INVASIVE PLANTS:
TAKING ROOT IN ALASKA

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A Kenai Peninsula – Cooperative Weed Management Area Project
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Curriculum Introduction and Acknowledgements

The following curriculum was designed for grades 9-12 and is intended to be a resource for educators to integrate into classes one of the most substantial threats to global biodiversity and agriculture alike – invasive species. The "Invasive Plants Taking Root in Alaska" curriculum will encourage students to delve into a locally relevant, rapidly developing environmental issue concerning invasive plants. Students will be introduced to core concepts of invasive species biology and challenged to think about complex ecological, economic and social impacts of invasive plants. The curriculum also provides ample opportunity for independent investigation and encourages critical examination of the issue of invasive plants and their spread.

The resources within the curriculum are arranged into sections that can be utilized separately or in tandem with other sections. This flexibility allows the curriculum to be added to lesson plans and provides the option to spend as little, or as much class time on this subject. The preface of each section contains objectives of each activity and estimated in-class time needed to complete the lesson. Many of Alaska's State Science Standards can also be met through implementation of this curriculum (See § 7). In addition, if you choose to expand the lessons, possible extensions are listed in § 6.

Alaska has been **very** fortunate in the past, to have relatively few problems with invasive plants. Nonetheless, many notorious invasive plants that have caused tremendous ecological harm elsewhere have recently been reported in "The Last Frontier". Spotted knapweed (*Centaurea biebersteinii*), purple loosestrife (*Lythrum salicaria*) and scotchbroom (*Cystisus scoparius*) have all been recorded outside cultivation in Southcentral Alaska (AKEPIC, 2006). Opportunities still exist to identify and prevent ecological problems of many noxious and invasive plant species. One step in this important task is ensuring that Alaskans are aware and knowledgeable about the impacts of invasive plants. The curriculum "Invasive Plants Taking Root in Alaska" was prepared to help improve awareness about the threat of invasive plants and the importance of protecting Alaska's diverse resources.

Thanks to those listed below who provided comments and ideas to improve earlier versions of this curriculum: Elizabeth Bella (USDA Forest Service – Chugach NF), Faith Duncan (USDA Forest Service - Tongass NF), Gino Graziano (Alaska Association of Conservation Districts) and Al Poindexter (Homer Soil and Water Conservation District).

Special thanks to Krista Holman (Ninilchik HS) for review and assistance with State Science Standards.

Help us improve the
"Invasive Plants taking Root in Alaska" Curriculum

Thank you for using this curriculum created by the Homer Soil and Water Conservation District and funded by US Forest Service – State and Private Forestry and the Alaska Association of Conservation Districts. In order to improve these materials we welcome any comments or suggestions for improvement. The curriculum has been provided as a free service but we would like to know who is using these resources and how effective they have been. Please take the time to fill out the following questionnaire and email to Caleb Slemmons at: caleb@homerswcd.org or fax to (907) 235-2364.

Instructor Name: _____
Email address: _____

School District: _____

School: _____

Curriculum used in what class(es):

Curriculum used on what grades:

Number of students:

Comments/suggestions:

Section 1. Lecture and notes

Section 2. Inquiry Activities

Section 3. Comprehensive Labs

Section 4. Technology

Section 5. Assessment

INVASIVE PLANTS:
Taking Root in Alaska
Curriculum Outline
(Grades 9-12)

Curriculum Web Address:
www.homerswcd.org/invedu

1. Introduction and Lecture Notes

a. Powerpoint presentation

CLASS TIME: 40-60 min

Objectives:

1. To introduce the topic of invasive plants and some core concepts about biological invasion and the ecological problems they can cause.

2. To stimulate discussion and encourage critical thought about invasive plants including where they come from, laws that regulate their use and about potential solutions for controlling their spread in Alaska.

NOTE: The following lecture notes and handouts, are intended to accompany the MS Powerpoint presentation file (InvasivePlantIntro07.ppt) included on the curriculum packet CD-ROM. The presentation will serve as a starting point for additional exercises and labs provided in this curriculum. The notes will help introduce the topic and are a good resource for students to complete the review guide and prepare for the test in § 5.

If you would like to request a copy of the presentation file, please contact the Homer Soil and Water Conservation District at the address listed in the front of this packet.

SLIDE #1: TITLE SLIDE – INVASIVE PLANTS: TAKING ROOT IN ALASKA

Invasive species are considered one of the foremost threats to biodiversity.
Currently invasive plants are gaining a foothold throughout Alaska.
This presentation and associated educational materials are designed to introduce this important topic, increase awareness of invasive plants in Alaska and how invasive plant species are introduced (vectors).

SLIDE #2: WHAT ARE INVASIVE SPECIES?

Do you know what invasive species are?
Do you know any examples? What about invasive plants?

SLIDE #3: DEFINITIONS

Exec. Order by Pres. Clinton, 1999 – Defined invasive species as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.", and set up National Invasive Species Council. This mandated federal agencies to work towards control and eradication of invasive species (US Department of Agriculture's National Invasive Species Information Center, 2006).
The terms: alien, exotic and non-native are often used interchangeably

SLIDE #4: NOT THESE ALIENS…

Insert raucous laughter?

SLIDE #5: THESE ALIENS

Photos of some invasive "alien" plants in Southcentral Alaska.

SLIDE #6: WHAT ARE "NOXIOUS" WEEDS?

<u>Topics For Discussion</u>
What is a weed?
The term "weed" is loosely defined and typically refers to any plant that is undesirable or is growing in an undesirable location. However many US states have legislation to define and list certain "noxious weeds" that are prohibited from being sold and transported. In Alaska, State Statutes (AS 03.05.010) identify a list of noxious weeds that are prohibited. However, noxious weed lists often focus on agricultural pest plants. How can these laws be enforced?

SLIDE #7: WHAT CAN INVASIVE PLANTS DO?

Japanese knotweed is sold as an ornamental and is rapidly spreading in Southeast Alaska This site grew along the roadside – eliminating the native berry-producing shrubs

SLIDE #8: WHAT ELSE?

Who cares about native plants? Native plants serve as the base of the food web and without them there may be limited food for animals or fish.
In addition to being an important food source and habitat for wildlife, native plants can also serve other important functions such as stabilizing soil and are an

important source of traditional medicines. Many invasive plants do not confer these benefits and can disrupt ecosystem processes.
It is estimated that over ½ of the species protected under the Endangered Species Act are threatened by invasive species. (Pimental et al, 2000)
Can disrupt hydrology, food webs etc. Purple loosestrife has been found to alter important wetland function and reduce the quality of habitat for some bird species (Blossey et al, 2001).

SLIDE #9: ECOSYSTEM FUNCTION/SERVICES ALTERATION

White sweetclover (*Meliolotus alba*), found and spreading in several areas of Alaska, fixes nitrogen and quickly creates its own suitable habitat which may not be beneficial to native species adapted to nitrogen poor soils. Sweetclover seeds may be viable for over 70 years (AKEPIC, 2005)!
Shortening fire return intervals - Fire was historically infrequent in shrublands dominated by saltbush and creosotebush in the southern Great Basin, Mojave, and western Sonoran deserts. Invasive grasses now create large amounts of continuous fine fuels where very little previously existed, and these fuels have increased the frequency of fire, especially after years of high rainfall (http://www.werc.usgs.gov/pubbriefs/brookspbmar2002.html) (Brooks and Pyke, 2001).

SLIDE #10: FOR EXAMPLE…A BOREAL FOOD WEB

SLIDE #11: FOR EXAMPLE…

Some invasive plants such as tall buttercup (*Ranunculus acris*) are toxic to horses, cattle, sheep and other rangeland animals (AKEPIC, 2005). They may also have the potential to harm native herbivores such as moose and caribou.

SLIDE #12: FOR EXAMPLE…

Snowshoe hares consume a variety of herbaceous plants during the summer, including species like vetch, strawberry, fireweed, lupine, bluebell, and some grasses. They also eat many leaves from shrubs.
A surprising fact, snowshoe hares younger than two weeks of age are killed primarily by red squirrels and ground squirrels. Between 1 percent and 40 percent of snowshoe hares survive each year.

SLIDE #13: ALASKA IS NOT IMMUNE

Alaska has been resistant to invasive plants common in the lower 48 due to partial geographic isolation, temperature extremes and limited development. However, many problematic invasive plant species are showing up here, becoming established and spreading along roads, trails and streams

SLIDE #14: ORANGE HAWKWEED

Chemical warfare – Orange hawkweed (*Hieracium auranticum*) has the ability, called allelopathy, to excrete special chemicals from the roots to effectively

poison potential competitors. This is one of the adaptations that make it such a successful invader.
Garlic mustard (*Allaria petiolata*) also has allelopathic abilities and has begun to invade areas in Southeast Alaska.

SLIDE #15: KODIAK

Can non-disturbed areas become invaded? Yes, although disturbance such as excavation or road building, often give an invasive a start. Some of the special adaptations of invasives make them very difficult to remove – many of them, such as orange hawkweed, have hardy seeds that remain viable for 8 or more years! Eradication attempts are expensive and may take many years before they show signs of success.

SLIDE #16: OTHER EFFECTS: AGRICULTURE, RECREATION, AESTHETICS

Invasion causes need for increased agricultural inputs (herbicide, pesticides and fertilizer). Some farmland has even been abandoned due to invasive weed infestations (eg. leafy spurge).
White sweetclover may have been imported to Alaska via imported forage and roadside seeding projects.
In Alaska it is spreading rapidly along exposed, sandy riverbanks. An infestation was found near the Anchor River in August, 2006 and removed by UAF Cooperative Extension and Homer Soil and Water District.
Sweetclover has special root nodules where a communal association with bacteria allow it to fix nitrogen. This benefit may gives it a substantial edge on native species.

SLIDE # 17: REED CANARY GRASS

Reed canary grass (*Phalaris aurundinacea*) is of considerable concern in Alaska and the Kenai Peninsula. It is known to readily invade wetland habitats and alter stream hydrology. It grows in dense stands creating mats of vegetation that are unsuitable for waterfowl. Resource managers are also concerned that it may alter stream channel "scouring" that provides habitat essential for spawning salmon (AKEPIC, 2005).

SLIDE #18: ORNAMENTAL PLANTS CAN BE INVASIVE?

Purple loosestrife (*Lythrum salicaria*) is an ornamental sold in some locations in Alaska and may be found in some seed mixes.
It can rapidly infest wetland areas and threaten salmon streams. It is reported to invade 20,000 acres of wetlands per year in the US. (Blossey et al, 2001)
Most ornamental and other non-native plants are NOT invasive and alternatives can often be found to replace invasives

SLIDE #19: INVASIVE PLANTS CAN ALSO IMPACT AQUATIC SYSTEMS

SLIDE #20: INVASIVE PLANTS CAN ALSO IMPACT AQUATIC SYSTEMS

Purple loosestrife is a prolific seeder (120 seeds per capsule and up to 900 capsules per plant). Outside of Alaska it quickly outcompetes native wetland plants and also alters wetland function by increasing evapotranspiration and changing decomposition rates (AKEPIC, 2005). It can also offset timing of nutrient inputs to salmon streams, compared to native species (AKEPIC, 2005). This ornamental plant was found escaped from cultivation at Chester Creek in Anchorage – volunteers removed it

But… From news reports

"So it's just one hop away from Potter Marsh, and then it's just one hop away from the Kenai Peninsula, where fishing industry is huge," Jamie Snyder (UAF Coop Ext) said.

"This plant, if it were to get established in Potter Marsh, would absolutely cover the marsh," said Michael Shephard, plant ecologist with the state and private forestry office of the U.S. Forest Service. "There would be no more geese, no ducks, no terns, no swans." (AP, 2005)

SLIDE #21: INVASIVE PLANTS CAN ALSO IMPACT AQUATIC SYSTEMS

Effects of the purple loosestrife invasion can travel up through the food web to higher levels including predators such as eagles.

In this simple example, all trophic levels and groups would be directly or indirectly affected.

SLIDE #22: EXPANSION OF PURPLE LOOSESTRIFE IN MASSACHUSETTS

It has already overtaken many wetland areas in the Eastern US and has spread throughout states such as Massachusetts. Control efforts have been costly and mostly unsuccessful.

SLIDE #23: WHY ARE INVASIVE PLANTS SUCCESSFUL?

When a plant is introduced to an ecosystem they may “escape” the pressure of the herbivores in its native range that helped keep the population in check. Native herbivores may not graze on non-native plants and attempts have been made in some cases to introduce natural predators to control invasive plants (biocontrol). The weevil pictured has been released in the Western US to control yellow toadflax (*Linaria vulgaris*) which is a common ornamental plant in Alaska. http://www.bio-control.com/7i.asp

SLIDE #24: WHY ARE INVASIVE PLANTS SUCCESSFUL?

Invasive plants often produce a large number of seeds that are well adapted for dispersal. Orange hawkweed (pictured) has seeds that are similar to common dandelion that can be carried miles from the parent plant. Other species have barbs to attach to passing animals that can carry them far into the backcountry.

SLIDE #25: WHY ARE INVASIVE PLANTS SUCCESSFUL?

SLIDE #26: WHY ARE INVASIVE PLANTS SUCCESSFUL?

Yellow toadflax (pictured – also called butter and eggs), spreads with lateral underground stems (rhizomes). Clones of the parent plant emerge from rhizomes and can resprout from impossibly small root fragments. This makes them very difficult to remove and mowing can actually further their spread.

SLIDE #27: WHY ARE INVASIVE PLANTS SUCCESSFUL?

Canada thistle (*Cirsium arvense*) has a massive root system and can grow up to 18 feet in length a year.
http://ipcm.wisc.edu/uw_weeds/extension/articles/CPpics/CanadaThistle03.htm

SLIDE #28: WHY ARE INVASIVE PLANTS SUCCESSFUL?

Being able to take advantage of a variety of environmental conditions is a common trait among invasive plants.
Many invasives establish in marginal habitats such as roadsides that may be dry, nutrient-poor and inhospitable to most native plants.
Several species of clover (pictured - *Trifolium spp.*) are used as forage and have been seeded along roadsides. However, unlike invasive plants, it does not typically spread into undisturbed sites.

SLIDE #29: WHERE ARE THEY COMING FROM?

Invasive plants are coming into Alaska from a variety of sources:
Most significantly are via ornamental plants, imported forage and roadside seeding projects, but also by hiking tourists and earth moving machinery.
They spread rapidly with disturbed soils on roadsides, trails, seismic lines and along streams.
Invasive plants are also spread through non-anthopogenic (not human caused) routes carried by wind, water and migratory birds and animals.
Aquatic invasive plants are transported with boats, imported aquarium plants and floatplanes.

Topic For Discussion

Is biological invasion a process that would occur without humans?
How have human affected the rate of invasion? Why? What effect will global warming likely have for invasives in Alaska?

SLIDE #30: INVASIVE PLANTS CAN BE EXPENSIVE…

Estimated cost to the US economy by invasive species is >$137 billion a year (Pimental et al, 2000)
Mediterranean star thistle (*Centaurea solstitialis*), not yet recorded in Alaska, has led to a decline in available water valued at $16–56 million a year in California (http://www.plant-talk.org/stories/24edit.html) (Chapin et al, 2000).
Canada thistle is very difficult to remove!
It produces 1,500 seeds per plant on average and up to 5,300.
Roots can grow horizontally, up to 18 feet a year and hold 1.5 years worth of carbohydrate reserves (Nuzzo, 1997).

Over 1.7 million acres are infested with Canada thistle in South Dakota and it costs them an estimated $47.8 million dollars in lost agriculture production (South Dakota State University Cooperative Extension Service, 2003).

SLIDE #31: WHAT CAN I DO?

Preventing the import and establishment of invasive plants is the best and cheapest way… Education plays a VERY important role in this task.
Get involved! Remove invasives and help with weed pulls. Let others know about invasive plants and don't buy "wildflower" seed mixes with unknown components.

Topic for Discussion

Knowing where they are coming from – how could you keep invasive plants from entering Alaska?
How could you remove what is already here? Will a law solve this problem?

SLIDE #32: MORE INFO

SLIDE #33: CONTACT INFO

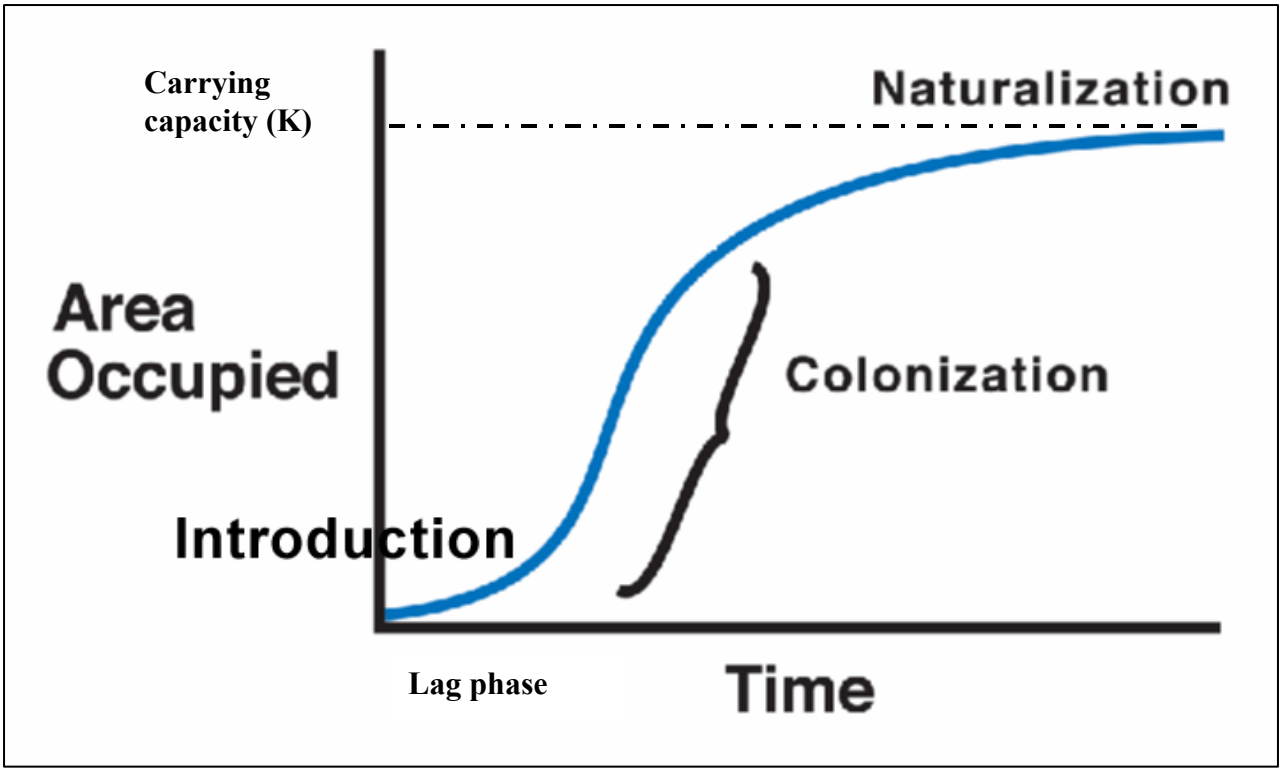
1. Introduction and Lecture Notes

b. Diagrams and handouts

The following handouts are a resource that can accompany the MS Powerpoint presentation file and lecture notes above or may be used separately. The handouts are listed below with suggested placement into the lecture or other potential uses.

	Use in lecture	**Other uses:**
The Phases of an Invasion	After Slide # 7	Good for a discussion of plant population dynamics to preface Plant Competition Lab 1: § 3
Setting Priorities Graph	After Slide # 7	Relevant to the inquiry activity "Callin' the Shots" § 2a
By the Numbers Handout	N/A	An interesting collection of numerical facts about invasive species can be used to introduce the topic of invasives and MS Powerpoint lecture.
Invasive Overview Map	After Slide # 13	Can be used to introduce the Web-based Mapping Exercise: § 4b
Invasive Ornamentals Map	After Slide # 17	Also a good visual for intro or follow-up to the Web-based Mapping Exercise in § 4b

Phases of an Invasion



This graph illustrates the typical stages of the invasion process. Cousens and Mortimer (1995). The initial phase after introduction is sometimes referred to as a "lag phase" because of the time preceding a rapid increase in population during colonization. The decrease in expansion occurs as the plant population approaches the carrying capacity (K) of available environmental resources.

INTRODUCTION →	**COLONIZATION →**	**NATURALIZATION**
individual plant	expands to a population of plants	populations expand to groups of populations (meta-population)

THE LAG PHASE can be caused by:
+ Environmental factors prohibiting colonization until disturbance or other alteration favors spread
+ Genetic factors which limit colonization until adaptation allows spread in novel environmental conditions
+ Or normal time required by species for range expansion

Setting Priorities: Value of Early Eradication

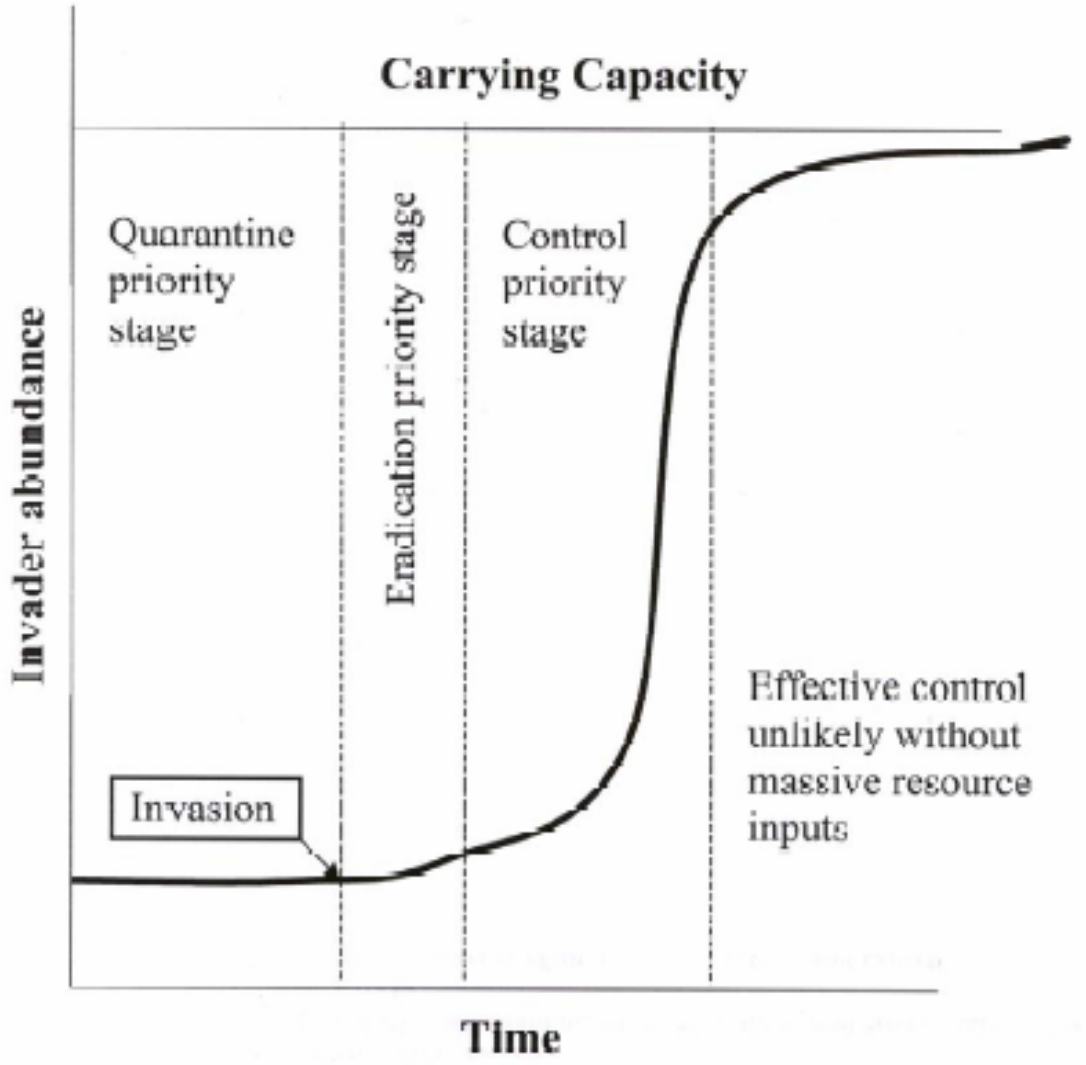


Figure from Hobbs, Richard J. and Stella E. Humphries. 1995. An integrated approach to the ecology and management of plant invasions. Conservation Biology 9(4): 761-770.

BY THE NUMBERS HANDOUT:
Invasive Species: Facts and Figures

• Invasive species are found on agricultural cropland and in natural and urban areas, and can be either terrestrial or aquatic. Invasive species represent all taxonomic groups- plants, animals and microorganisms- and cause harm by multiplying rapidly, crowding out native species, damaging agricultural and industrial resources and generally altering natural systems.[1]

• The invasion of nonnative species is the second greatest threat to rare, native species and the integrity of ecosystems.[2]

• More than 50 percent of species listed as threatened or endangered under the Endangered Species Act are adversely affected by nonnative plant, animal and marine species.[3]

• Nine out of 21 of the most endangered ecosystems in the U.S. are significantly impacted by exotic invasions.[4]

• 80 percent of the nation's fish communities are considered degraded because of decline or loss of native species and introduction of exotics.[5]

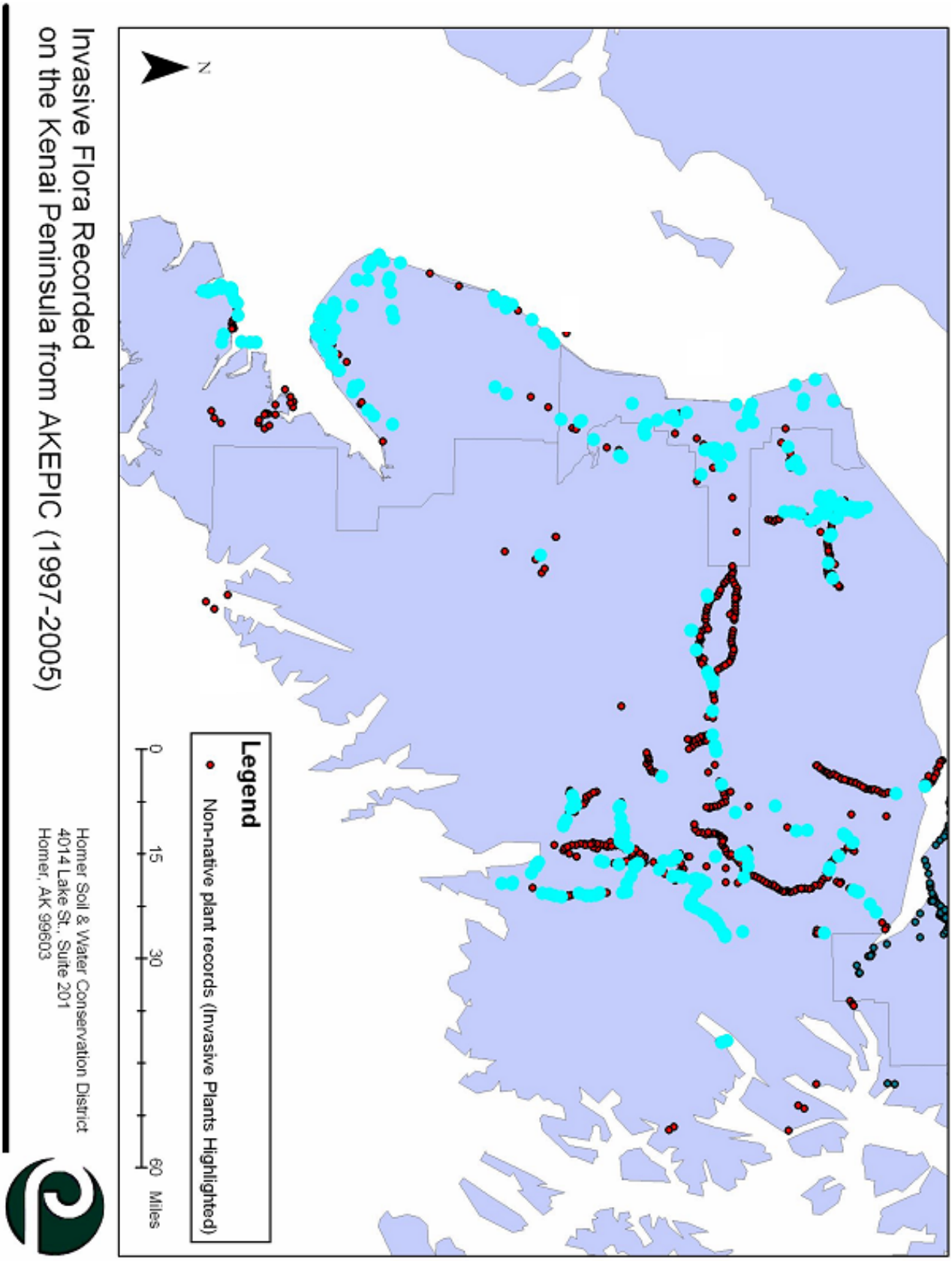
• The U.S. spends $120 billion annually on the control and impacts of more than 800 invasive species infestations. This does not account for the values of species extinctions and losses in biodiversity, ecosystems, services and aesthetics.[6]

• 126 million acres of land in the 48 contiguous United States are infested by 16 invasive plants, which does not account for all invasive plant infestations throughout the country.[7]

1 GAO, "Invasive Species: Clearer Focus and Greater Commitment Needed to Efficiently Manage the Problem, GAO-03-1 (Washington, DC.: Oct. 22, 2002); "Invasive Species: Federal and Selected State Funding to Address Harmful, Nonnative Species, GAO/RCED-00-219 (Washington, D.C.: Aug. 24, 2000).
2 Flather, C.H., L.A. Joyce and C.A. Bloomgarden. "Species Endangerment Patterns in the United States." USDA Forest Service Technical Report RM-241. Fort Collins, CO, 1994; Miller, R.R., J.D. Williams, and J.E. Williams. 1989. "Extinctions of North American fishes during the past century." Fisheries 14: 22-38; Williams, J.E., J.E. Johnson, D.A. Hendrickson, et al.; Scemske, D.W., B.C. Husband, M.H. Ruckelshaus, et al. 1994. Cited by Noss, Reed F. & Robert L. Peters, "Endangered Ecosystems: A Status Report on America's Vanishing Habitat and Wildlife." Defenders of Wildlife, Dec. 1995, p. 46.
3 Flather, C.H., L.A. Joyce and C.A. Bloomgarden; Scemske, D.W., B.C. Husband, M.H. Ruckelshaus, et al. 1994. Cited by Noss, Reed F. & Robert L. Peters, "Endangered Ecosystems: A Status Report on America's Vanishing Habitat and Wildlife." Defenders of Wildlife, Dec. 1995, p. 47.
4 Noss, Reed F. and Robert L. Peters. "Endangered Ecosystems: A Status Report on America's Vanishing Habitat and Wildlife." Defenders of Wildlife, Dec. 1995.
5 Noss, Reed F. and Robert L. Peters. "Endangered Ecosystems: A Status Report on America's Vanishing Habitat and Wildlife." Defenders of Wildlife, Dec. 1995.
6 Pimental, David, Rodolfo Zunigo and Doug Morrison. "Update on the environmental and economic costs associated with alien-invasive species in the United States." College of Agriculture and Life Sciences, Cornell University, 2004.
7 Duncan, Celestine A. and Janet K. Clark. "Invasive Plants of Range and Wildlands and Their Environmental, Economic and Societal Impacts." Weed Science Society of America, pg. 3.

From: North American Weed Management Association (2006)
http://www.nawma.org

AKEPIC – Alaska Exotic Plant Information Clearinghouse (http://akweeds.uaa.alaska.edu)



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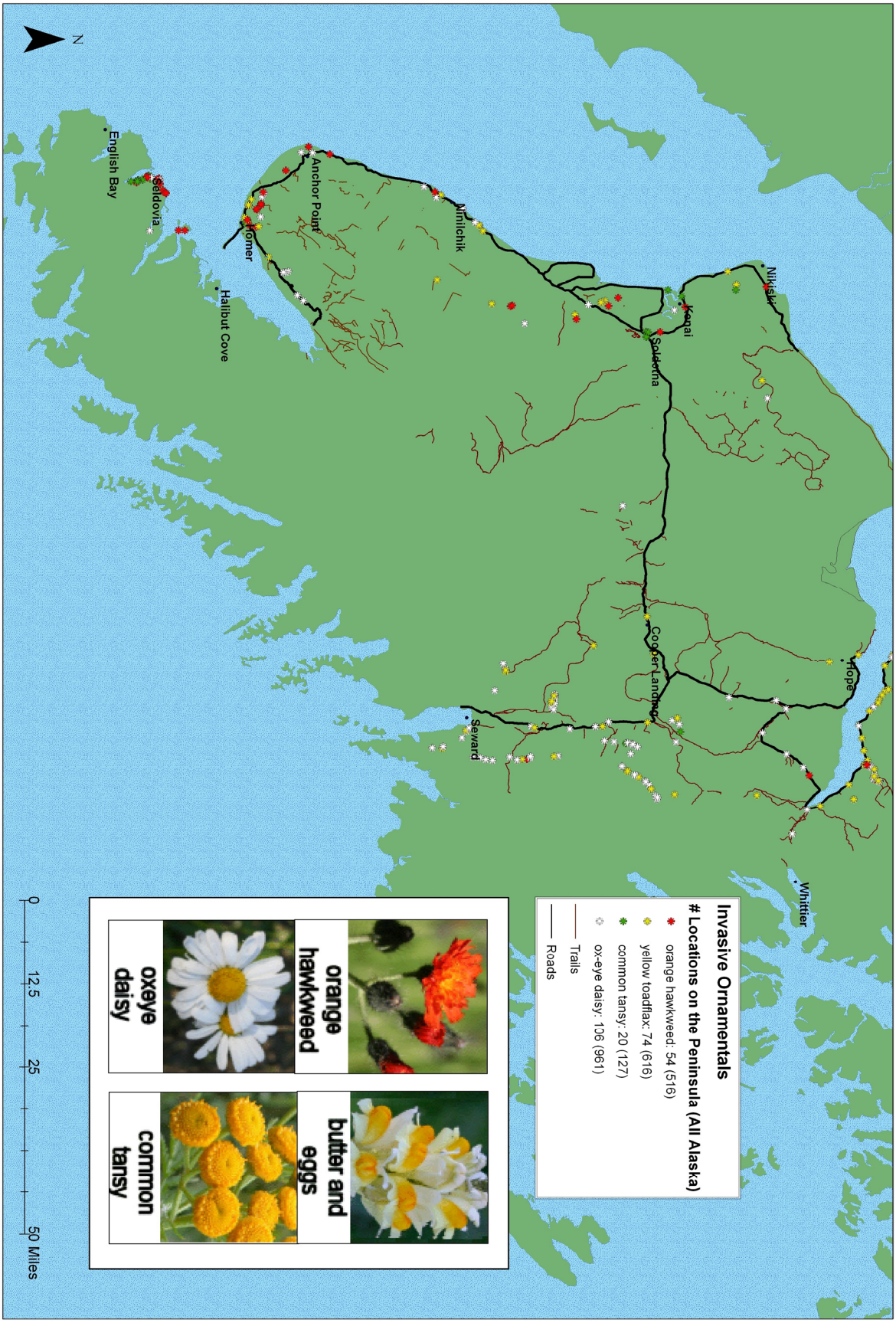


Ornamental Plants Invading the Kenai Peninsula from AKEPIC Records (1997-2006)

Homer Soil & Water Conservation District
4014 Lake St., Suite 201
Homer, AK 99603

2. Inquiry Activities

a. Callin' the Shots

CLASS TIME: 60 min

Objectives:

1. To challenge students in formulating ideas about controlling an incipient population of an aggressive invasive plant.

2. To facilitate understanding and critical consideration of the complicated issues of a real-world environmental concern.

Instructions:

1. Groups of 2-3 students can work together for this exercise which is intended to give the students an opportunity to think critically about the best way to deal with an early infestation of an invasive plant.

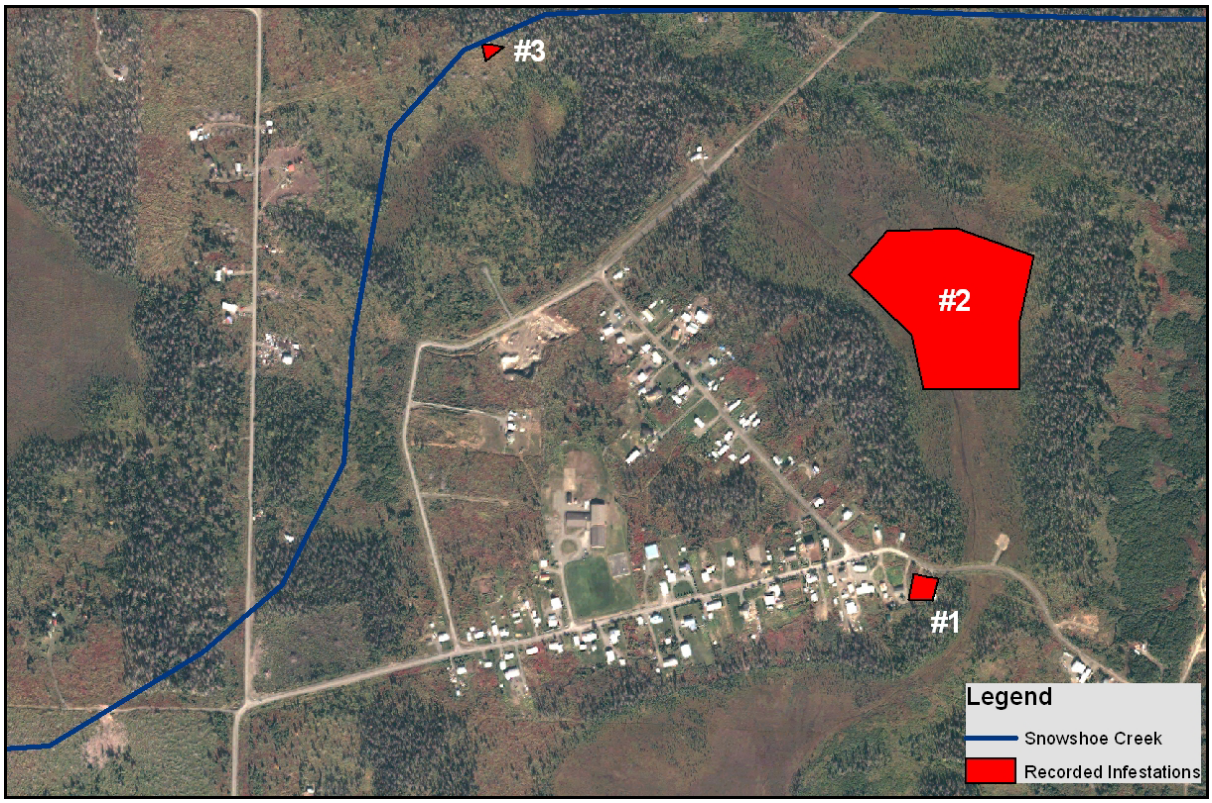
2. Propose the following the following potential situation in Alaska to the students:

"A new invasive plant has found its way to Alaska and has the potential to spread rapidly. Fortunately your team is on the case! As a natural resource expert your job is to research information about the invasive plant and work with local landowners contain and eradicate the invader before it spreads out of control."

3. One person in the group should be responsible for reading the decisions and keeping track of points (budget). There is a tally sheet to keep track of the budget on the last page. The others should get a copy of the map and site descriptions and "call the shots". There are also some questions for the students to answer and review what they have learned when they complete the exercise.

Callin' the Shots

A new invasive plant has found its way to Alaska and has the potential to spread very rapidly. As a natural resource manager your job is to help to contain and eradicate the invader and restore the affected lands. So far surveys have recorded it at only three locations on the Kenai Peninsula and all are still relatively small patches in your local community:



#1 – This infestation is **0.5 acre** in size and scattered in the lawn of a local mechanic named Gary West. This site was infested because he transplanted some of the plants from the park (#2). He seems willing to eradicate the plant because it is ruining his lawn.

#2 – The largest of the infestations is about **2.5 acres** of a nature preserve and creeping into the adjacent woodlot. Pam Stark, a maintenance manager, accidentally introduced the invasive by planting ornamental trees along the parking lot from Oregon that had weed seeds hitchhiking in the roots. She would like some help to correct this problem.

#3 – A very small infestation of only **two or three plants** in a somewhat remote setting. The source of this infestation is unknown but the owners, Carol and Mark Sanders, think the plants are "pretty" and are currently not willing to cooperate with the control effort.

Time to get to work! Initially you have to decide on a strategy about what sites to address first. Then you will have to work with the various landowners and come up with a solution that will work for everyone. Whew… This is going to be tough but if you choose your decisions wisely you can be a tremendous help to your community. If you are successful you can help protect local native plants, animals, agriculture and the tremendous cost of treating infestations once they become widespread.

Let's get started! You start on your first site with a budget of (+$5,000).

I. Unfortunately there is only enough funding this year to work on controlling one site. Your decision should be based on the size of the area which will determine how effective you are and the cost of control. Another important consideration should be the potential for spread from the site. What site do you want to work on first?

A. Get started working on site #3.....go to II
B. Work on addressing site #1…….....go to VII
C. Work on addressing site #2……..……..……go to X

Stephanie Sims from the Kenai Watershed Forum maps an infestation of invasive reed canary grass.
(Photo: Janice Chumley, Kenai Soil and Water Conservation District)

II. If you selected this site as the first to address, you chose wisely since it is the smallest and it will be the easiest to effectively control. It also has a high potential for spread since the Snowshoe Creek is nearby. You receive (+$5,000) grant for your decision to work on this high-priority site first. The landowners may need some convincing though… What do you want to do?

A. Plan on meeting with the landowners …….go to IV
B. Since it is just a few plants, you just wait until the landowners are not home and pull up the plants.....go to III

III. It may have seemed like a good idea but a neighbor saw you pulling up the plants and notified the landowners. They contacted your boss and you have to go take a class about public involvement which costs (- $2,000). Deduct this amount from your budget and .....go back to II

IV. The landowners refuse to meet with you because they are concerned that they will be forced to participate and claim that they have not had a problem with the plant spreading outside their yard. How would you like to proceed?

A. Write an editorial to the local paper to inform others that they are spreading the invasive and are unwilling to cooperate.....go to VI
B. Send a letter to the property owners that will help them understand problems the invasive plant can cause if allowed to spread.....go to V

V. A few weeks after receiving the letter, Carol Sanders comes by the office to learn more about the invasive plant and to talk about what it may take to control it. You explain that since it is only a few plants it can simply be carefully pulled (being sure to get all of the roots) and you even suggest an alternative plant that is similar but not known to be invasive.

She is finally appreciative for bringing it to their attention and offers to remove the plants herself. Great job! By taking a cautious approach you have avoided upsetting the landowner, successfully contained the infestation and saved the added cost of legal fees. Your boss is so impressed that you are offered (+$5,000) to add to your budget. If you have not addressed the other sites.....go to I and select another site to work on

VI. The landowners are infuriated that you gave them such a bad name in the community. They call your office and inform them that they are pursuing legal action for defamation of character. A lawyer mediates a settlement of (- $2,000) and you do not have the opportunity to work on control at this site.

VII. Although this site is important (near a road) and the landowner is willing, it is not the highest-priority site. If you selected this as your first site to address, deduct (- $2,000) from your budget, because you missed the opportunity to work on the most important site first. As such it is going to cost a bit more to do control since the plants have already begun to spread at that site.

Fortunately the land owner, Gary, has been around long enough to see the damage that has been caused by the invasive plant at the nature preserve. He also is concerned that it will overtake and ruin his lawn. So how do you want to proceed?

A. Begin chemical control using a professional contractor right away and follow up with reseeding the lawn..... go to VIII
B. Get volunteers to help with the control effort and use it as an outreach opportunity to get the word out about this invasive plant.....go to IX

VIII. The control effort is going well but members of the community are concerned about what is going on. Rumors are going around about some “alien” weed and poisonous spray is being used. You probably should have involved the public so that they support what you are trying to do. All of the rumors are getting out of hand so you have to have a public meeting to set the record straight. The meeting cost (- $1,000). Deduct this from your budget and..... go back to VII.

IX. The volunteers are very enthusiastic about helping to control the spread of this invasive weed. An added benefit of having volunteer help is that they spread the news to their friends. The mayor hears about your work and awards you a "community improvement grant" (+$5000). The control work is a success and greater awareness in the community insures that local citizens will be watching for other invasive weeds. If you have not addressed the other sites.....go to I. and select another site to work on

Volunteers learn to identify invasive weeds and get "hands on" experience pulling infestations near Kenai, AK (Photo courtesy of: Janice Chumley, Kenai Soil and Water Conservation District).

X. Although it is tempting to treat the largest site first, it is not the highest priority for control. If you selected this site to control **first or second**, deduct (- $5,000) from your budget since the other sites have spread and will cost more to treat. Because the core infestation is somewhat isolated and will be the hardest and most expensive to treat, it should be dealt with last. The sites that are smallest and most likely to spread (close to stream, trails etc) are the most important, as they represent the "leading edge" of the infestation

If you have not completed work on the other sites.....return to I and select another site.

Once you have defused the other two spot infestations, you are ready to take on the final site. Now you are ready to work on controlling the "core" infestation. The maintenance manager, Pam, is willing to defer to your knowledge. How do you want to perform control at the site?

A. Get volunteers from the local community to participate in a weed pull and follow with re-vegetation of native plants..... go to XII
B. Get volunteers from the local community to participate in a weed pull..... go to XIII
C. Utilize both a chemical (herbicide) and mechanical (mowing) treatment followed by re-vegetation by volunteers with native plants.....go to XI

XI. This is a great decision! By not relying on only one method of control you are much more likely to be successful. This concept is called "integrated pest management" and the approach states that the most effective control efforts take into account (and take advantage of) the biology of the pest.

By planting native plants you have reduced the likelihood that the site will become re-infested. The volunteer assistance also saved your program some much needed funds, so add (+$5,000) to your budget. It also got the public involved and increased the awareness of the invasive plant issue. .....go to XIV

XII. It is great to use volunteers and re vegetate the site but depending on pulling all the weeds at such a large site is unlikely to be successful. Your volunteers are worn out and feel that it's a waste of time to try to pull it all. The native plants begin growing but are soon smothered by the invasive plants that were missed. It cost less money to only pull the weeds but they came right back! Deduct (- $1,000) from your budget and try again..... go to X

XIII. Your volunteers are worn out and feel that it's a waste of time to try to pull it all. Even the areas that were cleared are quickly being overtaken because the soil is bare and no plants are competing with the remaining weeds. It cost less money to only pull the weeds but unfortunately they came right back! Deduct (- $2,000) from your budget and try again..... go to X

XIV. Nice work! See how your budget stacked up at the end and answer the questions below as a group. Try going through the exercise again and see if you can get a perfect score!

Budget Tally.

Start: ($5000)	(+)			
				End:

How did you stack up? What was your ending budget?

Broke - $5,000	$6,000-15,000	$15,000 – $25,000
NOVICE	SPROUT	WEED WARRIOR

Callin' the Shots: Follow-up Questions

1. What were your reasons for selecting the first site to begin work on?

2. What did you find about the benefits of having the public involved in what you were doing? What other benefits could also come from having people in the community involved?

3. What sort of mistakes did you make and how would you be able to do a better job the next time?

4. What would you propose to do to insure that the invasive weed did not come back?

5. There often many different ways to solve an environmental problem such as the one in this exercise. Did you think of another way of controlling the invasive plant infestations? What are the benefits? Drawbacks?

b. Just the Facts! Invasive plant factsheet

CLASS TIME: 40 min

Objectives:

1. To sharpen student's research skills and independently investigate the crucial facts about an aggressive invasive plant.

2. To summarize reports and literature into a one page fact sheet that can be posted to inform other students and faculty about an aggressive invasive plant in Alaska.

Instructions:

1. First, students will select or be assigned an invasive plant that has been recorded in Alaska to research (Canada thistle, spotted knapweed, purple loosestrife, Japanese knotweed or reed canarygrass).

These are listed on the curriculum webpage with some links at: http://www.homerswcd.org/invedu/otherinv.htm

Some other options are ornamental jewelweed, Tatarian honeysuckle, garlic mustard and white sweetclover.

2. Have the students do library/internet research to fill in the crucial facts on the fact sheet below about their invasive plant. An excellent place to get started is US Department of Agriculture's PLANTS database at http://plants.usda.gov. They need to support their findings by citing the references from which they draw their information.

Students should not "cut and paste" information drawn solely from internet resources. Instead, encourage them to draw from a variety of resources and synthesize the information into the fact sheet.

3. They should also attach a drawing and highlight key characteristics that will allow positive identification.

4. Once fact sheets are complete they can post them at school or a public bulletin board in their community.

INVASIVE WEEDS FACT FILE

Common name (s): _____

Scientific name: _____

Description and drawing:

_____

_____

_____

_____

_____

_____

_____

_____

_____

What does it do? What are the impacts?

How does it spread?

How can you control it?

Literature Cited:

3. Comprehensive Labs

LAB 1: PLANTS PROTECT THEIR TURF! A LAB IN PLANT COMPETITION

Adapted from Ganter (2003). **TOTAL CLASS TIME: 80 min**

Objectives:

1. To investigate the possibility that invasive plants compete with native plants for limited resources
2. To measure the effect of increasing competition on the native (target) plant
3. Connect these ideas to understand how invasive plants can damage native plant communities and the wildlife that depend on them

Materials needed:

Planting flats with 2x2 cell inserts
Potting soil
Alfalfa seeds
Rulers
Spinach seeds
Grow-lights or south-facing window

LAB 1 EXTENSION: COMPETITION AND NUTRITION

TOTAL CLASS TIME: 80 min

Objectives:

1. Build on the concepts of LAB 1 by investigating the effect of nutrient availability on competition.

Additional materials: Miracle Gro® water-soluble fertilizer (24-8-16)

LAB 2: INVASIVE PLANTS FIGHT DIRTY: INVESTIGATING ALLELOPATHY

Adapted from Frame et al. (2000). **TOTAL CLASS TIME: 50-80 min**

Objectives:

1. Introduce the concept of allelopathy and determine how it can affect plant germination and growth
2. Develop an understanding that invasive plants have special adaptations to help them outcompete native flora

Materials needed:

Seeds (radish, spinach, lettuce)
Petri dishes
Plastic wrap or parafilm
Disposable pipettes and Scissors
Beaker (50 mL or larger)
Grow-lights or south-facing window

If growing alfalfa for extract*:

Planting flats with inserts
Potting soil
Alfalfa seeds

*NOTE: You have the option of growing your own alfalfa sprouts or purchasing them in the health food section of your local grocery store

LAB 1: PLANTS PROTECT THEIR TURF! A LAB IN PLANT COMPETITION
Adapted from Ganter (2003).

Introduction:

OK, so we all know that animals, like bears, lynx and wolves (oh my!) compete and struggle for limited food and other resources. Did you also know that plants compete with each other in much the same way? Plants compete for light, nutrients, water and space. Once rooted, plants have limited opportunities to move around and seek food so it's essential that they "protect their turf".

Plants have adapted a variety of strategies to compete with their neighbors when they get too close. Some plants germinate very early in the spring to get ahead of its neighbors. Some plants may reach far beyond their neighbors for water and nutrients by growing long, deep roots. Some even release toxins to prevent the growth of other plants (see Lab 2)! Invasive plants are superior competitors which is part of the reason they can take over and grow out of control. In this lab you will test effects of increasing competition as your native "target plant" struggles to protect its turf.

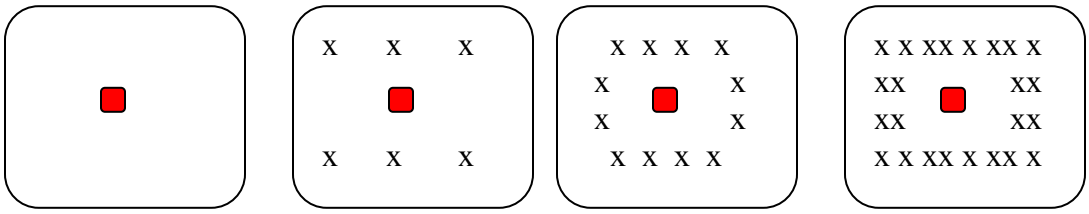
Lab Procedures:

DAY 1

1. Obtain two, 2x cell inserts for planting and fill to top with moistened potting soil.

2. Make a shallow (1/2") indentation (a pencil eraser works well) in the middle of each cell to plant the seeds. Carefully drop two spinach seeds in the indentation. This will be your "target plant" and will represent the native plant under competition for this lab

3. In three of the cells, place additional, evenly spaced indentations around the target for planting 6, 12 and 24 "invading" neighbors. One cell should have no neighbors and will be used to compare with those plants under competition.



Target plant (spinach) **x** – Invasive competitors (alfalfa)

4. Carefully drop two alfalfa seeds into each of the indentations and label each cell with your initials, date and number of competitors.

5. Barely cover with a small amount of soil, spray with water and place into a planting flat containing a ½ gallon (3.7L) of water. Place under growing lights if available (16h

light). Soil should be kept fairly wet until plants have germinated and water should be added to the flat as needed. NOTE: Using a clear, plastic lid (available at most greenhouses or garden supply stores) will help maintain moisture and maximize germination. It can be removed when plants are about 5 cm tall.

6. Make a prediction (hypothesis) about the growth of the target plant which you will measure in the following weeks.

DAY 3-15

1. If two plants have sprouted at each position of the cell, carefully thin by snipping off the smaller of the two plants at the soil surface with scissors and discard.

2. Measure and record the height of the middle or target plant and record number of leaves. Also make notes about anything else you notice about the invasive neighbors or how the plants are growing.

DAY 18-25

1. Make your final observations and plot them on a graph.

2. Summarize the outcomes in a lab report. Key questions to answer:

a. Did the data you collect support your hypothesis?

b. Which target plants would you predict to make the most seeds? Why?

c. What would happen to the native plants if the had to compete with larger and larger numbers of invasives?

LAB 1 EXTENSION: COMPETITION AND NUTRITION

Introduction:

One of the ways that plants compete with one another is for essential, but limited, nutrients in the soil. Plants need soil nutrients such as nitrogen and phosphorus to photosynthesize and grow. Many invasive plants have special adaptations that allow them to outcompete native plants in gathering nutrients. In this lab, you will investigate how the availability of nutrients can affect plant competition.

Lab Procedures:

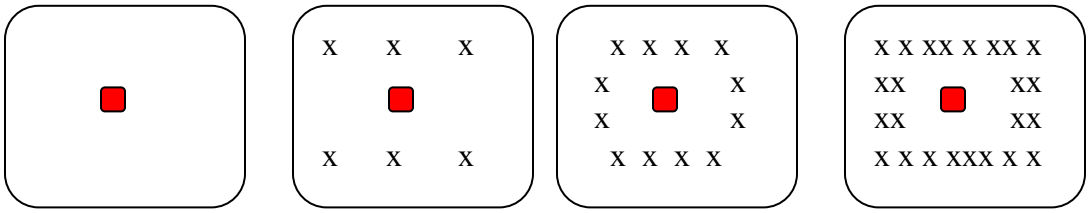
DAY 1

Prepare **TWO** sets of plants (8 cells) as in Lab 1 by
1. Obtaining four, 2x cell inserts for planting and fill to top with moistened potting soil.

2. Make a shallow (1/2") indentation (a pencil eraser works well) in the middle of each cell to plant the seeds. This center plant will be your "target plant" and will represent the native plant under competition for this lab. Carefully drop two spinach seeds in the indentation.

3. In three of the cells, place additional, evenly spaced indentations around the target for planting 6, 12 and 24 "invading" neighbors. One cell should have no neighbors and will be used to compare with those plants under competition.

4. Carefully drop two alfalfa seeds into each indentation and label each cell with your initials, date number of competitors.



Target plant (spinach) **x** – Invasive competitors (alfalfa)

5. Barely cover with a small amount of soil, spray with water and place **ONE SET** into a planting flat containing a ½ gallon (3.7L) of water. **ONE DUPLICATE** should be set in a separate flat containing ½ gallon (3.7L) of dissolved Miracle Gro® fertilizer (24-8-16) solution (1/2 teaspoon).

6. Place under growing lights if available (16h light). Soil should be kept fairly wet until plants have germinated and water should be added to the flat as needed.

7. Make a prediction (hypothesis) about the growth of the target plant which you will measure in the following weeks.

DAY 8

1. If two plants have sprouted at each position of the cell, carefully thin by snipping off the smaller of the two plants at the soil surface with scissors and discard.

2. Measure the height of the middle or target plant and record number of leaves on the datasheet. Also make notes about anything else you notice about the invasive neighbors or how the plants are growing.

DAY 15-25

1. Make your final observations and plot them on a graph.

2. Summarize the outcomes in a lab report. Key questions to answer:

a. Did the data you collect support your hypothesis?

b. How did the plants grown with added nutrients compare to those without fertilizer? Does it appear that nutrients were limiting the growth of the target plant? What about the competitors (invasives)?

c. Which target plants would you predict to make the most seeds? Why?

LAB 2: INVASIVE PLANTS FIGHT DIRTY: INVESTIGATING ALLELOPATHY
Adapted from Frame et al. (2000)

Introduction:

Plants may seem quiet and polite but when it comes to competition with other plants – it can get downright DIRTY. Some plants, native and non-native, even have the ability (called allelopathy) to excrete poison to potential competitors. This is one of the many adaptations that can give invasive plants, such as orange hawkweed, a "leg up" on natives. In this lab you will prepare an extract from plant tissues and test its ability to affect seed germination. For this exercise, the seeds of three different plants (radish, spinach and lettuce) will represent native plants and you will test the allelopathic effect of alfalfa on their germination.

Lab Procedures:

DAY 1

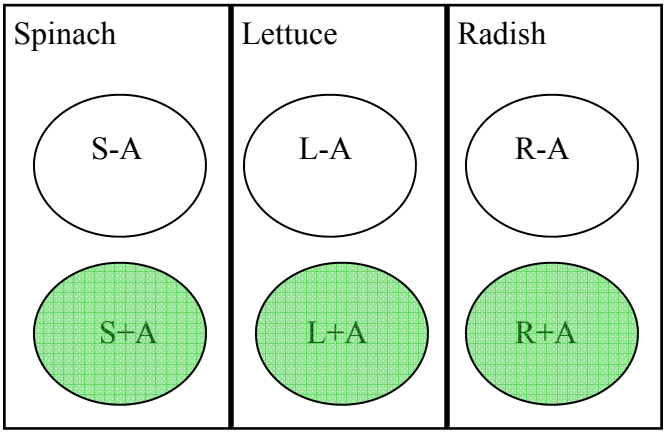
1. Plant one flat with 2x2 cells with approximately 10g of alfalfa seeds that are spread evenly across the surface

2. Moisten the soil by placing ½ gallon (3.7L) of water in the bottom of the planting flat. Water will wick up into the soil. Sprinkle a small amount of soil over the seeds and mist with water. Keep soil very moist until plants have germinated and are beginning to grow. Place under grow lights or a well-lit area.

DAY 12

1. Harvest alfalfa sprouts by clipping off stems at the soil surface. Collect 10g for each group and place in 50 mL of distilled water. Cover and place in a cool area in the lab for three days.

2. Each group should set out six Petri dishes and label as follows: S+A, S-A, L+A, L-A and R+A, R-A



DAY 15

1. Petri dishes should be lined with filter paper or a single sheet of paper towel.

2. Evenly distribute 20 seeds of radish, spinach and lettuce into the corresponding labeled dishes

3. Stir up the alfalfa extract prepared on DAY 12. Use a pipette to water each dish (+A) with 10mL of the alfalfa extract and each (–A) dish with distilled water.

4. Cover each with cellophane film and place under grow lights or a well-lit area. Make a prediction (hypothesis) about which seeds will have the highest rate of germination.

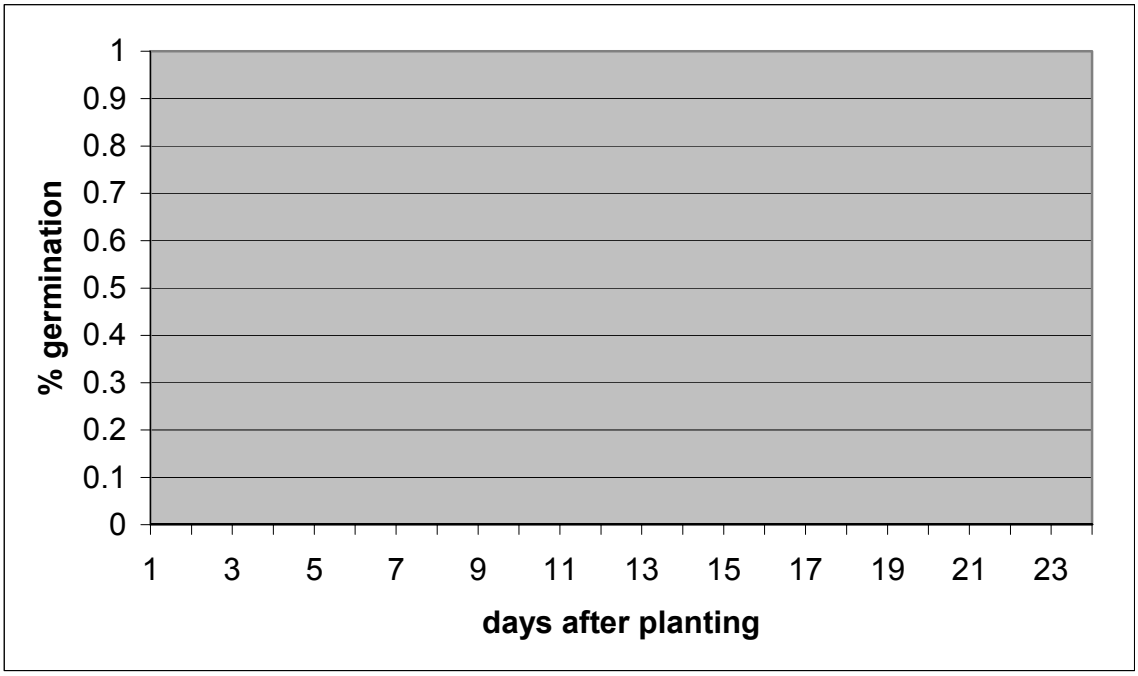
DAY 16-25

1. Make daily observations of the seeds and note the number of seeds germinated (seed coat broken). Calculate the % germination by:

seeds germinated per dish / total number of seeds per dish (20)

Also you should observe and record notes of the seedlings appearance as they emerge (ie. color, root lengths etc). If possible, measure a subset (10) of roots/shoots at the end of the experiment.

2. Summarize your data by preparing a graph of the number of seeds germinated over time. Write a brief lab report summarizing your results.



○- (S-A) ●-(S+A) □- (L-A) ■- (L+A) Δ- (R-A) ▲- (R+A)

LAB 2: INVASIVE PLANTS FIGHT DIRTY: INVESTIGATING ALLELOPATHY

VARIATION: Some of the students in the class can experiment with the concentration of the plant extract added to the Petri dishes in step 1 on Day 12 of the Lab. Have them label their beaker "2X" and increase the amount of plant tissue to 40grams. Dilute the tissue in 100mL of distilled water. This will give them 2X the ratio of tissue/solvent utilized by the other group to start and enough to make a dilution.

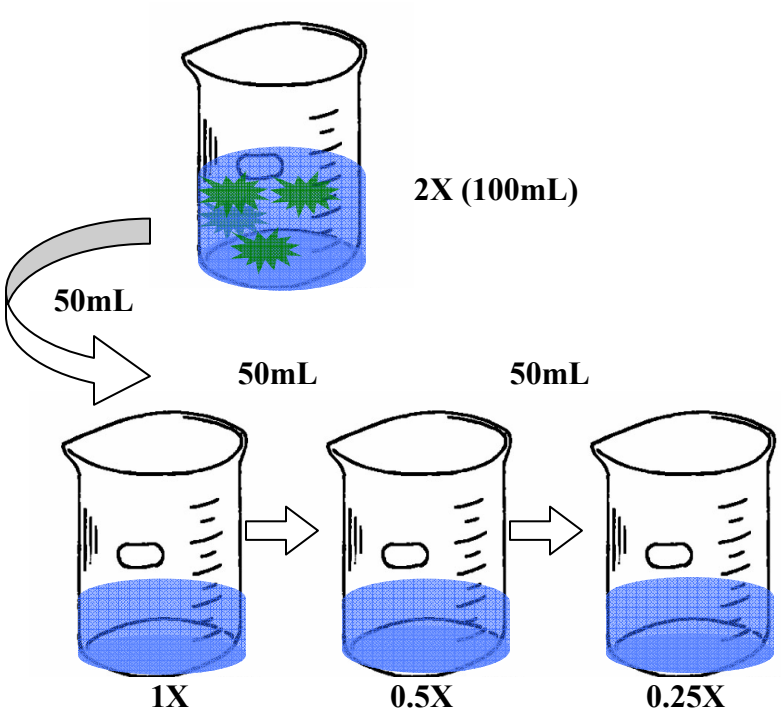
Additional materials:
Volumetric pipettes for transferring 50mL
Glass stirring rods

To prepare the dilution on DAY 15:
1. Add 50mL of distilled water to three, clean beakers that are labeled 1X, 0.5X and 0.25X.

2. Use a volumetric pipette to transfer 50mL from the **2X** plant tissue preparation to the 1X beaker (see illustration below).

3. Mix with a clean glass stirring rod and transfer 50mL of the 1X to the 0.5X. Mix and repeat to make the other dilutions. There should be 100mL in the 0.25X dilution when complete. **A clean pipette and stir rod should be used for each transfer.**

4. Prepare 5 Petri dishes with either spinach, radish or lettuce seeds as above. Pipette 10mL of each solution to the 4 dishes that are labeled with corresponding concentrations. One dish should get only clean, distilled water to serve as a control.



4. Technology
a. Biological Technology: Molecular Tools Reveal Invasive Plant Pedigree

CLASS TIME: 30 min

Objectives:

1. To direct students to recent research in invasive species biology and demonstrate the value of molecular tools to investigate plant species phylogeny.

2. To encourage critical thinking about solutions to invasive plant problems and other potential applications of biological technology.

Molecular Tools Reveal Invasive Plant Pedigree

Invasive garlic mustard has been found in Southeast Alaska and volunteers are working to control its spread. (Photo courtesy: Samia Savell, NRCS)

Introduction:
The Center for Environmental Research in Halle, Germany has recently published the results of a study that investigated the source of the invasive herb garlic mustard (*Alliaria petiolata*) (Durka, Bossdorf and Auge, 2005). Researchers are utilizing molecular techniques to trace the pedigree of garlic mustard in its native range in Central Europe.

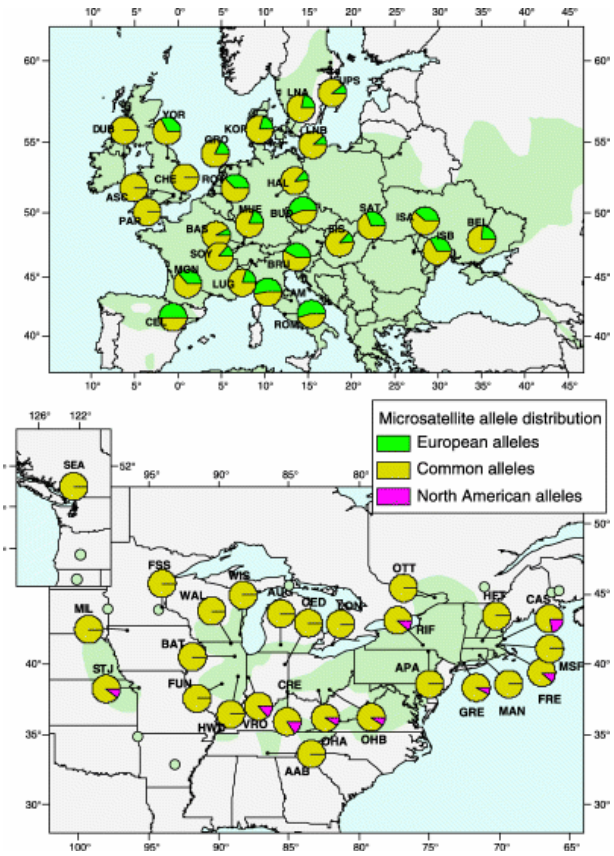
A member of the mustard family, Brassicacea, garlic mustard was introduced as a garden herb and has spread throughout the Eastern US and was found near Juneau in Southeast Alaska in 2001! Land managers and invasive plant experts in Southcentral Alaska are rightfully concerned about its potential introduction here. It is known to readily invade understory forested areas but has not yet been detected on the Kenai Peninsula or elsewhere in Southcentral Alaska. Keep an eye out for this aggressive invader that has caused tremendous damage to natural areas by outcompeting native understory plants.

What did they do?

Researchers including Durka and his team are making use of techniques in molecular biology to understand more about the genetics of invasive weeds and their source populations within their native ranges. For this study, researchers collected seeds of garlic mustard from 27 native range plants and 26 plants from introduced populations in North America. Seedlings were grown and DNA extracted from these tissue samples.

DNA was then amplified using the standard molecular process of Polymerase Chain Reaction (PCR). Individuals were analyzed for their relatedness by looking at variation in "microsatellites". Microsatellites are small, repeating sequences of base pairs (e.g. CACA…) within the genetic code. Within different alleles (sections of coding or non-coding DNA) microsatellites are often highly variable, or polymorphic. This is often the result of mutation during cell duplication or "slippage" that results in a unique DNA fingerprint. That means different individuals will have a different number of repeating sequences and the lineage of individuals can be traced by the variation in microsatellites. Similar techniques are being used to determine the genetic structure of invasive orange hawkweed (*Hieracium auranticum*) populations in the Western US, Canada and Alaska (Wilson, 2006). Seed samples from the Central and Lower Kenai Peninsula were submitted in the fall of 2006 by Caleb Slemmons (Homer Soil and Water Conservation District) and Janice Chumley (UAF- Cooperative Extension) to Linda Wilson at the

University of Idaho. These samples will be included in research to study the population genetics of hawkweeds (which have quickly become a serious problem in Alaska) and their ability to hybridize.



Map of the sampled populations of garlic mustard in its native and introduced ranges in N. America (Durka, Bossdorf and Auge, 2005)

What did they find?

The results indicate that the British Isles contributed greatly as a source for introduced populations of garlic mustard in North America. Central and Northern Europe were also linked to N. American populations by a high proportion of common alleles. The data suggest that there have actually been multiple introductions of invasive garlic mustard from different regions of Europe that ultimately led to its successful proliferation. Multiple introductions have been known from a number of other invasive species including the European starling.

One surprising result was that the N. American populations did not show evidence of reduced genetic variability when directly compared to the source populations in Europe. The phenomenon of a "population bottleneck" that occurs when the number of individual plants is critically small, typically leads to a reduction in fitness. Also known as inbreeding depression, this effect often causes deleterious mutation and can cause critically endangered species to spiral into extinction. When a non-native plant is introduced in a novel environment it may have very few individuals to reproduce with. One mystery in invasive species biology has been how do introduced plants, with only a small sampling of diversity from their native range, escape inbreeding depression and become very successful colonizers?

Molecular Tools Reveal Invasive Plant Pedigree

What do you think?

What do you think may have allowed garlic mustard to "escape" the problems of a population bottleneck when it was introduced?

What does this study tell us about preventing a species from successfully spreading? How could knowing the source of an invasive plant help in controlling it?

Garlic mustard was introduced as a garden herb, how do you think it could be brought to Southcentral Alaska? How can we keep it out?

What other ways could molecular biology help to understand and combat biological invasions?

b. Computer Technology: Web-based Mapping Exercise

CLASS TIME: 50 min

Objectives:

1. To provide students the opportunity to explore inventory data in Alaska for invasive ornamental plants including areas in their local communities.

2. To guide students comparing and contrasting regions and think about underlying causes of distribution patterns of invasive plants.

b. Computer Technology: Web-based Mapping Exercise

Computers are being used in a variety of ways to analyze and better understand biological invasions. One way that land managers and natural resource specialists utilize technology is through mapping with Global Positioning Systems (GPS). Handheld GPS units receive signals from satellites that determine the specific location where an invasive plant or plant population has been found.

Combined with specialized computer software, this allows the benefit of seeing where invasive plants are and helps to strategize about how to control them. In Alaska a statewide database called the Alaska Exotic Plant Information Clearinghouse (AKEPIC) is available for sharing recorded locations of invasive plants. A subset of this data including reported locations of 4 common invasive plants has been posted online. To get started go to http://www.homerswcd.org/invedu

1. First check out the statewide (All Alaska) map of the four common invasive plants: orange hawkweed, butter and eggs, common tansy and oxeye daisy. Where are most of the invasive plants recorded?

2. Now click to zoom in on each of the following regions and record or estimate how many of the four species were reported in that region.

Fairbanks:

Mat-Su Valley:

Anchorage:

What area seems to have the most records? How could you explain the pattern? What about the number of species reported?

3. Make some guesses about the Southeast. Do you think there will be all of the species recorded there? Why or why not?

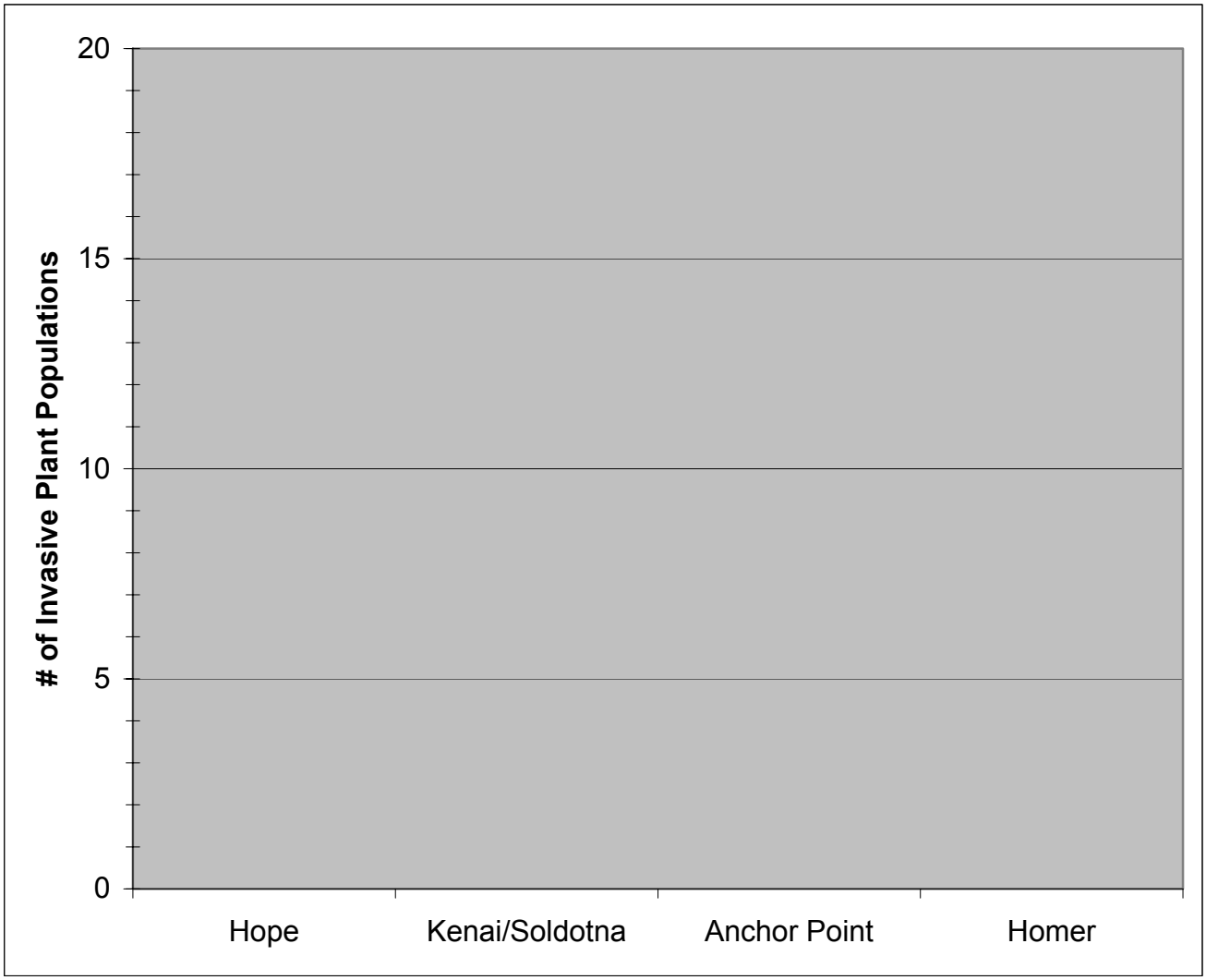
Click to zoom in to the Southeast from the All Alaska map. What do you think about the distribution of the recorded locations? Are there very many?

Now, you have two options - the northern section (Juneau, Haines and Sitka) or the southern section (Ketchikan and Petersburg). Compare these. Are the reported locations scattered or clustered? How does this compare with Kodiak Island?

4. Now lets look at the Kenai Peninsula - click on it from the All Alaska map. Do you see any patterns? Let's look a bit closer. Navigate to each of the locations below and prepare a table of the # of species and graph the # of reported infestations.

	Hope	Kenai/Soldotna	Anchor Point	Homer
Orange Hawkweed				
Butter and Eggs				
Common Tansy				
Oxeye Daisy				
TOTAL				

Complete the graph by marking an (x) for orange hawkweed, (o) for butter and eggs, (+) for common tansy and (•) for oxeye daisy. Use a (*) to mark the total in each area.



Now you are on your own! Check out some of the other areas, learn about some of the other invasive plants in Alaska and what you can do to help...

5. Assessment

a. Study guide/questions

The following review guide will help students to summarize the main points of the invasive plants curriculum. They should be able to complete much of the review guide by using the lecture notes and the handout in § 1 summarizing the invasion process.

Invasive Species Review Guide

Name:

1. What act created the Invasive Species Council and defined "invasive species" in the United States?

2. Describe the benefits of native plant species to an ecosystem. How are these species affected by the introduction of non-native, invasive plants?

3. Describe how invasive plants are introduced (vectors)? What does AS 03.05.010 mandate?

4. Identify two known invasive plants in Alaska. How could they affect the native ecosystem/food webs and identify ecosystem services that could be altered.

5. List six reasons why invasive plants are successful.

6. What is a “lag time” and what are the phases of the invasion process?

7. Explain how invasive plants relate to endangered species.

8. What are the phases of biological invasion? How have humans altered the rate?

9. Define chemical allelopathy and what factors affect plant competition.

Review Answers

Review Guide

1. Executive Order 13112
2. Native plants can serve many purposes including soil stabilization, water purification, atmospheric gas regulation and as food for primary consumers. Generally native plants are negatively affected by invasive plants and are often replaced through competition of limited resources and space.
3. Common vectors of invasive plants include: imported forage and other commodities including seed mixes, ornamental plants, machinery and hitchhiking on tires and gear of visitors. AS 03.05.010 prohibits the legal importation of a certain list of "noxious weed" seeds.
4. Identify two known invasive plants in Alaska. Answers will vary but the response should list a species that was covered in the lecture or other exercises. The student needs to identify a possible function of a native plant or plant community and what may be a result of replacement by an invasive.
5. From lecture: Lack of predators, produce abundant amounts of seeds and use successful dispersal mechanisms, seed have a high rate of germination, reproduce vegetatively as well as sexually, aggressive root systems and habitat generalists that thrive on disturbance
6. Lag time is the period of time after an invasive plant is introduced before it begins the logarithmic growth during colonization. The phases are: introduction, colonization and naturalization.
7. Invasive plants are known to be a substantial threat to species listed under the Endangered Species Act. It is estimated that ½ of endangered species are threatened by invasive species.
8. Humans have greatly increased the rate of biological invasion by transporting species and releasing them in novel environments.
9. Allelopathy is a type of competition that plants utilize by exuding certain chemicals that impede the growth or germination of neighboring plants. Major factors in plant competition are: space, water, light and nutrients.

b. Test questions

CLASS TIME: 60 min

Objectives:

1. To assess the students knowledge of key concepts of invasive plants as presented in the lecture and handouts.

NOTE: The following test is provided as a resource for assessing the student's performance. The review guide in the previous section will provide sufficient preparation for the exam below. The test assumes that students have reviewed the presentation materials and hand-outs in § 1. However, if other sections or labs have also covered, consider adding or substituting some questions that pertain to those exercises and labs.

Invasive Species Test

Name:

Directions: Select the appropriate answer to the following multiple choice questions.

1. ____ Which of the following statements is TRUE concerning introduced species?

    a. Most invasive species do not spread quickly
    b. Most non-native species are introduced as a result of human activity
    c. Invasions can occur naturally
    d. B and C are true
    e. All of the above

2. ____ How can invasive plants affect agriculture?

    a. Increase crop production and costs of fertilizers
    b. Decrease the need for pesticides
    c. Increased costs for pesticides and fertilizers
    d. Increase organic crop production

3. ____ Which of the following are ecosystem services that are known to be altered by invasive plants?

    a. Nutrient cycling
    b. Fire frequency
    c. Global warming
    d. Boreal food webs
    e. None of the above

4. ____ The means and route by which invasive species are introduced are called

    a. transport vectors
    b. interference routes
    c. distribution
    d. detours
    e. propagule pressure

5. ____ Which of the following set up the National Invasive Species Council and required Federal action concerning invasive species?

    a. The Lacey Act
    b. National Invasive Species Management Plan
    c. Executive Order 13112 on Invasive Species
    d. Plant Protection Act in conjugation with Animal Quarantine Laws

6. ____ Which of the following terms mean the same thing?

    a. invasive, noxious and weeds
    b. non-native, alien and exotic species
    c. alien, non-invasive and exotic species
    d. noxious weed, invasive species and prohibited weed

7. _____ Approximately what percent of the plants and animals on the Endangered Species list are thought to be threatened by invasive species?

    a. Less than 10 %
    b. 100 %
    c. Over 50 %
    d. 5 %

8. ____ Which of the following statements is FALSE concerning invasive plants?

    a. Invasive plants have high reproductive rates
    b. Invasive plants rely on multiple means of reproduction
    c. Invasive plants have seeds with a high rate of germination
    d. Invasive plants often lack natural predators in their new environment
    e. Invasive plants rely on only one type of reproduction (asexually)

9. ____ Which statement best defines an invasive species?

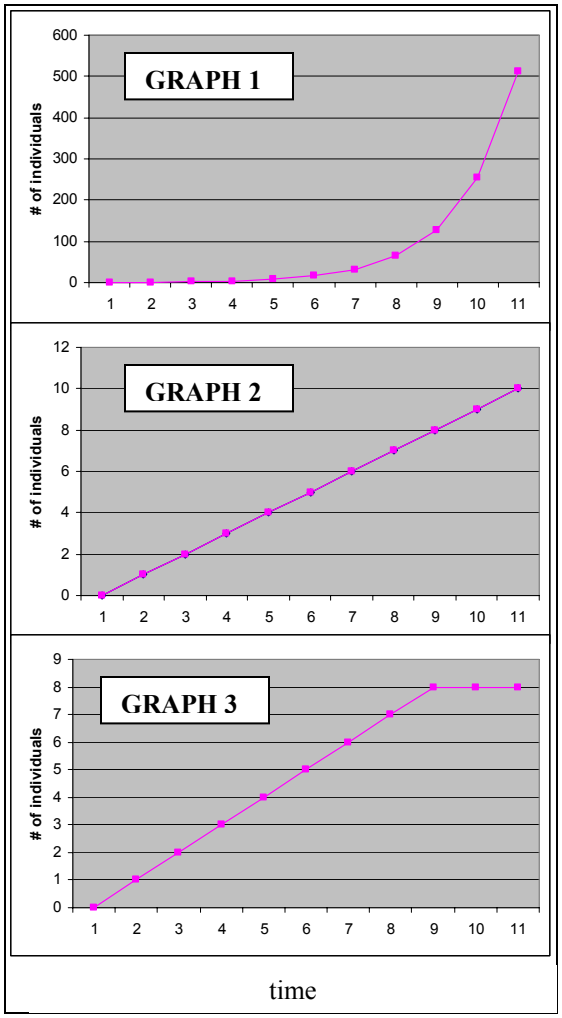
    a. A group of organisms that generally interbreed only among themselves and show persistent differences from members of allied groups of organism
    b. A non-native species, including its seeds, eggs, spores, or other biological material capable of propagating that species
    c. A non-indigenous species that historically occurred or currently occurs in the ecosystem under consideration
    d. A non-native species whose introduction causes or is likely to cause economic or environmental harm or harm to human health
    e. A non-native species whose introduction does not cause economic or ecological harm

10. ____In the invasion process, the population will continue to expand until it reaches what threshold?

    a. Stability
    b. Carrying capacity
    c. Asymptote
    d. Population growth

11. ____ Which graph represents a population with unlimited resources?

a. Graph 1
b. Graph 2
c. Graph 3



12. ____What is NOT considered an invasive species?

a. Orange hawkweed
b. Purple loosestrife
c. Devils Club
d. Ox-eye daisy

13. ____What is NOT an effect of invasive plants?

a. Outcompete native plants
b. Disrupt nutrient cycles
c. Increase species richness
d. Alters food webs

14. ____ Vegetative reproduction includes

a. Spread by underground rhizomes
b. Spread by seeds
c. Both A and B

15. ____ What is NOT a reason invasive species are successful in nonnative environments?

a. Symbiotic relationships with fungus
b. Lack of predators
c. High rate of germination
d. Aggressive root systems

16. ____ In the Alaska Administrative Code AS 03.05.010, what is the purpose of the "noxious weed" list?

a. To define which plants are considered alien species
b. To prohibit seeds of certain plants from being legally imported
c. To prohibits seeds of certain native plants from being exported

17. ____ Which is NOT a common way invasive plants are introduced?

    a. Ornamental plants
    b. Forage materials
    c. Natural selection
    d. On cars and machinery

TRUE/FALSE QUESTIONS

18. ____ All non-native plants are known to be invasive.

19. ____ Native plants are important for stabilizing soil and as food and cover for wildlife.

20. ____ Orange hawkweed is known to infest only disturbed soils

21. ____ Invasion of nonnative species is the second greatest threat to wetlands habitats.

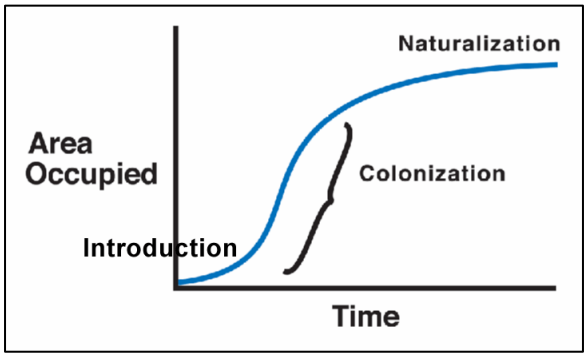
22. ____ Most nonnative plants are found in undisturbed locations off of roads and trails in backcountry areas

SHORT ANSWER RESPONSE

23. How can invasive plants cause a "cascade" of effects in a food web? Draw a simple example with three trophic levels.

24. Is biological invasion a process that would occur without humans? If yes, describe how humans have affected the rate of invasion?

25. Using the graph below, identify the "lag phase" period and explain why the plant population does not continue to increase at the naturalization phase.



26. What is chemical allelopathy? How can it provide an invasive plant with a competitive edge?

27. Cite an example of an invasive plant in Alaska. Describe how it was likely to have been introduced and what negative effects it could have on native plants or animals.

28. Invasive species have known ecological impacts but recent studies have illustrated the significant economic impact as well. Describe TWO examples of how invasive species can have a devastating impact on the US economy.

29. What are THREE of the limiting factors that native plants compete for when in competition with invasives?

30. List TWO steps that can be taken to reduce the spread of invasive plants.

Test Key

Multiple Choice
1. e
2. c
3. a
4. a
5. c
6. b
7. c
8. e
9. d
10. b
11. a
12. c
13. c
14. a
15. a
16. b
17. c

T/F Questions
18. False
19. True
20. False
21. False
22. False

Short Answer

23. Answers will vary but a complete answer should show organisms from at least three trophic levels (primary producer, primary consumer and secondary consumer) of a food web. The response should explain the connection of how invasive plants can affect the primary producers and consumers directly and how it is connected to upper trophic levels.

24. Yes. However, people have greatly increased the rate of biological invasion. Species introduction and colonization of a new environment has typically occurred very slowly. Humans have accelerated the rate by transporting species and releasing them.

25. Lag time is the period of time after an invasive plant is introduced before it begins the logarithmic growth during colonization. During naturalization, limiting environmental resources (e.g. water, nutrients) and lack of open space limit further expansion of the invasive plant population.

26. Allelopathy is a mechanism utilized by plants that involves release of certain chemicals. It provides a competitive edge by impeding the growth of neighboring plants and keeping space open for its growth and reproduction.

27. Answers will vary but should be an example given in the lecture or in one of the other exercises. Species likely to have been introduced as ornamental plants include orange hawkweed, common tansy, purple loosestrife, ornamental jewelweed, butter and eggs, Japanese knotweed and ox-eye daisy. Other species have likely been introduced as seed or forage contaminants. Response should link an effect or cite and example of effects on native plants or wildlife.

28. Answers will vary but should include some of the economic impacts discussed in the lecture such as increasing cost of agriculture production, costs of control and restoration, impacts to grazing lands, fires and costs of controlling them, water consumption and impact to recreational land uses.

29. Invasive plants compete for the same limiting resources all plants compete for: available water, light, nutrients and space.

30. Answers will vary. Possibilities include education/community weed pulls, control/containment of early infestations, certified weed-free seeds and forage, noxious weed legislation etc.

6. Additional Research Projects/Assignments

1. Taking it to the streets: mapping local invasive plants

Get a regional map to post in the classroom and provide students with a photo flip book or identification book of non-native plants (contact your local Cooperative Extension or Soil and Water Conservation District office). Using local maps, have students conduct a survey of the area around their home or school. Have everyone mark their maps with colored dots that correspond to a particular non-native plant. For example, green dots can represent common dandelion (*Taraxacum officinale ssp. officinale*) and have everyone post their records on the regional map in the classroom with push pins. Where were most of the non-natives found? Were there any invasives found? What was the most common species? The least common? (In Southcentral Alaska, this exercise is easiest early in the fall when plants are still in flower)

2. Get the word out: make an invasive plant poster

Collect information about an invasive weed and have students create a poster with a detailed photo or drawing and essential info to help people understand the problems it can cause. Many problematic plants are introduced by unwary gardeners and homeowners. The poster should clearly explain why it is a problem and maybe provide a similar alternative. Some invasive ornamentals planted in Alaska include: ornamental jewelweed, purple loosestrife, orange hawkweed and common or garden tansy. Hang the posters in a public place and help "spread the word, not the weed!"

3. Science fair or "Caring for the Kenai" Project Ideas

- Undertake a control project on a local infestation of an invasive plant (get permission first) and monitor the effectiveness of different treatments.

- Test for invasive plants in "wildflower" seed packets, bird seed mixes or samples of imported hay by planting them indoors and identifying the plants at maturity.

- Experiment with growing native plants or make an educational booklet to help gardeners learn about the problems that invasive plants can cause. Check out Alaska's Plant Materials Center website at http://www.dnr.state.ak.us/ag/ag_PMCPlantFlyers.htm for planting guides of select native species.

- Conduct a poll to determine how many people know about invasive plants. How many do they know? Do they know where they came from? What about greenhouse owners and landscapers?

- Make "invasive alternative" seed packets with educational info about problem plants to give away to parents or as a fundraiser.

- Test the germination of non-native plants compared to native plants. Compare growth rates or effectiveness of a control method.

4. Get the word out: show what you know

Have your students come up with a creative way to teach a middle school class what they have learned about invasive plants. Have them make a handout or a booklet that will help them identify what plants are invasive, non-native and native. Maybe collect plants from the field and have students try to label them with “noxious weed” (listed by Alaska Dept. of Agriculture in AS 03.05.010), “invasive”, “ornamental” and “native” (some plants may have more than one label).

7. STATE STANDARDS CORRELATION

Alaska State Science Standards Correlation for Grades 9-11

Standard A1 - Science as Inquiry and Process

Standard SA **Students develop an understanding of the processes and applications of scientific inquiry**	**Correlating Grade Level Expectations**	**Correlating Invasive Plant Curriculum Activity**
SA1: Students develop and understanding of the processes of science used to investigate problems, design and conduct repeatable scientific investigations, and defend scientific arguments.	SA1.1 [9-11] SA1.2 [9-11]	• Callin' the Shots • Lab Activities
SA2: Students develop an understanding that the processes of science require integrity, logical reasoning, skepticism, openness, communication and peer review.	SA2.1 [9-11]	• Callin' the shots • Lab Activities
SA3: Students develop an understanding that culture, local knowledge, history, and interaction with the environment contribute to the development of scientific knowledge, and that local applications provide opportunity for understanding scientific concepts and global issues.	SA3.1 [11]	• Callin' the shots • Just the Facts!

Standard C1 - Concepts of Life Science

Standard SC **Students develop an understanding of the concepts, models, theories, facts, evidence, systems and processes of life science**	**Correlating Grade Level Expectations**	**Correlating Invasive Plant Curriculum Activity**
SC1: Students develop an understanding of how science explains changes in life forms over time, including genetics, heredity, the process of natural selection, and biological evolution.	SC1.2 [10-11]	• Lecture notes/presentation • Lab Activities • Molecular Tools
SC2: Students develop an understanding of the structure, function, behavior, development, life cycles, and diversity of living organisms.	SC2.1 [9]	• Just the Facts!
SC3: Students develop an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy.	SC3.2 [10-11] SC3.3 [9]	•Lecture notes/presentation •Lab activities •Callin' the shots

Standard E1 – Science and Technology

Standard SE **Students develop and understanding of the relationships among science, technology, and society**	**Correlating Grade Level Expectations**	**Correlating Invasive Plant Curriculum Activity**
SE1: Students develop an understanding of how scientific knowledge and technology are used in making decisions about issues, innovations and responses to problems and everyday events.	SE1.1 [9-11]	•Callin' the shots •Just the Facts! •Molecular Tools
SE2: Students develop an understanding that solving problems involves different ways of thinking, perspectives, and curiosity that lead to the exploration of multiple paths that are analyzed using scientific, technological and social merits.	SE2.1 [9-11]	•Callin' the shots •Just the Facts!
SE3: Students develop an understanding of how scientific discoveries and technological innovations are affected by our lives and cultures.	SE3.1 [9-11]	•Lecture notes/presentation •Callin' the shots •Molecular Tools

Standard F1 – Cultural, Social, Personal Perspectives and Science

Standard SF **Students develop an understanding of the dynamic relationships among scientific, cultural, social, and personal perspectives**	**Correlating Grade Level Expectations**	**Correlating Invasive Plant Curriculum Activity**
SF1: Students develop an understanding of the interrelationships among individuals, cultures, societies, science and technology.	SF1.1 [9-11]	•Lecture notes/presentation •Callin' the shots
SF2: Students develop an understanding that some individuals, cultures, and societies use other beliefs and methods in addition to scientific methods to describe and understand the world.	SF2.1 [9-11]	•Lecture notes/presentation •Callin' the shots
SF3: Students develop an understanding of the importance of recording and validating cultural knowledge.	SF3.1 [9-11]	•Callin' the shots •Inquiry activity

Standard G1 – History and Nature of Science

Standard SG **Students develop an understanding of the history and nature of science**	**Correlating Grade Level Expectations**	**Invasive Plant Curriculum Activity**
SG1: Students develop an understanding that historical perspectives of scientific explanations demonstrate that scientific knowledge changes over time, building on prior knowledge.	SG1.1 [9-10]	•Lecture notes/presentation •Callin' the shots •Just the Facts! •Molecular Tools
SG3: Students develop an understanding that scientific knowledge is ongoing and subject to change as new evidence becomes available through experimental and/or observational confirmation(s).	SG3.1 [10]	•Lecture notes/presentation •Just the Facts! •Lab activities •Molecular Tools

8. Additional resources

Alaska Committee for Noxious and Invasive Plant Management
www.cnipm.org

Alaska Natural Heritage Program
http://akweeds.uaa.alaska.edu/

Center for Invasive Plant Management
http://www.weedcenter.org/

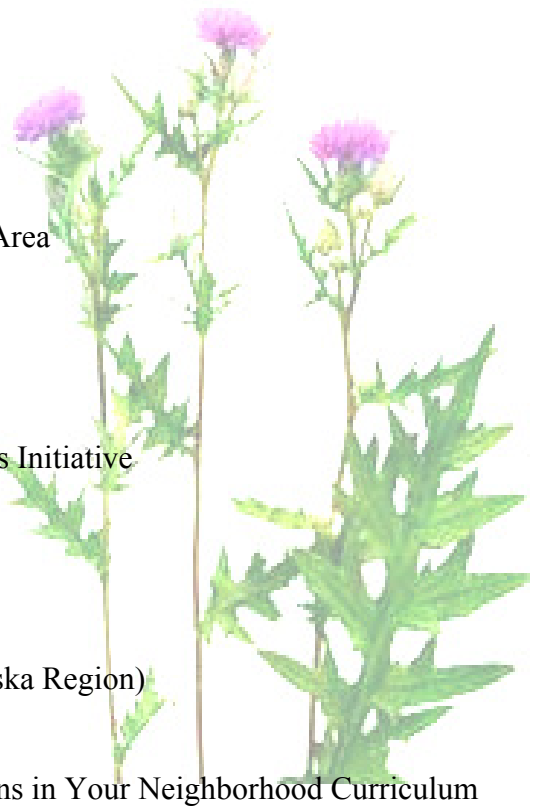
Homer Soil and Water Conservation District and
Kenai Peninsula Cooperative Weed Management Area
http://www.homerswcd.org

National Invasive Species Info Center
http://www.invasivespeciesinfo.gov/

The Nature Conservancy's Global Invasive Species Initiative
http://tncweeds.ucdavis.edu/

US Department of Agriculture – Plants Database
http://plants.usda.gov

US Forest Service – Forest Health Protection (Alaska Region)
http://www.fs.fed.us/r10/spf/fhp/



Also, check out the National Park Service's – Aliens in Your Neighborhood Curriculum
http://www.nps.gov/invspcurr/alienhome.htm

> The Alien Populations EXPLODE! Module is a very good exercise, and although it is designed for grades 6-8, it would be an appropriate add-on to this curriculum.
> http://www.nps.gov/invspcurr/alieninvasion.htm

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