potential socio-cultural effects impacts. Samuel Huntington (1996, p. 310) questioned the potential negative impacts of following everything American, as below:

> *"…Awareness of cultural diversity will lead to understanding and perhaps to challenging the Western, particularly American, belief in the universal relevance of Western culture. This belief holds that all societies want to adopt Western values, institutions, and practices. If they seem not to have the desire and are committed to their own traditional cultures, they are, in the view of many, victims of a false consciousness.*
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> *Normatively, the Western belief posits that people throughout the world should embrace Western values and culture because they embody the highest, most enlightened, liberal, rational, modern, and civilized thinking of humankind. The Western belief in the universality of Western culture suffers three problems: it is false, it is immoral, and it is dangerous to agricultural progress…"*

Some colonizing plants and animals are now permanently branded as '*invasive species*' because they are capable of successful colonization of new environments. Absurd parallels are drawn with military invasions. In the 1990s, another adjective was added to brand the successful colonizers as '*Invasive Alien Species*' (IAS). The combination of the two terms has been a real game-changer, the second adjective adding a potent but distasteful dimension to an already highly-charged term. With this acronym, there are significant amounts of funds doled out to various bodies to manage the *alien* invader armies, which are rapidly moving across the globe, threatening our existence. Exaggeration is a true reflection of the times we live in, to which this narrative fits well. Nowadays, most issues are prosecuted with hyperbole, instead of thoughtful reflections on the effects emotive words would have on the public.

The term IAS spread fast in English-speaking, 'Westernized' countries, including New Zealand, Australia, the USA and Europe. Regrettably, it is also commonly used in the largely non-English-speaking Asian-Pacific countries, which chose to follow the 'trend' rather than question its scientific basis. The flippant way in which the term is thrown around at weed conferences and also by the media indicates that now we really have a problem on our hands!

Even words and concepts evolve with time. Perhaps, an improved understanding of how some highly successful weeds and animal species can spread rapidly across the globe, crossing borders with or without assistance from humans, may have led

some genuine researchers to call them 'invasives', invoking Charles Elton's thesis. But much more likely, it is an artifact of the fierce competition for limited funds, globally, for research. To get a piece of this funding, the narrative must change to fit the prevalent thinking of the time, or a new narrative must be devised, and overstatement helps! Nonetheless, some credit must go to the proponents for placing the human agency at the centre of the argument. The IAS narrative (Convention of Biological Diversity, CBD, 2001) recognizes that disturbed habitats, colonized by these '*alien*' invaders have often been wholly or partially created by man, whose activities are also largely responsible for their global spread.

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Who are these *alien intruders*? Why do we have to use such dramatic words, which have potency to create fear and apprehension? How unfortunate is it that these terms have not been challenged enough by weed scientists? Is it because we fear of retribution and castigation by our scientific peers? Imagine the confusion on the minds of undergraduate biology students if the Ecology teacher does not correctly explain how these terms came about? I know of many weed scientists who are awestruck by these terms, and just go with the flow. Presently, I can only direct them not to be captivated by these powerful words but get more acquainted with the evolution of the terms (see discussions in Colautti and MacIssac, 2004; Shackleton, et al., 2019), the context of their use, and more broadly, on the history of *Weed Science*, well covered elsewhere (Timmons, 1970; Wyse, 1992).

It is quite clear that 'invasion ecology' has enjoyed a rapid ascension in the public domain, owing in part to the extensive use of powerful adjectives like 'invasive', 'alien', 'noxious' and 'exotic' (Colautti and MacIssac, 2004). A species is considered 'native' if it has existed in a given biogeographical area for an extended period of time, and/or if it has undergone significant evolutionary changes in this area, over a long period of time. 'Exotic', 'non-native' and non-indigenous species (NIS) are simply the opposites of 'native'. However, it is not easy to determine which plant species is 'native' to a region, or 'naturalized', and to differentiate native from non-native species.

The confusions and loose terminology lead to the unscientific branding of potentially useful taxa as some sort of villains. Besides, not everyone is convinced that the maligned 'invasive' plant species are harmful to the environment all the time (see discussions on Davis and Thomson, 2000; 2001). Many of the so-called 'invasive' species are highly beneficial to not just humans and animals, but also to the environment, under certain situations.

Mark Sagoff, an environmental philosopher, challenged the idea that 'non-native', 'exotic', or introduced species cause widescale ecological harm in the new environments to which they have been either deliberately or accidentally introduced. He also decried the use of pejorative terms in this discourse, which go against scientific norms, as follows:

> *"…Are non-native species harmful? That depends on your perspective. That non-native species harm the natural environment is a dictum so often repeated that one may assume it rests on evidence. It does not. Biologists often use pejorative terms such as "pollute," "meltdown," "harm," "destroy," "disrupt," and "degrade" when speaking about non-native species. These words, along with metaphors borrowed from war and from cancer pack political punch.*
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> *"…Insofar as they convey aesthetic, moral, or spiritual judgments, they have a place in political debates and policy discussions. What troubles me as a philosopher is that these value-laden terms and their underlying concepts pervade the scientific literature of conservation biology and invasion ecology. These concepts are not well defined; generalizations based on them are not tested. Indeed, if you try to prove that invasive species harm natural environments, you'll find your-self in a scientific maze of dead ends and circular logic…"* Mark Sagoff (2005)

A longer discussion on the topic is beyond this Editorial However, my view is that the term 'invasive' has been used within the 'invasion' biology theme as a descriptor of a specific capacity that an organism has (i.e., capability to colonize and establish), rather than to describe an ecological phenomenon. Objecting the overreach of the 'invasion' biology theme, Mark Davis (Davis, 2011), also strongly expressed his view, with which I agree:

> *"…Focused and persistent research will always be able to document some adverse effects of any species, native or non-native, on at least some other species. However, even if negative effects on other species are documented, ecologists should not feel empowered to declare a species to be "invasive" (harmful). Declaring harm is a value-based social decision, one that needs to be made through collaboration with the*

larger citizenry. This is not a scientific decision, even if scientists are making it..."

"…But for 30 years, it has been primarily invasion biologists, not their critics, who have been telling just half the story. Only recently has a more balanced perspective begun to emerge, a perspective the public needs to hear, since it is usually the public's resources that are used to manage these species..."

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Regrettably, there is still much confusion about the terminology in the IAS narrative. Despite objections, the provocative metaphors are still widely used in the discussions on weeds, misleading the public. The dominant discourse may also confuse young weed scientists. Therefore, it is time for *Weed Science*, as a mature discipline, to make a change in the use of the term 'invasion' to the more ecologically correct term 'colonization', which is a component of plant succession. Revisiting the attributes of successful colonizers (Baker, 1965) would make people understand weeds better. Attention should then focus on the processes by which weedy taxa 'colonize' new habitat. If one understood the factors that determine the outcome - success or failure of those colonization attempts - that would undoubtedly be helpful in how we may respond to an undesirable colonization event.

Can we change attitudes?

The hardened attitude towards colonizing plants (weeds) in many countries is due to the profits that can be made by landholders through farming. Despite agricultural production representing only a declining percentage of gross domestic product (GDP) in most countries, farmers, particularly in the developed countries form powerful political constituencies and lobby groups. Many growers and farmers who are wary of weeds have deeply entrenched opinions. They often mistrust alternatives and resist change because of personal experiences and biases, as well as property-related and economic factors. Pure and simple, it is a question of money.

Shifting the emphasis of weeds from '*foe' to friend*' requires vigorous campaigning by enlightened scientists, working within or outside governments. Presently, this view is championed mainly by popular websites and patrons of sustainable lifestyles who have not much to do with governments. However, recognition of the potential for utilization of weeds as bioresources by governments in different countries is necessary to have a broad societal effect. Relaxing the attitude towards colonizing species will come with time, but this can be hastened by economic incentives to manage weeds as part of the biodiversity within individual farmlands and vast farming landscapes, rural areas, or countryside.

The collective wisdom of all weed scientists and weed managers across continents may be required to bring about a change in farmers' mind-set, as well as an attitude change among landholders and governments. The recognition of biodiversity values of weeds and the tolerance of beneficial weeds in arable weeds has been recommended in European countries (see Marshall, 2002; Marshall et al., 2003; Storkey, 2006; Storkey and Westbury, 2007; and discussions in Chandrasena, 2007; 2014).

As far back as in 1980s, agro-ecologists Miguel Altieri and Matt Leibman built the case to argue that eliminating *all* weeds from the farming ecosystems can destroy valuable habitat for natural enemies of insect pests, and thereby increase costs for insect pest control (Altieri and Leibman, 1988). Stamping out weeds may even contribute to human malnutrition. In developing countries, replacing traditional poly-cultures that tolerate or even encourage some weed growth with large scale monocultures and near-100% weed control has undermined food security in rural communities (Altieri, 1999). In addition to posing threats to local food production, industrial-scale farming eliminates palatable, nutritious weeds from farmers' fields, robbing low-income communities of important sources of dietary vitamins and minerals. Many rural societies depend on edible weeds for food before their traditional crops mature, and especially in the event of crop failure. Such food systems are not served by an 'all-out war' against weeds.

There is a great deal of evidence of colonizing plants as some of the most useful medicinal plants in traditional medicine, as well as the sources of many modern pharmaceuticals. Although there is a general belief that the primary tropical forests, undisturbed and mystical, are the most likely habitat to discover new pharmaceuticals, perhaps because of their high biodiversity and endemism. However, the evidence from many traditional cultures is that this may not be true as they predominantly rely on non-forested, disturbed habitat for their medicinal plants (Voeks, 1996; Stepp, 2004; Stepp and Moerman, 2001). Stepp's (2004) analysis of 101 plant species from which 119 modern pharmaceuticals are derived, showed that at least 36 species are widely regarded as weeds. The results were an order of magnitude higher than would be predicted by random occurrence of weeds in the modern pharmacopeia.

There is mounting evidence that weeds are relatively high in bioactive secondary compounds and are, thus, likely to hold promise for future drug discovery. Secondary compounds in weeds perform a variety of ecological functions. Chief among these is allelopathy, where such compounds may inhibit the germination and growth of neighbouring plants and also act as chemical defences against herbivory. Many weed species interfere with crops through the release of allelopathic secondary metabolites. However, because allelopathy usually occurs through the complex chemical matrix of the soil, it has been hard to show a causal relationship (Zimdahl, 1999) conclusively. Thus, disturbed environments, even within forests, which are the province of colonizing species, appear to be areas most likely to harbour novel compounds that may become future medicines.

Colonizing species will always be the ultimate survivors in the conflict with man. Rather than a zero-tolerance towards particular taxa, it would be prudent and responsible to ecologically manage problematic weeds, on a 'case-by-case' basis, with an eye on their potential benefits. This requires moving away from autecological, 'species-led' approaches that are reactions to problems posed by single species. The agroecology practices promoted by Altieri (1999) are invaluable ecological risk management models, in the sense that they have long-proven benefits in ecosystems. Agroecology also encourages people to integrate closely with all components of biological diversity, including colonizing species.

An Ethno-biological perspective- Linking Plants and Humans

In discussing the relative variety and intensity of uses of common reed (*Phragmites australis)* by human groups, Kiviat and Hamilton (2001) suggested that the utility of a plant is related to several factors. These include (1) abundance and distribution of the plant; (2) length of time the plant and a human group have been in contact; (3) invention or transmission of traditional ecological knowledge of the plant; (4) ease of managing, acquiring, and processing the plant; (5) physical and chemical qualities of the plant (e.g., pharmaceutical or toxicological properties, fibre characteristics, nutritional composition); and (6) availability and variety of alternate taxa. These ideas reveal why some taxa are much valued, and others much disliked. Discussions of such ethnobiological perspectives would help in building better relationships between weeds and humans, particularly in developed countries where the conflicts between the two are most profound.

The importance of traditional cultures, their wisdom and sustainable interactions with plants and animals are routine subjects in Anthropology, and Social Science. Interactions between the humanities and *Weed Science* are almost non-existent and hence, both sides may gain from a closer exchange of views. Journals dedicated to Ethnobotany and Economic Botany often carry articles relating to human uses of colonizing plants. Increased appreciation of plant taxa can be achieved by studying these ethnobiological appraisals, as well as by exercising more common sense. Improved ecological knowledge and an understanding of a broader range of cultures, societies, and plants of value to humanity may assist those who apply 'weed risk assessments' when deciding whether or not to list particularly resourceful taxa as 'invasives' that should be controlled at any cost. I object to the presumptive 'branding' of taxa, carried out by bureaucrats, which tends to stick in the minds of the public. Applying '*a guilty until proven innocent*' approach to taxa with colonizing abilities, as practiced in some countries, belies common sense. It is also disrespectful to Nature and may not be tenable for long.

In a study in semi-arid areas of Brazil, Dos Santos *et al*. (2013) posed a series of questions: "*Are invasive species considered useful by traditional societies? How are they useful? Are they more or less useful than non–invasive species? Is there a relationship between the use categories and taxonomic groups (families, genera, and species)? What plant parts are preferentially used and how are they distributed by categories of usage? Are there differences in the perceived usefulness of native vs. exotic invasive plants?*"

In their study, a total of 56 invasive species were recorded, of which 55 were considered useful, and invasive species were considered useful more often than non–invasive species. The predominant use was as animal fodder, followed by medicine, food, and raw materials for industries. Nearly half (44%) of the animal fodder species also served as medicine for people. Herbaceous plants were the most common. Uses varied significantly within taxonomic ranks (species, genus, and family). The most recognized plants were also those that were most used locally. This study, just one of many from different countries, underscores the value of invasive species (weeds) in semi–arid Brazil, as well as the need to include local people in regional and national strategies to address invasive species management.

Weeds and Humans– the future

There is no simple remedy for the weed problem in its many manifestations. Therefore, we need to continue our studies on the best management strategies and control tactics to manage their negative impacts. As a discipline, *Weed Science* does understand quite well the reasons why colonizing species come to dominate landscapes. Weed management approaches need to be designed to prevent the introduction of potentially problematic taxa to new habitats and to provide rapid responses to minimize undesirable impacts where conflicts arise between man and colonizing species. I believe that this will be done best with a proper ecological understanding, and with a balanced view of economic implications, but without dramatizing weed issues, and certainly avoiding messages that create a visceral dislike for the colonizing plant taxa.

Evidence-based policy making is a sound goal in any country. However, only a small proportion of agricultural or environmental research has had the desired policy impacts. Most researchers in science are not trained to create policy effects from their work. Engagement with policymakers is not always encouraged, nor is it rewarded in most settings. Communication of scientific findings occurs mostly within the academic community; rarely outside it. There are exceptions, but across the various fields of human endeavour and mainly in science, little is done to link scholarship to policy systematically.

To exemplify, utilization opportunities for weeds is a topic not readily discussed at weed conferences. Is this because of some fear? Is it because weeds are so problematic that looking at them with a fresh set of eyes goes against the grain of *Weed Science*? I tend to agree with others (R. Zimdahl, 2019, *personal communications*, 28 December) who believe that it is mainly an educational problem. Nevertheless, there is a strong case building for investments in the utilization of weeds not least because it is a sensible weed management practice, but also because it provides a positive message for the public on the values of these plants, so severely mismanaged across the globe. Making a case for the utilization of weeds as bioresources is not difficult (see Kim and Shin, 2007; Chandrasena, 2007; 2014). The compilation of existing knowledge from different cultures should assist this task and, there is much to learn from the existing Economic Botany and Ethnobotany knowledge. A renewed attempt to explore weeds as bioresources requires efforts to highlight how traditional societies use all available knowledge of colonizing plants wisely and 'co-exist' with them.

Conclusions

A vast amount of global scientific literature indicates that man has not looked after the Earth's natural resources well. Most findings are that depletion of natural resources (soil, water, and vegetation) is almost unstoppable, and many resources, including tropical rain forests, are being depleted at an alarming rate and will soon reach unrecoverable levels. Continuing population growth in many parts of the world and the quest for profits from growing crops or over-exploiting natural resources (such as minerals, oil and gas and timber) remain the *root causes* of the high rate of biodiversity losses and depletion of those natural resources – not weeds! It is men – and not weeds – who face a profound dilemma.

Kenneth Bolding, an economist at University of Colorado said: "*Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist*" (see quote in NEF, 2010).

Agreeing with those sentiments, Tim Jackson (2012), a Professor of Sustainable Development at the University of Surrey, argued that the human society is faced with a profound dilemma: '*to refrain from growth is to risk economic and societal collapse; to pursue it relentlessly is to endanger Mother Earth's ecosystems on which our survival depends*.

Science tells us that weeds are only 'colonizing plants', and their management will be best undertaken within an ecological framework. Wherever or whenever man disturbs a habitat, they will be among the first *pioneers* to make use of the opportunity of space (*sensu lato*, Bunting, 1960). Downplaying this ecological emphasis, because of a focus on weed control, is disingenuous. In natural or man-made ecosystems, many weeds serve valuable ecological functions that need more recognition. Examples of their complex biological role, such as providing resources for wildlife, pollinating insects, slowing erosion, building soil, and generally enriching biological diversity, are abundant in global literature; these need to be studied more and given more extensive publicity. In a strategic approach to managing weeds, more people – weed scientists and students – should explore different ways of using these taxa for improving the human condition.

The summary condemnation of plant taxa, because we dislike them in particular situations is not a sensible way to approach a complex man-made problem. The genetic attributes of weeds that confer superior colonizing ability, competitiveness, and survival could be beneficial, not just in repairing damaged ecosystems, but also in sustainably

providing food and fibre for both humans and animals. A key to sustainable living is to *learn from weeds* to be more resourceful and *not ask for more*. If all men become thrifty, and asked for less, we could reduce our environmental impacts, both as individuals and as societies. Such a change would make our Earth a much safer place for all species.

To end this Editorial, I would pose the following questions to all weed scientists: '*Would you live in a world free of weeds*? Or, would you cherish understanding how our complex interactions with weeds will enrich our lives?

In an environmental ethic that all life is sacred, weeds are no more villainous than man himself!

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