



Ecological Principles for Invasive Plant Management





Ecological Principles for Invasive Plant Management

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Use this Information for More Effective Invasive Plant Management

Times are tough enough without having to worry about the infestation of invasive weeds. But invasive plants are coming, if **they haven't already, and the price of controlling them can be sky-high.** These costs can multiply quickly if your treatments **aren't carefully considered and planned** based on a knowledge of what works.

The information presented in this guide can benefit your land management efforts in a number of ways:

- By understanding ecological principles you can choose the best tools and strategies to repair damaged ecological processes.
- Knowing the principles can help you give **desired species the ecological 'leg up'** over invasive species.
- By using ecological principles to guide your management decision-making, your efforts will have enduring effect.

In this handbook, ecological principles are presented as part of the ecologically-based invasive plant management (EBIPM) framework.

EBIPM is a decision model for land managers interested in developing more effective and longer lasting integrated methods for managing invasive plants. There is great value in using EBIPM instead of just trying another treatment that may or may not work for your conditions. The model offers managers a step-by-step method to determine the best combinations of tools and strategies to give desired species the advantage in these complex rangeland ecosystems.

One thing this guide doesn't provide is a simple recipe to follow for controlling invasive plants. The idea of a one-time, **"silver bullet" approach to weed** management has been part of the problem for a long time. The thinking that this problem 1) is easily solved, 2) will go away by turning a blind eye or 3) can be fixed by poorly designed invasive plant management has not served us well.

Our encouragement to you is to read on and find out how this information will advance your management of invasive plants.



Keeping rangeland healthy poses unique challenges to land and resource managers, especially with the increasing infestations of annual grasses and other invasive plants.

The Key to Successful Restoration of Invasive Plant Dominated Rangelands

It's true, invasive plants are seriously trashing large tracts of rangelands throughout the west. Perhaps none are more widespread and destructive than that of the annual grasses cheatgrass and medusahead.

The continued and rapid spread of these grasses throughout the Great Basin have been the stimulus to developing the EBIPM model to provide land managers with processes to improve the situation. However, EBIPM can be implemented for any weed species.

On rangeland, managers often don't have the wide variety of options afforded farmers of croplands where invasive plant management allows for regular and costly

inputs such as chemical, biological, or mechanical weed control. Also, the system is often reset on an annual basis through plowing or replanting. As managers in rangeland systems have learned, they need to work with the system because major inputs are either absent or occur infrequently.

Learning to work within the ecosystem is a crucial piece of the puzzle to begin achieving greater success in restoring rangelands infested with invasive species. Advances in the understanding of ecological sciences may prove to be a key in managing invasions of rangeland systems and meeting goals for the land.



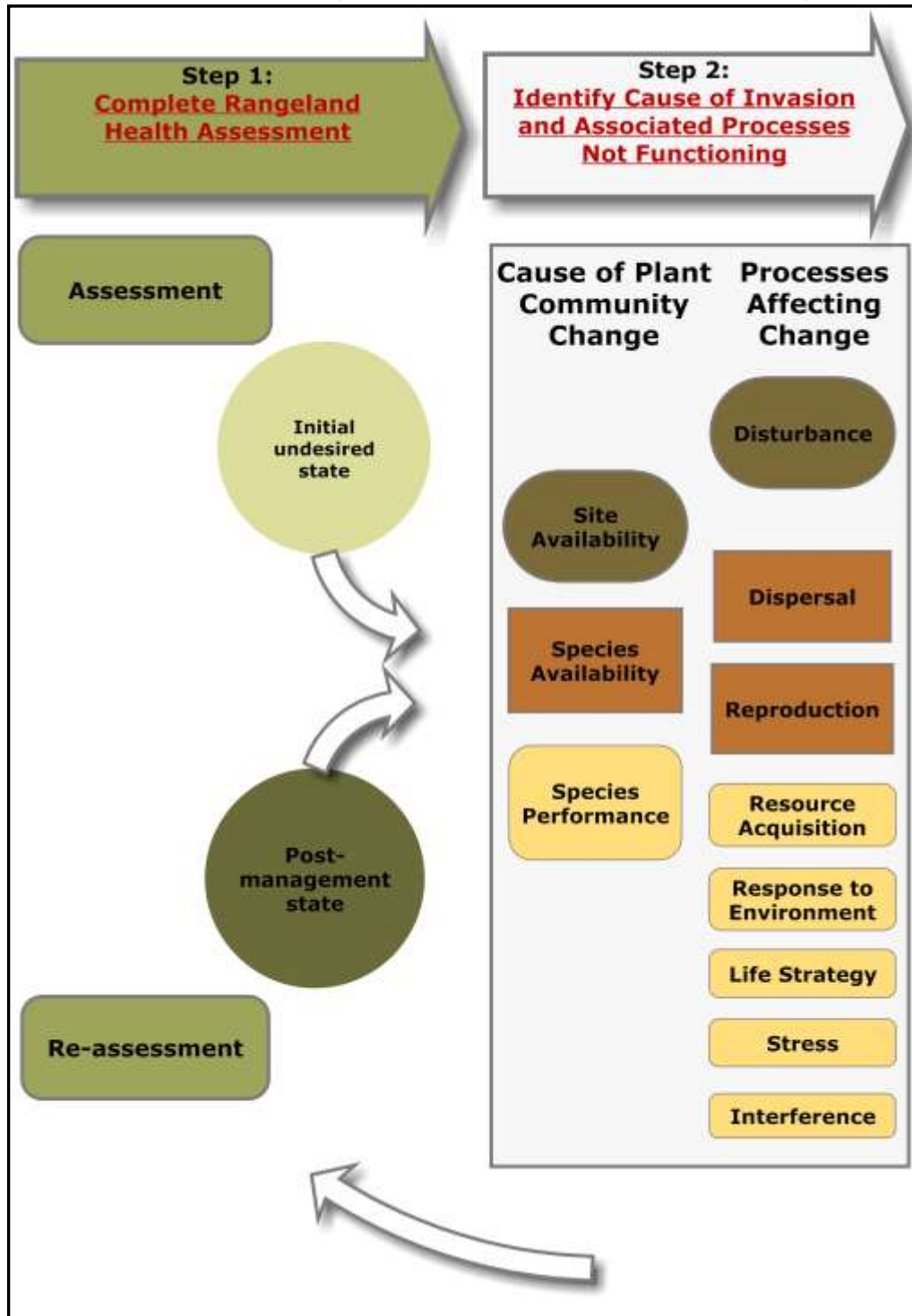
An understanding of ecological principles to guide decision-making on rangeland will help improve restoration of infested areas and will also increase success in management.

EBIPM and Ecological Principles—A Step in the Process

Ecologically-based invasive plant management (EBIPM) is a holistic framework that integrates ecosystem health assessment, knowledge of ecological processes and adaptive management to form a step-by-step decision model. The goal for using the EBIPM model is to move away from treating the symptoms, which are invasive plants, and to direct management efforts toward repairing the

underlying causes that are facilitating the invasions.

The current EBIPM framework has been under development to support wider adoption by managers. The model is easier to apply by integrating components of ecological knowledge in a user-friendly process. The framework can be adopted in



a step-by-step format to guide a manager to implementing practical and effective restoration of rangeland.

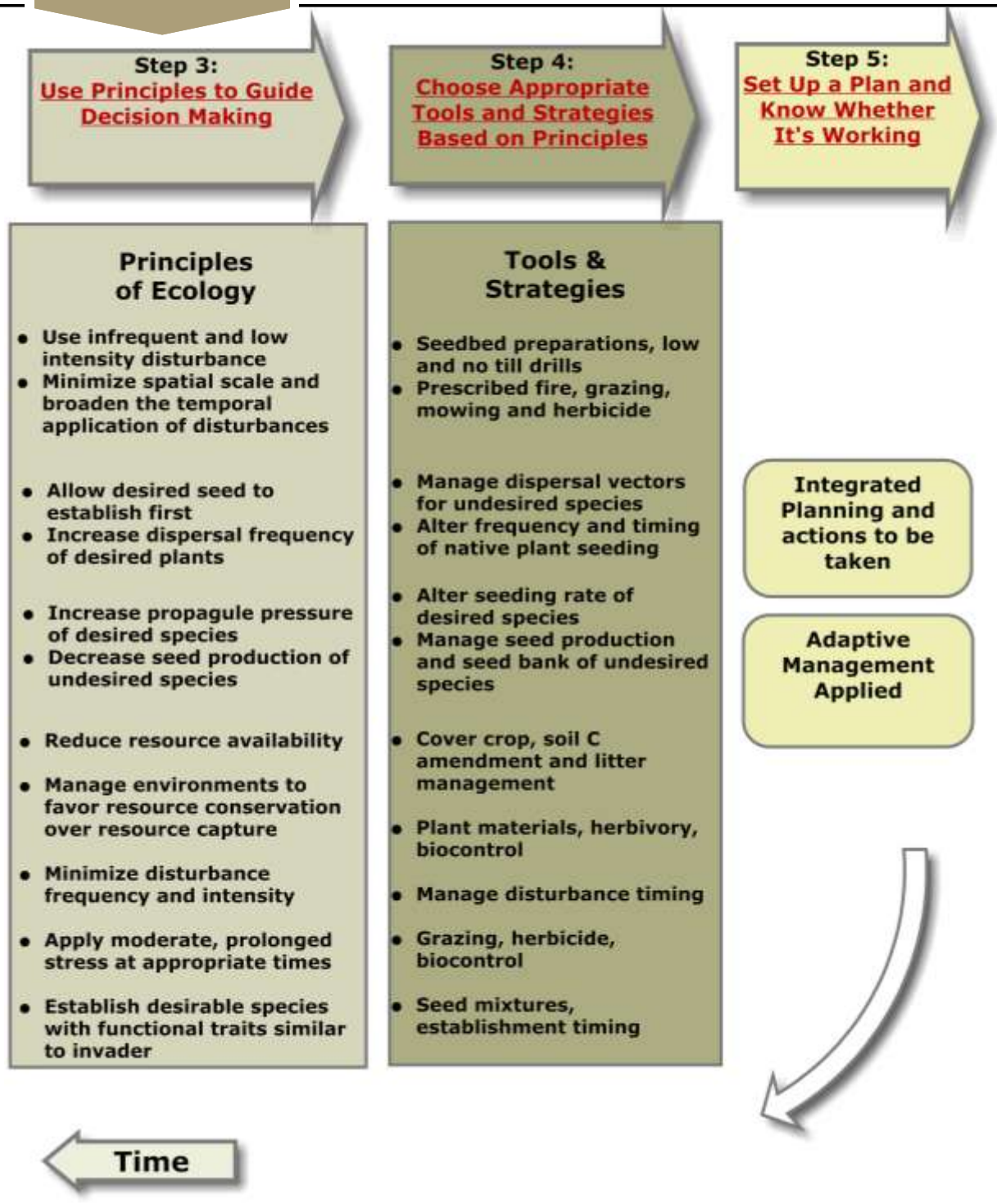
This guide is part of a series of handbooks developed to make implementing EBIPM an effective choice for land managers. All of the booklets are available as PDF files on

the EBIPM website at www.ebipm.org

or they can be requested as hard copies.

This particular guide focuses on Step 3 of the process in the model below where ecological principles are described. Ecological principles link ecological processes in disrepair to the tools and strategies that can best repair the system. The following pages will focus on these principles.

You Are Here



What are Ecological Principles?

In other sciences such as physics, scientific principles are well-established. For **instance, engineers wouldn't** go about building bridges without a clear understanding of the principles of physics to guide them in the design process.



The need for principles in land management is the same as the need for principles in other areas, such as engineering.

As land managers, we need to recognize there are ecological principles that guide ecological processes and by knowing these principles we can design more effective land management treatments.

A Need for Ecological Principles

The EBIPM model is based on managers having the ability to direct positive change on the land by being able to modify and repair ecological processes. This is fundamentally a different approach from the traditional focus of just eliminating invasive species.



EBIPM provides managers with science-based solutions to supplement their knowledge of their land and their specific situation.



The presence of invasive species is not so much a problem as it is a *symptom* of the problem.

While managers typically work off their own experiences and intuition to identify tools and strategies to apply for solving these problems, the EBIPM model can supplement this knowledge for more successful restoration. The approach integrates general ecological principles to provide managers a crucial link in choosing the best management tools and strategies for modifying the ecological processes.

Invasive weeds are really not the problem, it is ecological processes that are in disrepair. The invasive weeds are simply the symptom people can identify that alerts them to the situation. With the principles incorporated into the EBIPM model, it has some ability to predict outcomes in different scenarios. In other words, it can be applied to any situation which makes it practical and easy to implement.

The Principles

Principles are linked to ecological processes which affect the causes of plant community change, or succession. There are three causes of succession: site availability, species availability and species performance. Causes of succession are **described in more detail in ‘Applying EBIPM’** available at www.ebipm.org. There can be more than one principle for any process and it is likely there are multiple processes for each cause of succession.

For this guideline, the principles are outlined as they pertain to the ecological processes that affect each of the three causes of succession.

The following table outlines each of the ecological principles associated with the causes of succession and processes to which they are linked. Also note the page numbers, listed after each principle, to reference further detail about the principles and management targets.

Causes of Succession	Processes	Principles
Site Availability	Disturbance	<ul style="list-style-type: none"> • Desired species will be favored when disturbances are less frequent (pg. 10) • Desired species will be favored when disturbances are less intense (pg. 11) • Smaller-scale disturbances over time are less likely to promote growth of invasive plants (pg. 12) • Disturbance is usually needed to create safe sites in plant communities in late-stage succession (pg. 12)
Species Availability	Propagule Dispersal	<ul style="list-style-type: none"> • Increasing dispersal frequency of desired species and limiting dispersal frequency of invasive species can shift to a more desirable plant community (pg. 14) • Early arrival of less-competitive desired species can increase their competitiveness (pg. 15)
	Propagule Pressure	<ul style="list-style-type: none"> • Increasing amount of seeds of desired species and decreasing seed production of undesired species can improve the plant community (pg. 16) • Controlling seed production of invasive species is required to establish desired seedlings (pg. 17) • Seed production of desired species is reduced more than invasive species when vegetation is damaged (pg. 18)

Causes of Succession	Processes	Principles
Species Performance	Resource Acquisition	<ul style="list-style-type: none"> • Manage environments for low resource availability to favor desired species (pg. 21) • Successful establishment of desired species depends on controlling germination of invasive species (pg. 22) • Vigorous plants producing high amounts of biomass will limit resource availability and choose desired species with variability in growth traits to maximize resource use (pg. 23) • Species with similar resource use increase success in establishing desired species (pg. 23)
	Response to Environment	<ul style="list-style-type: none"> • Manage environments for resource conservation to favor desired species (pg. 24) • Inhibit performance of invasive species in low-nutrient environments by using appropriately-timed stresses (pg. 25)
	Life Strategy	<ul style="list-style-type: none"> • Use infrequent and less-intense disturbances to favor slower-establishing and growing desired species (pg. 26) • Establish species with diverse growth patterns to enhance stability of plant communities (pg. 26)
	Stress	<ul style="list-style-type: none"> • Use moderate, prolonged stress to favor desired species over short duration, intense stress, which favors invasive plants (pg. 27) • Choose species with plant tissue characteristics that resist stress (pg. 27)
	Interference	<ul style="list-style-type: none"> • Desired species that take up resources similar to invasive species will increase competitive ability (pg. 28)

Causes of Succession: Site Availability



A safe site provides a seed with an area that's conducive to seed germination and seedling establishment.

Disturbance is the central ecological process affecting site availability. Some form of disturbance is natural in all systems and is a necessary component to establish species.

On the other hand, disturbance also provides opportunities for invasive plants to establish. In order for a plant to establish there must be a sufficient amount of safe sites for incoming seeds. A safe site consists of conditions that allow a seed to germinate and a seedling to establish. It can include factors such as soil water content, air and soil temperature, light, soil organic matter, soil texture, density, the species and distribution of neighboring plants.



Process: Disturbance

When the word disturbance is mentioned, most people easily get a mental picture of an event or equipment that will alter the ecosystem, such as a tractor with a plow or disc. Disturbance often kills or damages existing plants causing a decrease in resource uptake.

However, not all disturbances are the same and a disturbance can be a surprisingly large number of activities. A disturbance can differ in type such as grazing, fire, flood or drought.

A disturbance can also vary in frequency, some being regular occurring; others may be a random occurrence. Consider also that disturbances may be high or low intensity; imagine a forest fire versus a grazing event. Finally, disturbances can be patchy or fairly even across the landscape.

With all the different types and levels of disturbances, there are several principles that can provide insight on how disturbance can be managed to encourage desired species and/or discourage establishment or increase in undesired species.



Disturbances, such as fire (above) or landslides (below), open up safe sites that allow seeds to germinate.



Disturbance Principle 1: Desired species will be favored when disturbances are less frequent

Many invasive species are characterized by rapid growth, short time from germination to seed set and abundant seed production. Generally, the opposite is true for desired perennial species commonly managed for on rangelands. These species usually have slower growth rates and longer time periods to produce seeds and limited seed production. Growth rate differences are the reason why frequent disturbance favors invasive species and less frequent disturbance tends to favor the desired species.



Less frequent disturbance generally means less resource availability which favors the desired species for their ability to conserve resources.

Disturbance Principle 2: Desired species will be favored when disturbances are less intense

More intense disturbances will often be much more devastating to desired species. In an intense disturbance, the nutrient cycle rates increase but there are fewer plants and species of plants to utilize the nutrients.

This sets up an increase in nutrient availability. Increases in nutrients can be used by invasive species with rapid growth rates. If there has been a severe disturbance, this is directly and positively related to an increase in invasive species.



Intense disturbances increase nutrient availability which favors undesired invasive species.

Desired species have growth traits that increase the longevity of root and shoot tissue. This trait allows for these species to conserve resources. This makes them more competitive in low nutrient situations, which is common when disturbances are not as severe.



Because of their longevity of root and shoot tissue, perennials can often survive a less-intense disturbance and then, since they're already established, utilize the nutrients.

Disturbance Principle 3: Smaller-scale disturbances over time are less likely to promote growth of invasive plants

Each plant species is faced with a trade-off between producing a small amount of large seeds or a large amount of small seeds. This is because there are only a fixed amount of resources that a plant can allocate to reproduction.

When a species produces many small seeds, the advantage provided in this strategy is an increased probability for colonizing an area. A species producing small numbers of a

larger seed is thought to provide advantages for establishing in areas where competition from neighboring vegetation is high.

Since invasive species tend to produce large amounts of small seeds, this life strategy will be an advantage in large

scale disturbances. A species establishing in this situation is limited only by the amount of seed that can disperse across the landscape, safe sites are not limiting in large scale disturbances.

Another characteristic with most invasive species is a rapid germination rate and minimal seed dormancy. This sets up a scenario where the invasive **species' seed bank can quickly and uniformly cover a disturbed area.** Once again this life strategy confers the advantage to invasive species in large scale disturbances.



Large-scale, intense disturbances favor invasive species because their life strategy generally includes producing a large number of small seeds and faster germination, establishment and nutrient uptake rates.

Disturbance Principle 4: Disturbance is usually needed to create safe sites in plant communities in late-stage succession

The amount of bare earth in a landscape is correlated to the distribution and the size of neighboring vegetation. This is an indicator of the degree of competition a seedling might experience and also the amount of

resources available at that safe site. Planning disturbance is much more important to create needed safe sites in landscapes where the plants are primarily in an older age class.



Preventing the seed dispersal of unwanted plants is essential and the most economical component of species availability.

Causes of Succession: Species Availability

In plant communities invaded by invasive species, there is usually a lack of seeds of desired species. In such situations, the area is degraded to the extent that a monoculture of an invasive species is growing. If seeds of the desired species **aren't present, then any other actions taken** to change the plant community to a more desired one will be a waste of effort and resources.

The lack of seed from a desired species may occur because not enough seeds are being produced or their dispersal is limited.

These limitations often overlap, so management requires managing both the frequency of dispersal and seed pressure of both undesired and desirable species.

The two main processes affecting species availability are seed dispersal and seed pressure (propagule pressure). Not all plants reproduce solely by seed, some species produce vegetative structures, such as rhizomes, that can grow new plants. Therefore, the term propagule is used to encompass a variety of structures from which a plant species can spread.



Ever noticed how effective cheatgrass seeds are at sticking in your socks and shoelaces or in the fur and hair of animals? This is one effective dispersal method plants use.

Process: Propagule Dispersal

There are a number of means by which a **species' seeds or vegetative parts spread** across distances including wind, animals, and waterways. Some species have dormancy or biochemical means that allow dispersal over time. Most species have a specific adaptation that confers an advantage for a particular dispersal method.

An example would be the plumes on a dandelion seed for superior dispersal by wind. This does not necessarily rule out other methods of dispersal as well.

There are several principles validating how dispersal can be managed to favor the establishment of desired species and discourage the establishment and subsequent spread of undesired species.



Photo: Lotte von Richter, Botanic Gardens Trust Sydney

For more on preventing the dispersal of seeds, see the Prevention Management Wheel or PMW at www.ebipm.org.

Dispersal Principle 1: Increasing dispersal frequency of desired species and limiting dispersal frequency of invasive species can shift to a more desirable plant community

The success of a particular species to establish at a site where availability is not lacking does involve some random elements. It makes sense that the more frequently a species disperses seeds or propagules, the greater the chance it has at arriving at an available site.

What this means for managers is in order for a plant community to shift to desirable species, it will involve making more seed available for desired species and lowering the frequency or even preventing seed dispersal of undesired species.



In applying seeding treatments, it's important to consider the type of seed as well as its intensity (how many seeds used), frequency and timing.

Dispersal Principle 2: Early arrival of less-competitive desired species can increase their competitiveness

In general, a species that arrives first to a site tends to be more successful at establishing. This has to do with a priority effect where a weaker competitor can persist even when more competitive species establish later.

Just like showing up at a restaurant for dinner, first come, first served. If a manager can shift (even small shifts can be beneficial) the timing of dispersal that will favor the desired species or determine how to delay dispersal of undesired species, the plant community change will be toward more desired species.



If desired species can fill the safe sites and establish first, they will more likely persist.



Getting desired species established first will help shift the competitive balance in favor of desired species which will help set the plant community in a positive trajectory.

Process: Propagule Pressure

Propagule pressure is another phrase for seed production or an increase in plants by vegetative plant parts. Managers can impact seed production of undesired species most readily as this is the way most species establish where there are gaps in plant communities.

Low seed production of desired species may leave an area available to potential invasion by undesired species. The following principles provide ideas on how seed production can be managed to increase desired species and limit both the establishment and population increases of undesired species.



Limiting or controlling an invasive species' ability to reproduce will greatly diminish its ability to dominate and, eventually, sustain itself in a given area.

Pressure Principle 1: Increasing amount of seeds of desired species and decreasing seed production of undesired species can improve the plant community

Site availability is usually irregular and uneven in most plant communities. Although some species are more competitive than other species, the ability to establish at a site does involve some random elements. Therefore, it makes sense that a species producing a large quantity of seeds has a greater chance of establishing than other less prolific seed producers simply due to the increase in the law of averages.

As managers, we can put this principle to use by increasing the seed of desired species either by implementing practices to increase seed production or by augmenting the natural seed by directly seeding the desired species. Through management we



Annual grasses like medusahead and cheatgrass have prolific seed production.

can jointly implement this understanding of propagule pressure and decrease the seed production of undesirable species.

Pressure Principle 2: Controlling seed production of invasive plants is required to establish desired seedings

Simply enough, invasive species often produce high amounts of seed compared to more desirable species. If, as managers, we do not simultaneously control the seed production of invasive species, we will be wasting resources in seeding desired species. Seeding alone will not tip the balance in favor of desired species.

Ecologically speaking, plants can allocate only a fixed amount of resources to reproduction. Therefore, species have life strategies that force choosing between producing large amounts of small seeds or small amounts of large seeds. If a species strategy is to produce large amounts of small seeds, it presumably has an advantage when colonizing an area. Given that invasive annual grasses follow this life

strategy is strong evidence of this advantage.

What then is the advantage of a species producing small numbers of large seeds? This life strategy confers an advantage in marginal sites where environmental stress or competition from neighboring plants may be high. Desired species often are in this life strategy category. Even though the percentage of desired species seeds establishing is higher than undesired species, the sheer number of undesired seeds will overwhelm desired species establishing.

Management planning to use tools to control the seed production of invasive species will increase the chances for a successful establishment of desired species.



Ecologically-based management that includes controlling the seed production of unwanted annual grasses can help in areas such as this, where medusahead is well-established and is beginning to create a monoculture on the landscape.



Because desired perennials generally do not react as well as invasive annuals when faced **with stress, it's essential that management programs focus on stressing the undesired** plants while having the least impact possible on desirable plants.

Pressure Principle 3: Seed production of desired species is reduced more than invasive species when vegetation is damaged

This principle also addresses the trade-off plants face in allocating resources and supplying energy for growth to either vegetative or reproductive plant parts.

Before viable seeds can develop, a plant must have a minimum amount of energy reserves. If, at any time during the **vegetative growth phase of a plant's life** cycle, it is damaged or stressed, the plant will be forced to reallocate energy and reduce its energy reserves to repair the vegetative parts damaged. This will ultimately reduce seed viability and/or total seed production.

From a management perspective, if strategies can be designed to stress the undesired species during vegetative growth so that it has to reallocate energy reserves away from seed production, this will be advantageous when it is not possible to fully control the entire population. Care must be taken because if desired species are stressed in the same manner as undesired species, this will likely have an even greater affect on the seed production of the desired species.

When designing management programs, the aim is to put as much stress on undesired species when it will least impact desirable species.

Causes of Succession: Species Performance

Species performance is the final leg of the three causes of succession. Performance of plants is associated with a wide range of ecological processes. These processes are varied and interactions frequently occur among them. This adds a level of complexity to management. Navigating the complexities of plant interactions is another area where EBIPM can be helpful.

The processes associated with species performance include how a species captures and utilizes resources such as water, nutrients, and CO₂ to maintain and increase population size.

It also can include the plant growth patterns that allow a plant to affect and respond to the immediate environment, the life cycle patterns of a species from germination, growth and mortality, and how a species responds to climatic conditions and how a

species responds to influences of neighboring plants.



For the purposes of EBIPM these processes associated with species performance have been grouped as follows:

1. Resource Acquisition
2. Response to Environment
3. Life Strategy
4. Stress
5. Interference

Managers have opportunities in management to affect these processes, either by altering the environmental conditions or choosing desired species that can compete better under given environmental constraints. The following key principles outlined hereafter can help identify how these major ecological processes influencing species performance can be manipulated to favor desired species.



It's important to understand that some desired species perform and compete much better with invasive annual grasses than others.



In western rangelands where the resources generally limiting growth are water, soil nitrogen (N) and phosphorus (P), and light, managing in a way that alters the availability of these resources can favor desired species.

Process: Resource Acquisition

What exactly is meant by ‘resources’ when referring to plants? Resources are any item a plant needs to obtain from the surrounding environment in order to survive. Not all resources may be limiting. From a management perspective, it should be recognized altering a resource that is not limiting may not alter the performance of a species.

Generally, and especially in western rangelands, the resources usually limiting growth are water, soil nitrogen (N) and phosphorus (P), and light. Most plant species will respond to additional N, as is commonly seen in agronomic practices. In

rangeland ecosystems, N is often limiting for optimum plant growth, any addition of N that occurs (through human action or occurring naturally) will result in plant growth.

Depending on regional climate and weather **as well as the species’ make up of a** community, water and light can also be a limiting resource.

The principles that follow show how resource availability can be managed to favor desired species and discourage establishment and growth of undesired species.

Resource Acquisition Principle 1: Manage environments for low resource availability to favor desired species

It sounds like something from a financial analysis, but this principle relates to a universal trade-off in plant strategies between constructing tough, long-lived tissue that yield a good return but at a low rate versus construction of thin, short-lived tissue that yield a short return on tissue at a high rate.

It comes down to whether a **plant's growth strategy is one of 'short timers' or one of 'in it for the long haul'**.

What this means for those plants that construct short-lived tissue (most invasive grasses) is they have an advantage in nutrient-rich environments. Plants that invest in long-lived tissue have shown to be advantageous in low resource environments (typical of desired species on western rangelands).

Management plans can take into account practices that keep nutrient levels at a minimum in order to favor the performance of desired species.



Generally, desirable plants construct tougher tissue and are 'in it for the long haul' while annuals are 'short-timers'.



Resource Acquisition Principle 2: Successful establishment of desired species depends on controlling germination of invasive species

Research has shown that both invasive species and desired species have similar resource requirements during germination and establishment. Also during this growth phase, both species need to obtain the greater amount of their needed resources from the immediate surroundings.

What are the implications of this information to management? Any advantages that a desired species can acquire from a low-resource environment will not be realized unless seed pressure and the rapid growth of invasive weeds are not first managed.

Many invasive species have faster germination than desired native species.

This head start confers an important initial size difference between invasive species and desired species. Bigger plants usually get more resources, so a slight head start in germination can result in large differences in competitive ability.

A key step to a successful seeding of desired species is to give them an advantage by getting those species to germinate earlier than invasive species or by reducing the germination of invasive species.



The pictures at right of medusahead (top) and bluebunch wheatgrass (bottom), which were taken on the same day from a field study, are a good illustration of the competitive advantage annual grasses, such as medusahead, get from early germination.

Resource Acquisition Principle 3: Vigorous plants producing high amounts of biomass will limit resource availability and choose desired species with variability in growth traits to maximize resource use



This principle follows the simple construct that the bigger or more abundant a plant is, the more resources it will acquire. From a management perspective, we want to limit resources that may be available to undesired species. A way to limit these resources is to have the desirable species producing high amounts of biomass.

The second part of this principle really relates to encouraging a diverse plant community in at least two ways:

1. by encouraging variability among species, and
2. by encouraging variability within desired species.



This variability will maximize resource use. One way to think about it is in monoculture situations, soil resources will only be utilized at one depth since there is little variability in the depth of roots of that species. The more spaces occupied above ground and below ground by desired species, the more resistant a plant community will be to invasion of undesirable species.

Resource Acquisition Principle 4: Species with similar resource use increase success in establishing desired species



Managers can be more effective in establishing desired species if they choose species able to utilize the same pattern of resource use as invasive species. By understanding the nature of this principle, land managers can level the odds against the invasive species and increase the chances of success in establishing desired species.

Process: Response to Environment

Ecologists refer to how a plant responds to the environment it is growing in as ecophysiology. Plants possess a broad range of traits in order to affect and respond to environmental conditions to which it is subjected. Unfortunately, the identification of these traits has not advanced the ability to develop predicting potential infestations of invasive plants. Nevertheless, some principles are emerging that can benefit managing systems to favor desired species over invasive species.



Examples of ecophysiology include how a plant allocates biomass, germination requirements and growth rate in response to its environment.

Response to Environment Principle 1: Manage environments for resource conservation to favor desired species

This principle was also introduced under the process of resource acquisition but it applies **under the process of a specie's response to the environment**. The central issue here is the difference in how invasive species allocate growth to the root and shoot systems as compared to desired species.

Desired species invest in growing heavily-protected tissues that take a high amount of energy to develop. Invasive plants invest in cheap, poorly protected tissue that uses minimum energy reserve.

What this translates to on the ground is invasive species have large leaf areas and fast-growing root lengths; this allows the invasive plants to rapidly acquire resources because they photosynthesize faster. Invasive species have the ability to grow

faster but the tissue is poorly protected against environmental stresses and damage from herbivores (insects or domestic livestock or wildlife). Desired species typically invest in plant tissue that conserves resources better than developing new growth which will be at an advantage in environments with low resource availability.



Annual grasses, like cheatgrass, grow 'cheap' tissue, allowing them to grow and acquire resources faster.

Response to Environment Principle 2: Inhibit performance of invasive species in low nutrient environments by using appropriately-timed stresses

By producing thinner leaves, invasive species can achieve a greater N-use efficiency and maintain greater growth in low N soils than desirable species. With a higher leaf area, invasive plants can allocate less N to each unit of leaf area to maintain similar levels of photosynthesis.

If a manager is going to effectively stress an invasive population in a low nutrient environment, at least two factors need to be taken into account. The first is the timing and the second is the magnitude of the stresses should occur when the invasive weeds are most vulnerable and are least able to rebound from the applied stress. Likewise, if desired species are present, applying the stress should occur when it will least affect the desired species.



Annual grasses like this cheatgrass produce thin or flat leaves with more width or leaf area. This allows them to maintain higher levels of photosynthesis and grow faster than more desirable species.



To take full advantage of species' response to their environment, management treatments should apply stress when: 1) invasive species are most vulnerable and 2) desired species will be least affected by the stress.

Process: Life Strategy

Life strategy, also called life history, indicates the patterns of germination, growth and death of plants as they pass from seed to maturity. Plants have evolved a range of strategies through time. A particular life strategy can allow for some general principles to emerge that can help land managers direct more desirable plant communities.



Life Strategy Principle 1: Use infrequent and less-intense disturbances to favor slower-establishing and growing desired species

A common trait of many invasive plants is a short period from germination to seed set and for perennial invasive species a short period between large seed crops. This life strategy is one that allows for a rapid population growth as is often seen in invasive species and is most beneficial when the survival of adult plants is much lower than survival of juvenile plants.

Less frequent and less intense disturbances favor the slower establishment and growth rate of desired species.

Conversely, when survival of adult plants is much higher than survival of juvenile plants, most invasive species are not favored. If we examine this strategy from a disturbance regime, when disturbances are frequent and intense, the life strategy of invasive plants (survival of adult plants is much lower than juvenile plants) is favored.



Life Strategy Principle 2: Establish species with diverse growth patterns to enhance stability of plant communities

When an ecosystem is stable, the plants are able to resist a change following a disturbance and are able to recover following a disturbance. Since disturbances

can be unpredictable (such as a wildfire), maintaining a seed bank of desired species that have different life strategies can provide more stability to the landscape.

Process: Stress

Any condition that limits a plant's growth can

be lumped together and called stress. In natural systems conditions are rarely optimal for growth. Stress can be a range of conditions from mild to severe. Disturbance usually induces some degree of stress.

Disturbances can be applied in various ways to induce stress on undesired species. Anytime a plant is damaged, stress can be induced. With

the few key principles relating to stress, a manager can alter conditions a plant comes under and, ultimately, the performance of species either positively or negatively.



Stress Principle 1: Use moderate, prolonged stress to favor desired species over short duration, intense stress, which favors invasive plants

Plant species have different tolerances to stress. A stress-resistant species is one that can avoid changes in production or size when exposed to stress. A resilient species can recover back to initial levels following stress.

A species' ability to resist stress is

usually associated with slower growth rates. But resilience is usually seen in species that have higher growth rates. Invasive species tend to have a high growth rate and higher resilience.

They are able to make adaptations to changing conditions readily. To favor desired species, if stress can be applied to modify species performance, it should be moderate, prolonged stress. Resistant species are better adapted in this scenario.



Because desired species are generally better at conserving resources, they can typically tolerate moderate, prolonged stress better than invasive weeds.

Stress Principle 2: Choose species with plant tissue characteristics that resist stress

Species that invest in long-lived, tough tissue will be more capable of functioning under stresses such as drought, freezing, wind abrasion, grazing, and low nutrient situations. If these stresses are common in the ecosystem being managed, species with high density plant parts (usually desirable species) will be more resistant to stress.



Process: Interference

Anytime plant vigor is reduced from a neighboring plant, this is interference. Vigor can be reduced by direct competition for resources, by allelopathy (where a plant produces biochemicals that negatively affect a neighbor) or by resource availability. Interference is the most difficult process to quantify and to date where ecological principles are least well-developed. There are some key patterns from which principles can be identified.



Competition for resources causes interference of neighboring plants.

Interference Principle 1: Desired species that take up resources similar to the invasive species will increase competitive ability

A species rooting depth, plant growth habits, and leaf structure all play an important role in the uptake of nutrients and resources in general.

The advantages invasive species often have in traits such as increased leaf areas and germination rates have already been highlighted. We need to recognize there is substantial variation in these traits among desired species as well and some desired species may well have plant traits that enable them to compete favorably with invasive species.

In areas where initial management of invasive plants is difficult and the conditions are expected to continue to favor the invasive plants, it becomes an important strategy in designing seed mixtures to choose species based on the traits of earlier germination and ability to produce higher leaf areas



Greenhouse studies show the difference in root growth between medusahead (left) and desired perennials (right) which were started at the same time.

When choosing seed mixes, desired species that have these traits similar to invasive species may be able to out-compete or at least compete better for resource capture and ultimately achieve more successful establishment of desired species.

Ecological Principles = Better Management

Using and understanding ecological principles can **enhance a manager's success against invasive** species. Making the links between how a plant grows and competes for resources will enable land managers to get a handle on invasive plant problems.

These principles can help managers formulate management strategies for more productive land to resist the onslaught of invasive annual grasses. The bottom line is there will be more efficient use of inputs and resources and more successful restorations.

On a final note, there are likely more ecological principles for invasive plant management than have been covered in this guide. As scientists focus on invasion ecology, more principles will emerge to benefit managers using an integrated decision framework to solve invasive species problems.

Additional Resources in our EBIPM Series:

- Revegetation Guidelines for The Great Basin: Considering Invasive Weeds



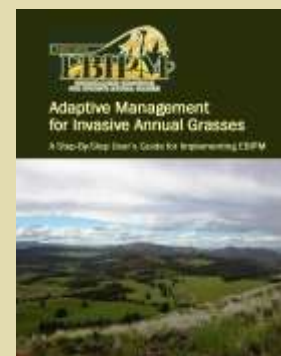
- Preventing & Managing Medusahead



- Adaptive Management for Invasive Annual Grasses



- Prevention Management Wheel - Knowing, Preventing and Managing the Dispersal of Seeds



- Applying Ecologically-Based Invasive Plant Management



- Implementing EBIPM: In the Field (DVD)



More resources are in development;
check www.EBIPM.org for the most up-to-date listings.

The Area-wide project is a USDA-ARS funded program to encourage and support enduring invasive annual grass management throughout the Great Basin.



When discussing and implementing EBIPM, terms come up that are used more regularly in ecology and they may not be as familiar. To make using the

model as practical as possible, we have defined some terms associated with the model and in discussions of EBIPM. Knowing the definitions makes the step-by-step process easier to follow.

Adaptive Management - A learn-by-doing approach to test, compare and gain knowledge on ideas for managing invasive species on a landscape scale.

Allelopathy - a biological characteristic of some plants by which they produce certain bio-chemicals that influence the growth and development of other plants.

Augmentative Restoration - A decision framework to enhance site-specific ecological processes that are damaged resulting in more successful restoration attempts.

Colonization - A species populating an area.

Dispersal - The movement of propagules (seeds) away from parent plant of population through time and space.

Disturbance - A temporary change in the usual environmental conditions (for instance: wildfire, flood, insect infestation or human disruption such as fire, construction or agriculture) and the central ecological process

affecting site availability. Disturbance can be a key to recruiting new arrivals of desired species or providing an opportunity for invasive plants to establish.

Ecological Niche - How a species or population responds to resources and competition and how it can alter those factors. Invasive species can exploit resources and outcompete native species.

Ecological Principles - Fundamental causes that link ecological processes to the relative abundance of desired or invasive species. Ecological principles can indicate a magnitude and direction of change that a management strategy likely will have on the dynamics of invasive and desired species.

Ecological Processes - These are cycles that occur in ecosystems, such as the water cycle, nutrient cycle, energy capture, and the events (disturbances) that can alter the cycling.

Ecophysiology - A physiological or morphological mechanism allowing a plant to affect and respond to the immediate environment. Examples would be how a plant allocates biomass, germination requirements and growth rate.

Herbivory - The process of an animal eating a plant.

Interference - The reduction of fitness of neighboring plants from various mechanisms including competition, allelopathy, and resource availability

Invasive Species - A non-native plant (in the case of EBIPM) whose introduction causes, or is likely to cause, environmental harm through their aggressive growth characteristics.

Life History - The patterns of birth, mortality and growth of individuals in a population as they pass from seed to adulthood.

Propagules - Any plant material, seeds, root fragments, etc, used for the process of reproduction.

Resources - Any item that a plant needs to procure from the environment that is necessary for survival. Not all resources are limiting, so manipulation of any particular resource may not alter species performance.

Safe site - An area providing a specific set of conditions allowing a seed to germinate and a seedling to establish and can include factors such as soil water content, air and soil temperature, light, soil organic matter, soil texture, density, identity, and distribution of neighboring plants.

Site Availability - One of the causes of succession and is most commonly associated with the process of disturbance. For a site to be available to incoming propagules, a specific set of conditions must be present to allow a seed to germinate and a seedling to establish.

Species Availability -The presence or absence of viable propagules, reproductive or vegetative, brought in by dispersal or present in the soil seedbank.

Species Performance - A range of ecological processes that determine how a species captures and utilizes resources to maintain and increase population size.

Stress - Any condition that limits plant growth. These factors can include drought, heat, cold, water logging, salinity, and herbivory, among others.

Succession - The natural sequence or progression of species that an area will follow over time that is caused by site availability, species availability, and species performance.

