

Invasive Species Terminology: Standardizing for Stakeholder Education

Abstract

The excessive number of terms associated with invasive species, and their often incorrect usage, hinders stakeholder education about the threats of invasive species. Here we introduce seven terms (*native*, *nonnative*, *introduced*, *established*, *invasive*, *nuisance*, and *range change*) that are applicable across invasive taxa, understandable, typically interpreted correctly, and useful for describing most situations regarding invasive species. We also list six terms to avoid (*native invasive*, *invasive exotic*, *invasive weed*, *alien*, *foreign*, and *nonindigenous*) that create confusion via their misuse and misinterpretation. The terms we propose will increase understanding, thereby promoting behavior changes aimed at limiting the negative impacts of invasive species.

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Invasion Education: The Need for a Common Language

Global movements of people and products have resulted in the intentional and unintentional transport of species for millennia. Countless species now occur well outside areas they could have reached naturally. This phenomenon, along with increased atmospheric carbon dioxide and land use change, is now recognized to alter ecosystems at the planetary scale (i.e., contribute to global change) (Ricciardi, 2007; Vitousek, D'Antonio, Loope, Rejmanek, & Westbrooks, 1997) and to be a threat to global biodiversity (Simberloff et al., 2012).

Most species that humans move to new locations pose no threats, but those that do can have devastating impacts. These species are referred to as *invasive* (as defined below and in Table 1). In the United States, the estimated annual costs of damage and management of invasive species may exceed \$120 billion (Pimentel, Zuniga, & Morrison, 2005). These costs continue as evidenced by more recent studies of specific invasive taxa. For instance, the annual global costs of damages caused by invasive insects to crops and human health are estimated to be at \$70 billion and \$6.9 billion, respectively (Bradshaw et al., 2016). Another example is the \$45 million spent on managing invasive plants in Florida (Hiatt, Serbesoff-King, Lieurance, Gordon, & Flory, 2019). Despite Extension stakeholders' prioritizing learning about invasive species and attending invasive species-focused events in significant numbers (Huang & Lamm, 2016; Nagle, Osborne, Stone, McCullough, & Sadof, 2014), there is still a need to expand awareness about the environmental and economic costs of invasive species (Steele, McGill, Chandran, Grafton, & Huebner, 2008). Effective communication strategies can advance these efforts.

Effective communication hinges on consistent and proper terminology. Debate among scientists regarding the precise uses of various terms, including *invasive species*, has been ongoing for decades (Blackburn et al., 2011; Colautti & MacIsaac, 2004). For instance, many terms are used to describe a species not from a given location, including *nonnative*, *foreign*, *nonindigenous*, *alien*, *exotic*, *invasive*, and *invasive exotic*. Some of these terms are technically incorrect and/or can be misinterpreted. This variability in terminology and incorrect use of terms may hinder stakeholder understanding of how to prevent and control invasive species. Here we propose a standardized set of terms aimed at creating unified messaging among Extension professionals and our clients about invasive species. We do not propose novel terms, nor do we try to resolve scientific debate. Rather, we strive toward a standardized, high-utility language for invasive species Extension education.

Objectives

We have three objectives:

1. Popularize the use of seven terms for educating Extension clientele about invasive species.
2. Promote understanding of these seven terms via examples of relevance to the United States.
3. Provide a list of terms to avoid due to their technical inaccuracy and/or often misinterpreted connotations.

We also discuss legal terms of relevance at the national level, provide an additional glossary (see appendix), and mention other terminology resources, all of which can be useful when educating clientele about invasive

species. This document is written for educational rather than legal purposes. Given that states vary in how they legally define terms, readers should refer to appropriate state agencies for relevant definitions. Regardless of the broad applicability of the seven-term list we developed, there inevitably will be situations when applying precise terminology will be challenging. Nevertheless, the resources provided here are designed to help navigate these situations.

Methodology

The terms we address, and their suggested uses, were developed by consensus over a yearlong discussion among the members of the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) Invasive Species Council (ISC). The goal of this discussion was to identify a concise set of easily understood terms required to educate clientele on invasive species. The UF/IFAS ISC consists of 36 scientists and Extension professionals who work closely with a wide range of stakeholders on issues pertaining to invasive species ecology and management. The mission of the UF/IFAS ISC is to provide "the leadership to build the capacity of all stakeholders to proactively address the management and prevention of invasive species through partnerships and science-based teaching and Extension programs" (UF/IFAS ISC, n.d., "Mission Statement"). Members of the UF/IFAS ISC have expertise spanning all invasive taxa, ensuring the broadest possible applicability of the list presented herein. Having a standardized list is critical considering the diversity of Extension stakeholders dealing with invasive species—for example, horticulturalists, foresters, gardeners, landscape architects, natural resources managers, and fisheries and wildlife managers, to name a few.

Standardized Terminology: What We Need to Communicate in Seven Terms

We reached a consensus on seven terms (Table 1) that we argue can be used to communicate most situations pertaining to invasive species and related topics. These terms are reliable, easily understood by nonscientists, and broadly applicable across taxa. These terms also encapsulate other terms that despite describing certain situations more precisely are overly complex for initial stakeholder education about invasive species.

Table 1.
Seven Terms to Use for Invasive Species Education

Term	Definition
Native	A species that occurs naturally in a specified geographic area.
Nonnative	A species that does not occur naturally in a specified geographic area.
Introduced	A species brought to a new geographic area intentionally or unintentionally by humans.
Established	A species having a self-sustaining and reproducing population in a specified geographic area without the need for human intervention. Applies to both native and nonnative species.
Invasive	A species that (a) is nonnative to a specified geographic area, (b) was introduced by humans (intentionally or unintentionally), and (c) does or can cause environmental or economic harm or harm to humans.
Nuisance	An individual or group of individuals of a species that causes management issues or property

damage, presents a threat to public safety, or is an annoyance. Can apply to both native and nonnative species.

Range change The circumstance of a species' current/existing range growing, shrinking, or shifting over time. This change can happen to native and nonnative species with or without human assistance.

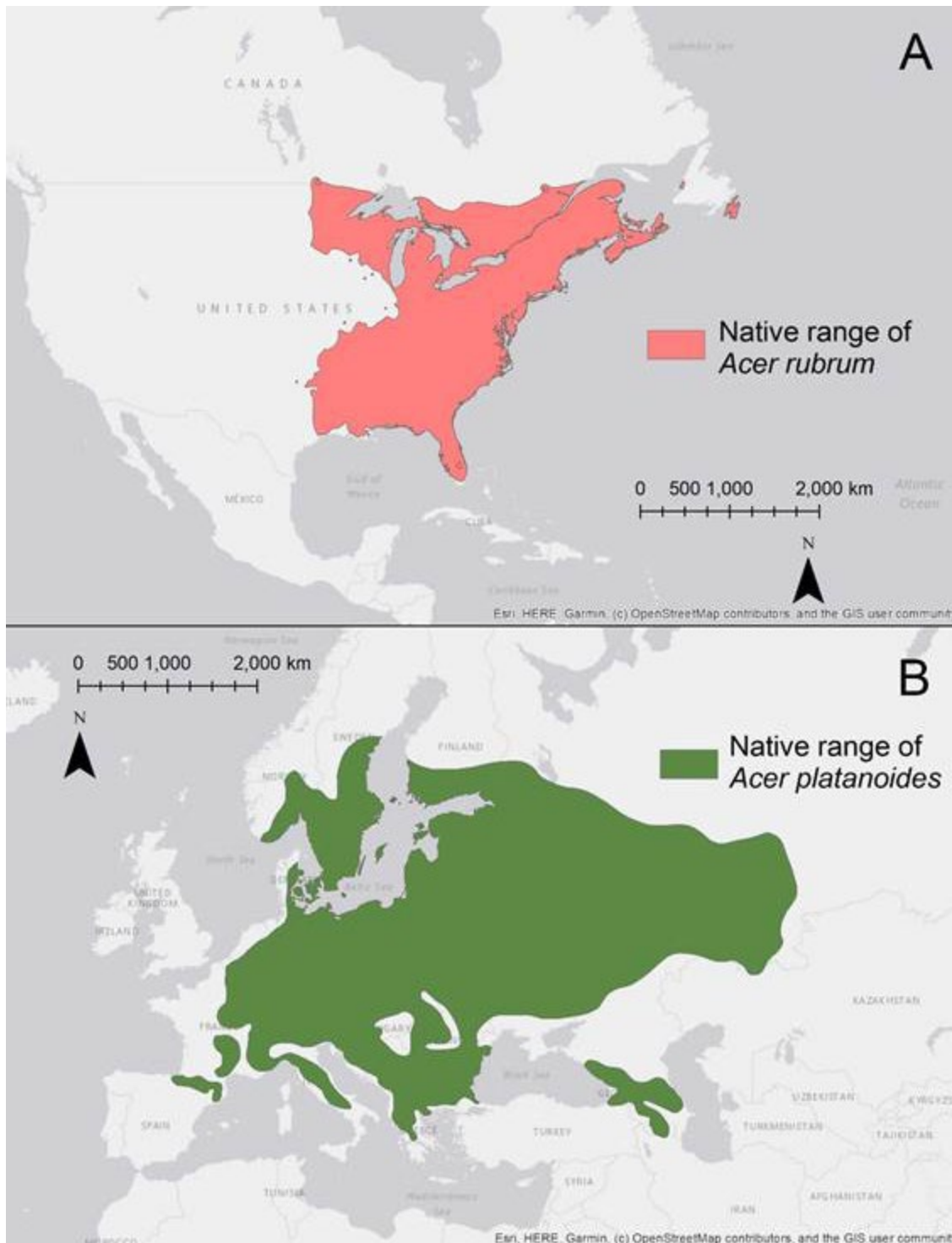
Terms 1 and 2: *Native Versus Nonnative*

A native species is one that evolved in a specified geographic area, whereas a nonnative species has evolved elsewhere. Both spatial and temporal contexts need consideration when classifying a species as native or nonnative.

Regarding spatial context, one must specify the geographic region to which a species is native or nonnative. We use Figure 1 to illustrate this point. The figure shows the native ranges of two common tree species, red maple (*Acer rubrum*) and Norway maple (*Acer platanoides*). Red maple is native to the United States, more precisely, the eastern United States, whereas Norway maple is native to much of Europe. In contrast, red maple is nonnative in Europe, whereas Norway maple is nonnative in the United States (although both now occur in these other geographic locations). Also important to note is the spatial context/geographic reference used by a source of information when classifying a species as native or nonnative. For instance, the U.S. Department of Agriculture (USDA) uses the entire United States as its geographic reference. Therefore, the USDA classifies pecans (*Carya illinoensis*) as native to much of the midwestern and southeastern United States (<https://plants.sc.egov.usda.gov/core/profile?symbol=CAIL2>) despite the historical distribution of this species ranging only from northern Mexico into eastern Texas and along portions of the Mississippi River drainage (Little, 1971).

Figure 1.

Geographic Extent/Native Ranges of (A) Red Maple (*Acer rubrum*) and (B) Norway Maple (*Acer platanoides*)



Note. Data for Panel A is from Prasad and Iverson (2003). Data for Panel B is from Caudullo, Welk, and San-Miguel-Ayanz (2017).

Regarding temporal context, one must consider the point in time when the species arrived at a geographic location as there are temporal guidelines when defining a species as native or nonnative. On a global scale, this differentiation is complicated due to the complex history of human movement. Therefore, a complete discussion of temporal context is beyond the scope of this article. Nevertheless, due to the profound impact

of European exploration and settlement of North America, including the overwhelming number of species introduced, a species is considered native to North America if it was present prior to European settlement. However, we also recognize the likelihood of indigenous peoples contributing to the spread of species (MacDougall, 2003), complicating the refinement of this pre-European settlement cutoff.

Finally, a species' designation as nonnative is not dependent on the absence/presence of that species. For instance, although African elephants do not freely roam the United States, they are still considered nonnative to the United States. Furthermore, nonnative species do not necessarily pose any economic or environmental harm; they are simply not from a specified geographic area.

Term 3: *Introduced*

An introduced species is one that has been brought to a new location by humans either intentionally or unintentionally. Therefore, an introduced species is also nonnative. Introduced species do not necessarily pose threats, and many are considered beneficial. For instance, many introduced species in residential landscapes benefit landscaping aesthetics (Figure 2), and many crop and livestock species (e.g., wheat, cattle, and European honeybees) provide nutritional benefits.

As with the terms *native* and *nonnative*, when stating that a species is introduced, one must do so relative to a specific geographic area. For instance, it is preferable to say that tulips (*Tulipa* spp.) are introduced to the United States rather than saying simply that tulips are "introduced."

Figure 2.

Examples of the Many Ornamental Plant Species Introduced to Enhance Landscaping Aesthetics: (A) Sago Palm (*Cycas revoluta*) With Juniper Ground Cover (*Juniperus conferta*), (B) Lavender (*Lavandula* sp.), (C) Tulips (*Tulipa* sp.), and (D) Liriopi Grass (*Liriope* sp.)



Term 4: *Established*

Many introduced species do not spread into new areas. For instance, many nonnative ornamental plants introduced into people's yards never spread beyond those yards. However, some species do escape from cultivation or confinement and, without human assistance, develop self-sustaining populations. These species have become *established* in a new geographic area. The United States has many introduced species that are established (Figure 3), including monk parakeets (*Myiopsitta monachus*) and the common dandelion (*Taraxacum officinale*). Both introduced species (Hyman & Pruett-Jones, 1995; Mack, 2003) have self-sustaining populations throughout the United States. Whereas monk parakeets cause significant economic damage (Avery, Greiner, Lindsay, & Pruett-Jones, 2002), the common dandelion is little more than an unwanted weed (see appendix for definition) in manicured lawns.

Note that species native to a given location technically also are established. Nevertheless, the term *established* is of utility in the sense that it can be used to differentiate between nonnative species that survive only with human care (e.g., crop species) and those that can exist, reproduce, and spread to new locations on their own.

Figure 3.

Two Examples of the Many Nonnative Species in the United States That Also Are Established: (A) Monk Parakeets (*Myiopsitta monachus*) and (B) the Common Dandelion (*Taraxacum officinale*)



Term 5: *Invasive*

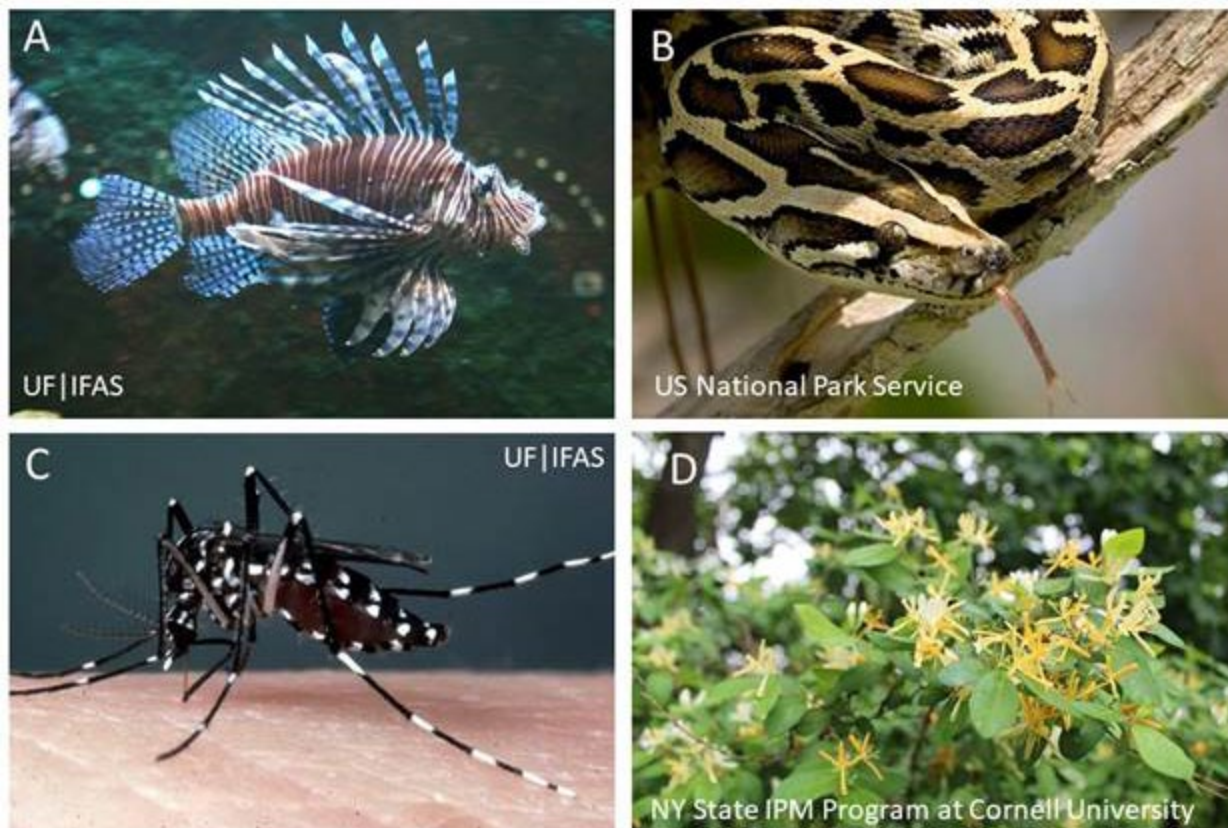
Three standard requirements need to be met to classify a species as *invasive*. The species must (a) be nonnative; (b) be introduced, intentionally or unintentionally; and (c) cause or be likely to cause environmental and/or economic harm and/or harm to humans. This definition aligns with that of U.S. agencies, as stated in Executive Order No. 13112 (1999), and given that it requires the species to either cause or potentially cause harm has the added benefit of guiding the prioritization of nonnative species management.

The United States has many invasive species present within its borders spanning multiple taxa (Figure 4).

One example negatively affecting U.S. marine ecosystems is the lionfish (*Pterois volitans/miles* complex). This species is native to warm waters of the Indian Ocean and the South Pacific (National Oceanic and Atmospheric Administration, n.d.). Introduced through the pet trade, lionfish have become abundant in marine ecosystems of eastern North America, causing negative environmental impacts via predation on and competition with native fish. They also have venomous spines that inflict pain to humans (McGuire & Hill, 2017). Another invasive species introduced by the pet trade is the Burmese python (*Python molurus bivittatus*). Ironically, this species is considered "nearly threatened" in its native range of Southeast Asia as it is captured there for the pet trade and its skin. This species is now spreading throughout southern Florida, decimating populations of native birds and mammals (e.g., McCleery et al., 2015), some of which are already threatened or endangered. Examples of invasive species that directly harm humans are the mosquito species *Aedes albopictus* and *Aedes aegypti*. These mosquitoes transmit diseases such as dengue, yellow fever, chikungunya, and those caused by Zika viruses. They also are vectors for nematodes, causing heartworm in dogs (O'Meara, 2014; Rey & Connelly, 2019). Finally, as with animals introduced via the pet trade, many invasive plants are introduced for horticultural purposes. One example is the vine Japanese honeysuckle (*Lonicera japonica*). This species, native to eastern Asia, now occurs in 42 states in the United States, where it alters forest structure and suppresses the reproduction and growth of other plant species (Schierenbeck, 2004).

Figure 4.

Four Examples of the Many Invasive Species in the United States: (A) Lionfish and Devilfish (*Pterois volitans/miles* complex), (B) Burmese Pythons (*Python molurus bivittatus*), (C) Asian Tiger Mosquitoes (*Aedes albopictus*), and (D) Japanese Honeysuckle (*Lonicera japonica*)



One complication with recognizing a species as invasive is that a species' impact can vary across regions

and over time. A nonnative species may pose economic or environmental threats in some portions of its nonnative range but not in others due to differences in abundance and/or other reasons. An established nonnative species also may be present in an area for a long time and then increase in abundance and become invasive with little warning. This phenomenon is referred to as *invasional lag* (Figure 5) and is common for both plants and animals (Crooks, 2005). Other than long periods until reproductive age (Iannone, Zellner, & Wise, 2013), little is known about the factors contributing to *invasional lag*. Regardless, *invasional lags* make it challenging to predict which species will or will not become invasive. This challenge necessitates periodic reassessment of invasive status for introduced and established nonnative species and communication with stakeholders about how and why invasive statuses change.

Figure 5.

Chinese Privet (*Ligustrum sinense*) Exhibiting Invasional Lag 80 Years After Introduction



Note. Adapted from "Chinese privet *Ligustrum sinense* Lour.," by L. Urbatsch, n.d.

(https://plants.usda.gov/plantguide/pdf/pg_lisi.pdf).

Term 6: Nuisance

Under certain circumstances, various native species can cause environmental or economic harm. Stakeholders often refer to individuals of these species in these circumstances as *invasive* or even *native invasive*. Both terms are incorrect, given that these species are neither nonnative nor introduced. The correct term to use for this situation is *nuisance*. Note that it is not possible to categorize an entire species as a "nuisance" as this classification is context dependent. For example, the vine trumpet creeper (*Campsis radicans*) (Figure 6, Panel A), although native to much of the United States, can overtake large areas and be difficult to remove (Gilman, 2014). Therefore, in the contexts of maintaining gardens or managing small, remnant natural areas, this aggressive growth can make any trumpet creeper growing at these locations a nuisance. Individual or groups of individual white-tailed deer (*Odocoileus virginianus*), which are native to

most of North America and northern South America, also can be considered a nuisance in the specific context of agriculture, where they cause millions of dollars in crop losses annually (USDA National Agricultural Statistics Service, 2002). All invasive species exhibit nuisance traits, but referring to them as *invasive* is preferred because doing so further clarifies the species as nonnative and introduced.

Figure 6.

Two Examples of Species of Which Individuals Can Be Nuisances in Certain Contexts: (A) Trumpet Creeper/Vine (*Campsis radicans*) and (B) White-Tailed Deer (*Odocoileus virginianus*)



Term 7: Range Change

The final term we introduce is *range change*. A range change occurs when a species' current/existing range expands, shrinks, or shifts. This change can happen to native and nonnative species with or without human assistance. Therefore, a native species whose range expands naturally (i.e., without humans intentionally or unintentionally introducing the species to new areas) should *not* be considered nonnative, introduced, or invasive. It is instead better to state that it is a native species experiencing a range change. Many tree species native to the United States are experiencing range changes in response to altered precipitation associated with climate change (Fei et al., 2017). Given that humans are not moving these species to new areas, intentionally or unintentionally, these species should not be described as nonnative, introduced, or invasive.

Terms to Avoid

Avoiding certain terms when educating about invasive species is also important as many terms are technically incorrect, create confusion, or evoke ideas unrelated to invasive species. Here we discuss six such terms, a summary of which can be found in Table 2.

The first term to avoid is *native invasive*. By definition, a native species cannot be invasive. Users of the phrase *native invasive* often are referring to a native species that in certain contexts causes management concerns. The individuals of the species causing these concerns are better referred to *nuisances*. An additional reason why *native invasive* should be avoided is that it detracts from the ultimate cause of invasive species—the translocation of species by humans.

The second term to avoid is *invasive exotic*. In this context, the term *exotic* is synonymous with the preferred term *nonnative*. The term *invasive exotic* (or *invasive nonnative*) creates confusion through redundancy. All invasive species are, by definition, nonnative. Furthermore, using this term may lead stakeholders to mistakenly equate nonnative species and invasive species. As discussed, many nonnative species are not invasive.

The third term to avoid is *invasive weed*. *Weed* is a cultural term, typically applied to a plant that is unwanted relative to a given situation, often within agricultural or horticultural contexts (USDA Natural Resources Conservation Service, n.d.). This term raises confusion, given that it is ambiguous and can be used sometimes mistakenly to refer to any unwanted plant, whether native, nonnative, or invasive.

Finally, the last three terms to avoid are *alien*, *foreign*, and *nonindigenous*. Despite being synonymous with the term *nonnative*, these terms are often used when referring to global movement of humans. For this reason, we argue that *nonnative* is preferred.

Table 2.
Terms to Avoid During Invasive Species Education

Term	Definition	Reasoning for avoidance
Native invasive	Often used to describe individuals or a group of individuals of a native species in a context in which they are a nuisance.	It creates confusion as invasive species by definition are nonnative. In addition, the term confounds two separate issues—biological invasions caused by humans moving species over vast distances and a native species that causes management issues.
Invasive exotic	Often used to describe a nonnative species that causes environmental and/or economic harm or harm to humans (i.e., a species that is invasive).	It is redundant and confusing. An invasive species by definition is exotic, but not all exotic species are invasive, and the term <i>exotic</i> has other potential interpretations (see appendix).
Invasive weed	Used to describe an invasive plant.	It is easier to say an invasive plant. In addition, <i>weed</i> is a cultural term describing a plant (native or nonnative) not wanted in a given situation (e.g., agriculture, home garden, etc.). For this reason, the term may lead people to believe incorrectly that all weeds are invasive.
Alien/foreign/nonindigenous	All three terms are synonymous with <i>nonnative</i> .	They evoke political ideals unrelated to invasive species. In addition, based on one's political beliefs, the terms may have negative connotations, despite most nonnative species not causing harm.

Legal Definitions

Inevitably, when discussing invasive species, one will come across legal terms. Despite having precise definitions (Table 3), these terms are often used incorrectly. These terms include *noxious weed*, *injurious*, *prohibited*, *conditional*, and *restricted*.

The first of these terms, *noxious weed*, is defined in the United States by the Agriculture Risk Protection Act, Public Law No. 106-224 (2000, p. 114) as "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment" (p. 114). The USDA Animal and Plant Health Inspection Services has well-defined guidelines for listing and delisting of noxious weeds.

The remaining legal terms are often used to describe animals but may also apply to plants. According to Merriam-Webster (n.d.), the term *injurious* is defined as "inflicting or tending to inflict injury." This term is important because government agencies can prohibit the importation and movement of a species within their jurisdictions if they determine the species to be injurious. A *prohibited* species has been determined to be injurious to humans or human interests such as agriculture, forestry, horticulture, or wildlife management. *Conditional* or *restricted* species are those species that can be possessed or imported for research, public exhibition, or commercial use in controlled settings that limit the possibility of escape. Possession of conditional or restricted species requires appropriate permits. They are not permitted as pets. *Prohibited*, *conditional*, and *restricted* are defined in the United States by the Lacey Act (1900). It is important to note that not all invasive species are listed on noxious or prohibited species lists. Often this is due to the harmful impacts of a given invader being noted prior to official legislation and due to the lack of required data supporting the need to list the species as noxious or prohibited.

Table 3.
Legal Terms Related to Invasive Species

Term	Definition	Source
Noxious weed	"Any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment."	Agricultural Risk Protection Act, Public Law No. 106-224 (2000, p. 114)
Injurious	"Inflicting or tending to inflict injury."	Merriam-Webster (n.d.)
Prohibited	A species determined injurious to humans or human interests (e.g., agriculture, forestry, horticulture, or wildlife management).	Lacey Act (1900)
Conditional/restricted	A species that can be possessed or imported for research, public exhibition, or commercial use in controlled settings that limit the possibility of escape. Possession requires appropriate permits. Species cannot be owned as pets.	Lacey Act (1900)

Other Resources

In addition to those terms defined above, we provide a glossary of other useful terms (see appendix). These terms are largely encompassed by our seven recommended terms (Table 1), although some provide additional detail. For instance, the term *adventive* describes a nonnative species that occurs in a location

regardless of mode of introduction. However, we can describe this situation without introducing yet another term by stating that the species is nonnative and established and that we do not know how it arrived at the given area. Some of the terms in the glossary also create unnecessary confusion. For instance, the term *naturalized* describes a nonnative species that has become established and maintains a reproducing population with no human assistance. Despite the wide use of this term in the ecological literature, Extension professionals report that this term, having the word *natural* nested within it, leads stakeholders to believe that a naturalized species is good. For this reason, *established* is the preferred alternative. We also recommend Frank (2000) and Hill (2008) as other terminology resources.

Conclusion

Invasive species pose great environmental and economic threats as well as direct threats to humans. However, variability in terminology and incorrect use of terms associated with invasive species hinder stakeholder understanding of these threats. Here we argue that in most situations, only seven terms are required to educate stakeholders effectively about invasive species. Although the debate among scientists regarding invasive species terminology persists, this debate does little to help those dealing with the problem of invasive species. These individuals need tools such as the terms presented here to help educate their stakeholders. Promoting broader public understanding of invasive species and their threats will foster support for invasive species prevention and control. The hope is that this support will help Extension professionals attain the resources they need to ensure behavioral changes aimed at preventing and mitigating the threats of invasive species.

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Appendix

Additional Terms of Utility for Educating Stakeholders About Invasive Species

Adventive—A nonnative species that has established in an area, but whose mode of arrival to that area is unknown. That is, it may or may not have been caused by human introduction.

Aggressive—This term means different things for different organisms. For animals, an aggressive species would mean the species is likely to attack when confronted or encountered. For plants, an aggressive species is one that can overtake and dominate the area where it grows. This term can be applied to both native and nonnative species.

Competitive—A species that is good at acquiring resources relative to other species. This ability can lead to the depletion of resources for other species. This term can be applied to both native and nonnative species.

Cultivated—A species (typically a plant) that is grown and maintained by humans.

Endemic—A species that occurs only in a given area—for example, the species is endemic to dunes in southern Florida.

Escaped—A species that now exists outside of cultivation, production, or domestication regardless of the mechanism by which this release occurred.

Exotic—This term is synonymous with *nonnative*. However, *nonnative* is a better term for education, as *exotic*, particularly in the pet trade and ornamental houseplant trade, can be perceived as fancy or unique rather than nonnative.

Feral—A species (typically animal) that has escaped from domestication and now occurs wild.

Indigenous—This term is synonymous with *native*. *Native* is preferred as this term, like *foreign*, *alien*, or *nonindigenous*, may be perceived in political rather than biological or ecological contexts.

Native range—This term refers to the geographic area from which a nonnative species originated (prior to humans moving the species around the globe) as well as the geographic area over which a native species is found.

Naturalized—This term is synonymous with the term *established*. A nonnative species that has now established and maintains a reproducing population with no assistance from humans. *Naturalized* is less favorable for education than *established* due to the word *natural* being nested within it. This inclusion of *natural* is reported by multiple Extension professionals to cause stakeholders to believe the species to be good or part of the natural ecosystem.

Pest—A species (typically animal) that is not wanted in a given area due to negative economic and/or environmental impacts. This term can be applied to both native and nonnative species.

Weed—A plant species not wanted in a given area because it has negative economic and/or environmental impacts. This term is also used to describe a species that largely occurs in disturbed areas or is unwanted in home gardens. This term can be applied to both native and nonnative species.

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