Wild plants, gathering, and sustainability

A Biology, Ecology, and Environmental Studies unit for grades 9-12

Developed by Allaire Diamond M.S., M.Ed. as part of the project **People, Plants & Gathering in Northern Maine**, a collaboration between the USDA Forest Service Northern Research Station and the University of Vermont, funded by the Northeastern States Research Cooperative. Principal project investigators: Dr. Marla Emery, USDA Forest Service, and Dr. Clare Ginger, University of Vermont.[1]

Lesson 1: Wild potential

Topics: Plants, ecosystems, human-plant interactions
Type of lesson: Research, evaluating sources, using **People, Plants & Gathering**, integrating biological and cultural information
Assessment: Oral report and mini-poster

Lesson 2: "When a butterfly flaps its wings…": Humans, natural systems, and the effect of scale

Topics: Balancing human needs with the natural world, plant and ecosystem resilience, life cycles, natural resource management
Assessment: Participation in class discussion, class master list of how gathering could affect ecosystems or landscapes

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Lesson 3 (or homework for Lesson 2): Gathering analysis

Topics: Evaluating sources, traditional management, natural resource management, plant and ecosystem resilience
Assessment: Reflective or analytical essay

Lesson 4: Policy recommendations

Topics: Natural resource management, natural resource policy and planning, traditional management
Assessment: Individual, small-group, or class list of policy recommendations

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[1] Photo by Michelle Baumflek

Lesson 1: Wild Potential

Topics: Plants, ecosystems, human-plant interactions

Maine Learning Results Addressed:
Science E1 Students describe and analyze the evidence for relatedness among and within diverse populations of organisms and the importance of biodiversity.

Background: In this lesson, students will be assigned a plant that has medicinal, edible, or craft uses for people in northern Maine. Using multiple sources, they will develop a teaching resource for their classmates about the plant and the uses people have for it. They will focus specifically on the ways the plant is gathered based on its use (for example, must the entire plant be harvested or are just the leaves sufficient?). Outcomes of this activity will be familiarity with a particular plant that has value to humans, as well as familiarity with several reputable online research resources.

Materials:

- Computer with Internet access
- Materials needed to make mini-poster (paper/pens/glue/etc. or digital).

Time: 40-80 minutes for research and poster making (shorter class period may require students to finish their mini-poster at home), 20-40 minutes for sharing.

Assessment: Mini-poster using poster rubric.

Activities:

1. Introduce lesson by asking students if they ever pick a plant in the wild, like blueberries, fiddleheads, or balsam tips, to use it for something. Get a few replies – ask which plant, what it is used for, and what part of the plant is used. Ask if there are special strategies the person uses when gathering to make sure they are getting the right kind of material – the ripest berries, cleanest bark, or whatever (but let student responses create the 'meat' of this discussion). If the class has already had lessons about plant anatomy, ask them to name plant parts that are used, as specifically as possible.
2. Explain that we are going to take some time today to learn about plants that people use in northern Maine, and we are going to approach this both as biologists and as anthropologists/social scientists. We are going to examine both the biological and cultural stories behind the plants.
3. Encourage student engagement by showing some examples of people gathering and using plants. Below are a few suggestions for short videos available online that show people gathering and using blueberries, black ash, and wild cranberries in Maine and similar regions. One or more of these films (or others that you find) could be shown before introducing the assignment to students. Note that online films work best if they are already loaded on your computer to avoid delays. Run them first before class to ensure this.
    a. Little girl picking and eating blueberries in Maine *(30 seconds)*: http://www.youtube.com/watch?v=CC4IOWpCKbg

b. Gathering highbush blueberries *(2 minutes)*: http://www.youtube.com/watch?v=cDw6k24GohY&NR=1
c. Trailer for 2010 film "Black ash basketry: A story of cultural resilience" (*2 minutes)*: http://www.youtube.com/watch?v=vgpJwpzTDEk
d. Trailer for the 1986 film "Our Lives in Our Hands" about brown ash basketry in northern Maine. *(1 minute)*: http://www.youtube.com/watch?v=f_DkWdVA6O0
The entire 49-minute film can be streamed at http://www.folkstreams.net/film,94
e. Gathering wild cranberries in Maine *(2 minutes)*: http://www.youtube.com/watch?v=fJ-r7tRzERA

4. Assign each student a plant from the website **People, Plants, and Gathering in Northern Maine**. A list of the plants is on the following page. Students should complete research and make their poster for homework. Directions are on the student worksheet.

Note: This website from Diana Hacker, author of many writing and research handbooks, has some good tips for evaluating online sources. Either use it to prepare for a brief discussion, or you may want to provide the URL to students for their own use.
http://www.dianahacker.com/resdoc/tips.html

5. In the next class period, students should display their posters and/or share them in a circle/sharing session. Ask students not to merely read from their poster but to highlight the most important points about their plant's biology, role in its ecosystem (ecology), and how it is gathered and used.

6. Assess posters with a poster rubric or checklist (not included).

<u>List of Plants to Research</u>

Ash, Brown (also called Black Ash)

Balm-of-Gilead

Beech, American

Birch, Paper

Blueberry

Burdock, Common

Cedar, Eastern White

Chive, Wild

Chokecherry

Coltsfoot

Comfrey

Cranberry, Highbush

Dandelion

Dogwood, Red Osier

Fiddlehead (Ostrich Fern)

Fir, Balsam

Flag Root (also called Calamus)

Goldthread

Hazelnut, Beaked

Maple, Sugar

Pearly Everlasting

Pine

Plantain

Raspberry, Red

Rose

Spruce

St. Johnswort

Strawberry, Wild

Sweetgrass (*Hierochloe odorata*; other plants are also called 'sweetgrass')

[2] Wild Potential: Plant Research

Plant: _____

Assignment: Research both the biological and cultural background of your plant.

Essential **BIOLOGICAL** information should include:

- the plant's Latin name and family name,
- its geographic range,
- information about its life cycle, reproduction, and growth,
- what ecosystems and/or biomes it is found in,
- what other plants, animals, or natural features it is associated with (for example, cliffs or streams),
- information about its role in its ecosystem or habitat. Does it provide important habitat for a bird or insect species? Does it provide shade for understory plants? Etc.

Essential **CULTURAL** information should include:

- what the plant is used for,
- specific cultural groups or traditions (if any) that use and value this plant,
- a description of how it is gathered,
- what plant parts are used and what condition they must be in,
- a description of how the plant or plant parts are processed.

Research this information using online, print, and/or oral sources. Begin with the website **People, Plants, and Gathering in Northern Maine** *(http://nrs.fs.fed.us/sustaining_forests/conserve_enhance/special_products/maine_ntfp/)*. From there, look at the Resources page for ideas of other places to get information. Be sure to use reputable sources; it is almost always safe to use sites that end with .gov or .edu, but watch out for sites ending with .com or .org. Ask your teacher if you have questions about whether or not to use a site; your teacher has some links to information about how to evaluate an online source when doing research. Be sure to record all of your information in proper bibliographic format, like this example in APA format:

> Cain, A., & Burris, M. (1999, April). *Investigation of the use of mobile phones while driving.* Retrieved January 15, 2000, from http://www.cutr.eng.usf.edu/its/mobile_phone_text.htm

[2] Photos by Suzanne Greenlaw (left) and Michelle Baumflek (right)

When you are done researching, make an 8.5x11" poster about your plant, highlighting the information you've found, that will be a **detailed**, yet **easily-understood** and **attractive** resource for your teacher and classmates. You may make this with a computer or by hand. You'll be sharing this with your classmates when you next get together.

Due: _____

Lesson 2: "When a butterfly flaps its wings…": Humans, natural systems, and the effect of scale

Topics: Balancing human needs with the natural world, plant and ecosystem resilience, life cycles, natural resource management

Maine Learning Results Addressed:
Science A4 Scale Students apply understanding of scale to explain phenomena in physical, biological, and technological systems.

a. Describe how large changes of scale may change how physical and biological systems work and provide examples.

Science E2 Students describe and analyze the interactions, cycles, and factors that affect short-term and long-term ecosystem stability and change.

a. Explain why ecosystems can be reasonably stable over hundreds or thousands of years, even though populations may fluctuate.
b. Describe dynamic equilibrium in ecosystems and factors that can, in the long run, lead to change in the normal pattern of cyclic fluctuations and apply that knowledge to actual situations.

Background: Following Lesson 1, students should have an appreciation for and some understanding of the diversity of plants that people value for food, medicine, and craft in northern Maine, from both a biological/ecological perspective and a cultural perspective. In this lesson, students are asked to use their knowledge of, specifically, the plant parts used by gatherers, the gathering methods, and the ecology of the plant to brainstorm how gathering methods could affect plant populations and the surrounding ecosystems. Students will participate in a categorizing and brainstorming exercise designed to help them make connections between gathering by humans and the health of plant populations and ecosystems.

Materials:

- Mini-posters from Lesson 1
- Pieces of newsprint with the words Organism, Population, Landscape, Ecosystem, Ecoregion written on them and then divided into two columns.
- Markers to write on posters

Time: 40-80 minutes

Assessment: Participation in class discussion, class master list of how gathering could affect natural systems, optional final response to writing prompt.

Preparation before class:

- If desired, or if students have not already been exposed to this topic, you may want to teach a lesson or assign a reading on the properties of ecosystems.
- Before class, hang pieces of newsprint with scale words on them around the room.
- Write this question on the board: *Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?* (This is the title of a 1972 talk by mathematician Edward Lorenz.)

Activities:

1. **Introduction.** Point out the question on the board and explain that the class is going to spend today exploring how gathering is part of a bigger ecological picture, how it possibly affects multiple levels of life and natural systems.
2. **Film.** If desired, show this short online film where one gatherer discusses his methods for sustainably harvesting wild leeks: Note that wild leeks were not a species that students researched as they are not common in northern Maine.

   http://www.youtube.com/watch?v=lAl6ZL0hiBk

3. **Definitions.** Review, or define for the first time, the following definitions. It might be useful to compare this discussion of scale terms with earlier lessons on biological scale (molecule, cell, tissue, organ, etc.) or to show a brief slide show with pictures of these terms/scales.
   a. **Organism:** Any biological entity capable of replication or of transferring genetic material.
   b. **Population:** Group of individual organisms of the same species living within a defined area.
   c. **Landscape:** The traits, patterns, and structure of a specific geographic area, including its biological composition, its physical environment, and its anthropogenic or social patterns. OR an expanse of scenery that can be seen in a single view.
   d. **Ecosystem:** A community of animals and plants and the physical environment in which they live.
   e. **Ecoregion:** A relatively large unit of land or water that is characterized by a distinctive climate, ecological features and plant and animal communities, e.g. Northern Appalachian-Acadian Ecoregion.
4. Explain that human actions, including gathering the plants the students have just learned about, can affect all of these levels. Keep the tone neutral, not suggesting that effects are positive or negative.
5. **Assessing human impacts on ecological scales.** Distribute the "Ecological Scale and Human Activity" worksheet. You may want to begin filling this out as a class, or have students do it alone or with a partner.
6. Without going over the entire sheet (unless this seems necessary), note that human effects on natural systems can be neutral, positive, or negative, and that the sheet has examples of all of these.
7. On the board, write the question **What plant gathering actions by humans can affect natural systems?** Ask students to revisit their plant that they have researched, and brainstorm at least one way that gathering the plant could affect each level of ecological scale. Remind them that effects on natural systems can be neutral, positive, or negative.
8. **Group brainstorming.** Break students into 5 small groups of 3 or 4. They should travel around the room and answer the question for each level on the pieces of newsprint, using the brainstorms they have just completed. When they get to a new paper they should first read everything written on it aloud. They should then add something to the paper. Groups or students can also initial other ideas written by

other groups if they agree with them. Time the students so that they spend approximately 5 minutes at each poster before moving on.

9. **Identifying patterns.** After all groups have visited all posters, bring posters to the front of the room. Ask students if they noticed any patterns between posters. Some patterns might include: Smaller actions have a bigger effect at the small scale (ex. Pulling up a plant could kill the organism, but not harm the population), some factors affect plants at all levels. Point out that some factors, like fire, can be caused by humans or natural causes, and that some factors, like fire again, can have either good or bad effects on plants at the level in question, depending on specifics, such as if the ecosystem is fire-adapted or the intensity of the fire. This could be another place to show the wild leek video mentioned above.
10. Ask students to share some of their ideas and record them on the board. As you do so, address the following points:
    a. **Gathering could have both positive and negative effects** on plant populations and ecosystems (eg. Gentle digging could aerate the soil and encourage growth; gatherers may transplant material to increase populations; or they may compact the soil and dig up every plant in an area).
    b. **Effects on individuals, populations, etc. differ based on harvest practices**, which include the time of year harvesting takes place, the plant part harvested, or specific quality requirements of gatherers. Note especially that experienced gatherers may have a different impact even though it might seem like they are doing the same thing as inexperienced gatherers. For example, both types of gatherers may dig up a plant's roots, but an experienced gatherer might take only certain pieces of the root and replant the plant, while an inexperienced gatherer might take the whole thing or discard the root without replanting.
    c. **Ecosystem effects are indirect**, such as when a plant is gathered so heavily that food does not remain for other animals that depend on it; or if a trail is worn to a gathering site that causes erosion or allows invasive plants to enter and take over; or if transplanting helps the plant population grow and resist invasive species; or if seeds or spores are spread as a result of gathering that could help the plant population grow.
    d. **Traditional gathering practices** affect ecosystems and populations because they encompass not only what we might first think of as gathering, but also more comprehensive rules of **tending or management** – including planting and other ecosystem changes that are meant to increase the amount of desired plants. Such practices include:
        i. Collecting seeds or other viable plant parts for replanting.
        ii. Selective burning of gathering sites to encourage plant growth
        iii. Limiting the amount gathered at any one time
        iv. Timing gathering to a season in which minimal harm would be caused to the plant
        v. Using tools appropriate to what needed to be gathered – to cause minimal harm to remaining plant parts
        vi. Taking only the part of the plant that was needed – leaving both viable plant parts and biomass at the site
        vii. Only taking individuals or plant parts that are the right ripeness

viii. Aerating soil with gathering tools (this could either increase or decrease the population, depending on the plant and place)
ix. Pruning plants to increase growth (includes coppicing, or cutting the main stem of a plant so that multiple sprouts will grow)
x. Weeding around plants
xi. Controlling insects or diseases that could harm plants

11. **Connection to primary scientific research literature.** Discuss one of the following two papers with students. The Law et al. paper has clearer figures and graphs, and a clearer conclusion, though it deals with a plant native to Asia. The Nantel et al. paper addresses wild leeks and American ginseng, yet it is more complex and may be only suitable for more advanced students. We recommend projecting figures or graphs from the papers on an overhead screen and discussing the general data with students. The Law et al. paper shows how human harvesting can impact the height of plants in frequently-harvesting populations over time, while the Nantel et al. paper uses some modeling techniques to demonstrate the projected effect of harvesting on population growth over time. We recommend using Figure 3 from the Nantel paper, but it will likely require some detailed explanation. Both papers are at the end of this lesson.

    Wayne Law, Jan Salick and Peter H. Raven. 2005. *Human-Induced Dwarfing of Himalayan Snow Lotus, Saussurea laniceps (Asteraceae).* Proceedings of the National Academy of Sciences of the United States of America, Vol. 102, No. 29, pp. 10218-10220.

    Patrick Nantel, Daniel Gagnon, Andree Nault. 1996. *Population Viability Analysis of American Ginseng and Wild Leek Harvested in Stochastic Environments.* Conservation Biology, Vol. 10, No. 2, pp. 608-621.

12. **Written response.** After the brainstorming and discussion has finished, ask students to do a final written response. Have them divide a piece of scrap paper into 4 quarters and record the following, one in each quarter:
    a. One thing they **learned** from this exercise
    b. One thing that **surprised** them from this exercise
    c. One **question** they have after finishing this exercise
    d. One thing they will **take away** or **share** with someone else
13. Have students pass in these papers; you can use them later to gauge the flow/success/direction of the discussion and their evolving thinking on this topic.
14. **Homework.** Assign students Lesson 3's reading and essay for homework if it will not be a class activity.

"When a butterfly flaps its wings…": Ecological scale and human activity
Name:_____

For each of the following human activities, classify the level of ecological scale that it will likely affect. Some activities may affect more than one scale. Remember that effects can neutrally, positively, or negatively affect natural systems. You are not being asked to judge whether an effect is positive, neutral, or negative, but rather just classify the scale at which the effect occurs.

O=Organism
P=Population
L=Landscape
E=Ecosystem
R=Ecoregion

a. ____Picking dozens of quarts of berries each week to sell in a farmers market or roadside stand
b. ____Building a shopping center with an access road and parking lot
c. ____Applying herbicides to a really good berry patch to keep weeds down
d. ____Clearing a few trees to expand a blueberry patch
e. ____Cutting trees for firewood for one's family
f. ____Building a house in the woods with a quarter-mile-long driveway
g. ____Building access roads and a shed in a berry patch to speed up harvesting, processing, and storage
h. ____Building a housing development with 30 single-family houses
i. ____Building a hiking trail
j. ____Picking several quarts of berries to make jam
k. ____Setting aside 300 acres of forest for a migration corridor for wildlife
l. ____Clearing a few acres of forest to expand a blueberry patch
m. ____Building a sawmill and log yard for large-scale wood processing
n. ____Digging up part of a plant's roots for transplanting
o. ____Paving a dirt road
p. ____Creating an artificial wetland at the edge of a parking lot for stormwater management
q. ____Removing weeds from a berry patch by hand
r. ____Building a dam on a river for a community-sized hydroelectric system
s. ____Cutting wood for several customers and processing it with a portable sawmill
t. ____Gathering a handful of berries for a snack
u. ____Building an industrial-scale paper plant
v. ____Pruning a tree or bush to increase its fruit yield
w. ____Building a housing development with 30 condominiums
x. ____Using a mechanical harvester to pick berries
y. ____Installing three wind turbines on a low ridge
z. ____Building a campground next to a lake
aa. ____Digging up several wild bloodroot plants and transplanting them behind one's house for easier future harvests
bb. ____Building a dam in a stream to create a backyard pond
cc. ____Building a dirt road to the top of a small mountain with a great view
dd. ____Cutting a willow shrub for basket material every other year
ee. ____Burning a field every other year to stimulate blueberry growth
ff. ____Planting multiple kinds of berries in a wooded setting

ANSWER KEY

Note that these answers are not hard and fast, but rather meant to stimulate discussion.

"When a butterfly flaps its wings…": Ecological scale and human activity

O=Organism
P=Population
L=Landscape
E=Ecosystem
R=Ecoregion

a. __P__Picking dozens of quarts of berries each week to sell in a farmers market or roadside stand
b. _P,L,E_Building a shopping center with an access road and parking lot
c. __P,L__Applying herbicides to a really good berry patch to keep weeds down
d. __O__Clearing a few trees to expand a blueberry patch
e. __O, *maybe* P__Cutting trees for firewood for one's family
f. __L__Building a house in the woods with a quarter-mile-long driveway
g. __L__Building access roads and a shed in a berry patch to speed up harvesting, processing, and storage
h. __L,E__Building a housing development with 30 single-family houses
i. __L,E__Building a hiking trail
j. __O__Picking several quarts of berries to make jam
k. __E,R__Setting aside 300 acres of forest for a migration corridor for wildlife
l. __P,L__Clearing a few acres of forest to expand a blueberry patch
m. __L,E__Building a sawmill and log yard for large-scale wood processing
n. __O__Digging up part of a plant's roots for transplanting
o. __L__Paving a dirt road
p. __P,L__Creating an artificial wetland at the edge of a parking lot for stormwater management
q. __O,P__Removing weeds from a berry patch by hand
r. __L,E__Building a dam on a river for a community-sized hydroelectric system
s. ____Cutting wood for several customers and processing it with a portable sawmill
t. __O__Gathering a handful of berries for a snack
u. __L,E__Building an industrial-scale paper plant
v. __O__Pruning a tree or bush to increase its fruit yield
w. __L,E__Building a housing development with 30 condominiums
x. __P__Using a mechanical harvester to pick berries
y. __L,E__Installing three wind turbines on a low ridge
z. __L__Building a campground next to a lake
aa. __O__Digging up several wild bloodroot plants and transplanting them behind one's house for easier future harvests
bb. __P,L__Building a dam in a stream to create a backyard pond
cc. __L,E__Building a dirt road to the top of a small mountain with a great view
dd. __O__Cutting a willow shrub for basket material every other year
ee. __P__Burning a field every other year to stimulate blueberry growth
ff. __P,L__Planting multiple kinds of berries in a wooded setting

Lesson 3 (could also be homework for Lesson 2): Gathering analysis

Topics: Evaluating sources, traditional management, natural resource management, plant and ecosystem resilience

Maine Learning Results Addressed:
Science E2 Students describe and analyze the interactions, cycles, and factors that affect short-term and long-term ecosystem stability and change.

a. Explain why ecosystems can be reasonably stable over hundreds or thousands of years, even though populations may fluctuate.
b. Describe dynamic equilibrium in ecosystems and factors that can, in the long run, lead to change in the normal pattern of cyclic fluctuations and apply that knowledge to actual situations.

Social Studies A1

c. Make judgments about conflicting findings from different sources, incorporating those from sources that are valid and refuting others.
d. Synthesize information from varied sources, fieldwork, experiments, and/or interviews that reflect multiple perspectives.

Background: M. Kat Anderson, Nancy Turner and Sandra Peacock, and Mary Hufford are all scientists and scholars whose work involves traditional human uses of land. Turner is an ethnobiologist whose work focuses largely on First Nations land management practices in British Columbia. She has collaborated with Sandra Peacock, a paleoethnobiologist at the University of British Columbia. M. Kat Anderson studies California Native American land management practices and researches and teaches at the University of California Davis. Mary Hufford is the director of the Center for Folklore and Ethnography at the University of Pennsylvania. She has studied folkways, including those involving plants, in the mid-Atlantic region and Appalachia for nearly 3 decades. The three excerpts provided here all give perspectives about how people gathering plants can positively affect ecosystems.

Materials:

- Copies of the three readings so that each student will get one reading (readings can be found at the end of this lesson).
- Copies of the student organizer for readings, one for each student

Time: Will vary depending on how quickly students read and process articles and write their essays. Ideally give this as a homework assignment with more than one night to complete.

Assessment:

1. Completed student organizer, assessed for completeness and detail.
2. Brief class wrapup after students have completed assignment. One point to make here is the difference between a **harvest strategy** and a **harvest/management strategy**. While a harvest strategy may be short-term and a way to just get what you want, a management strategy incorporates how to get what one wants and also ensure that future supplies will exist.

Readings:

Anderson, M.K. Excerpt from *Tending the Wild*: pp. 155-160, 172 ("Enhancing hazelnut flats"), 179-bottom of 183 ("Promoting open montane forests studded with large sugar pines"). From *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources.* Berkeley: University of California Press, 2005.

Hufford, M. "Ramp Suppers, Biodiversity, and the Integrity of the Mountains." In C*ornbread Nation III: The Best of Writing about Foods of the Mountain South*. Ed. R. Lundy. Chapel Hill: University of North Carolina Press, 2008. Available online from: www.sas.upenn.edu/folklore/faculty/mhufford/RampSuppers.pdf

Turner, N. and S. Peacock. Excerpt from *"Just like a garden": Traditional resource management and biodiversity conservation on the interior plateau of British Columbia.* Pp. 133-153, 161-165. In *Biodiversity and Native America.* Ed. P.E. Minnis and W.J. Elisens. University of Oklahoma Press, 2001.

Optional fourth reading:

David Pilz, Lorelei Norvell, Eric Danell, and Randy Molina. Excerpt from *Ecology and Management of Commercially Harvested Chanterelle Mushrooms.* United States Department of Agriculture Forest Service Pacific Northwest Research Station. General Technical Report PNW-GTR-576. March 2003. Pp. 45-47. Available at http://www.fs.fed.us/pnw/pubs/gtr576.pdf (Excerpt describes the results of a study on the effects of harvesting on chanterelle mushrooms)

Student organizer for reading on Wild Plants, Gathering, and Sustainability

*Your name:*_____

Reading title: _____

Reading author: _____

Directions: Complete this chart and the question on the back with information from the reading you chose. Use as much detail as you can and write in complete sentences. You may write on a separate paper if you choose.

Species	**Species uses** (food, medicine, etc.)	**Ecological scale(s)** related to this species that are discussed in reading (population, ecosystem, etc.)	**Harvest or harvest/management strategy #1** – name and describe	**Harvest or harvest/management strategy #2** – name and describe

Student organizer for Wild Plants, Gathering, and Sustainability, page 2

For **each species** discussed in the reading and listed on your table, answer this question in complete sentences and as much detail as you can:

What are the ecological effects of people gathering this plant?

Lesson 4: Policy Recommendations

Topics: Natural resource management, natural resource policy and planning, traditional management

Maine Learning Results Addressed:
Social Studies A1 Students research, develop, present, and defend positions on current social studies issues by developing and modifying research questions, and locating, selecting, evaluating, and synthesizing information from multiple and varied sources.

c. Make judgments about conflicting findings from different sources, incorporating those from sources that are valid and refuting others.
d. Synthesize information from varied sources, fieldwork, experiments, and/or interviews that reflect multiple perspectives.

Social Studies A2 Students make individual and collaborative decisions on matters related to social studies using relevant information and research, discussion, and ethical reasoning skills.

a. Develop individual and collaborative decisions/plans by considering multiple points of view, weighing pros and cons, building on the ideas of others, and sharing information…
b. Make a real or simulated decision related to the classroom, school community, civic organization, Maine, U.S., or international entity by applying appropriate and relevant social studies knowledge and skills, including research skills, ethical reasoning skills, and other relevant information.

Background: Land managers, foresters, and others make important, on-the-ground decisions about how land can be used and who can use it, and also about management activities such as logging or wilderness designation that could affect both the plants and wildlife on that land and any uses like gathering that also occur there. They often look to scientists and scientific evidence when trying to make their decisions. Students have now been exposed to the perspectives of many people who gather plants, learning both why that gathering is important to the gatherers' lives and also how it may affect the ecosystem at and around gathering sites. Though much of the evidence they've encountered is anecdotal, from gatherers' experiences, they nonetheless have a valuable perspective to contribute to a land manager about management activities. In this lesson they will synthesize their knowledge about plants, plant uses, gathering practices, and the ecological effects of gathering as they make some recommendations to land managers in Maine.

Materials:

- Student organizers from Lesson 3
- Large pieces of newsprint to hang on the walls
- Markers
- Tape

Time: 40 minutes

Assessment: Class list of policy recommendations, with all students as participants. Student written response to class list, assessed with a rubric or checklist (not included).

Activities:

1. **Introduction.** Explain that land managers and foresters make important, on-the-ground decisions about how land can be used and who can use it, and also about management activities such as logging or wilderness designation that could affect both the plants and wildlife on that land and any uses like gathering that also occur there. They often look to scientists and scientific evidence when trying to make their decisions.
2. **Recap of earlier lessons.** Remind students that they have now been exposed to the perspectives of many people who gather plants, learning both why that gathering is important to the gatherers' lives and also how it may affect the ecosystem at and around gathering sites. Though much of the evidence they've encountered is anecdotal, from individual gatherers' experiences, and not gathered using the scientific method, they nonetheless have a valuable perspective to contribute to a land manager about management activities.
3. **Scenario.** Present this scenario to students:

   You have been asked to make policy recommendations to a land manager who has just been hired to manage a 1000-acre parcel of land in the St. John Watershed in Northern Maine. The parcel is in the Spruce-Fir-Northern Hardwoods Forest Ecosystem, and it has rolling hills (covered largely with mixed hardwood forests), lowland forests (mostly coniferous or spruce-fir forests), forested wetlands, open wetlands, a few streams, and an area that has been maintained as a meadow. It has several points of vehicle access, all by rough dirt road, though a main paved road comes within a few hundred feet of the parcel (a dirt road accesses the parcel from the paved road). It has had timber management for the last 50 years, mostly in the mixed hardwood portion of the parcel. Because of this management, a network of forest roads also exists to allow the loggers access to the forest. Several gatherers, including black ash basketmakers, an herbalist, two wreathmakers, and people who collect wild plants for food (and possibly other gatherers as well) live in the nearest town, about 6 miles away.

   You have specifically been asked to make recommendations concerning gathering of wild plants. While you will be giving them to the land manager, your recommendations can be geared specifically toward her, toward the landowner (who lives several hours away) or toward the gatherers or others who may use the land.

   As you craft your recommendations, think about **who** (if anyone) can use the land, **what** (if anything) they can use it for and **what** (if anything) they must provide in exchange, **when** they can use it, **where** they will be able to go, **why** these rules will be put into place and **how** the manager will be able to communicate them to people and make sure they are upheld. Also consider the responsibilities of: the land manager, the landowner, and the gatherer or other user.

   Items to be written on newsprint around the room:
   Recommendations to the manager

Recommendations to the landowner
Recommendations to the gatherer or user
Who (if anyone) can use the land?
What (if anything) can they use it for, and what (if anything) should they provide in exchange?
When can the land be used?
Where will users be allowed to go? Will there be limits on their movements or access to certain areas?
Why will rules be put into place?
How will rules be communicated to people?
How will rules be upheld or enforced?

4. **Individual recommendations.** Students should go around the room, organizers in hand, and write recommendations on the pieces of paper. They should initial their recommendations or put initials next to someone else's recommendation that they agree with (can do this with an unlimited number of recommendations). But each student should write at least two recommendations of their own.

5. **Class recommendations.** Once this exercise has been completed, look at the recommendations with the most initials (use teacher judgment to avoid popularity contests) and with class discussion, and choose two recommendations from each poster to go into a master list.

6. **Student written response.** Compile the master list and have it neatly available for students (an overhead, handout, etc.), and then ask students to judge whether or not they think this is sufficient for good management of the parcel considering the gathering uses of it. Students should respond with a few written paragraphs that integrate their response to the reading, class discussions, etc. This is a position paper. If they don't agree with the recommendations, they should make other suggestions. This is their final assessment for the mini-module and should be a formal, clear, well-argued piece. Assess this response with a rubric or checklist (not included).

Human-induced dwarfing of Himalayan snow lotus, *Saussurea laniceps* (Asteraceae)

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Because evolutionary processes such as genetic drift and natural selection play a crucial role in determining the response that species will have to human-induced disturbances, there is increasing interest in the evolutionary aspects of conservation biology. Harvesting select individuals in natural plant populations can bring about unforeseen impacts that may negatively affect fitness. We analyzed how human harvesting affects two congeners known as snow lotus. Over a period of 100 years, there was a negative trend in plant height ($r^2 = 0.4361$, $P < 0.001$) for the intensely collected and rare species, *Saussurea laniceps*, but not in the less intensely collected species, *Saussurea medusa*. Additionally, *S. laniceps* were significantly smaller in areas of high harvest than in areas with low harvest ($Z = 4.91$, $P < 0.0001$), but this was not so for *S. medusa*. Humans can unconsciously drive evolution and must be considered when managing threatened species.

conservation | human selection | Tibetan medicine

The process of natural selection is well known to alter the traits of wild plants and animals (1, 2), as "artificial selection" alters the traits of crop plants and domesticated animals (3–5). Anthropogenic activities, such as harvesting of wild plants, also may lead to evolutionary change in natural populations, although this process is much less well understood. Harvesters who collect plants based on certain traits may unintentionally select against that trait in the remaining population. Here, we investigated whether human harvesting has selected for smaller plants in the rare Tibetan snow lotus, *Saussurea laniceps*.

Explorers and plant collectors have roamed many parts of the world to record and catalog the botanical diversity of our planet (6). Plant collections from these expeditions, typically housed in herbaria, provide scientists with records for taxonomic, systematic, and morphological studies. Because herbarium specimens provide us a glimpse of the past, we also can use these collections to examine possible changes in the distribution and phenotype of plants, particularly as a result of anthropogenic changes (7–17). However, with herbarium material alone, one cannot be certain whether a change in phenotype through time is due to a particular selective agent. To test for the role of human selection on harvested plants, we paired herbarium studies with field sampling and paired congeneric plant species that have experienced different levels of unconscious human selection.

Saussurea laniceps and *Saussurea medusa* (Asteraceae), known collectively as snow lotus (Fig. 1), are endemic to the eastern Himalayas. Both species have limited distributions on rocky habitats >4,000 m. Snow lotus is used in traditional Chinese and Tibetan medicine for the treatment of headaches and high blood pressure and to regulate menstrual cycles and treat menstrual problems (18). Although *S. laniceps* are primarily harvested as medicinal plants, they also have become popular souvenir items with tourists because they are strange-looking, rare, and grow in exotic locations (19). *S. medusa* are smaller and less frequently collected for medicine, sale, or souvenir. Larger individuals of *S. laniceps* are preferentially collected, because these are thought to be more potent and efficacious. Further, larger plants are easier to find. Regrettably, the whole plant of this monocarpic, long-lived species is harvested during the final flowering period, just before seed set, so that harvesting is a strong selective agent. Traditionally, snow lotus has been collected primarily on a small scale for local use. However, with better roads and the growing interest in alternative medicines, snow lotus has experienced increasingly intense harvest over the past 30 years.

Fig. 1. Snow lotus used in traditional Tibetan and Chinese medicine. Shown are *S. laniceps* (*a*), the preferred species, and *S. medusa* (*b*), which is seldom collected or marketed.

Methods

Using historical herbarium samples and comparing them with those collected for the medicinal trade today, we documented the change in size (plant height) of *S. laniceps* and *S. medusa* over time. Both species reach their maximum size during flowering, therefore collections of flowering plants represent the plant at its largest size. We measured 218 individuals of *S. laniceps* and 309 individuals of *S. medusa*, the earliest dating back to 1872, collected by N. M. Przewalski (Zoological Institute of the Russian Academy of Science, St. Petersburg, Russia).

Plant height was measured on specimens of *S. laniceps* and *S. medusa* from eight different herbaria: the Missouri Botanical Garden (MO); the Gray Herbarium (GH) at Harvard University, Cambridge, MA; the Smithsonian Institution (US), Washington, DC; the Kunming Institute of Botany (KUN); the Beijing Institute of Botany (PE); the Royal Botanical Garden at Kew (K), London; the Natural History Museum in London (BM); and the Royal Botanical Garden at Edinburgh (E). These collections were the main repositories for specimens of the early explorers to northwest Yunnan, China. The collection dates of each specimen were recorded. The current sizes of plants were measured from recent collections being sold in the markets of northwest Yunnan.

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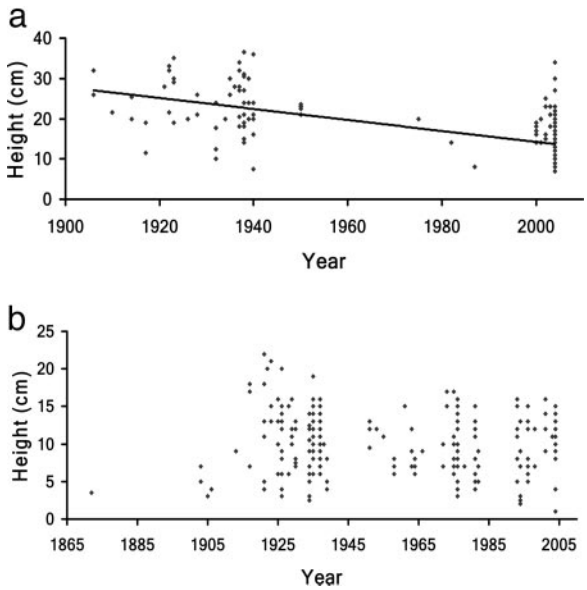

Fig. 2. Heights of snow lotus plants at flowering. (*a*) Decline in height of *S. laniceps* from herbarium specimens and field collections over the past 100 years ($r^2 = 0.4361$, $P < 0.0001$). (*b*) Height of *S. medusa* collections from the past 120 years, with no significant decline.

We also measured the heights of *S. laniceps* and *S. medusa* plants belonging to present-day populations in heavily harvested and seldom-harvested areas. To determine heavily harvested and protected sites and thus to categorize collection pressures, we interviewed doctors and collectors. The protected sites were sacred Tibetan lands on the side of Khawa Karpo, one of the most sacred Tibetan mountains (20); the heavily harvested sites were common property alpine areas. We then measured flowering plants, from the top of the flower to ground level, that were found in these areas.

Statistically, we analyzed plant size over time, which was not normally distributed, by using Spearman's rho, a nonparametric correlation, and analyzed the relationship of plant height by year of collection. We tested for a difference in plant size between harvested and protected sites, which had unequal sample sizes that were not normally distributed, by using a Wilcoxon signed-rank test. All statistical tests were carried out by using JMP software (version 5.1, SAS Institute, Cary, NC).

Results

Saussurea laniceps showed a significant decline in size over time (Fig. 2*a*, $r^2 = 0.4361$, $P < 0.001$), whereas *S. medusa* showed no significant change in size (Fig. 2*b*). We repeated this analysis by including only herbarium specimens to ensure that the results were not an artifact of the most recent plants measured in the medicinal shops rather than on herbarium sheets; the results of this test were not qualitatively changed and were still significant ($r^2 = 0.130$, $P < 0.001$).

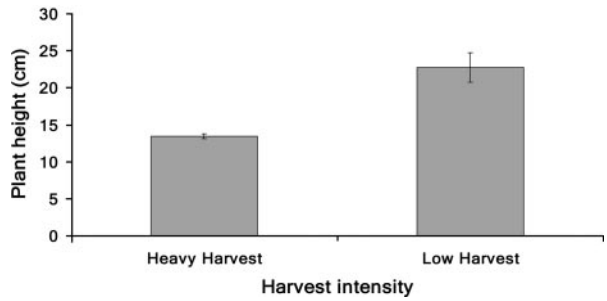

Fig. 3. Height of *S. laniceps* plants found at heavily harvested and protected sites. Plants found in heavily harvested sites were on average 9 cm smaller than plants found in protected areas (average plant height ± SE; low harvest, 22.7 cm ± 2.0; high harvest, 13.4 cm ± 0.4).

Furthermore, we compared the size of flowering plants that grew in heavily harvested areas with those that were protected in Tibetan sacred areas where very little harvesting took place (Fig. 3). We found that *S. laniceps* in the heavily harvested areas were on average 9 cm smaller than plants found in low-harvested areas ($Z = 4.91$, $P < 0.0001$). There was no significant difference in the height of *S. medusa*.

Discussion

Selection caused by humans is a powerful force whether conscious or unconscious, "artificial" or natural (21, 22). Paradoxically, with unconscious human selection, when a species posses a certain trait that is valued by people (e.g., large size), individuals with that trait will be preferentially harvested, and this selection will leave individuals that possess less desirable traits (e.g., small plants). Evidence for this process has been reported from fisheries that harvest larger fish, resulting in smaller fish and lower yields (23). In our case, we observed that human harvesting of larger individuals of a rare plant for medicinal purposes resulted in the rapid evolution of smaller individuals over only 100 years. If plants that are smaller have decreased fitness because of lower seed yield (24–28), then the conservation status of this rare plant may be further threatened by this short-term evolutionary change. The immediate demographic effects of harvesting as well as the dwarfing of plants in response to unconscious anthropogenic selection may put threatened plants at greater risk of extinction.

Methodologically, our study demonstrates that herbarium specimens allow us to examine phenotypic changes due to selection in extant populations, which can facilitate conservation assessment and monitoring. This research is yet another example of how herbarium and museum collections are essential to conservation biology (29–31).

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1. Endler, J. A. (1986) *Natural Selection in the Wild* (Princeton Univ. Press, Princeton).
2. Kingsolver, J. G., Hoekstra, H. E., Hoekstra, J. M., Berrigan, D., Vignieri, S. N., Hill, C. E., Hoang, A., Gibert, P. & Beerli, P. (2001) *Am. Nat.* **157,** 245–261.
3. Darwin, C. (1859) *On the Origin of Species* (John Murray, London).
4. Vavilov, N. (1922) *J. Genet.* **12,** 47–89.
5. Harlan, J. R. (1992) *Crops and Man* (Am. Soc. Agron./Crop Sci. Soc. Am., Madison, WI).
6. Lyte, C. (1983) *The Plant Hunters* (Orbis, London).
7. Jones, P., Beebe, S., Tohme, J. & Galwey, N. (1997) *Biodiversity Conserv.* **6,** 947–958.
8. Prance, G. T. (2001) *Taxon* **50,** 345–359.
9. Ter Stege, H., Jansen-Jacobs, M. J. & Datadin, V. K. (2000) *Biodiversity Conserv.* **9,** 215–240.
10. Funk, V. A., Zermoglio, M. F. & Nasir, N. (1999) *Biodiversity Conserv.* **8,** 727–751.
11. Prasad, S. N., Vijayan, L., Balachandran, S., Ramachandran, V. S. & Verghese, C. P. A. (1998) *Curr. Sci.* **75,** 211–219.
12. Primack, D., Imbres, C., Primack, R. B., Miller-Rushing, A. J. & Tredici, P. D. (2004) *Am. J. Bot.* **91,** 1260–1264.
13. Saltonstall, K. (2002) *Proc. Natl. Acad. Sci. USA* **99,** 2445–2449.
14. Skov, F. & Borchesenius, F. (1997) *Ecography* **20,** 347–355.
15. Skov, F. (2000) *Taxon* **49,** 503–515.
16. Delisle, F., Lavoie, C., Jean, M. & Lachance, D. (2003) *J. Biogeogr.* **30,** 1033–1042.
17. McGraw, J. B. (2001) *Biol. Conserv.* **98,** 25–32.

18. Yang, J. S., & Chuchengjiangcuo (1989) *Diqing Zang yao* (Yunnan min zu chu ban she, Kunming Shi).
19. Yang, Q. S., Chen, S. T. & Zhou, Z. K. (2003) *Acta Bot. Yunn.* **25,** 297–302.
20. Anderson, D., Salick J., Moseley, R. K. & Ou, X. K. (2005) *Biodiversity Conserv.*, in press.
21. Salick, J. (1992) *Evol. Biol.* **26,** 247–285.
22. Salick, J. & Merrick, L. (1990) in *Agroecology*, eds. Carroll, C. R., Vandermeer, J. H. & Rosset, P. M. (McGraw–Hill, New York), pp. 517–548.
23. Conover, D. O. & Munch, S. B. (2002) *Science* **297,** 94–96.
24. Weiner, J. & Thomas, S. C. (1986) *Oikos* **47,** 211–222.
25. Herrera, C. M. (1993) *Ecol. Monogr.* **63,** 251–275.
26. Ollerton, J. & Lack, A. (1998) *Plant Ecol.* **139,** 35–47.
27. Charron, D. & Gagnon, D. (1991) *J. Ecol.* **79,** 1137–1146.
28. Nantel, P., Gagnon, D. & Nault, A. (1996) *Conserv. Biol.* **10,** 608–621.
29. Wilis, F., Moat, J. & Paton, A. (2003) *Biodiversity Conserv.* **12,** 1537–1552.
30. Lienert, J., Fischer, M. & Diemer, M. (2002) *Biol. Conserv.* **103,** 65–76.
31. MacDougall, A. S., Loo, J. A., Claden, S. R., Goltz, J. G. & Hinds, H. R. (1998) *Biol. Conserv.* **86,** 325–338.

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Population Viability Analysis of American Ginseng and Wild Leek Harvested in Stochastic Environments

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Abstract: *Many populations of threatened American ginseng (*Panax quinquefolium*) and vulnerable wild leek (*Allium tricoccum*) have declined and gone extinct because of overharvesting in Canada. We assessed the impact of harvesting on populations of these species in stochastically varying environments and estimated their extinction thresholds and minimum viable populations. With both species we used four transition matrices taken from the literature in stochastic population projections under various harvesting regimes. For American gingseng the mean population growth rate (λ) declined with increasing harvesting rate (h) according to the number of years between harvests (t_r), as $-0.54\ h\ t_r^{-0.90}$. When plants with more than two leaves are harvested every 5 years, a harvest rate of approximately 30% was sufficient to bring the λ below the equilibrium value of 1.0. Extinction thresholds, the minimum number of plants needed to rebuild a population, varied from 30 to 90 plants, and the minimum viable population size was estimated at 170 plants. Only a dozen populations known in Canada exceed 170 plants, so most populations could not support any harvesting without serious threats to their long-term persistence. For wild leek, two harvesting strategies were identified from confiscated, illegal harvests from Gatineau Park (Québec): (1) "choosy" harvesters collect fewer but larger bulbs, and (2) "busy" harvesters collect numerous but smaller bulbs. These data allowed simulations of more-realistic harvesting strategies. The rate of the decline λ along the harvest gradient was faster for wild leek than for ginseng and varied with harvesting strategies. At harvesting rates between 1 and 8% the probability that λ falls below the equilibrium value was less than 5%. The extinction threshold of wild leek was estimated at 140–480 plants and the minimum viable population at 300–1030 plants, according to the threshold chosen. Remnant wild leek populations in Québec rarely contain more than a few hundred plants, indicating the serious threat commercial harvesting represents for this species. For both species we found that the whims of a stochastically varying environment significantly reduce sustainable harvest levels.*

Análisis de viabilidad poblacional del ginseng americano y el puerro silvestre cosechados en ambientes estocásticos

Resumen: *Muchas poblaciones del ginseng americano en peligro (*Panax quinquefolium*) y el vulnerable puerro silvestre (*Allium tricoccum*), han declinado y se han extinguido debido a una sobrecosecha en Canada. En este estudio hemos evaluado el impacto de la cosecha sobre poblaciones de estas especies en ambientes que varían estocásticamente y estimamos sus umbrales de extinción y sus poblaciones mínimas viables. Con ambas especies, usamos cuatro matrices de transición tomadas de la literatura para proyectar estocásticamente las poblaciones bajo diversos regímenes de cosecha. Para el ginseng americano, la tasa de crecimiento poblacional media (λ) declinó con el incremento de la tasa de cosecha en función del número de años entre cosechas (t_r) de acuerdo con $-0.54\ h\ t_r^{-0.90}$. Cuando las plantas con más de dos hojas son cosechadas cada 5 años, una tasa de cosecha de aproximadamente un 30% fue suficiente para llevar a λ por debajo del valor de equilibrio de 1.0. Los umbrales de extinción, o sea el número mínimo de plantas necesario para reconstruir la población, varió entre 30 y 90 plantas y el tamaño poblacional mínimo viable fue estimado en 170 plantas. Sólo una docena de las poblaciones conocidas en Canada superan las 170 plantas, por lo tanto,*

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la mayoria de las poblaciones no podrían soportar cosecha alguna sin serias amenazas para su persistencia a largo plazo. Para el puerro silvestre se identificaron dos estrategias de cosecha a partir de cosechas ilegales confiscadas por oficiales conservacionistas en el Parque Gatineau (Québec). Los cosechadores "escrupulosos" recolectan bulbos de mayor tamaño pero en menor cantidad y los cosechadores "atareados" recolectan bulbos de menor tamaño pero en mayor cantidad. Estos datos permitieron llevar a cabo simulaciones de estrategias de cosecha más realistas. La tasa de declinación de λ a lo largo del gradiente de cosecha fue más rápida para el puerro silvestre que para el ginseng y varió de acuerdo con las prácticas de cosecha. Con tasas de cosecha que variaron entre 1 y 8%, la probabilidad de que λ caiga por debajo del valor de equilibrio fue de menos del 5%. El umbral de extinción del puerro silvestre fue estimado en unas 140–480 plantas y la población viable mínima fue estimada en unas 300–1030 plantas de acuerdo con el umbral elegido. Las poblaciones remanentes de puerro silvestre en Québec raramente contienen más de unos pocos cientos de plantas, lo que pone de relieve la seria amenaza que la cosecha comercial representa para esta especie. Encontramos que para ambas especies, los impulsos de un ambiente que varía estocásticamente reduce significativamente los niveles de cosecha sostenibles.

Introduction

It is difficult to predict how long a wild population of herbaceous plants will persist when a part of the population is regularly harvested because vital rates vary over time as they respond to varying environmental conditions. Even in habitats stable in terms of disturbance regime, relatively good seasons of growth alternate randomly with relatively bad ones. We investigated the problem of population persistence for two North American forest perennials that reach the northern limits of their distribution ranges in southern Québec: American ginseng (*Panax quinquefolium*; Araliaceae) and wild leek (*Allium tricoccum*; Liliaceae). The edible bulbs of wild leek and the medicinal roots of ginseng are currently harvested in the wild. Because these species occur in the most developed and populated areas of the southern parts of Québec and Ontario, many of their populations have disappeared because of habitat destruction (Dagenais 1985; Charron & Gagnon 1991; Couillard 1993). Recent observations estimated that 14% of known ginseng populations and 20% of known wild leek populations have disappeared in Québec (Nault & Gagnon, unpublished data). Fragmentation of mature forests has probably increased the vulnerability and accessibility of these plants.

In Canada, American ginseng is listed as rare (Argus & Pryer 1990) and occurs naturally in only a few small populations in southern Ontario & Québec (Bouchard et al. 1983; Gagnon & Charron 1987; White 1988). These populations are usually found in *Acer saccharum–Carya cordiformis* deciduous forest communities on rich mesic soils, now a very restricted habitat. The species has been assigned a threatened status by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; White 1988). Since 1989, export of wild American ginseng has been officially discontinued from Canada (Small et al. 1994). Under the Québec regulation on threatened or vulnerable species (Bill 108, Government of Québec 1989), wild leek has been assigned a vulnerable status, prohibiting commercial sales (Couillard 1995). American ginseng is presently under consideration for listing as a threatened species (Lavoie 1992; Couillard 1995).

The official status designations of these plants were motivated mostly by strong indications that the size of many populations of both American ginseng and wild leek have declined and, in many places, gone extinct because of overharvesting in Canada (Dagenais 1985; White 1988). Moreover, demographic studies have shown both species to be sensitive to harvest (Charron & Gagnon 1991; Nault & Gagnon 1993). The chances are high that in many harvested populations the harvest rate had exceeded the mean growth rate until these populations reached their extinction threshold.

American ginseng and wild leek are long-lived forest herbaceous perennials with contrasting population biologies and harvesting regimes. *Panax quinquefolium* reproduces exclusively by seeds after a short prereproductive period of three years or more. Populations are typically dominated by individuals with three leaves, and the survival of these plants of intermediate size is the most critical process for population growth and maintenance (Charron & Gagnon 1991). The aerial shoots develop after the deciduous forest canopy has closed in late spring, and the leaves persist until autumn, when fruits become mature. Wild populations are scarce and difficult to locate, and the roots are highly priced on the Asian market. Diggers most likely collected roots only when seeds were ripe and planted on site the seeds of harvested plants, thus fostering recruitment. Large plants were dug out with care to keep the root intact, minimizing soil disturbance. Seedlings and juveniles were left for the next harvest because populations were revisited every 5–8 years (White 1988).

Allium tricoccum is a spring ephemeral with a short photosynthetic period. The leaves develop immediately after snowmelt, synthesize storage compounds before

the forest canopy has closed, and decay shortly afterwards (Nault & Gagnon 1988). The length of time the leaves are functional depends largely on the spring climate conditions and is reflected in year-to-year variations in vital rates (Nault & Gagnon 1988; Nault & Gagnon 1993). Slow annual growth of small-sized plants leads to a long prereproductive stage of 7 to 10 years. Most population growth and maintenance is due to vegetative propagation (Nault & Gagnon 1993). Seed production varies greatly from year to year, but input of seedlings contributes to only 1–4% of the population growth rate (Nault & Gagnon 1993). Harvesters collect, nonselectively, large volumes of wild leek bulbs with shovels, throwing away leaves and small plants and leaving the forest floor heavily disturbed. Populations are often small but easy to locate, so most harvests are of total populations and are done without any conservation measures.

Because vital rates of American ginseng and wild leek have been shown to vary over time, extinction of their remnant populations can be attributed to a combination of bioecological uncertainties, such as environmental stochasticity, and human pressures. Environmental stochasticity, the natural fluctuations in the life conditions of all individuals of a population (May 1973), is considered a major factor in many population extinctions (Shaffer 1981; Gilpin & Soulé 1986; Menges 1991, 1992; Boyce 1992; Foley 1994). In a varying environment even a population with a mean growth rate ($\hat{\lambda}$) greater than 1.0 can go extinct, providing that variance in vital rates is large enough (Lande & Orzark 1988; Menges 1992). It is thought that population sizes necessary to buffer environmental stochasticity and random catastrophes will be sufficient to protect the genetic integrity of plant populations and will prevent demographic stochasticity from driving them to extinction (Menges 1991; Lande 1993).

The relationship between environmental stochasticity, population sizes, and average time to extinction have been studied with analytical models (Goodman 1987; Lande 1993; Foley 1994). Despite the ability of these models to provide useful insights into the processes of population extinction (Belovsky 1987; Belovsky et al. 1994), they could not be used for MVP estimation with the empirical data we had.

Transition matrices constructed from empirical data have been used to perform population projections of rare and endangered plants (Fiedler 1987; Mehrhoff 1989; Menges 1990; Charron & Gagnon 1991; Nault & Gagnon 1993; Schemke et al. 1994) and in assessing the impact of harvesting (Usher 1996; Getz & Haight 1989; Pinard 1993). In a stochastically varying environment the projection of a stage-classified population is obtained by the equation $\boldsymbol{x}(t+1) = \boldsymbol{A}_t\boldsymbol{x}(t)$, where the $\boldsymbol{x}$ are vectors containing the number (x_i) of plants per stage class i at a given time step, and $\boldsymbol{A}_t$ are observed transition matrices (Menges 1990). The transition coefficients (a_{ij}) in these matrices are the proportion of the plants of a given stage that have grown or regressed to another given stage, or remained in the same stage, between two censuses (Lefkovitch 1965). When individuals (or ramets) have been classified by size, the transition coefficients incorporate the rates of growth, survival, and fecundity. These vital rates vary over time in the same population (Menges 1992).

In theory, a great number of transition matrices $\boldsymbol{A}_t$ alternate at random in a varying environment. In practice, because detailed demographic studies are time-consuming, the number of matrices $\boldsymbol{A}_t$ are typically few, so stochastic population projections are performed with two or more alternated matrices having the same frequency of occurrence during the projection (Bierzychudek 1982; Caswell 1989; Cohen et al. 1983; Menges 1990) or having a frequency estimated from environmental data (Åberg 1992). This method assumes that the mean and variance of each transition coefficient in a limited set of $\boldsymbol{A}_t$ matrices are representative of their mean and variance in a much larger set. These assumptions can rarely be tested because sufficiently long time series are usually lacking.

If the variance of the a_{ij} is large enough among matrices, some series of population sizes ($N(i) = \Sigma\, x_i(i)$) will fall below the extinction threshold during a stochastic projection (Menges 1992). The extinction probability of this population is the proportion of series that actually fall below this threshold within projection time (Menges 1990). By examining the relation between the starting population size $N(0)$ and this extinction probability, one can estimate the MVP (Menges 1992). This MVP is sensitive to the variance of the one-step estimates of population growth rate $\lambda(i)$ (Lande & Orzark 1988; Menges 1992), which depends on the matrix-to-matrix variance of the transition coefficients. MVP estimates will also change according to the extinction threshold chosen (Ginzburg et al. 1982).

We used stochastic projection models with previously published transition matrices of American ginseng and wild leek populations (Charron & Gagnon 1991; Nault & Gagnon 1993). Our objectives were (1) to assess quantitatively the impact of harvesting on these two species in stochastically varying environments, using the available data to run realistic harvest simulations, and (2) to estimate their population extinction threshold and minimum viable population sizes (MVP). Under natural conditions many individuals are needed to allow population growth; therefore, our models assumes that the extinction threshold is the population size below which no increase of the population is possible. This definition is consistent with the property of the extinction threshold as an absorbing boundary. Extinction thresholds and associated MVP are extremely useful in population management because they help identify populations at risk and settle restoration priorities. Because our models

aimed for accurate predictions and because ginseng and wild leek have been submitted to different harvesting regimes, our treatment of each species is different.

Methods

Transition Matrices and Extinction Thresholds

For American ginseng, four transition matrices modified from Charron and Gagnon (1991) were taken (Table 1). These matrices were constructed from census data of four different populations, two populations censused for 3 years and two for 2 years. For wild leek, the four transition matrices from Nault and Gagnon (1993) were used as they appear in the original publication. They were constructed from census data of five consecutive growing seasons.

The extinction threshold is the minimum starting number of individuals (or ramets) needed to rebuild a population—to ensure a population growth rate (λ) > 1. This minimum number is a property of a given transition matrix because the transition coefficients determine the number of individuals that will go through the life cycle in a given number of years. Therefore, we computed an extinction threshold for each matrix of both species. This was done by a modified population projection algorithm in which at each matrix multiplication $\boldsymbol{Ax}(t)$, the number of plants $x_i(t + 1)$ in a given stage i was the integer part only the figure obtained by the matrix multiplication $\boldsymbol{Ax}(t)$. In other words, no fraction of individuals was allowed to contribute to the growth of the population as in the usual algorithm of matrix exponentiation. The starting population, $N(0)$, in which individuals were distributed according to the stable stage distribution, was changed until the growth rate of the population corresponded to the dominant eigenvalue λ of the matrix $\boldsymbol{A}$, if its $\lambda > 1$. The lowest $N(0)$ needed to obtain this λ was the extinction threshold.

Analysis of Confiscated Wild Leek Harvests

Five confiscated samples of wild leek bulbs were obtained from the conservation division of Gatineau Park (Québec, Canada) and were used to estimate average

Table 1. Transition matrices (A_t) of four populations of American ginseng (*Panax quinquefolium*) used in stochastic projections (equation 1).[a]

	Size-class[b]					
	Seed	*0*	*1*	*2*	*3*	*4*
Population 1, 1986–1988						
Seed	0	0	0	1.350	13.24	18.50
0	0.090	0	0	0	0	0
1	0	0.155	0.245	0	0	0
2	0	0.015	0.585	0.515	0.060	0
3	0	0	0	0.400	0.845	0.190[c]
4	0	0	0	0.030	0.045	0.740[c]
Population 2, 1986–1988						
Seed	0	0	0	0.595	6.535	33.59
0	0.150	0	0	0	0	0
1	0	0.250[d]	0.525	0.055	0	0
2	0	0.015	0.385	0.430	0.030	0
3	0	0	0.040	0.440	0.770	0.105
4	0	0	0	0.025	0.170	0.855
Population 3, 1986–1987						
Seed	0	0	0	0	21.78	28.29
0	0.010	0	0	0	0	0
1	0	0.210	0.330	0	0.020	0
2	0	0	0.330	0.710	0.040	0
3	0	0	0	0.140	0.770	0.220
4	0	0	0	0	0.040	0.610[d]
Population 4, 1986–1987						
Seed	0	0	0	0.290	11.06	25.50
0	0.060	0	0	0	0	0
1	0	0.240	0.750	0	0.020	0
2	0	0	0.150	0.730	0	0
3	0	0	0.100	0.200	0.730	0.250
4	0	0	0	0	0.140	0.750

[a] *Modified from Charron and Gagnon (1991).*
[b] *0 = seedlings; 1–4 = plants with 1, 2, 3, and ≥ 4 leaves, respectively.*
[c] *Average a_{4-3} and a_{4-4} of all population matrices to replace the real value 0.00 obtained because no individual of class 4 was sampled in this population.*
[d] *Correction of typographical errors found in the published matrices.*

bulb size and size-structure of the harvests. The total fresh mass of each harvest was determined, and subsamples of about 200 bulbs were randomly taken to estimate the individual bulb mass. The selected bulbs were freed from remaining leaf bases, roots, and rhizomes; they were washed, oven dried at 70°C for 3 days, and then weighted to ± 0.0005 g. Because the total leaf width (TLW) defines size-classes in the matrix model (Nault & Gagnon 1993), the limits of all TLW size-classes were transformed to grams of dry bulbs. For this we used regression equations obtained for TLW and bulb dry mass from samples taken in 1984 and 1985 (Nault 1986). This classification was used to calculate the proportion of each TLW size-class in the harvested samples. The matrix model also separates the plants of a given size-class according to their reproductive status and whether or not they are issued from vegetative division. The proportion of these stages within each size-class for each censused year was taken from the data of Nault and Gagnon (1993).

Stochastic Population Projections and Harvesting Models

In stochastic population projections, transition matrices are obtained from the same population censused for more than 2 years. The ginseng matrices were obtained from different populations. We thus assumed that the site-to-site variance of the transition coefficients was representative of their year-to-year variance. This may not be entirely true, but in the absence of longer-term census data there was no alternative.

For ginseng, the environmental transition matrix, $\boldsymbol{P}_1$, defined the random alternation of the four population matrices, $\boldsymbol{A}_t$, so that each had the same frequency and the same probability of replacing any other one. For wild leek, two environmental transition matrices were defined: $\boldsymbol{P}_1$ as above and $\boldsymbol{P}_2$ where each annual matrix had the same frequency but in which the exceptionally good growing season (represented by the 1984–1985 matrix) was always followed by a relatively bad season (represented by the 1985–1986 matrix). This alternation scenario simulated the negative carry-over effect of an exceptional season reported for this spring ephemeral (Nault & Gagnon 1993).

The projection of a stage-classified population under a post-reproduction harvesting regime is obtained by $\boldsymbol{x}(t + 1) = \boldsymbol{A}\boldsymbol{x}(t) - \boldsymbol{u}(t)$, where $\boldsymbol{u}(t)$ is a vector containing the number of individuals harvested in each stage class (Getz & Haight 1989). This equation defines a post-reproduction harvesting regime because each year the individuals are collected after they have grown and eventually reproduced. The equation that defines a pre-reproduction harvesting regime would be $\boldsymbol{x}(t + 1) = \boldsymbol{A}(\boldsymbol{x}(t) - \boldsymbol{u}(t))$. In a stochastically varying environment, the post-reproduction model would simply be rewritten as

$$\boldsymbol{x}(t + 1) = \boldsymbol{A}_t\boldsymbol{x}(t) - \boldsymbol{u}(t), \quad (1)$$

and the prereproduction model as

$$\boldsymbol{x}(t + 1) = \boldsymbol{A}_t(\boldsymbol{x}(t) - \boldsymbol{u}(t)). \quad (2)$$

For ginseng populations, stochastic projections used a post-reproduction harvest model (equation 1) because harvesters are reported to collect the plants when the fruits are ripe. Their bright red color makes the plants easy to locate, and the seeds can be sown on site (White 1988). In equation 1, $\boldsymbol{u}(t) = h\boldsymbol{a}\boldsymbol{x}(t)$, h is the harvest rate set between 0 and 0.30 corresponding to the portion of the population that is harvested; $\boldsymbol{a}$ is a vector in which values of 1 identify the stage classes harvested and values of 0 identify the stage classes not harvested; and $\boldsymbol{x}(t)$ is a stage vector containing the number of plants per stage at time t. In the model only plants with three or more leaves were harvested, as suggested by the survey data of White (1988). Stochastic population projections were run with harvest rates of 0, 0.01, 0.05, 0.10, and 0.30, each with rotation periods of 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 years.

For wild leek, stochastic projections used a prereproduction harvest model (equation 2) because this spring ephemeral is visible only before sexual reproduction and bulb division have taken place. In equation 2, $\boldsymbol{u}(t) = \boldsymbol{a}hX(t - 1)$, $\boldsymbol{a}$ is a vector containing the proportion of each stage classes found in real harvests; h is the harvest rate set between 0 and 0.20 corresponding to the portion of the population that is harvested; and $X(t - 1)$ is the residual number of harvestable plants (TLW > 0.8 cm) of the previous year. The vector $\boldsymbol{a}$ was determined from samples of confiscated materials. The projection was constrained so that it was not possible to harvest more ramets of a given stage than there actually were (if $u_i(t) > x_i(t)$, then $x_i(t) - u_i(t) = 0$). Stochastic population projections were run with annual harvest rates of 0, 0.01, 0.02, 0.03, 0.04, 0.05, 0.10, and 0.20, each with environmental transition matrices $\boldsymbol{P}_1$ and $\boldsymbol{P}_2$ and the two harvesting strategies. Because wild leek populations are harvested each year, all simulations were run with a rotation of one year.

With each species (and each environmental transition matrix $\boldsymbol{P}$, for wild leek), harvesting simulations used the same random sequences of matrices and were run on a time horizon of 200 years (200 iterations), thus generating a series of population sizes $N(1), N(2), \ldots, N(200)$. The mean growth rate $\hat{\lambda}$ was obtained by regressing $\log_{10}(N(i))$ against time; the slope of the regression line then corresponded to $\hat{\lambda}$. This is equivalent to the numerical method of calculation of $\widehat{\ln\lambda}$ given by Heyde and Cohen (1985) and Cohen (1986; in Caswell 1989, equation 8.70). The number of iterations gave a stabilized $\hat{\lambda}$. A series of one-step estimates of population growth rate $\lambda(i)$ was computed as $N(i + 1)/N(i)$. The variance of $\lambda(i)$ was computed with the standard formula for the variance of

a random variable. The 95% confidence interval of $\hat{\lambda}$ was estimated as

$$\widehat{\ln\lambda} \pm 1.96\sqrt{\mathrm{var}(\ln \lambda(i))/m}$$

where m = number of iterations (200; Caswell 1989).

In a series of transition matrices there is often one matrix that stands out from the others because of unusually bad or good growing conditions during the census interval. The frequency of this unusual matrix can be modified in distinct population projections to explore the sensitivity of the growth rate to the frequency of this matrix. Therefore, harvesting simulations were repeated with a mean matrix in which transition coefficients are average values of those in the four matrices. Mean matrices are defined as $\bar{A} = \Sigma\, b_t A_t$, where A_t is one of the observed population matrices and b_i is the frequency of probability of occurrence of that matrix such that $\Sigma\, b_i = 1$. The dominant eigenvalue of this matrix $\bar{A}$ corresponds to the growth rate μ of the population ($\mu = \lambda_1^{\bar{A}}$); the value of $\hat{\lambda}$ defined above should be close to μ (Caswell 1989). The most different matrices were of ginseng population three (the lowest λ) and for wild leek of 1984–1985 (the highest λ). For each harvest rate the frequency b_i of the unusual matrices was successively set at 0.25, 0.1, 0.05, and 0.01, representing a chance of occurring every 4, 10, 20, and 100 years.

The growth rate of a population harvested annually (μ_b) can be predicted from the mean matrix as

$$\mu_b \approx (1 - \Sigma h_i e_i)\, \mu_0 \,, \qquad (3)$$

where h_i is the annual harvest rate of size class i, e_i is the sum of the elasticity values of size class i, and μ_0 the growth rate of the population when not harvested. Elasticity values give the proportional change in μ resulting from a proportional change in any given transition coefficient (a_{ij}) of the mean matrix (de Kroon et al. 1986). With ginseng, calculation of predicted μ_b excluded the elasticity associated with fecundity (first row of the elasticity matrix) because it is assumed that harvesters leave the fruits on site (White 1988). If equation 3 is used with any single matrix A, the growth rate μ is replaced by λ_1^{A}.

For both species (and each environmental transition matrix P, for wild leek) 50 stochastic population projections of 100 years were run without harvesting. Each projection used a different random sequence of matrices and generated a random series of growth rates $\lambda(1)$, $\lambda(2), \ldots, \lambda(100)$. From each series of $\lambda(i)$ we computed a corresponding series of population sizes $N(i)$ with the formula $N(i + 1) = \lambda(i)N(i)$. The number of simulated years during which the values of $N(i)$ stayed above the extinction threshold is an estimate of the population persistence. The extinction probability was computed as the proportion of simulated series of $N(i)$ having a persistence lower than 100 years. By changing the starting population size, $N(0)$, simultaneously for all 50 series of $N(i)$, we determined the lowest $N(0)$ needed to have an extinction probability 0.05 ($\pm$ 0.01) over 100 years. This $N(0)$ was the minimum viable population (MVP). The different values of $N(0)$ ranged from the extinction threshold to 2000, with increments of one individual when the right (smaller) range of $N(0)$ had been identified. All simulations were run with the spreadsheet software EXCEL 3.0 (Microsoft Corporation 1991, Redmond, Washington).

Results

Size Structure of Confiscated Wild Leek Harvests

The analysis of samples of confiscated wild leek harvests revealed two harvesting strategies: a strategy of "choosy" harvesters and a strategy of "busy" harvesters (Fig. 1). The choosy types harvested plants mostly in the largest size-classes, with a peak at size class 5 (ramets with two leaves, each 3–5 cm wide). Four confiscated samples out of the five analyzed presented this strategy. These samples weighed from 2.3 to 8 kg (fresh mass) and contained between 550 and 2000 bulbs. The busy type seemed less selective, harvesting more broadly and more rapidly, collecting a greater quantity of middle-sized ramets (size-class 4: one large or two small leaves; Fig. 1). A single confiscated harvest representing the busy type contained more plants (8.8 kg, 3600 bulbs) and debris than the average in the choosy type of harvest. Using the total fresh mass of the bulbs (85 kg) harvested by the 16 illegal harvesters, the average dry mass of one bulb (3.5 g) and a dry-to-fresh mass ratio of 1:4, we estimated the total confiscated harvest of 1993 to be 25,000 ramets in Gatineau Park.

Mean Population Growth Rate

For ginseng the slope of the linear decline of the mean population growth rate ($\hat{\lambda}$) along the gradient of harvest pressure varied according to the rotation period (Fig. 2). The relationship between the rate of decline of $\hat{\lambda}$ and the rotation period is an exponential function described by the following equation:

$$\hat{\lambda}_b = \hat{\lambda}_0 - 0.54\, b\, t_r^{-0.90}, \qquad (4)$$

where λ_b is the mean growth rate under harvesting rate b, t_r is the rotation period in years, b is the harvesting rate, and λ_0 is the mean growth rate of the population when not harvested. Note also that $\hat{\lambda}$ tended toward the growth rate μ of the mean matrix $\bar{A}$, as expected (Table 2; Caswell 1989). This growth rate μ increased as the frequency of a bad growing season decreased (Table 3). But even if it occurred only once every 100 years, the population could not survive an annual harvest rate higher than 10%.

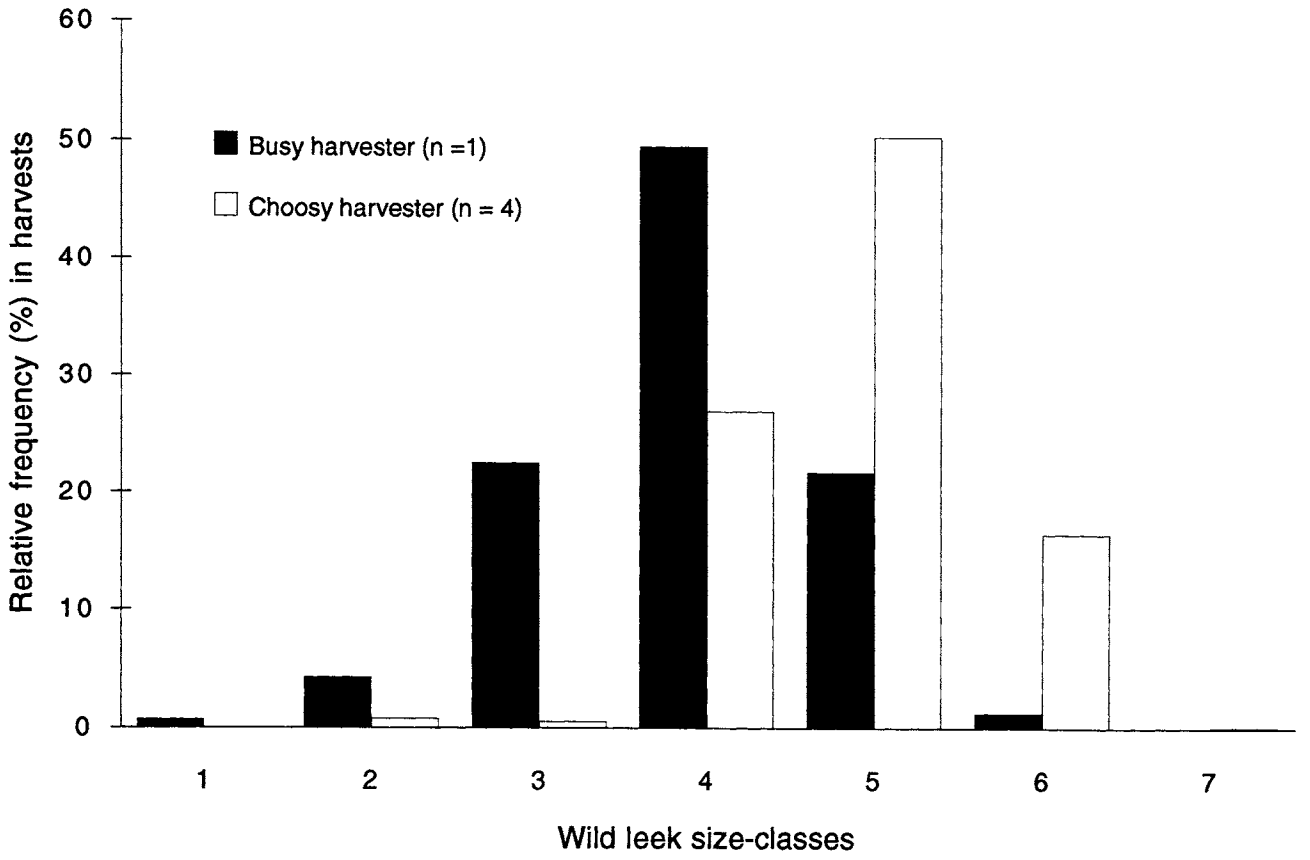

*Figure 1. Comparison of the size distribution of wild leek (*Allium tricoccum*) plants harvested according to the harvesting strategies "choosy" or "busy." The size-classes are based on total leaf width (cm) as follows: 1: ≤0.8; 2: 0.9-2.0; 3: 2.1-3.8; 4: 3.9-6.5; 5: 6.6-10.0; 6: 10.1-15.0; 7: > 15.0.*

With an annual harvest rate of 10% the $\hat{\lambda}$ of the wild leek population has a 95% chance of falling between 0.972 and 1.026 for all harvesting strategies and environment alternations (Fig. 3). The main difference among simulations was between harvesting strategies. This difference increased along the gradient of harvest pressure (Fig. 3). With a harvest rate of 20% the maximum impact (lowest $\hat{\lambda}$) was that of a choosy harvester when a good growing season was always followed by a bad one ($\boldsymbol{P}_2$). The minimum impact was that of a busy harvester with the environmental transition matrix $\boldsymbol{P}_1$. With harvesting rates below 5% the differences were less pronounced. The frequency of an exceptionally good reproduction year did not alter greatly the decline of the population growth rate along the gradient of harvest pressure (Table 4).

Extinction Threshold and Minimum Viable Populations

The extinction thresholds of American ginseng populations vary with the deterministic growth rates set by their transition matrices (Table 5). Among the four populations studied by Charron and Gagnon (1991), population 1 was very close to its extinction threshold. It was not possible to compute an extinction threshold for population 3 because its deterministic growth rate (λ) was less than 1. The MVP for this set of matrices, using an extinction threshold of 91 (560 including seeds; Fig. 4), was estimated at 172 plants (1068 including seeds). We estimated that a population of 172 has a probability of extinction of 0.04 over 100 years. Moreover, populations that fell below 91 in the simulations did so within 4 years, otherwise they persisted for 100 years. Beyond 4 years the sizes reached by the simulated populations were too large to have a chance of falling below 91, even if the $\lambda(i)$ were less than 1.0 more than 1 year in a row.

If the plants were distributed as the stable stage distribution associated with the mean matrix, a population of 172 plants would have 55 plants with more than two leaves (Fig. 4). None of the populations studied by Charron and Gagnon (1989) reached this number (Table 5). Only three populations in Québec are presently known to have more than 500 plants, but most populations have less than 50 (Nault & Gagnon, unpublished data). In Ontario the average number of plants in known populations was estimated as 10 to 20 plants (White 1988).

The extinction thresholds of the wild leek populations also vary with the deterministic growth rate set by the

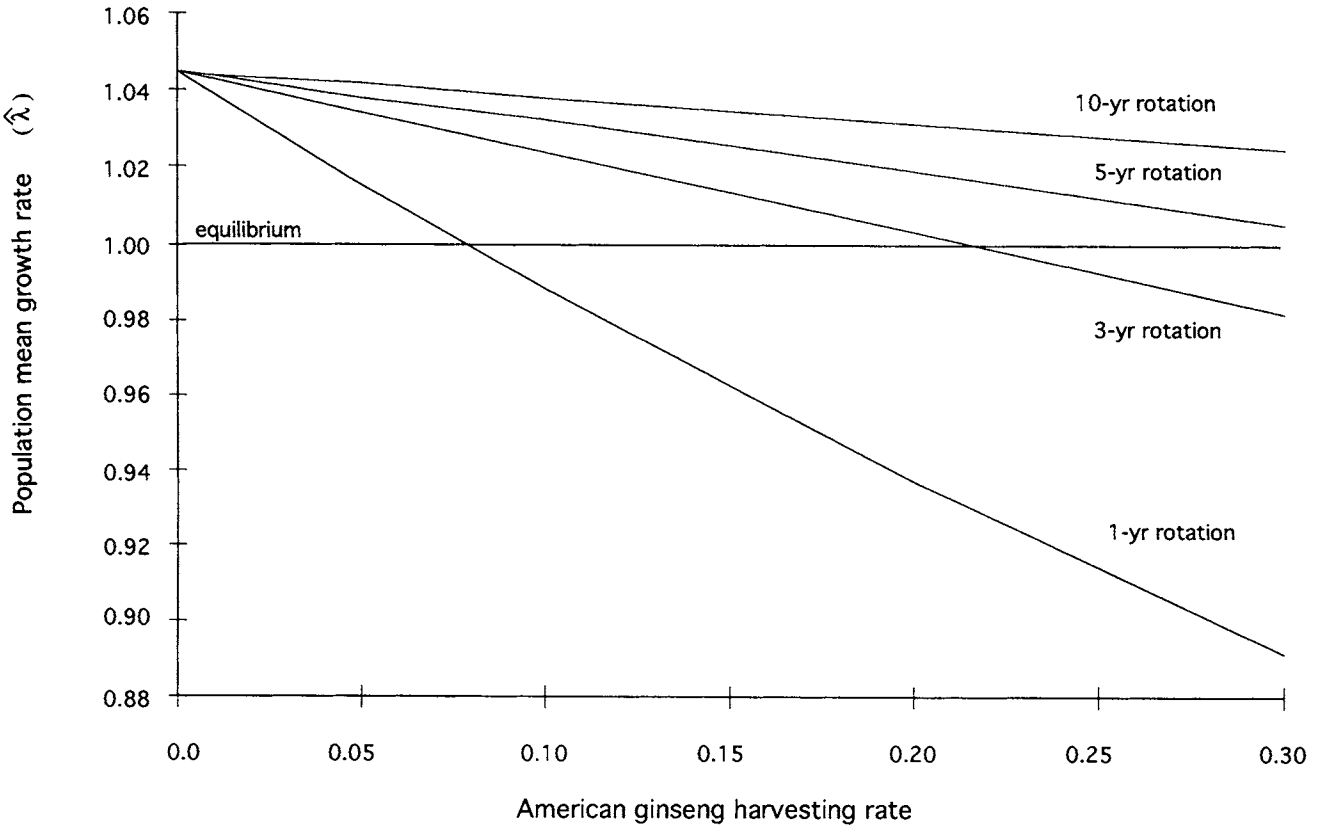

*Figure 2. Decline of the mean growth rate ($\hat{\lambda}$) of a population of American ginseng (*Panax quinquefolium*) on the harvesting gradient for different rotation periods. Mean growth rates ($\hat{\lambda}$) were computed from 200-year stochastic projections using four transition matrices.*

annual transition matrix (Table 5). The MVP for this population was estimated around 300 or 1000 individuals, depending on whether we used an extinction threshold of 140 (set by the mean matrix) or 482 (set by the matrix with the lowest λ; Table 5; Fig. 4). If the individuals were distributed as the stable stage distribution associated with the mean matrix, a population of 303 or 1032 plants (502 or 1705 individuals including seeds) would have 209 or 713 plants of harvestable size (leaves more than 0.8 cm wide; Fig. 3). Remnant wild leek popula-

Table 2. Mean growth rates ($\hat{\lambda}$ and μ) of an American ginseng (*Panax quinquefolium*) population under different harvest rates, in a stochastic environment, simulated with the four population matrices of Table 1.

	Harvest rate (%)[a]				
Variable	*0*	*1*	*5*	*10*	*30*
λ	1.045	1.039	1.016	0.988	0.892
var(λ_t)[b]	0.0831	0.0826	0.0811	0.0795	0.0759
var(ln(λ_t))	0.0806	0.0810	0.0829	0.0855	0.0973
μ	1.045	1.039	1.016	0.989	0.892
predicted μ_b[c]	1.045	1.040	1.018	0.992	0.888

[a] *Harvest rates represent the percentage of plants harvested in size-classes 3 (three leaves) and 4 (≥ four leaves)*
[b] *Variance computed with the standard formula of the variance of a random variable.*
[c] *The growth rate of a population harvested annually (μ_h) can be predicted by $\mu h \approx (1 - \Sigma h_i e_i)\, \mu_0$, where h_i is the harvested rate of size class i, e_i is the sum of the elasticity values of size class i (excluding the values for reproduction), and μ_0 is the population growth rate of the mean matrix with no harvesting (= 1.045).*

Table 3. Growth rate (μ_b) of an American ginseng (*Panax quinquefolium*) population under different harvest rates, simulated with mean matrices[a] computed with four different probabilities of an unusually bad year.

	Harvest rate (%)[b]				
Probability[c]	*0*	*1*	*5*	*10*	*30*
0.25	1.045	1.039	1.016	0.989	0.892
0.10	1.072	1.067	1.043	1.015	0.914
0.05	1.082	1.076	1.052	1.023	0.922
0.01	1.089	1.082	1.059	1.030	0.927

[a] *$A = \Sigma b_t A_t$, where the A_t are population transition matrices and each b_t is the frequency or probability of occurrence of a population matrix such that $\Sigma b_t = 1$.*
[b] *Harvest rates represent the percentage of plants harvested in size-classes 3 and 4.*
[c] *The probability (b_3) is the frequency of an unusually bad year as represented by the matrix of population 3 (see Table 1).*

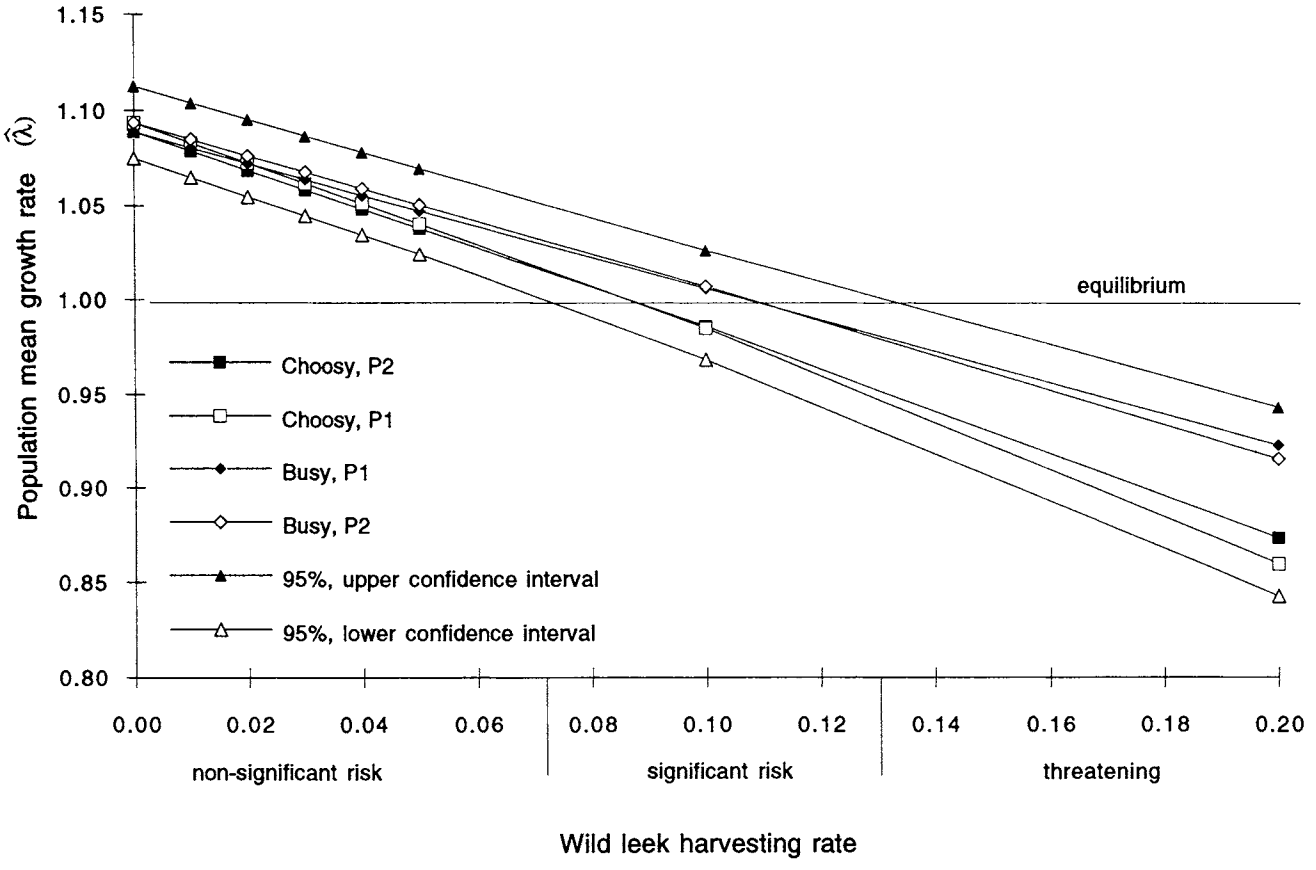

*Figure 3. Decline of the mean growth rate ($\hat{\lambda}$) of a population of wild leek (*Allium tricoccum*) on a harvesting gradient for two harvesting strategies, each simulated using environmental transition matrix* $\mathbf{P}_1$ *and* $\mathbf{P}_2$*. Harvesting strategies are based on size-structure of harvests. The "choosy" type harvested plants mostly in the largest size classes, and the "busy" type harvested more broadly with a greater quantity of middle-sized plants (Fig. 1).*

tions in Québec are typically sparse and rarely contain more than a few hundred plants.

The estimated MVP of wild leek was not much influenced by the environmental transition matrix used, but the shape of the extinction probability curve, as it declines along $X(0)$, differed between environmental transition matrices (Fig. 4). Extinction probabilities were higher when projections were made with environmental transition matrix $\boldsymbol{P}_2$. Also, the curves were steeper when the extinction threshold was set lower (Fig. 4). We estimated that all calculated wild leek MVP have an extinction probability of 0.06 over 100 years. As for ginseng, wild leek populations that went below the extinction threshold in the simulations did so very early (within 3 years); otherwise they persisted for 100 years.

Discussion

Impact of Harvesting Ginseng and Wild Leek

There are some indications that many harvesters of American ginseng collect all the large plants (two leaves or more) they can find (Lewis 1984). A survey of 29 harvesters of American ginseng in Ontario revealed that most respondents follow conservation measures such as harvesting late in the season, sowing the seeds, leaving the younger plants, and rotating their visits (White 1988). Despite such measures, mean collected root mass has decreased constantly (White 1988). In Québec the importance of harvesting is unknown (Gagnon & Charron 1987).

The maximum sustainable rate of harvest on any population is the rate at which the $\hat{\lambda}$ falls below the equilibrium value of 1.0. For ginseng populations the maximum rate of annual harvest would be a little more than 5% (Table 2). Because of the variance in $\lambda(i)$, however, the growth rate of a population under this harvesting pressure still has a chance of falling temporarily below the equilibrium. This sustainable harvest rate is about three times lower than the maximum value of 15.8% estimated previously under the assumption of a favorable and unchanging environment (Charron & Gagnon 1991).

The gradient of harvesting rates on a wild leek population can be divided into three ranges of rates for which the risk that the $\hat{\lambda}$ will drop below 1.0 is nonsig-

Table 4. Growth rate (μ_b) of a wild leek (*Allium tricoccum*) population under different harvest rates, simulated with mean matrices[a] computed with four different probabilities of an unusually good year.

	Harvest rate (%)[b]							
Probability[c]	*0*	*1*	*2*	*3*	*4*	*5*	*10*	*20*
Choosy harvesters								
0.25	1.091	1.081	1.071	1.061	1.051	1.040	0.988	0.873
0.10	1.082	1.072	1.062	1.052	1.042	1.032	0.982	0.875
0.05	1.078	1.069	1.059	1.049	1.040	1.030	0.980	0.877
0.01	1.076	1.066	1.057	1.047	1.037	1.028	0.979	0.878
Busy harvesters								
0.25	1.091	1.083	1.075	1.066	1.058	1.050	1.009	0.925
0.10	1.082	1.074	1.066	1.057	1.049	1.041	1.002	0.923
0.05	1.078	1.070	1.062	1.054	1.046	1.039	0.999	0.923
0.01	1.076	1.068	1.060	1.052	1.044	1.036	0.998	0.923

[a] $\overline{\mathbf{A}} = \Sigma\, b_t \mathbf{A}_t$, *where the* $\mathbf{A}_t$ *are population transition matrices and each* b_t *the frequency or probability of occurrence of each matrix, such that* $\Sigma\, b_t = 1$.
[b] *Harvest rates are expressed as the percentage of plants harvested in a whole population, according to size distributions shown in Fig. 1.*
[c] *The probability* (b_1) *is the frequency of an exceptionally good year as represented by the matrix of 1984–1985 (see Nault & Gagnon 1993).*

nificant (< 5%); significant (> 5%, < 95%); and threatening (> 95%). If we set the maximum sustainable harvest rate at the upper limit of the nonsignificant risk range, it would be less than 8% (Fig. 3). This is about two times lower than the 15% maximum rate estimated previously under the assumptions of an unchanging environment and a harvest strategy in which collected plants are uniformly distributed in the largest size-classes (Nault & Gagnon 1993).

The strategies used by wild leek harvesters have a significant impact on population maintenance. The busy harvesters, when collecting the same number of plants as the choosy ones, had less impact. This is because the busy type of harvester collected more in the small size-classes, in which plants are known to contribute less to population growth according to the elasticity matrices (Nault & Gagnon 1993). But because the busy harvesters collect more plants than the average choosy harvesters, they would have a greater overall impact.

For wild leek the slope of the declining curve of $\hat{\lambda}$ along the gradient of harvesting pressure ranged from −0.83 to −1.09 (Fig. 3). These slopes are steeper than that of −0.51 obtained with a ginseng population harvested annually (Fig. 2). Therefore, simulated annual harvests had more impact on wild leek than on ginseng populations. The greater sensitivity of wild leek to harvest may be due to prereproduction harvests of large plants in a population that maintains its number mostly by bulb division of these large plants. High elasticity values are concentrated in large size-classes in wild leek (Nault & Gagnon 1993), compared to ginseng in which high elasticity values are more evenly distributed among size-classes (Charron & Gagnon 1991). Because wild leek is visible only in spring, the only conservation measure would be to delay bulb harvest until the end of the photosynthetic season, when bulbs are filled with reserves (usually at the end of May in Québec; Nault & Gagnon 1988). The number of bulbs necessary to obtain the same mass would then be greatly reduced.

Implications for Conservation

The MVP for both studied species is about twice the size of their corresponding extinction thresholds. We cannot tell if this is a general trend, but such a similarity between these two different species was unexpected. This simple ratio, if general, could become a convenient rule of thumb.

Table 5. Extinction thresholds ($N_t(0)$ and $N_p(0)$), population sizes (N_{obs}), and deterministic growth rates (λ) computed for each matrix of American ginseng (*Panax quinquefolium*) and wild leek (*Allium tricoccum*).

Species	*Matrix*	$N_t(0)$[a]	$N_p(0)$[b]	N_{obs}[c]	λ
Ginseng	1 (1986–1988)[d]	529	87	60–80	1.055
	2 (1986–1988)[d]	146	30	75–76	1.170
	3 (1986–1987)	—	—	75–76	0.880
	4 (1986–1987)	560[e]	89	128–132	1.050
Wild leek	1984–1985	132	77	1640	1.130
	1985–1986	797[e]	479	2628	1.024
	1986–1987	191	113	2319	1.106
	1987–1988	156	93	3710	1.100
	1984–1988[d]	234[e]	139	3026	1.091

[a] $N_t(0)$ *is the total starting population distributed as the stable stage distribution associated with each individual matrix.*
[b] $N_p(0)$ *is the number of plants (=* $N_t(0)$ *− number of seeds) according to the stable stage distribution.*
[c] N_{obs} *is the number of plants observed during censuses (minimum and maximum for the ginseng). For ginseng,* N_{obs} *are from exhaustive censuses; for wild leek,* N_{obs} *are from a subsample of 18 m² of a much larger population* ($N_{obs} \approx 10^6$).
[d] *Mean matrices.*
[e] *Numbers used to compute the minimum viable populations (MVP).*

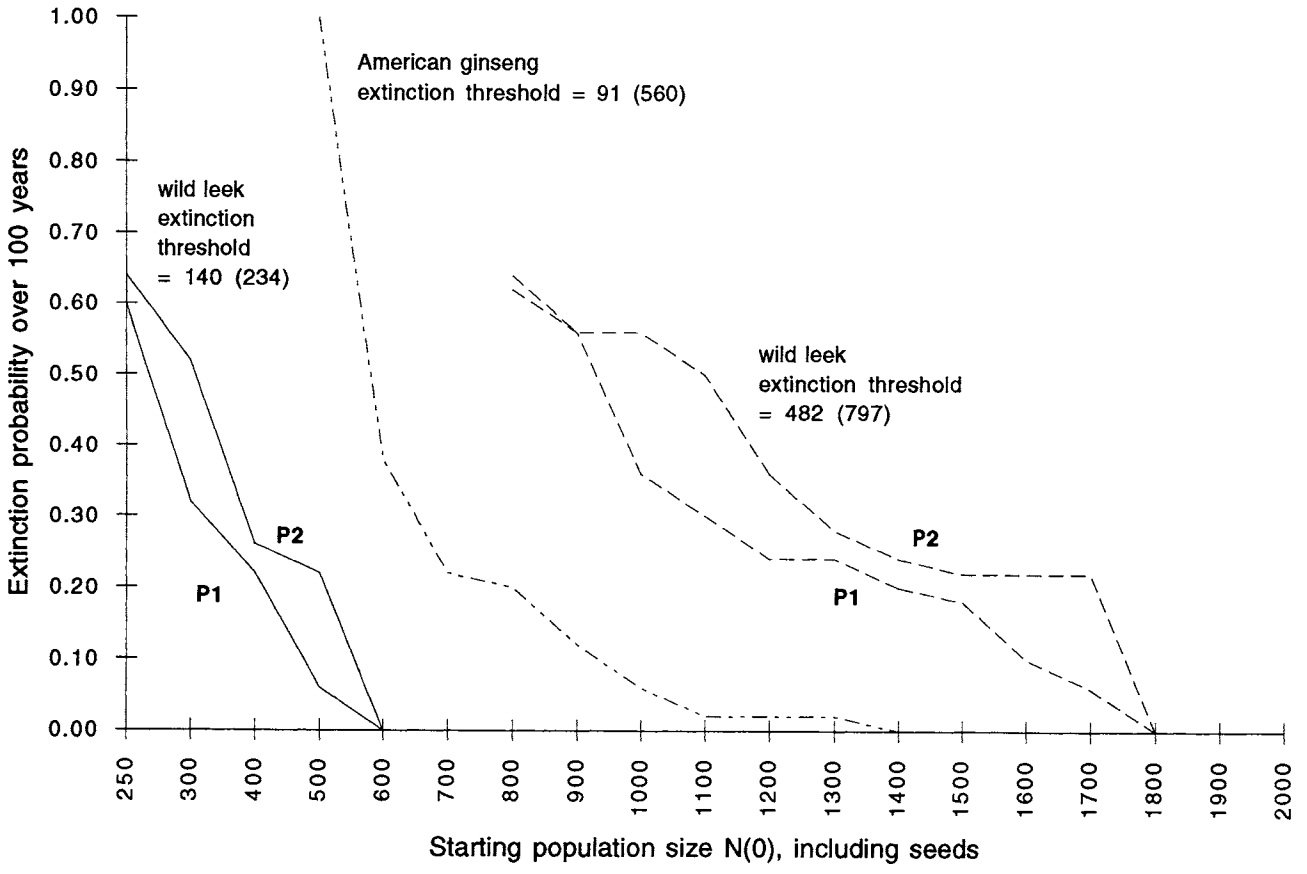

*Figure 4. Extinction probability over 100 years for populations of American ginseng (*Panax quinquefolium*) and wild leek (*Allium tricoccum*) as a function of starting population size.* $\mathbf{P}_1$ *and* $\mathbf{P}_2$ *are different environmental transition matrices. Figures in parentheses represent total population numbers, including seeds.*

For American ginseng the results of harvesting simulations and MVP estimation suggest that most small, isolated populations found in Québec and Ontario are too small to support any harvesting. Populations above MVP may not support more than very low harvesting rates on a long rotation period. For instance, with an annual harvesting rate of 10% persistence T (in years) above MVP increases as the logarithm of $X(0)$ $T = 116\log_{10}(X(0)) - 349$. This means that even a population of 485 plants (3000 individuals when including seeds) would go below its MVP in less than 100 years.

Our results show that increases in the harvesting rotation period are beneficial for ginseng populations. With the average rotation period of 5 years (White 1988), a harvest rate of 30% would give a mean growth rate of 1.007 with a 95% confidence interval of 0.967-1.049 (Fig. 2). Most reproductive plants are found in age classes 4-7 years and older, and seeds have a dormancy of 1.5 years (Charron 1989), so we expect that seeds produced during harvest year will reach reproductive size 7 years later. Also, in 5 years only a small proportion of juveniles will reach a size large enough to yield relatively good seed crops. Therefore, rotation longer than 5 years would be more prudent. At such a low sustainable level, however, harvesting of wild roots of ginseng can hardly generate a reasonable income.

The sowing of seeds is also likely to be beneficial. Charron and Gagnon (1991) showed that, with a probability of seedling recruitment higher than 20%, all populations studied reached a $\lambda > 1$. Using a germination rate of 34% (half of the rate obtained in an experimental garden; Charron 1989) in the four transition matrices, the $\hat{\lambda}_0$ in equation 4 increased from 1.045 to 1.186. This would allow, in theory, an annual harvest rate of up to 30%. Therefore, sowing seeds would be an efficient method of enhancing the viability of existing wild populations in Canada. But because these calculations are based on "mature" populations and because only older plants produce a large number of seeds, there is reason to be even more conservative.

Large populations of wild leek seem able to support low harvesting rates (below 8%). For a population containing 10,000 plants of TLW > 0.8 cm, however, this represents only 800 bulbs per year, a collection typical

of a single, choosy harvester. With an annual harvest rate of 20% ($\hat{\lambda}$ = 0.873), persistence above MVP increases as the logarithm of $X(0)$: $T = 17\log_{10}(X(0)) - 48$. Regulations over the number of harvestable plants, in relation to population size, would be difficult to enforce.

It appears likely that many populations of both wild leek and American ginseng in Québec have declined and even disappeared because of overharvesting. Since the 1930s American ginseng has been cultivated in Canada. Today the species is cultivated mostly in southwestern Ontario and southern British Columbia (Small et al. 1994). In this last province, the net income for the sales of ginseng roots on the Asian market reached $28 million (Canadian) in 1993 (Schreiner 1994).

In 1983 commercial trade of wild leek bulbs in Québec was estimated to be worth from $290,000 to $580,000 (Canadian) per year (Dagenais 1985). The official designation of the species as vulnerable in Québec will allow harvests for personal use only and will lead to legal actions on commercial retailers. Cultivation of wild leek would decrease the harvesting pressure on wild populations because cultivated plants would meet the same market demands as those taken by collectors. Production costs would be higher, however.

In a context of commercial production, efforts should be taken to protect and improve the viability of remnant wild populations of both species as living gene banks. It is hoped that the commercial value of the species will make these efforts more appealing to various levels of government as well as private interests. Ginseng and wild leek could contribute to public awareness about plant conservation in Canada because these species possess high cultural, educational, and ecological value. Ginseng has a long history of medicinal use, both by Asian and American cultures. Wild leek was also used by aboriginal peoples of Canada and is a well-known spring ephemeral. With their foliage developing immediately after snowmelt, wild leek plants play an important ecological role by capturing soil nutrients that might otherwise be lost from the site (Muller 1978).

Limitations of the Harvesting Models and Extinction Probability Estimates

Our conclusions may appear extremely conservative because they do not stem from results of experimental harvests and because of almost unavoidable gaps in knowledge. For both species the effect of plant density on vital rates is unknown; the models we used did not explicitly incorporate density dependence. Density dependence in matrix population models for the perennial herb *Viola fimbriatula* gave population trajectories with undamped oscillations when the density function was discontinuous (Solbrig et al. 1988, 1990). Such a behavior would increase extinction risk. In any case, the incorporation of a realistic and explicit nonlinearity in a projection model requires a lot of data (Ginzburg et al. 1990). Most probably, transition coefficients derived from field observations on natural populations already incorporate density effects, but to an unknown extent.

Because of lack of relevant data, our stochastic projections did not include random catastrophes, which can represent a major risk for populations (Menges 1991; Lande 1993; Mangel & Tier 1994). Sugar maple stands on rich mesic soils are the typical habitat for both species. Small-scale disturbances, such as windthrows, may occur in these forests and can possibly damage whole patches of forest herb populations. The distribution of such environmentally caused catastrophes for a given population is hard to estimate (Foley 1994). Another major cause of population extinction for both species in southern Canada has been habitat conversion or destruction by development. Legal designation of wild leek as vulnerable in Québec should decrease this kind of catastrophe.

Despite these knowledge gaps, we think our approach has much to offer and has reduced the uncertainty about the effects of harvesting wild leek, American ginseng, and other organisms in stochastic environments. When organisms are harvested it should be remembered that the whims of a stochastically varying environment significantly reduce sustainable harvest levels. Harvesters usually seek large, mature individuals. Yet, the population viability of most iteroparous forest herbs and woody plants studied so far appears to depend highly on the survival of mature individuals (Silvertown et al. 1993). This may be particularly true at the northern limit of the distribution of ginseng and wild leek because more-variable or -rigorous climatic conditions lead to more-episodic recruitment.

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Literature Cited

Åberg, P. 1992. Size-based demography of the seaweed *Ascophyllum nodosum* in stochastic environments. Ecology **73:** 1488–1501.

Argus, G. W., and C. Pryer. 1990. Rare vascular plants in Canada, our natural heritage. Canadian Museums of Nature, Ottawa.

Belovsky, G. E., J. A. Bissonette, R. D. Dueser, T. C. Edwards, Jr., C. M. Luecke, M. E. Ritchie, J. B. Slade, and F. H. Wagner. 1994. Management of small populations: concepts affecting the recovery of endangered species. Wildlife Society Bulletin **22:** 307-316.

Bierzychudek, P. 1982. The demography of Jack-in-the-Pulpit, a forest perennial that changes sex. Ecological Monographs **52:**335-351.

Bouchard, A., D. Barabé, M. Dumais, and S. Hay. 1983. The rare vascular plants of Quebec. Syllogeus series, no. 48. National Museums of Canada, Ottawa.

Boyce, M. S. 1992. Population viability analysis. Annual Review of Ecology and Systematics **23:**481-506.

Caswell, H. 1989. Matrix population models: construction, analysis, and interpretation. Sinauer Associates, Sunderland, Massachusetts.

Charron, D., 1989. La dynamique des populations de Ginseng (*Panax quinquefolium* L.) dans le sud du Québec. M.S. thesis. Université du Québec à Montréal, Montréal.

Charron, D., and D. Gagnon. 1991. The demography of northern populations of *Panax quiquefolium* (american ginseng). Journal of Ecology **79:**431-445.

Cohen, J. E. 1986. Population forecasts and confidence intervals for Sweden: a comparison of model-based and empirical approaches. Demography **23:**105-126.

Cohen, J. E., S. W. Christensen, and C. P. Goodyear. 1983. A stochastic age-structured population model of striped bass (*Morone saxatilis*) in the Potomac River. Canadian Journal of Fisheries and Aquatic Sciences **40:**2170-2183.

Couillard, L. 1993. Rapport sur la situation de l'ail des bois (*Allium tricoccum*) au Québec. Direction de la conservation et du patrimoine écologique. Ministère de l'Environment du Québec, Ste-Foy.

Couillard, L. 1995. Enfin une désignation légale pour neuf plantes du Québec. Naturaliste Canadien **119:**28-30.

Dagenais, J. 1985. Rapport sur la situation de l'ail des bois (*Allium tricoccum* Ait.) au Québec. Association des Biologistes du Québec. Ministère du loisir, de la chasse et de la pêche du Québec, Direction générale de la faune, Québec.

de Kroon, H., A Plaisier, J. van Groenendael, and H. Caswell. 1986. Elasticity: The relative contribution of demographic parameters to population growth rate. Ecology **67:**1427-1431.

Fiedler, P. L. 1987. Life history and population dynamics of rare and common mariposa lilies (*Calochortus* Pursch: Liliaceae). Journal of Ecology **75:**977-995.

Foley, P. 1994. Predicting extinction times from environmental stochasticity and carrying capacity. Conservation Biology **8:**124-137.

Gagnon, D., and D. Charron. 1987. Report on the status of *Panax quinquefolium* in Québec. World Wildlife Fund Canada, Toronto.

Getz, W. M., and R. G. Haight. 1989. Population harvesting: Demographic models of fish, forest, and animal resources. Monographs in population biology, no. 27. Princeton University Press, Princeton, New Jersey.

Gilpin, M. E., and M. E. Soulé. 1986. Minimum viable populations: the processes of species extinction. Pages 13-34 in M. E. Soulé, editor. Conservation biology: The science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts.

Ginzburg, L. R., L. B. Slobodkin, K, Johnson, and A. G. Bindman. 1982. Quasiextinction probabilities as a measure of impact on population growth. Risk Analysis **2:**171-181.

Ginzburg, L. R., S. Ferson, and H. R. Akçakaya. 1990. Reconstructibility of density dependence and the conservative assessment of extinction risks. Conservation Biology **4:**63-70.

Goodman, D. 1987. The demography of chance extinction. Pages 11-34 in M. E. Soulé, editor. Viable populations for conservation. Cambridge University Press, Cambridge, England.

Government of Québec. 1989. An act respecting threatened or vulnerable species and amending the act respecting the conservation of wildlife. 2nd session, 33th legislature 1989: Bill 108 (1989, chapter 37). National Assembly of Québec, Québec Official Publisher.

Heyde, C. C., and J. E. Cohen. 1985. Confidence intervals for demographic projections based on products of random matrices. Theoretical Population Biology **27:**120-153.

Lande, R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. American Naturalist **142:**911-927.

Lande, R., and S. H. Orzark. 1988. Extinction dynamics of age-structured populations in a fluctuating environment. Proceedings of the National Academy of Sciences USA **85:**7418-7421.

Lavoie, G. 1992. Plantes vasculaires susceptibles d'être désignées menacées ou vulnérables au Québec. Direction de la conservation et du patrimoine écologique, Ministère de l'Environnement du Québec, Ste-Foy.

Lefkovitch, L. P. 1965. The study of population growth in organisms grouped by stages. Biometrics **21:**1-18.

Lewis, W. H. 1984. Population structure and environmental corrolaries of *Panax quinquefolium* (Araliaceae) in Delaware County, New York. Rhodora **86:**431-438.

Mangel, M., and C. Tier. 1994. Four facts every conservation biologist should know about persistence. Ecology **75:**607-614.

May, R. M. 1973. Stability and complexity in model ecosystems. Princeton University Press, Princeton, New Jersey.

Mehrhoff, L. A. 1989. The dynamics of declining populations of an endangered orchid, *Isotria medeloides*. Ecology **70:**783-786.

Menges, E. S. 1990. Population viability analysis for an endangered plant. Conservation Biology **4:**52-62.

Menges, E. S. 1991. The application of minimum viable population theory to plants. Pages 45-61 in D.A. Falk and K. E. Holsinger, editors. Genetics and conservation of rare plants. Oxford University Press, New York.

Menges, E. S. 1992. Stochastic modeling of extinction in plant populations. Pages 253-275 in P. L. Fiedler and S. Jain, editors. Conservation biology: The theory and practice of nature conservation, preservation and management. Chapman and Hall, New York.

Muller, R. N. 1978. The phenology, growth and ecosystem dynamics of *Erythronium americanum* in the northern hardwood forest. Ecological Monographs **48:**1-20.

Nault, A. 1986. Étude de la biologie d'une population d'ail des bois (*Allium tricoccum* Ait.) au parc de la Gatineau. M.S. thesis. Université du Québec à Montréal, Montréal.

Nault, A., and D. Gagnon. 1988. Seasonal biomass and nutrient allocation patterns in wild leek (*Allium tricoccum* Ait.), a spring geophyte. Bulletin of the Torrey Botanical Club **115:**45-54.

Nault, A., and D. Gagnon. 1993. Ramet demography of *Allium tricoccum*, a spring ephemeral, perennial forest herb. Journal of Ecology **81:**101-119.

Pinard, M. 1993. Impacts of stem harvesting on populations of *Iriartea deltoidea* (Palmae) in an extractive reserve in Acre, Brazil. Biotropica **25:**2-14.

Schemske, D. W., B. C. Husband, M. H. Ruckelshaus, C. Goodwillie, I. M. Parker, and J. G. Bishop. 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology **75:**584-606.

Schreiner, J. 1994. Root of success. Canadian Geographic Nov.-Dec. **94:**42-48.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience **31:**131-134.

Silvertown, J., M. Franco, I. Pisanty, and A. Mendoza. 1993. Comparative plant demography: Relative importance of life-cycle components to the finite rate of increase in woody and herbaceous perennials. Journal of Ecology **81:**465-476.

Small, E., P. M. Catling, and E. Haber. 1994. Poorly known economic plants of Canada. 4. *Panax quinquefolium* L. Bulletin of the Canadian Botanical Association **27:**70-72.

Solbrig, O. T., R. Sarançon, and W. Bossert. 1988. A density-dependent growth model of a perennial herb, *Viola fimbriatula*. American Naturalist **131**:385–400.

Solbrig, O. T., R. Sarançon, and W. Bossert. 1990. Effect of varying density and life table parameters on growth rate and population size of *Viola fimbriatula*. Acta Oecologica **11**:263–280.

Usher, M. B. 1966. A matrix approach to the management of renewable resources, with special reference to selection forests. Journal of Applied Ecology **3**:355–367.

White, D. J. 1988. Status report on the american ginseng (*Panax quinquefolium* L.). Committee on the Status of Endangered Wildlife in Canada, Ottawa.

CHAPTER 5

Landscapes of Stewardship

The more research that's done on reconstructing fire histories and stand structures of ancient forests, the more obvious it is that Indian burning crafted the structure and composition of pre-Eurasian [contact] vegetation in Mediterranean climates throughout California.

JAMES BARRY, Sierra Miwok, senior state park ecologist (2001)

Had California been devoid of human habitation during the Holocene, the vegetation in many places—its structure, composition, extent, and distribution—would appear quite different today. Desert fan palms would not be growing in many, perhaps all, of the Sonoran Desert canyons where they now form green oases. In some areas where valley grasslands exist today, there would be forests, woodland, or chaparral. Many of the rain-fed montane meadows would have long since vanished, engulfed by montane forest. In some oak savannas there would be fewer enormous valley oaks, and the lower montane forests of the Sierra would boast fewer towering sugar pines. The ranges of some animals would be different, too; for example, island foxes would be absent from the southern Channel Islands. In short, many of the natural features of the present-day California landscape are not, strictly speaking, "natural," but are rather in part the product of deliberate human action.

The vast treeless prairies of the northern and central coast are one of the most conspicuous examples of how California Indians shaped the landscape. Without the efforts of their Indian caretakers, these prairies would now be covered with coastal scrub, chaparral, or coastal coniferous forests. George C. Yount described how such prairies were maintained in and around present-day Benicia: "During 100s of years, fires have spread overall the country, in the dry season of the year, and by this means the timber has been destroyed, except on the tops of lofty mountains, and in the neighborhood of creeks and rivers, so that all is one widespread prairy, of richest soil, ready and waiting for the plough of the husbandman." "Natural" fires seldom

occurred along California's coast, so these were set intentionally by the Patwin.[1]

The California landscapes that early explorers, settlers, and missionaries found so remarkably rich were in part shaped, and regularly renewed, by the land management practices employed by native peoples. Many of the biologically richest of California's habitats were not climax communities at the time Euro-Americans arrived but instead were mosaics of various stages of ecological succession, or fire subclimaxes, intensified and perpetuated by seasonally scheduled burning. In a very real sense, some of the most productive and carefully managed habitats were in fact Indian artifacts. In many cases these landscapes experienced far greater degrees of managerial care and ecologically sophisticated manipulation than are found today.[2]

Over time, indigenous peoples' investment of time and energy in tending many habitats produced real biological changes in those habitats. Important features of major ecosystems may have developed as a result of human intervention, and many plant communities (coastal prairies, valley oak savannas, and montane meadows) had essentially become dependent on ongoing human activities of various kinds.[3]

It is highly likely that over centuries or perhaps millennia of indigenous management, certain plant communities came to *require* human tending and use for their continued fertility and renewal and for the maintenance of the abundance and diversity patterns needed to support human populations. As a result, the removal of California Indians from their homelands to reservations and rancherias led to a gradual decline in the area, number, and diversity of managed landscapes.

Some native people, displaced during Euro-American settlement of their lands, returned to their homelands years after relocation only to find them overgrown and untended. Maria Lebrado Ydrte, granddaughter of Chief Tenaya of the Southern Sierra Miwok and part of the tribe that was driven out of Yosemite Valley by the Mariposa Battalion, returned to her beloved Yosemite after seventy-eight years. She shook her head and said, "Too dirty too much bushy." The open meadows she had known in her childhood were covered with trees and shrubs.[4] Her great-grandson, James Rust (Southern Sierra Miwok), echoed Maria's original disapproval of the way the land had been treated by non-Indians:

> In the old days there used to be lots more game—deer, quail, gray squirrels, rabbits. They burned to keep down the brush. The fires wouldn't get away from you. It wouldn't take all the timber like it would now. In those times the creeks ran all year round. You could fish all season. Now you can't because there's no water. Timber and brush now take all the water. There never were the willows in the creeks like there are now. Water used to come right out of the ground. I remember Yosemite when I was a kid. You could see from one end of the Valley to the other. Now you can't even see off the road. There were big oaks and big pines and no brush. There were nice meadows in there. (Pers. comm. 1989)

Constance Gordon-Cumming, an artist who visited Yosemite Valley in the 1880s, shrewdly warned of the consequences of no human intervention:

> Indeed, there is a corner of danger, lest in the praiseworthy determination to preserve the valley from all ruthless 'improvers' and leave it wholly to nature, it may become an unmanageable wilderness. So long as the Indians had it to themselves, their frequent fires kept down the under-wood, which is now growing up everywhere in such dense thickets, that soon all the finest views will be altogether hidden, and a regiment of wood-cutters will be required to clear them.[5]

Galen Clark, who had lived among the Southern Sierra Miwok for many years, tried, in a letter dated 1894, to convince the commissioners of Yosemite Valley to reinstate Indian burning:

> My first visit to Yosemite was in the summer of 1855. At that time there was no undergrowth of young trees to obstruct clear open views in any part of the Valley from one side of the Merced River across to the base of the opposite wall. The area of clear open meadow ground, with abundance of luxuriant native grasses and flowering plants, was at least four times as large as at the present time. The Valley had then been exclusively under the care and management of the Indians, probably for many centuries. Their policy of management for their own protection and self-interests, as told by some of the survivors who were boys when the Valley was first visited by whites in 1851, was to annually start fires in the dry season of the year and let them spread over the whole valley to kill young trees just sprouted and keep the forest groves open and clear of all underbrush, so as to have no obscure thickets for a hiding place, or an ambush for any invading hostile foes, and to have clear grounds for hunting and gathering acorns. When the fires did not thoroughly burn over the moist meadows all the young willows and cottonwoods were pulled up by hand. . . . Since Yosemite has been under the care of the State of California it was for many years the policy of its manager to protect the Valley as much as possible from the ravages of fires and to preserve all the young trees from destruction. This constant vigilant care for the preservation of Yosemite has resulted in the whole Valley being overrun with dense thickets of young forest trees,

shrubbery, and underbrush, and an accumulation of a vast amount of highly combustible material, which in the event of accidental fires, is a fearful menace to the safety of property and the beauty of the landscape scenery. . . . Since then the forest growth has so far encroached upon the borders of the meadow land that there is not one fourth of that amount, and what there is left is becoming so thickly covered with young willow and cottonwoods of four or five years' growth that there are really not fifty acres of clear ground in Yosemite, except such as has been under very recent cultivation. During the seasons of 1891 and 1892 men were employed to thin out some of the thickets of young pines and cedars and clear up the old logs and combustible matter, in order to be able to more readily control destructive fires when accidentally started. One hundred and fifty acres were in this way partially reclaimed at an average expense of $20 an acre. It is of the utmost importance that this kind of work should be continued from year to year until the whole Valley is reclaimed from a threatened wilderness and restored in some degree to its original condition.[6]

Much of the landscape in California that so impressed early writers, photographers, and landscape painters was in fact a cultural landscape, not the wilderness they imagined. While they extolled the "natural" qualities of the California landscape, they were really responding to its human influence. The chalk drawings and paintings of Thomas Ayres, Albert Bierstadt, and Thomas Hill, among others, reveal centuries of fire management. The wildflower displays they depicted were edible plant gardens. The parklike appearance of Yosemite Valley and the incredible fecundity of parts of the great Central Valley were marks of centuries of human management.

Ironically, many of the first non-Indian visitors and settlers described the countryside in ways that hinted of human intervention. They regularly compared the landscapes to gardens, parks, or orchards. The Belgian gold miner Jean-Nicolas Perlot wrote that the oak woodlands near Stevinson (the acorn collection grounds of the Yokuts) "presented an appearance of a prairie planted with fruit trees."[7] Dr. Lafayette Bunnell, in an unpublished article earmarked for *Century Magazine*, wrote of "a great variety of evergreen and deciduous trees, planted by Nature's landscape gardeners" and observed that because "the undergrowth was kept down by annual fires while the ground was yet moist, to facilitate the search for game, the Valley at the time of discovery presented the appearance of a well kept park." But according to the European rationale, only raw, unspoiled, unused nature was capable of emanating this kind of beauty. It did not occur to them that the size of the trees and the open pattern in which they grew were products of human intervention.

New Evidence for Shaping California

There are three broad realms in which California Indians acted as agents of environmental change in many plant communities in California:

Genetic modification. Indians modified the gene pools and genotypes of plants through selective harvesting, burning, and transplanting. Over hundreds to thousands of years, various characteristics of many useful plant species were undoubtedly selected for by California Indian groups, thus modifying their genotypes. These species probably still exhibit suites of character traits that are adaptations to small-scale human disturbance regimes.

Dispersal. Indians were conscious and sometimes inadvertent agents of plant dispersal, and their practices have rearranged the distribution of some species and created unusual polymorphisms.

Habitat modification. With various resource management techniques, Indians expanded and maintained habitat suitable for desired species, changing ecosystems in both time and space without necessarily altering the character traits of component species.

There are a number of ways in which we now recognize the profound influences of previous human modification of species and habitats in California. One can discern how different the vegetation was when Indians were the sole inhabitants by walking the land after a catastrophic fire. Old village sites reappear where impenetrable chaparral lay before the fire. Sandstone cave areas with indigenous pictographs are exposed after coastal scrub is burned back by wildfires.

More detailed reconstructions of interactions between indigenous people and the natural environment in North America have recently materialized through research in the field of historical ecology, which combines knowledge in the realms of the social, physical, and biological sciences and the humanities. This field relies on the compilation, analysis, and interpretation of findings from plant ecology, paleoecology, archaeology, pyrodendrochronology, and other disciplines to identify specific biotic resources, ecosystem types, and whole biomes that were likely to be significantly influenced by historic and prehistoric indigenous management practices.[8]

Invaluable information also comes from those California Indian elders who remember details of burning and other horticultural practices of their ancestors. These findings are incorporated into a comprehensive framework for interpretation, giving us the most complete window to the past. The examples of changes wrought by California Indians highlighted in this chap-

ter demonstrate the potential far-reaching ecological consequences of human selection for specific traits, dispersal of plants and animals, and land management practices designed to modify habitats.

ENHANCING HAZELNUT FLATS

People of many tribes in California picked hazelnuts *(Corylus cornuta* var. *californica)* by the basketful and ate them raw or roasted. They were often hulled by hand at leisure in the village. The Wintu also hulled hazelnuts by beating them with a willow switch. Often a supply was dried, stored in the shell, and kept on hand through the winter and spring. The Yurok pounded hazelnut kernels into a flour, added warm water, and used the mixture to nurse sickly children or ill persons with weak stomachs.[48]

In addition to being a food source, hazelnut shrubs provided Indians with materials for many cultural uses—but only after the shrubs had been burned, because fire induced the sprouting of straight young shoots. The young hazelnut shoots that came up after fires were used by a number of northwestern tribes to make various kinds of baskets, including cradleboards and carrying baskets. The new growth was also twisted to make rope, and employed in the construction of fish traps for salmon and surf fish baskets. The Pomo and Ohlone used the straight new hazel branches for arrows. The Miwok and Yokuts selected sprouts that had grown for two years since the last fire and bent them into looped sticks for stirring acorn mush. The Karuk used older hazelnut wood (one-half inch in diameter), perhaps three years after the last fire, to fashion circular frames for snowshoes.[49]

Harold Driver recorded that the Karuk and Wiyot burned "hazel bushes" for "better basketry warp." Yurok weaver Lucy Thompson reported that the Yurok deliberately set fires to enhance nut production: "In taking care of the hazel flats, they go out in the dry summer or early in the fall months and burn the hazel brush."[50] Entire hillsides were also burned by the Karuk. Georgia Orcutt, a Karuk elder, told anthropologists in the early 1950s that there "used to be more hazel nuts than now" and that the "hazel shoots were better when the brush was burned down each year." "Now the brush has grown up all around," she continued, "and nothing is any good any more."[51]

The Thompson Indians of southern British Columbia also burned hazelnut bushes to enhance nut production, and this may have been a common practice in much of the Pacific Northwest.[52] Burning probably enhanced the food supply for myriad wildlife. Squirrels, chipmunks, woodrats, and other small mammals as well as birds feed on the nuts. Grouse commonly

eat the catkins. Rabbits and deer browse on the whole plants. Today weavers in California still gather young hazelnut shoots, in many cases substituting pruning for former burning practices, to encourage production of desirable material.[53]

PROMOTING OPEN MONTANE FORESTS STUDDED WITH LARGE SUGAR PINES

Dubbed "the most princely of the genus" by the botanist David Douglas, sugar pine *(Pinus lambertiana)* was valued by various tribes for the construction of earth lodges, sweat houses, and war bows. The pitch was used in Kashaya Pomo whistles and was an adhesive in Karuk households. Nuts were fashioned into jewelry by northwestern tribes. The sweet resin exuding from wounds and fire scars, which contains the sugar pinitol, was relished by different tribes; it was eaten on the spot or dried for later use. It also had medicinal properties: dissolved in water, it was used as a wash for sore or blind eyes by the Sierra Miwok. The Mono made a tea of pine sugar for relaxing muscles during tedious labor. The Yokuts concocted a medicine that was heated and put on the abdomen of the parturient by midwives. The Kawaiisu ate the dried powder as a laxative.[83]

The nuts of the sugar pine provided a concentrated source of fats and protein. The nuts can be pounded into a flour and made into a soup. Many tribes gathered large quantities of nuts. One Miwok family might collect as much

as half a ton of cones each year. They were stacked upside down by the women and covered with dry pine needles, then ignited to burn away the pitch.[84]

In August 1903 Merriam watched an old Northern Miwok woman at West Point preparing sugar pine nuts. The cones, still green, contained nuts that were as yet hardly ripe. They were roasted for a short time in a fire, after which they were removed and split lengthwise with a knife, making it easy to get at the nuts between the scales. The nuts were then shucked and the meats removed and pounded in a small portable mortar. The nut flour was made into a soup.[85]

Men in many tribes skillfully climbed the trees just before the cones opened and swayed the limbs, which caused the pendent cones to snap off. Some of the grandest trees can rise more than two hundred feet, as this pine is the tallest and largest of the world's one hundred species of pines; further, horizontal limbs often do not occur until one-third of the way up the trunk of mature trees. Thus climbing the largest of these trees was a heroic feat. Native people adapted their climbing approach and apparatus to the stature of the tree. The Sierra Miwok, for example, propped a dead tree against the trunk to serve as a ladder, or used a special climbing pole. To retrieve the cones on young trees, the Pomo lashed a deer antler to the end of a straight pole.[86] These harvesting practices left the resource base intact. Mature trees that reached an age of more than five hundred years must have had grandfathers, fathers, sons, and grandsons for many generations climb their trunks.

Sugar pine, along with giant sequoia *(Sequoiadendron giganteum)*, ponderosa pine *(Pinus ponderosa)*, and white fir *(Abies concolor)*, dominate the montane forests in certain areas of the Sierra Nevada.[87] Many of the Sierran sugar pines undoubtedly would not have grown so large had it not been for indigenous burning practices, which kept the brush down and minimized the possibility of catastrophic crown fires. According to the ecologists Neil Sugihara and Joe McBride, "recurrent non-stand-replacing fires are a key factor favoring sugar pine in white fir-dominated mixed-conifer forests. Frequent fires during the pre-settlement period favored sugar pine regeneration. These fires also enabled sugar pine to become an important component of the large trees, typically becoming the largest trees in the stand."[88] (See Figure 18.) Virginia Jeff (Central Sierra Miwok, pers. comm. Aug. 1989) recalls that in the 1920s her father took two precautions to protect large trees before setting fires in the fall: he put sand or dirt on the pitch of pines so that they would not burn and raked the debris from around the oaks. Why set fires? "They burned so they would not have big fires," says Virginia. "It looks terrible today—mountain misery [an understory plant] is high and dead limbs are everywhere."

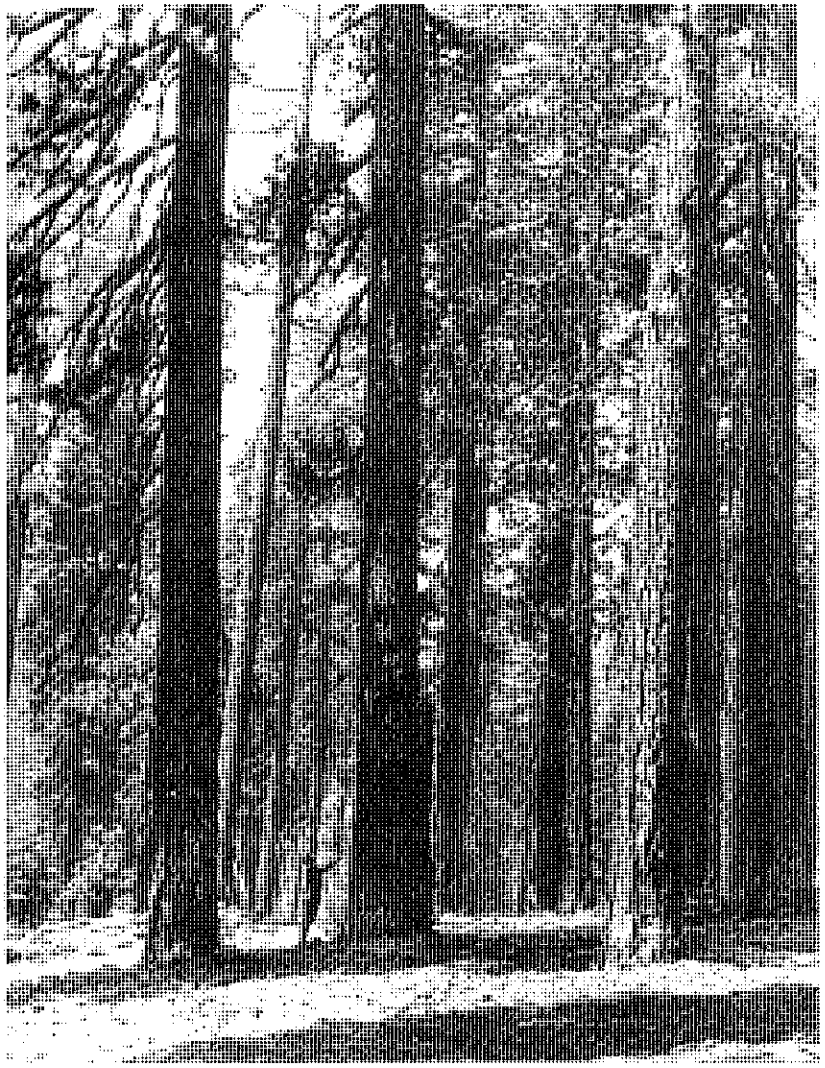


Figure 18. A timber "cruiser" checking the height and condition of a sugar pine *(Pinus lambertiana)* near Susanville, Lassen County, circa 1915. Large-diameter sugar pines and ponderosa pines *(Pinus ponderosa)* were desirable to Indians and non-Indians alike. California Indians harvested the nuts for food and jewelry, the resin for medicines, the roots for baskets, and the wood for structures and war bows, often leaving the trees intact. Non-Indians felled sugar pines and ponderosa pines for lumber. Courtesy of Special Collections, Meriam Library, California State University, Chico, #SC15570.

Scientific studies have shown that competition from brush severely retards sugar pine seedling establishment and growth. Overtopped trees decline, being intolerant of shade. Forest ecologists classify sugar pine as a fire-dominant species, adapted to grow in the forest gaps caused by light- to medium-intensity fires. Without fire, it succeeds to white fir (Wayne Harrison, pers. comm. 2004).

In 1955 Herbert Mason pointed out that "the practices of civilized man in his association with the sugar pine differ from the practice of aboriginal man. This difference tends to create conditions favoring incense cedar and white fir at the expense of sugar pine." He went on to say:

> There is evidence that fire, whatever its cause, has occurred frequently enough in forests to have resulted in a relatively stable "fire type" vegetation. This was pointed out long ago by Jepson. In other words, certain types of vegetation cover are able to maintain themselves in the face of recurrent fire so long as the fire is not of too great intensity at any one time. Most low-and middle-altitude vegetation of California has this "fire type" character. The recurrence of minor fires prevents the building up of conditions conducive to disastrous high-intensity fires. Thus recurrent fire, regardless of cause, is and has been a part of the normal disharmonic fluctuation of environmental conditions.[89]

Many California Indians talk about the way the lower and mid-elevation montane forests used to look in the old days and how the Indians used to burn:[90]

> They always started the fires at the bottom of the slope—never at the top of the slope. The fires rarely got into the crowns of the trees—it mainly stayed in the brush—burning only the undergrowth. Fire sometimes would scorch the trees. Fires were set in the same areas on a five to ten year period, closer to five years. The fires were set for many reasons: to increase visibility, to give nutrients, to decrease brush, for the regrowth of certain plants such as sourberry and manzanita, to thin vegetation, to attract animals to new feed, and to increase food production. Fires were set between 1,500 and 6,000 feet elevation from the San Joaquin to the Granite Creek area. . . . They'd also burned gathering sites, along the edges of creeks, and up the mountain from the trail, and at the south end of canyons. Whatever was going to burn the easiest was set on fire, the duff or grass. Duff or downed wood was never raked. (Ron Goode, North Fork Mono, pers. comm. 1989)[91]

Ironically, several of these individuals have lost their homes—including baskets, mortars and pestles, and other valuable cultural items—to fires that burned out of control because fire suppression policies made possible the buildup of fuel.

Fire scar studies conducted by Tom Swetnam and Anthony Caprio show that before the era of fire suppression, the fire return intervals on southwest-facing slopes where sugar pines occur were only five to ten years. The ecologist Norm Christensen concludes that lightning-ignited fires occurred only once in fifty or more years on most sites, leaving native peoples as the only possible cause of the more frequent fires.[92] Richard Reynolds, Bruce Kilgore, and others have argued that California Indians augmented the frequency of fires and that this human influence was great enough to alter the fuel and vegetational structures characteristically found in prehuman montane forests.[93]

Imagine a carpet of wildflowers and grasses surrounding noble, widely spaced sugar pines and other conifers. This open forest structure would have been palatable to native ungulates and would have provided a source of seeds, bulbs, and greens for human foods and medicines. According to Melba Beecher and her sister, Lydia Beecher (Mono), wildflower seeds and grass grains were as important as acorns years ago. Some of these, such as the farewell-to-spring flowers *(Clarkia williamsonii)*, were burned to enhance abundance: "The Indians used to burn to increase the seed crops such as tarweeds [*Madia* sp.], *Clarkia* spp., snowdrops *[Plagiobothrys nothofulvus]*, chia *[Salvia columbariae]*, wild sunflower [Hall's wyethia, or *Wyethia elata*], and red maids *[Calandrinia ciliata]*. A burn makes these plants come out more" (anonymous North Fork Mono elder, pers. comm. 1991).

Early written accounts reinforce the idea that small seeds were significant in the diets of tribes of the Sierra Nevada and elsewhere where sugar pine grows. An understory of grasses would expand the aerial extent of a fire while not burning too hot around large sugar pines and California black oaks, both of which were extremely important food resources.

Melba Beecher remembers that her mother and other elders gathered the grains of a wild grass at higher elevations in Jose Basin. On one field trip with her sisters; Iliene and Steven Cape; and a Forest Service botanist, Joanna Clines, in the Sierra National Forest (at about 4,500 feet elevation), she pointed out this edible grass, which turned out to be California brome *(Bromus carinatus)*. She also mentioned that the flower stalks were broken off at the joint and used in basketry. She said, "There used to be a lot of it in the hills by Pine Ridge and where that bridge is washed out by Mersick Peak and below Stevenson Mountain. It *[Bromus carinatus]* was all through the Jose Basin" (pers. comm. 1997).

CHAPTER FIVE

"Just Like a Garden"

Traditional Resource Management and Biodiversity Conservation on the Interior Plateau of British Columbia

SANDRA L. PEACOCK AND
NANCY J. TURNER

They [Stl'atl'imx, or Lillooet] burned them [the hills] so that they would get good crops there. They told others who went there, "Do the same at your place, do the same at your place." Their own hills were just like a garden.

THE LATE BAPTISTE RITCHIE,

LIL'WAT [STL'ATL'IMX] ELDER, 1971

INTRODUCTION

It has always been puzzling to us that the most productive, prolific areas to find particular edible or useful plants, especially wild root vegetables, are invariably in those localities where they have been traditionally harvested in immense quantities. One might logically assume that such populations, having been intensively exploited, might show decline compared to places where they were not harvested, but this does not seem to be the case. This observation is

supported by many elders, who insist that the best places to collect particular plant resources today are where they have always been harvested.

Elders also observe that, since the harvesting of many culturally important plants has decreased, or ceased altogether, plants are not as plentiful and habitats not as productive. This depletion of traditional resources is attributed to several causes, one of the major ones being that people no longer look after the plants as they did in the past. Practices such as landscape burning, pruning, tilling, and even picking are said to improve the resources, making them more bountiful and enhancing their quality.

These observations, combined with a growing body of ethnobotanical evidence from British Columbia (Gottesfeld 1994a, 1994b; Turner 1997a, 1998, 1999; Turner et al. 1980, 1990), suggest indigenous peoples actively managed the resources of their environment to ensure a reliable, predictable supply of culturally significant plants—whether for food, materials, or medicines. Management decisions were not solely economic ones, but were embedded in social contexts and encoded in religious philosophies and oral traditions. These strategies, whether intentionally or incidentally, promoted and conserved biological diversity across the landscape.

In this chapter, we present evidence that aboriginal peoples of British Columbia's Interior Plateau have traditionally been active managers of their plant resources and that within the present century there has been a deterioration of certain habitats and resources due, in part, to the cessation of management practices as well as the impacts of industrial society. First, we provide a brief description of the Interior Plateau region, its environment, and its indigenous peoples. Next, we outline the culturally important plant resources of the Plateau and examine the practices used to manage these resources at the population, community, and landscape levels. We discuss the relationships of these management strategies to the creation and maintenance of biodiversity and identify the issues relating to them, including recent environmental deterioration and

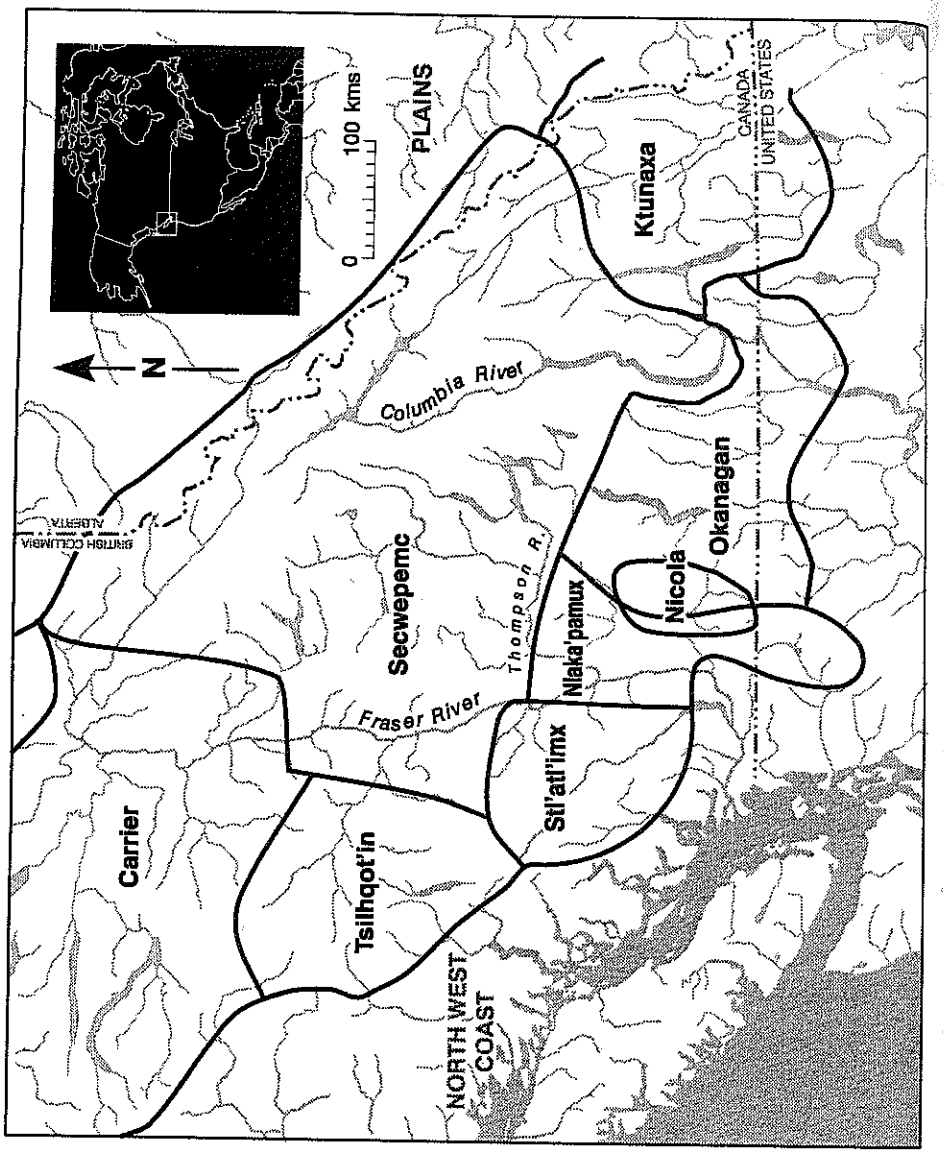
biodiversity. Finally, recommendations for reinstatement of some traditional management practices and philosophies in eco-restoration are provided.

THE PEOPLES OF THE INTERIOR PLATEAU

The Interior Plateau of British Columbia is defined by its physiography as well as by the cultural traditions shared by its indigenous peoples. It covers a vast, diverse area of south-central British Columbia, situated between the Coast and Cascade Mountains to the west and the Rocky Mountains to the east. The landscape is characterized by gently rolling uplands, punctuated by highlands and mountains and dissected by the deeply incised river valleys and lakes of the Fraser, Thompson, and Columbia river drainages. In all, the Interior Plateau encompasses three degrees of latitude and nine degrees of longitude (Parish et al. 1996).

This juxtaposition of low-, mid-, and high-elevation environments and variable topography results in a diversity of flora and fauna throughout the region. Dry valleys, grasslands and shrub-steppe, extensive plateau lands, upland forests, and high mountain ranges are all found within the boundaries of the Interior Plateau. In all, the territory encompasses nine major biogeoclimatic zones: Bunchgrass; Ponderosa Pine; Interior Douglas-fir; Montane Spruce; Engelmann Spruce–Subalpine Fir; Interior Cedar-Hemlock; Sub-Boreal Pine–Spruce; Sub-Boreal Spruce; and Alpine Tundra (British Columbia Ministry of Forests 1988; Meidinger and Pojar 1991). Each of these zones is represented by characteristic plant and animal species, and each provided particular resources to the traditional Plateau economy.

Culturally, the Interior Plateau is considered part of the Plateau Culture Area as originally defined by A. L. Kroeber (1939). The southern portion, the focus of this discussion, is the traditional territory of Interior Salish–speaking peoples, including the



Map 5.1. The traditional territories of the Interior Salish peoples and neighboring groups as recorded by Teit (1900:450).

Secwepemc (Shuswap) and their neighbors the Stl'atl'imx (Lillooet), the Nlaka'pamux (Thompson), and the Okanagan. These peoples shared many cultural traditions, including a diversified gathering-fishing-hunting economy, with intensive use of wild plant foods.

At the time of European contact, the Interior Salish peoples were seasonally transhumant, living in semipermanent villages along the major river systems of the Plateau, as their ancestors had for generations. These villages, consisting of groups of extended family pithouse dwellings, were occupied during the winter months. Families dispersed from these locales over the harvesting season to hunt, fish, and gather plants. The diverse environment—and, as we shall see, peoples' management strategies—created "patches" of resources that were both spatially and temporally distributed; thus, task groups moved to riverine, lacustrine, upland, and montane ecosystems at various times throughout the year to take advantage of different plant and animal resources through the growing seasons. Specific resource harvesting locales were visited year after year, in a patterned and predictable seasonal round. As G. Palmer (1975a:213) notes, "the zoned pattern of resources in the [Canadian] Plateau allowed a typical riverine community to exploit almost any type of habitat occurring in the Plateau within the distance of a few miles. This situation favoured economic diversification. . . ."

PLANT RESOURCES AND MANAGEMENT STRATEGIES

Plants were essential to all aspects of life on the Plateau, with over 300 different species whose roots, shoots, leaves, berries, and/or wood were utilized as foods, materials, and medicines. As indicated in table 5.1, various management strategies were utilized to maintain and enhance these plant resources, ranging from maintenance of particular habitats using fire to practices affecting only the

Fig. 5.1. Nlaka'pamux woman digging roots at Botanie Valley, an important root gathering ground managed by Interior Salish peoples. Reproduced from Teit 1900.

Fig. 5.2. Balsamroot or spring sunflower (*Balsamorhiza sagittata*), a former root staple traditionally pitcooked in earth ovens.

resource species themselves. These management activities may be grouped into three categories on the basis of spatial scale:

1. Population management: activities designed to enhance the reliability and productivity of any culturally significant species at the population level.
2. Community management: strategies that create and maintain diversity in selected habitats or locales, often successional, where populations of culturally significant plant resources occur.
3. Landscape management: The totality of peoples' management effects, including systems of decisionmaking and social sanctions that control the management and harvesting of plant resources in various habitats throughout a large geographic area, such as a traditional territory.

TABLE 5.1.

Summary of Culturally Important Plants of the British Columbia Interior Plateau with Associated Management Practices

Category	Use and Approx. No. of Species	Examples Species (Common Name)	Management Notes
Food	Berries (Total ~50)	*Amelanchier alnifolia* (saskatoon, serviceberry) *Fragaria* spp. (wild strawberry) *Prunus virginiana* (choke cherry) *Ribes inerme, R. irriguum* (wild gooseberry) *Rubus idaeus* (wild raspberry) *Rubus leucodermis* (blackcap) *Shepherdia canadensis* (soapberry) *Vaccinium membranaceum* (black huckleberry) *Vaccinium oxycoccus* (bog cranberry)	all except wild strawberry are woody perennials; fruit picking generally did not impact plants; diversification and use of alternative species in poor crop years was practiced; seasonal rounds; most said to be enhanced by periodic landscape burning; some (e.g., soapberry, huckleberries) were pruned periodically
Food	Seeds and nuts (total ~6–8)	*Balsamorhiza sagittata* (balsamroot) *Corylus cornuta* (hazelnut) *Pinus albicaulis* (whitebark pine)	hazelnut bushes were burned individually; hazelnuts and pine seeds gathered (sparingly) from rodent caches
Food	Root vegetables (Total ~35)	*Allium cernuum* (nodding onion) *Balsamorhiza sagittata* (balsamroot) *Calochortus macrocarpus* (mariposa lily) *Cirsium undulatum* (wild thistle) *Claytonia lanceolata* (spring beauty) *Erythronium grandiflorum* (avalanche lily) *Fritillaria lanceolata* (chocolate lily) *Lewisia rediviva* (bitterroot) *Lilium columbianum* (tiger lily) *Lomatium macrocarpum* (desert parsley) *Potentilla anserina* (silverweed) *Sagittaria latifolia* (wapato) *Sium suave* (water-parsnip)	all are herbaceous perennials with bulbs, corms, rhizomes, tubers, or taproots; all selectively harvested by season, age, size, life-cycle stage; part of seasonal round harvesting cycles; most said to be enhanced by periodic landscape burning; propagules often incidentally or intentionally replanted; some weeded during harvest; specific sites harvested in several-year cycles
Food	Green vegetables (Total ~18)	*Balsamorhiza sagittata* (balsamroot) *Epilobium angustifolium* (fireweed) *Heracleum lanatum* (cow-parsnip) *Lomatium nudicaule* ("Indian-celery") *Opuntia* spp. (prickly-pear cactus) *Rubus* spp. (raspberry, blackcap, thimbleberry) *Typha latifolia* (cattail)	all are herbaceous perennials or woody perennials (*Rubus* spp.); all selectively harvested as shoots or leaves by season, age, size, life-cycle stage; part of seasonal round harvesting cycles; some said to be enhanced by picking; cactus propagules incidentally replanted
Food	Tree inner bark (Total ~7)	*Pinus contorta* (lodgepole pine) *Pinus ponderosa* (ponderosa pine) *Populus balsamifera* (cottonwood)	all tree species; harvested by partial bark and cambium removal, but not girdling; selectively harvested by season; part of seasonal round harvesting cycles
Food	Lichen (1)	*Bryoria fremontii* (black tree lichen)	selectively harvested by abundance, taste, season, tree species, location; pulled from coniferous tree branches, allowing regeneration from remaining thallus
Food	Mushrooms (Total ~8)	*Pleurotus ostreatus* (oyster mushroom) *Tricholoma magnivelare* (pine mushroom) *Tricholoma populinum* (cottonwood mushroom)	seasonally available; selectively harvested by size, age; cut and ground litter recovered for multiple harvests (for ground mushrooms)
Food	Casual foods, flavorings and sweeteners, emergency foods, beverage plants (Total ~50)	*Arctostaphylos uva-ursi* (kinnikinnick: leaves thirst quencher) *Ledum glandulosum* (trapper's tea: beverage) *Larix occidentalis* (western larch: chewing gum) *Pseudotsuga menziesii* (Douglas-fir: sugar)	variously herbaceous or woody perennials; leaves, gum, shoots, or other parts selectively harvested by season or at times of need; seldom harvested intensively in any locality

TABLE 5.1. (continued)

Category	Use and Approx. No. of Species	Examples Species (Common Name)	Management Notes
Smoking	Tobaccos and tobacco flavorings (Total ~10)	*Arctostaphylos uva-ursi* (kinnikinnick: leaves smoked) *Cornus sericea* (red-osier dogwood: inner bark smoked) *Nicotiana attenuata* (tobacco; leaves smoked) *Ligusticum canbyi* (Canby's lovage: roots smoked) *Lomatium nudicaule* (seeds as tobacco flavoring)	*Nicotiana* formerly cultivated, annual; others are perennials, materials harvested selectively from living plants; *Ligusticum* roots highly valued; tops stuck back in ground by some people after harvesting root; dug after flowering
Materials	Pit-cooking matting (Total ~12)	*Agropyron spicatum* (bluebunch wheatgrass) *Cornus sericea* (red-osier dogwood: branches) *Penstemon fruticosus* (shrubby penstemon: leafy shoots) *Pseudotsuga menziesii* (Douglas-fir: boughs) *Pinus ponderosa* (ponderosa pine: needles) *Rosa* spp. (wild rose: branches)	all herbaceous woody perennials; materials harvested selectively from living plants as plucking or "pruning" or (for ponderosa pine) as fallen needles
Materials	Woods for construction and manufacture (Total ~25)	*Acer glabrum* (Rocky Mountain maple) *Amelanchier alnifolia* (saskatoon or serviceberry) *Cornus sericea* (red-osier dogwood) *Crataegus douglasii* (black hawthorn) *Juniperus scopulorum* (Rocky Mountain juniper) *Pinus ponderosa* (ponderosa pine) *Populus balsamifera* (cottonwood) *Pseudotsuga menziesii* (Douglas-fir) *Taxus brevifolia* (Pacific yew)	all trees or shrubs; many harvested or coppiced as branches or stems from living plants; some dead trunks selected (as opposed to cutting live trees); trees selectively cut (e.g., cottonwood for dugout canoes)
Materials	Woods and others for fuel, tinder (Total ~25)	*Artemisia tridentata* (big sagebrush) *Betula papyrifera* (paper birch) *Juniperus scopulorum* (Rocky Mountain juniper) *Pinus* spp. (pines)	most are trees or woody perennials; materials often harvested from downed/dead trees or selectively as branches from living trees
		Populus balsamifera (cottonwood) *Pseudotsuga menziesii* (Douglas-fir) *Salix lasiandra* (Pacific willow)	
Materials	Bark sheets for manufacture or lining caches (Total ~10)	*Abies lasiocarpa* (subalpine fir) *Betula papyrifera* (paper birch) *Pinus monticola* (white pine) *Populus balsamifera* (cottonwood) *Prunus emarginata* (bitter cherry)	all trees; birch and cherry outer bark only removed, without killing tree; others removed in large sheets, which would kill trees if living; possibly dying or dead trees selected for cottonwood bark; barks harvested selectively by size, season, tree characteristics
Materials	Stem, leaf, root fibers/fibrous tissues (Total ~25)	*Acer glabrum* (Rocky Mountain maple: inner bark) *Apocynum cannabinum* (Indian-hemp: stem fiber) *Elaeagnus commutata* (silverberry: inner bark) *Picea engelmannii* (Engelmann spruce: roots) *Salix exigua* (sandbar willow: stems) *Scirpus lacustris* (tule: stems) *Thuja plicata* (western red-cedar: roots) *Typha latifolia* (cattail: leaves)	all are woody or herbaceous perennials; materials cut (stems, leaves) or pulled in strips (barks) from living plants by pruning; herbaceous materials harvested selectively by size, season, plant growth form, habitat
Materials	Dyes, stains (Total ~25)	*Alnus* spp. (alders: bark) *Echinodontium tinctorium* (Indian paint fungus) *Letharia vulpina* (wolf lichen) *Mahonia aquifolium* (Oregon-grape: inner bark)	various types of materials; harvested selectively and sporadically as required
Materials	Adhesives, caulking, waterproofing agents (Total ~10)	*Abies lasiocarpa* (subalpine fir: liquid pitch) *Pinus contorta* (lodgepole pine: pitch) *Populus balsamifera* (cottonwood bud resin) *Pseudotsuga menziesii* (Douglas-fir: pitch)	harvested selectively from living trees

TABLE 5.1. (continued)

Category	Use and Approx. No. of Species	Examples Species (Common Name)	Management Notes
Materials	Scents, cleansing agents, Miscellaneous (Total ~125)	*Abies lasiocarpa* (subalpine fir: boughs as scent) *Anaphalis margaritacea* (pearly everlasting: flowering tops, leaves as menstrual padding) *Artemisia tridentata* (big sagebrush: leaves as scent) *Equisetum hiemale* (scouring rush: abrasive) *Juniperus scopulorum* (Rocky Mountain juniper: boughs as scent) *Lomatium dissectum* (chocolate-tips: roots as fish poison) *Mentha arvensis* (Canada mint: tops as scent) *Typha latifolia* (cattail: seed fluff as diapering) *Urtica dioica* (stinging nettle: tops as cleansing agent) (see Turner et al. 1990:38–40 for more examples)	various herbaceous or woody perennials; most materials selectively harvested from living plants; usually harvested by season, life-cycle stage
Medicines	Whole plants or leafy branches (Total: ~250–300 plant preparations)[a]	*Artemisia dracunculus* (wild tarragon: wash for sores) *Ceanothus velutinus* (snowbrush: tonic, general illness) *Clematis ligusticifolia* (white clematis: wash for sores, scalp) *Gaillardia artistata* (brown-eyed Susan: influenza, tonic)	various herbaceous or woody perennials; most materials selectively harvested from living plants; usually harvested by season, life-cycle stage
Medicines	Bark tissues (Total ~50–60)	*Abies lasiocarpa* (subalpine fir: coughs, tuberculosis, many ailments) *Cornus sericea* (red-osier dogwood: poultice; coughs) *Oplopanax horridus* (devil's-club: diabetes, stomach problems) *Populus balsamifera* (cottonwood: tonic) *Rhamnus purshiana* (cascara: laxative)	barks usually removed from whole twigs or as portions from trunk; trees not girdled; harvested selectively from a number of individual plants
Medicines	Pitch, resin, latex (Total ~35)	*Abies lasiocarpa* (subalpine fir: sores) *Pinus contorta* (lodgepole pine: salve, colds) *Pseudotsuga menziesii* (Douglas-fir: salve, colds)	pitch removed from injured or insect-damaged trees or from bark blisters
Medicines	"Roots" (Total ~100–125)	*Balsamorhiza sagittata* (balsamroot: sores) *Heuchera cylindrica* (alumroot: sores) *Ligusticum canbyi* (Canby's lovage: colds, sores) *Valeriana sitchensis* (mountain valerian: colds) *Veratrum viride* (false hellebore: arthritis: TOXIC)	virtually all are herbaceous perennials; roots selectively harvested by size, life-cycle stage; fragments left behind often capable of regeneration; *Ligusticum* said to be enhanced by burning, and tops replanted
Medicines	Leaves and/or shoots (Total ~75)	*Chimaphila umbellata* (pipsissewa: childbirth); *Equisetum hiemale* (scouring rush: childbirth; eye medicine) *Urtica dioica* (stinging nettle: leafy shoots for arthritis)	herbaceous or woody perennials; leaves/shoots harvested selectively from living plants, which can then regenerate
Medicines	Flowers, fruits (Total ~35–40)	*Achillea millefolium* (yarrow flowers: kidney, toothache; leaves, roots also used) *Shepherdia canadensis* (soapberries: indigestion, ulcers) *Symphoricarpos albus* (waxberry: eye medicine)	herbaceous or woody perennials; flowers/fruits harvested from living plants, by season, life-cycle stage
Medicines	Miscellaneous, or unspecified incl. fungi (Total ~30–35)	*Lycoperdon perlatum* (puffball: spores as poultice for burns, sores)	gathered sporadically or incidentally

Source: Based on Turner 1979a, 1998; Turner et al. 1980, 1985, 1990; Turner and Ignace, unpublished notes, 1996.

[a] Note that these numbers are only approximations, based on the summaries calculated for Nlaka'pamux (Thompson) herbal medicines. They are based not on species *per se*, but on the numbers of particular medicinal preparations used in treating a specific illness or condition (see Turner et al. 1990:43–54). Although each cultural group has its own traditional medicines, the Nlaka'pamux medicines seem generally representative of the species, plant parts, and applications used in other areas of the British Columbia Plateau. The examples provided are generally of species and medicines widely used by Plateau peoples.

We recognize that these management activities are not mutually exclusive, but interact with one another in promoting biological diversity, whether intentionally or incidentally. Management activities at the population level will have an impact on the composition of the community, which will, in turn, be reflected on the landscape. Similarly, decisions concerning the overall timing of management and harvesting of resources in a traditional territory will have repercussions at the community and population levels.

Population Management

The fundamental unit of management was the species. Populations of plants with cultural utility were encouraged through a number of strategies associated with aboriginal harvesting practices. These strategies were based on both biological and cultural considerations and were employed to ensure the continued productivity of key resources. They include the selective harvesting of plants based on well-defined criteria; a number of extractive techniques that increased, rather than decreased, overall population levels; and a system of scheduling that regulated the timing and frequency of the harvest.

Harvest Criteria

The harvesting of plant resources was, and is, selective, being neither random nor all-encompassing. The criteria used to select plants for harvest varied considerably between species and depending upon the type of plant resource and its intended use. Cultural preferences, the physiology of the plant, and environmental factors all influenced the selection process (e.g., Turner 1992a). However, in general, the most important criteria were the yearly growth cycle, reproductive status (e.g., flowering versus nonflowering), and maturity and size. Habitat preference also played a role.

The yearly growth cycles of culturally important species were well known and carefully monitored, as the desired qualities of a particular resource varied throughout its development, either seasonally (spring versus summer) or yearly as the plant matured. On a seasonal basis, variations in growth cycles meant certain species could only be harvested during a short period at any given location even though the plant might be present throughout the year. The green shoots of cow-parsnip (*Heracleum lanatum*), for example, were harvested in early spring, before the plant flowered. After this, the stalks became unpalatable and undesirable. On a yearly basis, variations in growth often meant that a particular plant was left to mature for several years prior to harvesting.

The reproductive status of an individual plant, which is linked to growth cycles, was also an important criterion for selection. For example, a number of important root vegetables were harvested only after the plant had gone to seed. In addition, many medicinal roots were collected after flowering, at which point the roots were considered more potent. Similarly, the leaves of nonfruiting cattail (*Typha latifolia*) plants were selected for harvest over the fruiting ones. There were also cultural prohibitions against harvesting certain plants at certain reproductive stages. For example, women were to avoid collecting the "male" (flowering or fruiting) individuals of desert parsley (*Lomatium macrocarpum*) in favor of the "female" vegetative ones.

Plants were also selectively harvested based on size preferences. According to Secwepemc elder Mary Thomas, multiflowered (and therefore large-bulbed) individuals of avalanche lily (*Erythronium grandiflorum*) were preferred. Similarly, only the "carrot-sized" roots of balsamroot (*Balsamorhiza sagittata*) were dug, leaving the larger "mothers" to flower and go to seed. Elders consistently report that in root collecting the medium-sized individuals were picked, leaving the smaller roots to regenerate and the largest plants to go to seed. Mary Thomas, for example, recalls digging chocolate lily (*Fritillaria lanceolata*), spring beauty (*Claytonia lanceolata*), and avalanche lily

with her grandmother, who taught her to leave the smallest bulbs and corms. In fact, her grandmother would sort through the children's baskets at the end of the day, removing the smallest "roots" and replanting them.

Habitat preference was another criterion used in selective harvesting. Plants growing in a specific location were often preferred to their counterparts in other regions. Medicinal plants were considered purer and more potent when collected from higher elevations in the mountains. Berries from certain locales were said to taste sweeter than others. Indian-hemp (*Apocynum cannabinum*), an important fiber plant, was said to be tallest and thickest in damp areas, while those found on sidehills were bushier and not as desirable. Further, if a habitat was particularly productive for one root, it was generally productive for other species as well, a fact that tended to concentrate harvesting activities on the landscape.

Extractive Technologies

The specific tools and techniques used to harvest plant resources varied according to the species and the intended use of the plant. However, the net result of harvesting was to create a disturbance regime within any given plant population. This was accomplished through digging, tilling, weeding, pruning, coppicing, and, in some instances, the selective burning or pest management of individual plants.

Digging was the most common harvesting technique and was used to collect a wide variety of edible roots and medicinal plants. A digging stick, "a pointed stick about four feet in length, with a crutch-shaped handle" (Dawson 1892:19), commonly manufactured from the fire-hardened wood of shrubs such as saskatoon (*Amelanchier alnifolia*) or black hawthorn (*Crataegus douglasii*), with a handle of birch (*Betula* sp.) or sometimes antler or goat horn, was the basic tool (see fig. 5.1). It was used to pry roots out of the ground, an extremely effective technique for extracting large tap-

Fig. 5.3. Secwepemc elder Mary Thomas holding a "carrot-sized" balsamroot taproot.

rooted species such as balsamroot or those with deep roots such as desert parsley.

An alternative method of root digging involved cutting a small patch of turf around a number of roots, flipping it over, and removing the appropriate-sized roots from the underside. This was commonly practiced with spring beauty and chocolate lily, whose "roots" grow just below the ground surface. With avalanche lily, a large clump of turf was removed, then the bulbs were dug out from the subsurface soil. Dirt and small "roots" were replanted, but the turf was left off, as a form of weeding. Elders also mention that they frequently weeded during root digging to remove unwanted, nonutilitarian species, especially grasses.

Pruning or coppicing was another form of harvesting practiced on the shoots and stems of herbaceous and woody perennials used as food and materials. Cow parsnip was picked in its shoot stage in the spring, then left to mature and flower, die back, and shoot up again the following year. This management approach is very similar to that for a well-known domesticated perennial vegetable, asparagus (*Asparagus officinalis*).

Stems of shrubs such as red-osier dogwood (*Cornus stolonifera*), used for sweatlodge frames, saskatoon (*Amelanchier alnifolia*), used for arrows and other implements, and sandbar willow (*Salix exigua*), used for rope, were also cut from living plants. Mary Thomas recalls her mother observing large, bushy overgrown saskatoon bushes and saying, "It's time to cut them back." She then cut the older stems to the ground, and the next year the shoots that grew up were just right for basket rim hoops. A few years later, berry production on these bushes was excellent in terms of both quantity and quality of the fruit. Tule (*Scirpus lacustris*), cattail (*Typha latifolia*), and Indian-hemp (*Apocynum cannabinum*), other culturally important herbaceous perennials, were sought for their stems, leaves, and stem fiber, respectively, and were cut in enormous quantities at their full maturity in late summer and fall. Since their rhizomes were not impacted, however, they would grow up anew each spring.

Certain species of berries, such as soapberry (*Shepherdia canadensis*) and huckleberries (*Vaccinium* spp.), were harvested by breaking off the berry-laden branches. This, too, was a form of pruning. Hazelnut (*Corylus cornuta*) and perhaps other fruiting bushes were burned individually as well to encourage vigorous new growth in the following years (Turner 1999).

The bark and wood of a wide range of trees were also important to Plateau peoples. Bark sheets of birch (*Betula papyrifera*) and bitter cherry (*Prunus emarginata*) were harvested for use in basketry and other purposes, but only the outer bark was taken; the inner bark was left to protect the tree and to allow it to continue to grow (Turner 1997b, 1998).

Bark removed totally, either to access inner bark and cambium for food (e.g., lodgepole pine, *Pinus contorta*) or for use as medicine (e.g., cascara, *Rhamnus purshiana*), was generally taken in small patches, so that the tree was not girdled and would be able to heal after a while. Living trees with characteristic scars of bark removal are seen throughout the Plateau (e.g., Cole and Lockner 1989).

Of course, trees needed for the wood of their trunks, or those whose bark could not be removed in part, were cut or girdled, but this was evidently done selectively. By at least one account, people sometimes purposefully used windfalls and dead or dying trees to avoid killing living ones.

Scheduling

The scheduling of plant harvesting was regulated by a number of constraints. On one hand, the timing and frequency of collecting were imposed by the life cycles of the plants themselves, which varied between species and according to the micro-environment (e.g., aspect, precipitation, elevation) of a harvesting locale. These, in turn, had to be balanced with cultural preferences for species at certain growth stages, as well as with conflicts that might arise when several species were available simultaneously for harvesting in different locales.

Decisions concerning where, when, and what to harvest were dictated by cultural preferences and necessity, but limited by the spatial and temporal availability of the plant resources. This required indigenous peoples to move extensively from resource patch to resource patch throughout their traditional territory on a seasonal basis. Elder Mary Thomas recalled, for example, that in her area Secwepemc women first dug desert parsley roots in the valley bottoms, then the lower-elevation spring beauty corms and avalanche lily bulbs, then balsamroot, all at lower elevations. By this time the saskatoons, soapberries, and some of the other berries were ready to be picked. In midsummer, people would move up to the mountains and dig more spring beauty and avalanche lily "roots." After this, the huckleberries were ready to be picked, as well as some of the other later-ripening fruits such as high-bush cranberries (*Viburnum opulus*) and hazelnuts. Similar rounds of progressive resource access are noted for other British Columbia Plateau peoples (Turner et al. 1980, 1990; Turner 1992b), as well as for peoples to the south on the Columbia Plateau (Hunn et al. 1990; Marshall 1977).

Decisions concerning how much and how often to harvest were closely linked with fluctuations in the annual productivity of resources. The people of the Plateau were well aware of the cyclical nature of the yield of many key plant resources. Fruits are well known for having multiyear cycles of heavy and light bearing years; people's use of saskatoons, huckleberries, and other alternative species reflected these cycles. The cycles of productivity were also known for species and populations that had been burned. Furthermore, specific root digging beds, once harvested, were left to develop for a few "fallow" years before people returned to the exact spot. Thus, seasonal movements, in conjunction with the rotation of resource patches, ensured the continued productivity of a specific population (this is discussed in greater detail in the section on Landscape Management).

Summary of Plant Management Strategies

In summary, the traditional plant management activities practiced by the aboriginal peoples of the Interior Plateau ensured a reliable, predictable, and productive supply of culturally important plant species.

At the population level, plant management was practiced through harvesting strategies dictated by both cultural and biological factors. Harvesting created disturbance regimes that had both intentional and incidental but generally positive effects on the productivity of targeted species. By selecting individuals at certain life cycles, or according to age and size, indigenous peoples thinned the populations, decreasing intraspecies competition. Weeding also decreased

competition between desired and undesired species, giving the culturally important plants a competitive advantage. Pruning and coppicing of herbaceous plants and shrubs encouraged the growth of new shoots, leaving the root systems intact, as did the burning of selected individuals such as hazelnut bushes. The intentional replanting of "roots" and their propagules was also an important factor in maintaining population productivity.

Incidental impacts of harvesting practices included localized soil disturbances from digging and tilling. In addition, the accidental detachment of portions of taproots, tubers, corms, and bulbs would enable vegetative reproduction of the species. In our experience, it is difficult to extract the entire root: often a small portion is left behind to regenerate vegetatively. Further, harvesting of some species was done at a time when seeds were in production, and the activities associated with harvesting—digging, tilling, turning over the turf—would help to distribute seeds and propagules.

Not only did people actually seem to enhance the growth and abundance of particular species through time, but they may have, in some instances, extended the range of particular species through purposeful or accidental transport and replanting. Today some people like Mary Thomas have transplanted spring beauty, wild onions, bitterroot, and avalanche lily into their gardens. In the past, such root vegetables were commonly stored by burying them fresh in underground caches (Dawson 1892; Teit 1900, 1906, 1909; Turner et al. 1980, 1990). Caches that were not emptied in one season might well produce growing plants in the succeeding years.

The use of controlled fires to manage plant communities is well documented for indigenous peoples throughout the world (e.g., Anderson 1993a; Boyd 1986; Day 1953; Gottesfeld 1994a, 1994b; Lewis 1973, 1977, 1982; Lewis and Ferguson 1988; Timbrook et al. 1982). It is not surprising, then, that this was one of the most important management tools of the Plateau peoples, who burned upland habitats at specified times of the year and at regular intervals to enhance the productivity of roots and berries. The continued

productivity of these habitats was ensured through alternating harvest locales.

Finally, while these plant management techniques had economic motives, they were embedded in a larger decisionmaking system structured by religious and moral ideologies. These principles guided people's interactions with the natural environment and ensured careful, considered, and considerate use of plant resources.

INFLUENCES OF PLANT MANAGEMENT STRATEGIES ON BIODIVERSITY

Based on the preceding discussion, it is clear the indigenous peoples of the interior of British Columbia were active managers of plant resources at the population, community, and landscape levels. But what was the influence of these management strategies on biodiversity?

Biodiversity may be measured in a number of ways, including:

- Genetic diversity: the genetic variation within a population, or the variety of species, genera, and families within a community;
- Species diversity: the number of species in a community and their relative abundance;
- Structural diversity: variations in how plant communities are structured, both horizontally and vertically.

Disturbance is one of the principal factors influencing biodiversity. As mentioned previously, indigenous plant management techniques are forms of human disturbance that can influence which species occur in a particular habitat as well as the relative abundance of those species. Disturbances such as those created by traditional management practices tend to be occasional and spatially focused. This has the effect of creating mosaics, increasing habitat diversity within a landscape, and, as a consequence, increasing species diversity.

At the population level, selective harvesting practices are the main form of disturbance. Digging, tilling, weeding, and pruning alter the composition and structure of the population and, ultimately, of the larger community. Of particular interest is the fact that, without exception, the species managed are perennials. Unlike many annuals, most perennials have a range of regenerative and reproductive strategies and, consequently, can respond to harvesting in several ways. Virtually all of them have a capacity for regeneration through various means, from regrowth of shoots and leaves from underground or aerial parts, to healing over of tree trunks when bark patches are removed, to the more obvious abilities for propagation from seed or spore. Many are very long-lived. As a result, traditional harvesting technologies did not necessarily remove the individual or its genetic material from the population, as seeds, root fragments, and rhizomes were left behind (we liken this to the botanical equivalent of dairy farming!). Traditional disturbance regimes, therefore, can actually stimulate growth, enhancing the population and maintaining genetic diversity.

At the community level, frequent, low-intensity fires disrupted successional sequences in the habitat and reduced the overall dominance of a particular community type, such as coniferous forest, on the landscape. These actions, along with repeated harvesting in preferred locales, created patches of "cultivated" habitats, which are diverse in terms of their species and structure. Further, a mosaic of "cultivated" or managed and "natural" or unmanaged habitats would result in a greater genetic diversity.

The key to the use of disturbance regimes in promoting biodiversity is regulating the intensity (size) and frequency of the disturbance events in the community. When there is very little disturbance, species with a competitive advantage will eventually take over. If there is a high level of disturbance, species that can recover from disturbance quickly will take over. Thus, the size and frequency of disturbance change the distribution of species in a given area.

This is where landscape management becomes important. Traditional landscape management strategies monitored the frequency and intensity of harvesting and burning practices on a regional scale to ensure appropriate levels were maintained. Rotating use of harvesting grounds and burning locales on multiyear cycles, and controlled access to resource areas, resulted in intermediate levels of disturbance. These management principles were ultimately embedded in religious ideologies and enforced through social mechanisms.

In summary, indigenous peoples of British Columbia's Interior Plateau were much more active managers of their environment than traditional views of hunter-gatherers of the region would allow (see, for example, Hayden's [1992:535] treatment of the impacts of root harvesting on plant species). In these models, hunter-gatherers are seen as adapting to their environment, not modifying it. However, as Richard Ford (1985) and others (Harris 1989; Rindos 1984) have pointed out, the plant management activities of hunter-gatherers are guided by the same dynamics as those of horticultural and agricultural peoples, but at differing degrees of intensity. Based on Ford's model, we suggest the indigenous peoples of the Plateau were essentially cultivators who managed and maintained plant resources to ensure a predictable, productive, and continued supply of culturally significant plant species. Further, through the use of these sophisticated strategies and disturbance regimes, aboriginal peoples of British Columbia domesticated their environment to a certain extent and, in doing so, helped to conserve genetic, specific, and structural biodiversity.

Ramp Suppers, Biodiversity, and the Integrity of the Mountains

MARY HUFFORD

It is mid-April and throughout the tributaries of West Virginia's Big Coal River, peepers are announcing spring. High in the hills, coves drained by chortling creeks are alight with the whites of trillium, the yellows of spice bush, the reds of wake robins, and the bright greens of ramps. From the valleys the bare woods appear spangled with the russet blooms of hard maples, the green-tinged yellows of soft maples, the white bursts of service and dogwoods, and the deep pinks of Judas trees. Soon, they say, the bass will be leaving the river and swimming up into the creeks to spawn.

I am sitting fairly high in the hills myself, paring knife in hand, in a modest rectangular building officially known as "The Ramp House." Perched as far up the hollow of Drew's Creek as a person can drive in a two-wheel-drive car, the Ramp House faces the Delbert Free Will Baptist Church across a small parking lot. For more than forty years the Ramp House has functioned as a community center, where women of the church hold weekly quilting bees and families assemble for reunions. But its name registers its most public and celebrated purpose: sheltering friends, neighbors, and kin who come together each spring to feast upon ramps.

Ramps, *Allium tricoccum*, are wild leeks. Thriving throughout the Appalachian range in rich, dark woodlands near mountain streams, ramps are among the first edible foods to appear in the early spring, when they pierce the gray and brown leaf mold with a spire of tightly furled, onion-scented leaves. In June the lance-shaped leaves wither, and the plant sends up a stalk with an umbel of white flowers. Underground the stems swell into white bulbs connected by a mass of fibrous rootlets. These diminutive leeks reek of garlic, only stronger.

Throughout the Appalachian South, ramps are hailed with feasting at ramp suppers and festivals. The most famous of these community fund-raisers include the Ramp Festival at Cosby, Tennessee, and the Feast of the Ramson at Richwood, West Virginia. Richwood, in fact, is home to the NRA—the National

Ramp Association. But many smaller events proliferate throughout April and well into the month of May. From noon until 8 P.M., the women who organize this particular event at the Ramp House will serve nearly 500 plates piled high with potatoes, fried apples, pinto beans, cornbread, and ramps.

The week before the ramp supper is one of the year's busiest, and members of the Delbert Free Will Baptist Church divide the labor of production. Each evening the women meet in the Ramp House to clean and refrigerate the ramps brought in by the men from the upper-elevation hollows wrinkling the ridgelines. The female camaraderie on these evenings, pungent with the aroma of ramps, coffee, and sassafras tea and punctuated with laughter, makes this an event in its own right. "We sit in a circle and clean ramps and talk," Delores Workman told me at last year's ramp supper. "It's a lot of fun. I love my ramp circle."

"You should hear the tales Jenny tells," laughed Judy Griffy. Hoping to, this year I am in the Ramp House the night before Ramp Day, chopping ramps and tape-recording the talk of a dozen women, worn out from a week of preparation, but excited about the day ahead. Only one man is present, Laffon Pettry's husband, Bob. Bob tolerates the women's razzing with good humor. "You put down that cigarette and get your knife and get busy," Mabel Brown warns him as he tries to take a break. "You'll be the first one we fire, Bob!"

"He's slightly outnumbered, isn't he," murmurs Theresa Elkins.

"He'd better watch it here with this gang of females!" Mabel teases, brandishing her knife.

Dusk gathers outside, and in the wake of the setting sun the stars are brightening into the sign of the ram, for which it is said that ramps were long ago named "ramsons" by the Swedes. Inside, the air is thick with the smell and the talk of ramps. Jenny Bonds tells about a ramp-themed basket her granddaughter gave her for Christmas, containing ramp vinegar, ramp seeds, dried ramps, ramp jelly, pickled ramps, even ramp wine. "I had some of the jelly," said Jenny. "It stunk." Other possibilities are advanced: ramp pizza or Jenny's ramp casserole, with sausage, potatoes, and cheese.

Historically, in these mountains, female sociality has flourished around the gathering and processing of greens and other wild produce. On the heels of ramps a host of other greens start popping up: dandelions, poke, shawnee lettuce, woolen britches, creasies, and lamb's tongue. And around these, women have fashioned women's worlds. "That was the big deal when everybody used to go green picking," said Carrie Lou Jarrell, of Sylvester, West Virginia, on another occasion. "That was the event of the week. Mrs. Karen Thomas would come up

and she always brought Jessie Graybill with her, and then Miss Haddad would come, and most of the time Maggie Wriston came with her. And usually Sylvia Williams was always there to do green picking with them. I knew from the time I came into the world that she was just a good friend. But that was the thrill of my life to get to go with all of these women, because they talked about good stuff."

Such talk is one means of crafting locality. It catches people up into a dense fabric of kinship and community and fastens that fabric to places and events in the mountains. Through such talk the women enunciate their place in the hills, a place remarkable not only for its biodiversity but for the interweaving of biodiversity and community life. In the Ramp House the women laugh over how Violet Dickens once mistook sassafras tea for bacon grease and poured it over the frying ramps: "We need you to come season the ramps," Mabel kidded her the other day. They compare the aromas of poke and collard greens and marvel at how window screens get black with flies when you're cooking them. They wonder where the creasies (dry land cress) are growing this year, and Jenny points out that creasies won't grow unless you till the soil.

In southern West Virginia a mixed mesophytic forest (known among ecologists as the world's most biologically diverse temperate-zone hardwood system) is not just a product of nature. It is integral to a cultural landscape that has taken shape over many generations. On Coal River, I have heard people say the best place to look for red mulberry trees, now in serious decline, is on farms; that the cows that grazed throughout the mountains well into the twentieth century kept the snake population down; and that Peach Tree Creek was named for peach trees encountered there by the first white settlers entering the region in the early 1800s. In the Ramp House they say you can start your own ramp patch from the bit of root they're chopping off at the ends. "Mabel has a few ramps growing in her yard," said Jenny. "I do, Edna does, and Sadie does. You don't, do you Theresa? You're going to have to plant you a patch of ramps and some molly moochers."

This week the molly moochers are coming in. Molly moochers are morel mushrooms. They say you can hear them popping up through the dried leaves when it rains. Old apple orchards, scattered throughout the woods where people used to live, make good places to go molly mooching. A neighbor found fifty-six today in an old apple orchard behind Laffon's house. "He found thirty-seven yesterday," said Laffon.

"Gladys was finding them out there," says another woman.

"Oh Gladys," Laffon chuckles. "She's the queen of the molly moochers!"

The salient feature of ramps is the smell. The Menominee Indians called it "*pikwute sikakushia*": the skunk. "*Shikako*," their name for a large ramp patch

that once flourished in northern Illinois, has been anglicized to Chicago: "the skunk place." Our chopping of leaves is filling the air with aromatic organosulphur compounds, characteristic of members of the *Allium* family but carried to extremes in ramps and their consumers. Some have seen in this practice of restoring the body while emitting a sulphurous odor a rite of death and resurrection, serendipitously coinciding with Easter. Actually with ramps the motif appears to be breath and insurrection. Liberating organosulfides seems to comprise, if not a rite of inversion, at least a delicious form of back talk: the country back-talking the city, the improper back-talking propriety. The efforts of official institutions to quell this annual olfactory uprising have been rehearsed at every ramp supper I've attended.

"Let me get this down so I can move on," said John Flynn at the 1995 ramp supper. "We did not eat ramps. There were very strong women in my family who did not like the odor. Also, if you ate ramps and went to school, they sent you home because of the odor. There were a lot of authoritarians in the school, so you didn't do a lot of ramp eating. Someone might get up the guts to do it once, but they didn't do it twice. The odor was the issue." Ways of annulling the odor creep into ramp talk.

"I like them raw," said Jess Duncan of Sylvester, "like you'd eat a hot pepper or something with a sandwich."

"Fried potatoes, pinto beans," added Pat Canterbury.

"You can't beat them," said Jess, "and they don't stink if you don't eat very many of them."

"They do too," said Pat.

"If you eat them with a sandwich, they don't," Jess insisted. "My wife's never complained."

"Now, if you're confined close," cautioned Bob Daniel, of Dry Creek, one morning in Syble's Bed and Barn, "say in an office with people, I'm sure it would offend people like that, but in my line of work I don't think I bother anybody with them."

"If you don't like the smell," laughed Mae Bongalis, "go the other way. Stay at your house!"

The most famous official censure of ramps was brought on by the late Jim Comstock, editor of the *West Virginia Hillbilly*. Comstock, inspired by scratch-and-sniff advertising for perfume and coffee in several local papers, announced the Richwood ramp supper one year by lacing the printer's ink for his spring issue with ramp juice. "We got a reprimand from the postmaster general," Comstock recalled. "And we are probably the only paper in the United States that's under oath to the federal government not to smell bad."

Behind the powerful aroma it appears there really is something good for what ails you. Ramps have long been recommended for their germicidal and toning effects. The beliefs that ramps are good for the heart, that they thin and purify the blood, and that they relieve the common cold are widespread. Scientific research suggests that such faith in ramps is well placed. The allicin (diallyl-sulfide oxide) in ramps, which has antibiotic properties, has been linked with reduced rates of cancer. Ramps are higher in vitamin C than oranges. They contain cepaenes, which function as antithrombotic agents. Ramps also contain flavonoids and other antioxidants that are free-radical scavengers.

As the first of the wild foods to appear, ramps satisfy the body's craving for living food at the end of a winter filled with produce that's been dried, canned, frozen, or shipped from faraway places. "They used to say," said Jenny Bonds, "that people that lived out like we did didn't live near grocery stores, so they said in the springtime you always need green things, like vegetables. So they said in the springtime the country people got ramps, that was our spring tonic."

"What does a spring tonic do?" I asked.

"Cure for spring fever, I guess," said Jenny.

"Strawberry rhubarb pie is my spring tonic," said Laffon Pettry.

Spring fever is twice cured by ramps, which lure people into the higher reaches of the mountains. "Ramps are fun to hunt," said John Flynn. "You can go out in the yard and get all the poke you want, but you have to go into the forest to look for ramps."

"The higher you go," said Woody Boggs on another occasion, "the more ramps and the bigger."

Ramp patches in the mountains have long functioned as a common resource. Most of the ramps served at the ramp supper, some fifteen bushels, do not come from people's personal patches. They come from the upper-elevation coves rising high above the Ramp House. "I've got a few planted up the holler here," said Dennis Dickens, of Peach Tree Creek, a beloved octogenarian who passed away this year. "They just grow at an elevation of about, I'd say, 2,000 to 2,500 feet. Real rich soil."

For many, eating ramps in the mountains is as much a rite of spring as attending the ramp supper. "I love them," said Bob Daniel, over breakfast at Syble's one spring morning. "I like to dig them and eat them right there. Sit down in the woods with a piece of cornbread and eat them."

"That's the fun part," said Mary Jarrell, speaking in Lloyd's Convenient, which she operates with her husband at the mouth of Rock Creek. "Getting them and cooking them out. We'd go to several places, like Hazy, where they've

closed it off. We would always go and take a skillet and make cornbread and take some potatoes and get the ramps and clean them and fix them on top of the mountains."

"We'd take our cornbread and pinto beans," said Mae Bongalis, of Naoma, during the 1995 ramp supper. "And go to the mountain, up Board Tree Hollow, dig ramps all afternoon. Then we'd clean them in a little stream coming through the patch, wash them and cook them and then have dinner. They taste better that way, too."

The higher elevations, known simply as "the mountains," have long functioned as what anthropologist Beverly Brown terms a "de facto commons," an open-access area where people go to hunt, picnic, and party, gather a variety of roots, herbs, nuts, and fruit, or to enjoy some solitude. Ramps inaugurate an annual round of small-scale subsistence harvesting of woodland bounty, and they afford the first opportunity to get back into the mountains. But they are fortifying throughout the growing season. "Ramps are sweet this time of year," said Tony Dickens of Pettry Bottom, one late September evening. "You'll come across a ramp patch when you're out ginsenging. Last week I dug more ramps than ginseng!"

Supporting an unusually diverse seasonal round, central Appalachia's mixed mesophytic forest distinguishes these mountains among America's de facto commons. Telltale signs of this diversity abound in the hollows and coal camps, and in yards and homes on the river: the handful of butternuts curing on a step, the coal bucket of black walnuts ready for shelling, the hellgrammites seine at the ready on the porch, the ginseng drying in the rear window of a car, the squirrel meat marinating in a bowl, the gallon of blackberries ready for canning, the plastic bag full of homemade "deer jerky," the jar full of "lin" (white basswood) honey, the pawpaws in the freezer, the molly moochers soaking in salt water, the pickled ramps in the pantry.

The traditional knowledge that sustains this annual round of harvesting is anchored in a people's landscape inscribed all over the mountains, a literary work writ large.

The hills rising away from the Ramp House are rich in family and community history. Names bestowed on every wrinkle in the ridgeline commemorate people, events, and moments in the seasonal round. What appears to be a jumble of coves, ridges, creeks, knobs, branches, gaps, and forks is as legible to some residents as a metropolitan grid is to an urbanite. "These different little hollows," said Howard Miller, "they had a name for each one, so when a neighbor talked to another neighbor about a certain thing that happened at this holler, they knew

exactly where it was at, they knew even from Beckley down to Racine down to Madison."

The names for the coves anchor local history and knowledge in the land: Mill Holler, Peach Orchard Holler, School House Holler, and Bee Light Holler, where they baited bees in order to "line" them to wild hives, filled with honey from mixed mesophytic flowering trees like basswood ("lin"), tulip tree ("yellow poplar"), and yellow locust ("mountain locust"). Thus indexed, the landscape is a dynamic repository of rural life, knowledge, and history, which elderly raconteurs render into narrative. "Quill Holler's below the ramp house," Howard went on. "They used to get a hollow straw and drink sugar water where they notched a sugar tree. Something like these straws at a restaurant, but it's a plant."

The cultural landscape is rife with landmarks. Over generations of working the seasonal round, a language for navigating the mountains discriminates them into a wide array of landmarks: not only the high walls, mine breaks, auger holes, and other traces of industry, but into "knobs," "drains," "coves," "swags," "ridges," "crossings," "gaps," "flats," "bear wallows," "orchards," "home places," "sink holes," "walk paths," "hill climbs," "camp rocks," "bottoms," "brakes," "graveyards," "bee trees," "den trees," and "benches."

This landscape supports the common world celebrated in the Ramp House. Cultural practices like ramp suppers, ramp talk, and roaming the mountains have co-evolved with an industrial landscape as ways of holding together a world chronically visited with environmental, social, and economic crisis. Only by bracketing out the civic commons is it possible to reduce a mountain to "a worthless piece of dirt," as one industry spokesman put it, "good for nothing, save for snakes and scrub pine." An alternative view—of biodiversity flourishing in the context of community life—is rehearsed in stories and jaunts that map the commons back onto the land.

Many of the ramps for this year's ramp supper came from Hazy Creek, a long, lush, meandering hollow that hooks around Shumate's Branch like a sheltering arm. Hundreds of people lived at the mouth of Hazy in the 1940s when the coal town of Edwight was the bustling hub of the river between Whitesville and Glen Daniel. Though Hazy Creek and Shumate's Branch were evacuated of dwellings in the 1980s, people continue to comb the hollows of Hazy Creek for ramps, ginseng, molly moochers, yellow root, mayapple, bloodroot, berries, and signs of history.

According to Dennis Dickens, Hazy got its name before the Civil War. "Some hunters came through there," said Dickens, "and they camped over along Drew's Creek. And they decided to go over in Hazy to hunt one day. They got to the top

of the mountain, they looked down in there, it was foggy and hazy. They said, 'No use to go down in here, it's too hazy. We'll not do any good.' And called it 'Hazy Creek.'" Though the coal industry has closed Hazy Creek to the public (Cherry Pond Mountain is slated for mountaintop removal), people still enter with permission to gather plants and hunt, or to visit historic sites and cemeteries.

On a trek up Hazy for ramps in 1996, Dave Bailey and Woody Boggs distilled sights on the overgrown landscape into signs of former communities everywhere: the rusting incline hidden on the hillside; the sludge pond, its banks "reclaimed" in thorny field locust; a stand of Indian corn near Charlie Rock, named for Charles Wiley; the remains of a "splash dam" once used as a skidway for easing timber out of the mountains; red dog from the slate dump that burned for years and was haunted by an old woman's ghost; a big rock that Woody says Hobart Clay could have cleared in his Hazy machine, and campsites marked by the presence of ramps. "People have camped there for years," commented Dave. "They set them out so they'd have some."

As access is increasingly curtailed, people vividly reconstitute Hazy Creek through stories. In a conversation that Woody Boggs videotaped in Andrew, Dave Bailey and Cuba Wiley conjure and reoccupy Hazy as a capacious and generous landscape where they both lived for many years. Cuba, who hasn't been up in Hazy lately, wonders what it's like since the people moved out in the late 1980s. "People tell me I wouldn't know it up that hollow now," he says.

Dave imaginatively takes him up there, and Hazy Creek floods into the room through their words and gestures. "You go up there, Cuba, where the mines is, you go across that creek, go over to the left, go right on up that road to the mines. You can stop the car where the road's washed out, you walk maybe to the top of the hill, and the side of the mountain is covered with ramps."

"Well," picks up Cuba, invoking another space where ramps grew, "what about the Straight Fork of Hazy, where Three Forks used to come in together, and I used to go in the Straight Fork of Hazy, and just go up there a little piece on up that hollow and walk in on the right, and that scoundrel mountain was lined with them."

"That's right," says Dave. "Just as far as you could see."

They go on to the Everett Fork, Hiram Fork, and Bradley Mountain (where Lige Bradley fled from marauding Yankee and Confederate troops during the Civil War, and where people returned to tend and harvest apples in the Wayne Bradley Field long after Bradley was evacuated for strip-mining). On the way out, Dave and Cuba pause for moment at Road Fork and Sugar Camp.

"You know what?" says Cuba, "I'm gonna tell you something. I was in Sugar

Camp, way up in there, I could look down over there at the Coffee Pot Restaurant and all that, and that walk path that goes right on up through there takes you to Bradley."

"Yup," says Dave. "I know where it's at."

"I believe I could find it yet," Cuba resumes. "That walk path, I'd turn left and go up just a little ridge, about fifty or seventy-five yards and that scoundrel ridge was lined with ramps, and I'll tell you who else went in there and found them before he died: Calvin Clay. Calvin Clay and them found that patch."

"I didn't know they were in there," Dave marveled.

"Sugar Camp," says Cuba. "Good patch, buddy."

Reconstituting Hazy, Dave and Cuba walk its paths, populate it with fellow gatherers, and savor its views, routes, and destinations. Stories of plying the seasonal round, of gathering ramps, molly moochers, fishing bait, and ginseng, are like beacons lighting up Hazy's coves, benches, walk paths, historic ruins, and camp rocks. In fact, such stories and inscriptions constitute a rural industrial landscape as coherent, as saturated with "traditional cultural properties," as representative of America's rural-industrial history as any landscape recorded on the National Register.

Like other productions of the commons, ramps, ramp patches, and ramp talk are resources for holding together a way of life that is continually being dismantled by plans for progress. The civic commons of the Ramp House and the commons of the cultural landscape are mutually sustaining and cannot be reclaimed by covering a stream with spoil and putting a pond on top of a highland complex, moving a smokehouse from a home place to a pioneer village, or relocating a family cemetery from its ancestral grounds to a commercial cemetery many miles away.

The commons on Coal River models an alternative, integrated, community-based approach to the conservation of natural and cultural resources. The seasonal round, itself a cultural production, outlines a roster of "services" we might expect from central Appalachia's post-mining landscapes. Common pool resources like the ramp patches of the named systems of coves might qualify for protection not as endangered species but as vital resources for mountain life—"traditional cultural properties." Such sites, scattered throughout the mountains, define the social collective, serving both as touchstones to a shared past and as thresholds to a future in which a historic, mixed mesophytic landscape continues to form a hedge against chronic social, environmental, and economic crises.