# **kNOweeds** Curriculum Conceptual Framework

The following conceptual framework outlines key elements addressed in this guide for integrating invasive plant species topics into the K-12 curriculum. This framework is organized into three main sections:

**BUILDING BASICS** consists of concepts related to the importance of plants to humans and the environment, as well as concepts of plant biology which are important for understanding invasive plant issues.

**INTRODUCING INVASIVES** adds understanding about the ecology of invasive plants and their impacts.

**TAKING ACTION AND LENDING A HAND** provides information about how invasive plants are managed and constructs awareness of how learners can use their knowledge to take action on invasive plants. This section also includes ideas about citizen science and working with groups, as well as resources to assist in learning and doing more.

## BUILDING BASICS

Constructing Knowledge About Plant Uses and Plant Biology

1) **Plants are important: Values and Uses**
   a) Plants provide products that are of both sustenance and economic values.
      i) Wood Products
         (1) Historical use of plants for building materials
            (a) Native American teepee poles, brush shelters, etc.
            (b) Logs used before mills were available
         (2) Wood is an important building material in modern construction, and the wood and paper products industry is an economically important industry in Montana.
      ii) Food
         (1) Gathering
            (a) Food is gathered from wild sources for personal use as well as for sale. Gathering, along with hunting, is the oldest way that humans acquired food, and is still practiced in many parts of the world.
            (b) In Montana, Native Americans gathered a huge variety of plant foods, many of which are still gathered today.
            (c) Wild plants are gathered by many Montanans today for food, medicinal purposes, and crafts. Berry and mushroom gathering is of economic as well as personal value.

(2) Agriculture is Montana's primary industry in economic terms. It is also an important component of the social structure and cultural heritage of many Montana communities.

(a) Direct: Many human food crops are grown in Montana, primarily grains, legumes, vegetables, and cherries.

(b) Indirect: Hay and other feed crops support the livestock industry.

iii) Medicinal

(1) Native Americans used hundreds of plant species in Montana for medicinal purposes.

(2) Current uses of plants for medicine include Pacific yew for cancer treatment.

iv) Other products

(1) Fuels: biodiesel and ethanol are renewable transportation fuels which are being produced in Montana to increase efficiency, reduce vehicle pollution, and support Montana's agricultural and tourism sectors.

(2) Clothing: Cotton and a few other plants still supply much of our clothing and many other household goods.

b) Plants have aesthetic, recreational, and spiritual values to people.

i) Wildflower viewing, forest recreation, gardening, cooking, art, and nature observation are some of the ways in which plants enrich people's lives.

c) Plants play vital ecological roles to sustain life.

i) Plants protect water sources and waterways:

(1) Plants hold soil in place, thereby slowing or preventing erosion and stopping sediments from entering streams, benefiting humans and aquatic life.

(2) Plants absorb toxins: Pollutants such as metals, oils, fertilizers, and microbes are filtered out of water by plants as water moves through wetlands, riparian areas and forests.

ii) Plants provide oxygen that is necessary for all animals on earth.

iii) Plants slow the effects of global warming by sequestering carbon.

iv) Plants provide food and shelter for other organisms, including other plants, animals, fungi, microbes – pretty much everything else on earth!

**2) Plant Biology**

a) Anatomy: Plants all share certain anatomical characteristics. Plant anatomy, or "morphology", describes the structure and parts of a plant: the leaves, stems, flowers, roots, etc.

b) Identification and classification: There are standard terms used to describe the parts of plants. These terms are used to help classify and identify plants. Organisms can be classified according to life needs, behavior, physical characteristics, habitat requirements, etc.

c) Species: A species is a group of plants which are similar to one another and capable of interbreeding with one another, but not with others.

d) Needs and Habitats: All plants share basic needs: air, water, sunlight and nutrients. However, plant species vary in how they acquire and use those resources, giving them different habitat requirements. These habitat requirements determine, in part, where different species of plants live. Habitat is composed of many integrated components.

e) Plant Distributions: Plant scientists use many methods to study plant densities (the number of plants in a unit area) and patterns, or the way plants are distributed in space.

f) Life histories: Plants have patterns of growth, reproduction, and lifespan that vary from species to species, and are associated with requirements for survival in particular conditions.

   i) Life cycles refer to the number of growing seasons an individual plant lives (annual, biennial, or perennial). All living things, including plants, go through various stages of life cycles.

   ii) Growth form describes the general size, woodiness, and general leaf shape.

   iii) Reproductive strategies: some species reproduce by seed, others vegetatively, and some use both strategies.

g) Populations and demography: A plant population is the group of individuals of a species living in an area small enough that they can all interbreed. Demography is the study of how plant populations change over time.

h) Plant Interactions: Plants may interact in ways that have positive or negative effects.

   i) Competition has a negative effect on both plants that use a resource in short supply.

   ii) Amensalism has a negative effect on one plant but doesn't affect the other. Examples may include detrimental shading of one plant by

another, or allelopathy, in which one species releases a chemical harmful to another.

iii) Commensalism has a positive effect on one plant but no effect on the other. An example is the beneficial shading of one plant by another.

iv) Mutualism is an interaction that favors both plants, such as nitrogen fixation.

v) Parasitism occurs when one plant lives in or on another and receives nutrients from its host, benefiting the parasite to the detriment of the host.

i) Communities: Plant species living together in a habitat comprise a plant community. Communities are described by many features, including species lists, how those species are distributed spatially, and the physical structure of the vegetation. Species diversity refers to the richness and distribution of species in a community.

j) Ecosystems

i) Plants and other ecosystem components are often interdependent and interact in sometimes complex ways. Plants support a diverse assemblage of other species, and form the basis for the rest of the web of life in an ecosystem.

ii) Abiotic components interact with biotic ones.

(1) Rock and soil cycles, water, climate, and weather all influence habitat for plants, and in turn are influenced by plants and other life forms.

k) Geographical features are integral components of suitable habitat for plants and other life forms. Geographical mapping is a powerful tool for understanding and tracking distributions of plants and other organisms.

## INTRODUCING INVASIVES

### Learning About Invasive Plant Ecology and Impacts

**3) Invasive Species Ecology**

a) Introduction:

i) There are many definitions of weeds and many words and terms used to describe invasive plant species: weeds, exotic, non-native, non-indigenous, introduced, alien, and noxious.

(1) Exotic, introduced, non-native and non-indigenous refer to a species that has been introduced by humans to a place outside

its natural or native range. Some of these can be very beneficial to humans, such as garden species or food crops.

(2) A weed refers to a plant that is growing in an area where it is unwanted.

(3) An invasive species expands rapidly into new environments and persists there. Generally, these species displace native or other desirable vegetation, and may cause considerable environmental and economic harm. Only about 1% of non-native species become invasive. Harmful invasive species may also be called noxious. In Montana, there are laws mandating the control of noxious weeds.

ii) There is a variety of perspectives on the harmfulness of non-native and even invasive species. Some invasive species may have both negative and positive effects.

b) Mechanisms of invasion

i) Release from native limiting factors: When a species is removed from its natural habitat to a new one, it often leaves behind all the other organisms with which it has evolved for millions of years. These include herbivores, parasites, and pathogens.

ii) Plants are introduced by humans to areas outside their native range in many ways. Some species that are introduced for horticultural purposes "escape" domestication and become invasive. Seeds and other plant parts capable of regeneration are carried by clothing, vehicles (including boats and planes), soil, animal feed, seed mixes, pets and livestock, and water.

iii) Attributes of invasive species: Invasive plant species generally share some attributes that allow them to establish and spread where they do not occur naturally. These traits enable them to establish themselves quickly in disturbed environments and crowd out other species. Characteristics favorable to thriving in a disturbed environment include rapid growth, abundant seed production, persistent seeds, high germination rates, and tolerances for a wide range of environmental conditions.

iv) Human factors: A variety of human activities favor invasive species. Most of these involve altering natural plant communities and disturbing ground:

(1) Clearing ground for roads, trails, buildings and agriculture

(2) Overgrazing by livestock

(3) Removal of predators which allows herbivorous prey species to overpopulate

(4) Global climate change alters the environment in ways that tend to favor plant invasions.

v) Natural factors: Some natural processes such as fire, flooding, and wildlife grazing may favor the spread of invasive species.

(1) Resistance: The ability of a community to avoid change in the face of a disturbance.

(2) Resilience: The ability of a community to recover from change.

**4) Impacts of Invasive Plants**

i) Ecological impacts:

(1) Impacts to plant species: Invasive plants can reduce the numbers of other plants, occasionally to the point of eliminating them entirely from an area. Rare or endangered plants may be at risk from invasive plants. Plant invasions may also affect the genetics of native plants by hybridizing with them.

(2) Effects on plant communities: Invasive species can decrease the richness of native plant communities, turning diverse natural areas into near monocultures.

(3) Impacts to wildlife: Invasive plants can degrade or eliminate the vegetative basis of natural habitats, negatively impacting a large variety of fauna, from soil organisms, invertebrate and vertebrate pollinators, herbivores, and seed-eaters, to the predators which feed on all of these.

(4) Effects on ecosystems: Plant invasions may alter ecosystem processes such as fire cycles, erosion, sedimentation of waterways, water cycles, and nutrient cycles.

ii) Economic impacts

(1) Invasive plants cause millions of dollars of loss to Montana's economy every year.

(2) Plant invasions affect the economy by reducing agricultural production, recreation and tourism, and land values and causing related job losses.

(3) Invasive plants also cost millions of dollars to control.

iii) Benefits of weeds: Invasive species may have some positive ecological and economic effects.

(1) Invasive plants may be used for food, medicine, or agricultural products (e.g., honey).

(2) Invasive species may provide ecological services in the absence

of native species, such as slowing erosion or providing habitat (e.g. tamarisk and songbirds)

**5) Invasive plants in Montana**

a) Montana currently has 34 plant species listed as noxious weeds. There are other species that show invasive tendencies, but have not yet colonized sites in Montana.

b) Information about Montana's invasive species can be obtained from a variety of sources (see listing in this guide).

## TAKING CONTROL AND LENDING A HAND

Learning How Invasive Plants are Managed and Turning Knowledge into Action

**6) Weed Management**

a) Federal and state laws regulate the spread and control of weeds in Montana. Laws related to endangered species and pesticide use are also related to invasive species.

b) Weed management is the responsibility of private landowners, various branches of federal, tribal, state, county and city governments, non-profit organizations, and concerned citizens.

c) Integrated Weed Management is the use of a variety of methods to manage weeds. It is generally the most effective way to achieve long-lasting results in limiting weed species. Some or all of the following may be used in integrated weed management.

i) Weed management plans. Having a carefully thought-out and adaptive plan for weed management increases long-term effectiveness and may lower long-term costs. A plan identifies land management goals, the site's desired plants, and weed management objectives; assesses management options and strategies; determines monitoring methods; and assesses costs.

ii) Surveys, inventories and mapping. Collecting data on weed occurrence, distributions, and population changes helps identify needs and priorities and set goals for management. There are several standard methods used to collect reliable data on plant locations and numbers.

iii) Prevention is the most effective and efficient way to manage invasive plants. Prevention includes controlling the movement of seeds; minimizing the disturbance of desired plants; maintaining diverse, robust plant communities through good management practices; monitoring areas at risk; and restoring disturbed areas with native or other desirable vegetation.

iv) Control methods vary depending on what weed species is being controlled, where it is, what the objectives for control are, and who is responsible for control. Each control method has pros and cons, and some are short-term solutions while others have longer term effects.

(1) Manual and mechanical techniques include pulling, mowing and digging.

(2) Biological controls are plant-attacking organisms such as insects and pathogens which are introduced from the invasive plant's native range. They are carefully chosen to be host-specific to minimize potential damage to non-target species.

(3) Targeted grazing uses carefully controlled grazing by sheep or goats to control weed species.

(a) Grazing is usually timed to maximize damage to targeted species while minimizing damage to native or non-target plants.

(b) Grazers may need to be "trained" to consume some weed plants.

(4) Controlled burning uses fire to destroy plants in a targeted area, and works primarily on annual grasses.

(5) Herbicides are chemicals that stop or retard the growth and/or reproduction of plants.

(i) Herbicides usually act quickly and effectively. Must be reapplied every 2-4 years depending on the plant species, residual, and site. Herbicides are selective and non-selective.

Selective herbicides do not impact target grass species.

Non-selective herbicides impact all plant species.

(ii) Plants may evolve resistance to herbicides if the same herbicide is used over a long period of time on the same plant. This can ultimately render them less effective.

(iii) Herbicide use can allow invasive annual cheatgrass to thrive and also impact forb (broadleaf plant) reproduction.

(iv) Herbicides can have adverse effects on the health of humans and the environment, particularly if not used according to labeled directions.

(v) Monitoring allows managers to assess the effectiveness of efforts to control invasive species and to adapt management practices as needed.

(vi) Site recovery may include removing invasive species; planting native or other desired species; stabilizing soil; tending and protecting newly established vegetation; and altering site management. Types of site recovery include:

(1) Restoration: Return to exact ecological condition prior to disturbance.

(2) Reclamation: Construction of site to provide pre-disturbance functions. Emphasis on soil remediation.

(3) Rehabilitation: Return site to functioning system. Emphasis on plant ecological function.

(4) Revegetation: Restricted to the vegetation phase of all of the above.

(5 ) Research provides the knowledge used to manage invasive plants in the most effective and ecologically sound ways. Good communication among plant scientists and between scientists and managers is essential to integrating research and management.

(vii) Education is a vital component of weed management.

(1) Education efforts include disseminating information about the significance of invasive species and how to prevent their spread to the general public, students, landowners, and those charged with managing public lands.

(2) Education may take many forms, such as presentations, field trips, printed materials, and websites.

7) **Education** builds the capacity of individuals or groups to address weed issues on private and public lands.

a) Mentoring

i) Mentoring promotes the responsible usage of land and resources by teaching others about sustainable land stewardship and the importance of healthy ecosystems.

ii) After learning about sustainable land stewardship and the importance of health ecosystems, the "mentored" then mentor, continuing the positive exchange of knowledge and cycle of learning.

b) Community Outreach
   i) The sustainable usage of land requires the involvement of the entire community.
   ii) Those already trained in the importance of healthy ecosystems share the message with other community member via demonstrations, pamphlets, posters, presentations, publications, etc.

**8) Agency Support**

a) Land management agencies are charged with managing land and resources for the enjoyment of present and future generations.

b) Land management is a substantial task in the West, given the large amount of public land. Only with the help of community members and land users can agency land managers effectively stay abreast of the diverse land issues with which they are continually faced.

**9) Citizen Science and Service**

   i) Students can survey, record and map native and invasive plants in their community or natural area. Such information can be used directly by students as well as shared with those responsible for invasive plant management.
   ii) Students can partner with natural resource managers from local governments and organizations to help research and manage weeds.
   iii) Students can present information about native plant communities, invasive plants, and weed control to a variety of audiences in a variety of ways.

**10) Resources and organizations**

a) Federal, state, county, city and tribal government agencies and offices and private organizations are responsible for invasive plant research, management, and education.

b) There are repositories or central sites for contributing information collected on invasive plants.