Alpine/Aeolian Unit 4

Good Critters, Bad Critters

Overview

Native insects evolved along with the few plants that are able to survive in the alpine/aeolian ecosystem. Relationships among insects and plants in this ecosystem are only partially understood, but native insect pollinators are known to play a crucial role in plant reproduction. For example, insects are critical links in the reproduction of *ʻāhinahina*, the Haleakalā silversword. This well-known endemic plant cannot self-pollinate.

Today, native insects in the alpine/aeolian zone are threatened by the invasion of non-native insects such as the Argentine ant. Native arthropod species (many of which are endemic to Haleakalā) evolved without ant predators because there are no ant species native to Hawaiʻi.

To date, more than 40 species of ants have been collected in the Hawaiian Islands. Among these is *Linepithema humile*, the Argentine ant. This ant is of particular concern to resource managers and researchers at Haleakalā National Park. Unlike most other ant species that tend to be limited to sea level and lowland areas, the Argentine ant has become established at higher elevations. Researchers have identified two separate populations within park boundaries. These populations have been steadily expanding.

In this unit, students learn about the interdependence of native insects and plants in the alpine/aeolian ecosystem. They also learn about a threatening, invasive species of ant and what is being done to control the spread of these ants.

Length of Entire Unit

Five or six 50-minute periods

Unit Focus Questions

1) How do native plants and arthropods depend upon each other in the alpine/aeolian ecosystem?

2) What are the impacts of alien invaders such as the Argentine ant?

3) How do the role of native species and the biological and behavioral characteristics of alien species affect natural resource management decisions?

Unit at a Glance

Activity #1

To Spray or Not to Spray

Students propose a response to a management dilemma that arose in 1968, involving protecting ‘*āhinahina*, the Haleakalā silversword, from insect damage.

Length
One class period, followed by a homework assignment

Prerequisite Activity
None

Objectives
- Propose a course of action in response to a hypothetical conservation problem.
- Critique proposed measures based on new information.

DOE Grades 9-12 Science Standards and Benchmarks
LIVING THE VALUES, ATTITUDES, AND COMMITMENTS OF THE INQUIRING MIND: Students apply the values, attitudes, and commitments characteristic of an inquiring mind.
- Open-mindedness: When appropriate, modify ideas, explanations, and hypotheses based on empirical evidence or data.

“MĀLAMA I KA ‘ĀINA”: SUSTAINABILITY: Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.
- Conservation of Resources: Analyze, evaluate, and propse possible solutions in sustaining life on Earth, considering the limited resources and fragile environmental conditions.

Activity #2

Ant Alert: How Does Invasion Threaten Natives?

Students compare the invasive Argentine ant to other ant species to understand why the Argentine ant is such a potential threat to the alpine/aeolian ecosystem on Haleakalā. In teams, they teach each other about the threat Argentine ants pose.

Length
Two or three class periods, preceded by homework reading

Prerequisite Activity
None

Objectives
- Identify and describe similarities and differences between Argentine ants and other ant species.
- Illustrate traditional Hawaiian social values and concepts using ant behavior as examples.
- Explain how Argentine ant biological and behavioral characteristics enable them to pose a threat to native Hawaiian insects and plants.

DOE Grades 9-12 Science Standards and Benchmarks
DOING SCIENTIFIC INQUIRY: Students demonstrate the skills necessary to engage in scientific inquiry.
- Formulate scientific explanations and conclusions and models using logic and evidence.

USING UNIFYING CONCEPTS AND THEMES: Students use concepts and themes such as system, change, scale, and model to help them understand and explain the natural world.
- Change: Explain the effect of large and small disturbances on systems in the natural world.

Activity #3

Controlling the Argentine Ant

Students propose ideas for controlling the spread of Argentine ants in Haleakalā National Park, compare their ideas to what's already being done, and evaluate the efficacy of current control efforts.

Length
Two class periods, followed by a homework assignment

Prerequisite Activity
Activity #2 "Ant Alert: How Does Invasion Threaten Natives?"

Objectives
- Propose ideas for controlling the spread of Argentine ants in Haleakalā National Park.
- Perform calculations to assess the effectiveness of an experimental effort to control the spread of Argentine ant populations.

DOE Grades 9-12 Science Standards and Benchmarks
RELATING THE NATURE OF TECHNOLOGY TO SCIENCE: Students use the problem-solving process to address current issues involving human adaptation in the environment
- Collect, organize, and analyze information from reliable sources to identify alternative solutions.
- Evaluate the effectiveness of the actions taken to resolve the problem or issue and its overall effect on self, others, and the environment.

Enrichment Ideas

- Do Internet research to find out more about the current status of silverswords on Maui and recent research on silversword ecology.

- Have an ant-baiting competition. Divide the class into groups and give each group an index card and small amounts of three types of bait (such as tuna fish or canned cat food, peanut butter, and honey). Students should smear a small amount of each kind of bait on a separate spot on the card, label the bait types, and then place their cards somewhere in or outside the classroom where they think the card is most likely to attract ants.

  Let the cards sit undisturbed for 20-25 minutes while students write answers to these questions:
  1) Where did your group choose to place its bait card? Why do you think this is a likely place to attract ants?
  2) Which bait do you think ants will be most attracted to? Why?
  3) What other insects or animals do you think will be attracted to the bait card? Why?

  Send student groups or representatives out to collect the bait cards and observe the presence of ants, the baits they are feeding on, whether there seem to be different kinds of ants present, and what other insects or animals are present.

  Have students check their hypotheses against their observations, and discuss differences. You may want to announce the "gold, silver, and bronze medal winners" in the ant-baiting competition.

- Print the HINS report on the Argentine ant (see reference below). On pages 2-3, this report outlines methods used to control (or attempt control of) Argentine ants, including several chemical agents that have since been outlawed. Have students research one or more of these outlawed chemicals focusing on its environmental and health effects. In reporting their findings, ask students to write or talk about factors that should be considered in selecting chemical pesticides for use at home, on farms or gardens, or in agricultural areas.

- Design an educational program or materials to help stop the spread of Argentine ants to other parts of Haleakalā National Park.

Resources for Further Reading and Research

Carr, Gerald, Elizabeth Powell, and Donald Kyhos, "Self Incompatibility in the Hawaiian Madiinae (Compositae): An Exception to Baker's Rule," *Evolution*, Vol. 40, No. 2, 1986, pp. 430-434.

Kobayashi, Herbert K., *Ecology of the Silversword: Haleakala Crater, Hawaii. Final Report Hale N-3*, Hawai'i Natural History Association, 1973.

Loope, Lloyd L., Arthur C. Medeiros, and F. R. Cole, *Proceedings of the Conference on Science in the National Parks, 1986, Volume 5: Management of Exotic Species in Natural Communities,* L. K. Thomas, Jr. (ed.), The U.S. National Park Service and The George Wright Society, 1988, pp. 52-62.

Loope, Lloyd L. and C. F. Crivellone, *Status of the Silverswords in Haleakalā National Park: Past and Present. Technical Report 58*, Cooperative National Park Resources Studies Unit, University of Hawai'i at Manoa, 1986.

Medeiros, Arthur C. and Lloyd L. Loope, *Rare Animals and Plants of Haleakalā National Park*, Hawai'i Natural History Association, 1994.

HNIS (Harmful Non-Indigenous Species) report for the Argentine ant (*Linepithema humile*) can be downloaded from <www.hear.org/hnis/index.html#invertebrates>.

Hawai'i Ecosystems at Risk, "Pest Ants in Hawai'i" at <www.hear.org/AlienSpeciesInHawaii/ants/index.html>.

Myrmecology at <www.myrmecology.org>. This site includes general background on ants and the study of ants as well as a variety of links to other ant-related sites.

Activity #1

To Spray or Not to Spray

● ● ● Class Period One *To Spray or Not to Spray?*

Materials & Setup

- Silversword image acetate (master, p. 7)
- Silversword species card from Alpine/Aeolian Unit 3, Activity #4 "Web of Life Game," p. 30
- Overhead projector and screen

For each student

- Student Page "What Would You Decide?" (pp. 8-9)
- Student Page "Now You Know . . ." (pp. 10-11)

Instructions

1) Show the acetate of the silversword. Ask students if they know what it is. Once you have identified this plant as the *'āhinahina*, or Haleakalā silversword, ask students if they have ever seen this plant or know anything about it. Use the notes on the species cards to raise interesting points about the *'āhinahina* as the discussion progresses.

2) Divide the class into groups of three or four students.

3) Hand out the Student Page "What Would You Decide?"

4) Give groups about 20 minutes to read the scenario, discuss alternative courses of action, and agree on one.

5) Bring the class back together and discuss the scenario and group decisions for the remainder of the class period. Have student groups present their courses of action and explain their reasoning. Then draw out common themes by asking questions such as these:
   a) How easy was it to come to an agreement about what to do?
   b) What were some of the disagreements or different points of view that came up?
   c) Do you have any doubts or uncertainties about the course of action you chose? If so, what are they? Why did you decide to take this course of action despite those doubts?

6) Assign the Student Page "Now You Know . . ." as homework. Note that students will need to take home their copies of the "What Would You Decide?" student page as well to complete this assignment.

Journal Ideas

- Do you think it is important to protect native plants such as the *'āhinahina* from possible extinction? Why or why not?
- Describe a decision you wish you could have changed later. What can you do to help make good decisions even if you don't know what will happen in the future? How can resource managers use the same approaches to make good decisions about protecting native plants and animals?

Assessment Tools

- Participation and conduct in small groups
- Participation in class discussion
- Student Page "Now You Know . . ."
- Journal entries

ʻĀhinahina *(Haleakalā silversword) in bloom*
(Photo: R. C. Zink, Haleakalā National Park)

What Would You Decide?

Take a trip more than thirty years back in time. The year is 1968. The superintendent of Haleakalā National Park has a tough decision to make.

Park staff members have become concerned about the damage that insects appear to be doing to *'āhinahina*, the Haleakalā silversword (*Argyroxiphium sandwicense* subsp. *macrocephalum*), one of the best-known plants in the park. Recent reports from an entomologist (a person who studies insects) and a park naturalist suggest that insects may be damaging the plants so that almost no seeds are produced.

'Āhinahina was once so common in the summit area that many hillsides shimmered with the silvery plants, reminding visitors of winter or moonlit landscapes. In the late 1800s and early 1900s, visitors to the summit of Haleakalā would often collect the silverswords as souvenirs, uproot them for the fun of seeing the round plants bounce and roll down the cinder slopes, or dig them up for sale as garden plants.

Over the years, human vandalism along with browsing by domestic cattle and feral goats (free-roaming animals descended from domesticated goats that escaped or were turned loose) had reduced silversword numbers to a fraction of their former abundance. By the 1940s these problems were brought under control by the national park, but populations of this unique plant were not rebuilding as quickly as expected. Some populations even continued to decline.

Now, with the news that insects appeared to be damaging the silverswords by eating the flowers and seeds, the superintendent is in a dilemma. Part of his job is to protect the native plants and animals found in the park. The silversword has become an important symbol of the park, recognized around the world. He wants to do everything in his power to make sure the *'āhinahina* survive.

There is a "pesticide" (substance toxic to pest insects or plants used to control their populations) that seems as though it could be effective on a range of insect species. This pesticide was used in the early 1960s on bushes around the observatories near the summit to control large concentrations of insects that sometimes interfered with the operation of the observatories. The insecticide appeared to be effective at killing insects on the vegetation and keeping them away for three to four months after each application.

Some people on the park staff say the superintendent should start a program for spraying the silverswords with this pesticide. They say this pesticide has a good chance of taking the pressure of insect predation off the silverswords and increasing their chances of reproducing.

Danny and a silversword
(Photo: Haleakalā National Park)

Other people on the park staff think the silverswords should not be sprayed. The silversword ecosystem includes several endemic insects (found only in Hawai‘i or only on Haleakalā) including flies, bees, moths, planthoppers, and beetles. These staff members believe there is too much risk of harming the native insect species that evolved along with the silversword.

Still other park staff members believe there needs to be more research before any decision is made. They point out that little is known about which insects are doing the most damage to *‘āhinahina*, what effect the pesticide would have on different insect species, and whether spraying would be effective at all. Furthermore, they say, there’s not enough evidence to prove that insect predation is actually decreasing the silverswords’ ability to reproduce.

Your Group’s Assignment

What do YOU think the superintendent should do?

1) Discuss with your group what you think the right decision would be and why.
2) Come to agreement on a course of action.
3) Be prepared to explain your reasoning when your group presents its decision to the rest of the class.

Now You Know . . .

Beginning in the 1970s, there was more attention given to research about *'āhinahina* and their habitat. Researchers, mostly based at the University of Hawai'i and at the park, have added greatly to our knowledge about these magnificent plants. Here is some of what's been learned about silverswords and insects since 1968.

• In 1973, botanist Herbert K. Kobayashi completed an extensive study of silversword ecology in the Haleakalā summit basin. Part of his research focused on the relationship between *'āhinahina* and insects that have been observed causing damage to the plants. In his report, he points out three considerations that counter the commonly held view that insects are a main cause of declining silversword populations:

1) The insects that have been observed to do the most damage are larvae of insects specifically associated with the Haleakalā silversword. In other words, like several other insect species, they depend on *'āhinahina* for their survival. These insects evolved over a long period of time together with the silversword, and would run out of food if their larvae damaged the silverswords so badly that they could not reproduce.

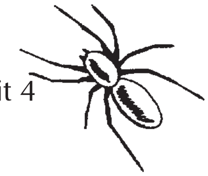
2) In 1969 and 1971, Kobayashi examined hundreds of *'āhinahina* flowers and found none with seeds completely destroyed by insects. Even the most heavily damaged populations had some viable (capable of germination) seeds available for dispersal. Viable seeds survive because the insects do not eat the entire flower.

3) Large, dense populations suffer the most insect damage, while smaller isolated populations are the least damaged. Despite apparently heavy insect infestations, large populations of *'āhinahina* have remained on the cinder cones and lava flows for at least 100 years, so high infestation does not necessarily lead to a drop in number. Even if a larger population were to be drastically reduced, the smaller, more isolated populations may then serve to re-establish larger populations.

• In the mid-1980s, University of Hawai'i botanists Gerald Carr and Elizabeth Powell teamed up with Donald Kyhos from the University of California to learn that silverswords cannot produce fertile seeds without cross-pollinating with other plants. *'Āhinahina*, which flower only once after many years of growth, depend on insect pollinators in order to reproduce.

• According to Lloyd Loope and Art Medeiros, both researchers at Haleakalā National Park, the greatest threat to *'āhinahina* now appears to be the potential loss of its insect pollinators. These endemic insects may be threatened by the non-native Argentine ant, which has established itself in small and growing areas of silversword habitat. Park researchers and resource managers are working to control the spread of this invader.

• In his 1973 report on silversword ecology, Herbert Kobayashi expressed concern about trampling as a source of damage to young silversword plants. The *keiki 'āhinahina* are small and not always easily seen by hikers. And the cinders the plants grow in are easily displaced by trampling feet. As more people visit Haleakalā, Kobayashi warned that trampling would probably become a more important source of damage to silverswords. Researchers also need to be careful about damaging young *'āhinahina*, especially when they are walking off-trail.



Today, visitors are encouraged to stay away from the silverswords to avoid trampling keiki *plants and damaging shallow roots. (Photo: Haleakalā National Park)*

• The insecticide proposed for use on silversword insects in the 1960s was DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane). DDT was also used around the observatories in 1964. DDT grew to be a popular insecticide largely because it was so effective against the mosquito that spreads malaria and the louse that carries typhus. It seemed to be an ideal pesticide because it was cheap and because laboratory tests showed that it was relatively nontoxic to mammals.

In 1962, Rachel Carson's book, *Silent Spring*, was published. In it, Carson looked at modern agriculture and its dependence on chemical insecticides. DDT was one of those insecticides. At the time, DDT was routinely sprayed on beans, peanuts, tomatoes, and other crops. Carson laid out a compelling collection of evidence about the environmental and human health problems associated with DDT. She pointed to studies that correlated fish and bird mortality with DDT. Where it was used against Dutch elm disease, for example, DDT killed earthworms that fed on fallen leaves, as well as robins that fed on the earthworms. Falcons and other birds of prey contaminated with DDT produced thin-shelled eggs that hatched before fully maturing.

Silent Spring helped spark an uproar among U.S. citizens concerned about health and the environment. It is often identified as the beginning of the modern environmental movement. In 1972, the federal government bowed to public pressure and ordered a ban on DDT in the United States.

ʻĀhinahina on the Rebound

(Census of silverswords from Ka Moa o Pele cinder cone)

Year	Number of Plants
1935	1470
1962	1248
1971	3990
1981	6405
1991	6019

Your Assignment

Based on everything you've learned during this activity, write a one-to-two-page paper in which you:

1) Briefly describe your group's response to the "What Would You Decide?" scenario; and
2) Explain whether and how the information in this student page changes your thinking about what the superintendent in that sceanrio should do.

Activity #2

Ant Alert: How Does Invasion Threaten Natives?

● ● ● **In Advance** *Student Reading*

- Assign the Student Page "That Ant is a Tramp" as homework reading (pp. 20-23).

● ● ● **Class Period One** *Ants Video*

Materials & Setup

- *Nova* video, "Ants! Little Creatures Who Run the World" (included with this curriculum)
- VCR

For each student

- Student Page "Ant Video Note Sheet" (pp. 24-25)

Instructions

1) Watch the *Nova* video entitled, "Ants! Little Creatures that Run the World." The entire video lasts approximately 1 hour, so if you have a shorter period than that, play video from beginning through the leafcutter ant segment. This is 47 minutes of run time. Or play as much of the video as you can during the class.

2) During the video, ask students to fill in the Student Page "Ant Video Note Sheet." Let students know they do not necessarily need to remember the species names of different kinds of ants on this note sheet. However, they should be able to describe the ant species well enough that someone who's watched the video would know which ant they are describing.

3) As homework, have students review their class notes and the "Argentine Ants" student page from the previous homework assignment to prepare for a brief in-class quiz the following class period.

● ● ● **Class Period Two** *Argentine Ants Teaching Teams Preparation*

Materials & Setup

For each student

- Student Page "Argentine Ants Quiz" (pp. 37-38)

For each student teaching team

- One copy of the appropriate topic set (see class period two instructions) from the Student Page "Argentine Ants Teaching Teams Background" for each team member (pp. 26-36)

Instructions

1) Have students complete the Student Page "Argentine Ants Quiz."

2) Divide the class into four or more teams. Each team should consist of at least three students. Assign each team a topic from the list below, making sure that each topic is covered by at least one team. Explain to students that they will be working in teams to teach the rest of the class about a specific topic related to Argentine ants and the threat they pose to native ecosystems on Maui.
Topic #1: The location and spread of Argentine ants in Haleakalā National Park
Topic #2: The threat Argentine ants pose to native arthropods in the alpine/aeolian ecosystem
Topic #3: Biological and behavioral characteristics that make Argentine ants a strong invader
Topic #4: Characteristics of Argentine ants that affect how they spread and can be controlled

3) Hand out the appropriate section of the Student Page "Argentine Ants Teaching Teams Background" to the teams, making sure each team member receives a copy of the information on the group's topic.

4) Have team members use the information from the initial homework reading and the student page you just handed out to develop a creative presentation that will teach other students about the team's topic. Ideas include writing and performing a song or chant, making a visual representation, developing a multi-media presentation, or performing a skit or comedy routine.

5) Each team must also come up with two questions they want other students to be able to answer after their team presentation and have these questions written on a piece of paper that can be handed in.

Teaching Option

- If you want to pare down this activity from three class periods to two, or prefer to present the information yourself, substitute a lecture and discussion format. Use the Student Page "Argentine Ants Teaching Teams Background" for your background notes.

● ● ● **Class Period Three** *Team Presentations*

Instructions

1) Invite members of each team to stand up in front of the class and make their presentation. Go in the order in which the topics are listed above. Complete all the team presentations on a given topic before moving on to the next one. Prior to each presentation, have the team hand in its list of two questions that other students should learn to answer based on the presentation.

2) If there is time at the end of the class, have a class discussion focusing on the implications of what students have learned about Argentine ants for resource management in the park.

3) Select one or more questions from presentations on each topic, and either orally assign them as homework, or use them to prepare a quiz for the following class period or a later homework assignment.

Journal Ideas

- Do you think resource managers in Haleakalā National Park should make eradicating or controlling nonnative species such as Argentine ants a top priority? Why or why not?
- Think about the social structure and operation of ant colonies. Identify one aspect of ant behavior from which humans could learn valuable lessons and explain how that would benefit people. Then identify one aspect of ant behavior that would be destructive if people adopted it, and explain your thinking.

Assessment Tools

- Student Page "Ant Video Note Sheet" (teacher version, pp. 16-17)
- Student Page "Argentine Ants Quiz" (teacher version, pp. 18-19)
- Participation in preparing and delivering team presentation
- Team presentations: Assess on the basis of creativity, conformance with information provided, and thoroughness in answering the questions the team identified for other students.
- Journal entries

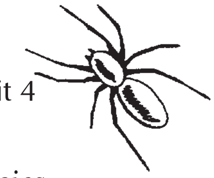
Teacher Version

Ants Video Note Sheet

This list of possible responses is not complete, but provides guidelines for assessment and discussion.

Write something you learned from the video about ants, termites, or other social insects that illustrates each of these traditional Hawaiian values.

Laulima — Cooperation, many hands or people working together on a task to accomplish a goal	• Large numbers of wood ants feeding on caterpillars and moths ensures success. • Termites can repair tremendous damage to their home because so many work together. • Kenyan raid ants bunch together before invading a termite nest, combining the force of numbers with organized aggression. • Herdsman ants form living bridges over gaps. The moving colony crosses these bridges. • Millions of driver ants act like a super-organism, killing almost everything in its path. Ants release those trapped in slug slime, and several ants work together to carry heavy loads back to the nest.
‘Ohana — Extended family system, the primary component of society. Individual interests are not as important as the interests of the group.	• Living in family groups has been the key to cockroach success. They digest food only with the assistance of small organisms in their guts. These are passed from parent to offspring during feeding. • All ants belong to extended families and carry prey home to share. • Raising many close sisters together ensures success for the whole colony. Individual ants can afford to risk their lives since they will soon be replaced. • Desert ant workers may die after only a few days in the scorching heat, but when they do find food they carry it immediately back to the nest. • Leaf cutter ants are “robots,” programmed to serve the colony.
Kuleana — Responsibilities and roles. If each member of society fufills their *kuleana*, all needs for survival will be met.	• When their nest is damaged, soldier termites come out first to defend, then workers come out to repair. • Worker ants are dedicated to caring for the eggs, grubs, and cocoons of their younger sisters. • Male ants die soon after mating, and the newly mated queens establish new colonies. • During times of plenty, honeypot ants are filled by their sister workers with sweet food to eat during lean times. • When driver ants go foraging, soldiers guard the column, cut up prey, form living bridges for other ants to cross, and hold back obstacles along the trail. Workers clear the trail and carry prey back to the nest. Other workers throw out “garbage” from the nest. • Thousands of herdsmen ants link legs to form a living cradle that serves as the colony’s nest.



Write at least two similarities and two differences between Argentine ants and other ant species on the video. Here are six areas of comparison to use for ideas. There are others, as well.

Argentine Ant Characteristics and Behaviors

- Argentine ant colonies reproduce by "budding." The new queens walk to their new nest site after having mated in the nest. Argentine ant males die after mating.
- Argentine ants are voracious predators.
- Argentine ants do not have permanent nests. They may move the entire nest from time to time.
- Argentine ant nests have more than one queen.
- Argentine ants do not defend their nests from other Argentine ants in the same area.
- Other

Note Two Similarities and Two Differences Between Argentine Ants and Other Ant Species

Similarities

- Wood ants are voracious predators during the summer.
- Kenyan raid ants are also predatory, pursuing termites and raiding their nests.
- Driver ants are particularly voracious predators, forming rivers of ants from which very little escapes alive.
- Driver ants move their nests frequently (in search of food).
- Herdsman ants regularly move their nests.

Differences

- Harvester ants in Arizona reproduce through mating flights. Tens of thousands of winged males and future queens from many colonies gather in an "ant orgy." The mated females fly off to form new colonies.
- Malaysian herdsman ants get all their food from honeydew produced by bugs that they tend.
- Certain ants in South America make their homes in the hollow stems of a plant that also produces white nodules that serve as food for the ants. In return, the ants defend the plant against predators.
- In the Amazon, some ants grow hanging gardens in nests of chewed plant fibers.
- The ancestral piles of wood ants are passed through generations. Some may date back to the 1900s.
- Leaf cutter ant colonies, numbering two to three million workers, have a single queen.
- Honeypot ants defend their nests and prey against ants from other nests. Entire colonies may be overrun and the honeypots dragged off to the victorious colony.

Teacher Version

Argentine Ants Quiz

1) Explain Argentine ants' response to a disturbance in their environment, such as a vibration, change in weather, or a manipulation of their nest.

   Answer should be based on this excerpt from the text:

   > Even a slight disturbance such as a vibration or a small manipulation of the nest will send Argentine worker ants scurrying away from the nest trying to carry larvae and pupae (their "brood") to a safer place. Entire colonies may move in response to physical disturbance, changes in weather conditions, or changes in their food source.
   >
   > Argentine ants are so sensitive that even a hiker or picnicker walking by or sitting down could create enough of a vibration or disturbance to cause a nearby nest to relocate.

2) How could this type of response help Argentine ants "hitch a ride" with humans?

   It would take no more than a few ants and their cargo of brood to relocate into a hiker's pack, a picnicker's cooler or garbage bag, shipments of nursery stock, or other items. Once they have reached their new destination, they might be able to establish a new colony.

3) How many different populations of Argentine ants are known in Haleakalā National Park today?

Two

4) Is the size of those populations getting bigger, getting smaller, or staying about the same?

Both are getting larger.

5) Give two reasons why Argentine ants are considered a threat to native insects and plants in Haleakalā National Park.

Responses should be based on the following points from the text:

There are no native ants on the Hawaiian Islands, so most of the insects that evolved here are not adapted to defend themselves against the aggressive predatory abilities of large colonies of Argentine ants. Native Hawaiian insects are often soft-bodied and flightless—easy prey for the Argentine ant.

Argentine ants also may prevent native insects from using rocks, logs, and other objects for cover. These ants often nest under objects of this type. In the extreme environment of the alpine/aeolian zone, that cover may be important refuge to the native insects to shelter them against the midday sun, the nighttime cold, and the wind.

Argentine ants reduce the populations of native arthropod species. The effects are especially severe at higher elevations, where the prey species are fewer in number. Species that are known to be severely affected by Argentine ant predation in the park include native bees and moths, which are the main pollinators for native plants such as the silversword.

Argentine ants have no predators, competitors, or parasites in the alpine/aeolian ecosystem.

Argentine ants are well known for displacing native insect and ant species elsewhere in the world. Researchers and resource managers at the park are concerned that the same thing could happen at Haleakalā.

That Ant is a Tramp

In 1967, scientists identified a new species of ant in Haleakalā National Park: *Linepithema humile*, the Argentine ant. This ant is thought to be native to Argentina and Brazil. Like every other ant species on the Hawaiian Islands today, it is an alien species. There are no native ant species here, although as you quickly learn if you leave food out at home, there are now plenty of ants around.

Most of the ants found on Maui and the other Hawaiian Islands cannot survive at the higher elevations of Haleakalā National Park. In fact, only two ant species other than the Argentine ant have been found above 2000 meters (6560 feet) within park boundaries. Neither of the other two species seem to pose a threat to the native plants, animals and insects of the alpine/aeolian zone of Haleakalā. But Argentine ants do.

Argentine ants (Photo: Neil Reimer, U.S. Department of Agriculture)

Before we get into that part of the story, however, let's take a step back in time and look at the spread of Argentine ants in Hawai'i.

Argentine Ants Find a New Home

The Argentine ant probably established its presence in Hawai'i because of military activity. In 1940, it was discovered at Fort Shafter in Honolulu. There were several established colonies by that time. By 1949, the ants had spread beyond the confines of Fort Shafter. By that time, there was no looking back for the Argentine ant, which has since spread to all of the major Hawaiian Islands except Molokai. Even though Argentine ants first established their Hawaiian presence on O'ahu, they are no longer found there. They are believed to have been out-competed by another introduced species, the big-headed ant (*Pheidole megacephala*).

By 1950, Argentine ants had reached Maui, where they were reported in Makawao. And in 1967, the first Argentine ant was identified in Haleakalā National Park.

How did the Argentine ant get to the park? It did not fly. It was not carried there in the digestive system of a bird or a pig. Most probably, Argentine ants traveled to their new home on Haleakalā with people who did not even suspect that they were carrying such an aggressive intruder with them.

The Biology and Behavior of a Tramp

Argentine ants are one of several species of ants that have come to be called "tramp species." They are well adapted to living in close association with humans and are easily dispersed around the world as we ship goods and travel from one place to another.

One reason that tramp ants have been so successful at thriving in close proximity to humans is that they are well adapted to a changing environment. Human activity tends to create an unstable environment—one that is prone to change as we move things around, clear land, do landscaping, and go about other daily activities.

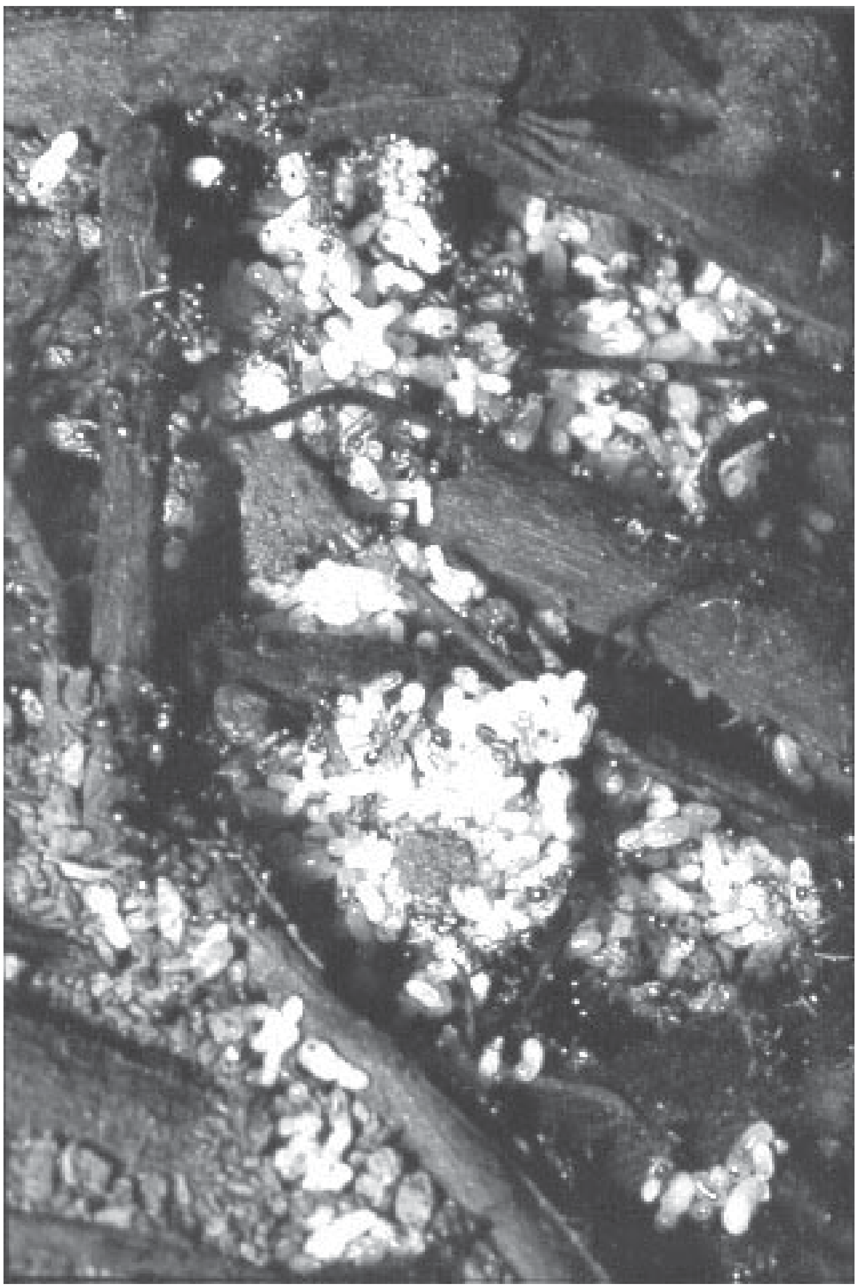
Tramp species are extremely mobile. Even a slight disturbance such as a vibration or a small manipulation of the nest will send Argentine worker ants scurrying away from the nest trying to carry "larvae" and "pupae" (the early developmental stages that constitute an ant colony's "brood") to a safer place. Entire colonies may move in response to physical disturbance, changes in weather conditions, or changes in their food source.

Argentine ants are so sensitive that even a hiker or picnicker walking by or sitting down could create enough of a vibration or disturbance to cause a nearby nest to relocate. If a few ants and their cargo of brood were to relocate into the hiker's pack or the picnicker's cooler or garbage bag, they could easily be transported to an uninfested area of the park. Once there, they could establish a new colony.

The rapid-response movement combines with other features of Argentine ant biology to make it a successful hitchhiker. These characteristics are shared among most tramp ant species.

Polygyne Colonies

These ants are "polygyne." In other words, each nest has more than one queen—one estimate is that there are typically one to 1.6 queens per 1,000 worker ants. Smaller queens sometime forage with worker ants. If a queen and some workers become hitchhikers together, they may be able to start a new colony in an uninfested area.



Argentine ant nest (Photo: Ellen VanGelder)

A Brief Look at Ant Society and Reproduction

Most ants in a colony are wingless, infertile female workers. They do the labor that keeps the colony alive, including defense, foraging, and brood-tending.

Ant queens are the only female ants that can reproduce. A queen mates once in her life, storing all the sperm from that mating in her body and using it as needed during the course of her reproductive life.

Ant males are produced only to mate. After mating, they die.

The difference between ant worker larvae and queen larvae is not in the genetics of the eggs they come from. Larvae are "differentiated" into these castes based on what they are fed and when. The development of male ants also depends on feeding. Ant workers feeding their "brood" of eggs, larvae, and pupae respond to environmental signals such as food availability and the presence or absence of pheromones (scent signals) from a queen.

If the queens are removed from an Argentine ant colony, worker ants respond by producing new males and queens from existing larvae. They do this through changes in feeding.

Colonies Reproduce by Budding

Unlike queens of many other ant species, Argentine ant queens and males do not fly from the nest at mating time. The colonies reproduce by "budding." Mating happens within the nest, and the new queens leave the nest on foot to establish a new nest close by. Like other tramp ants, Argentine ant populations spread outward from a single point. Unless, of course, the ants hitch a ride.

Unicolonial Populations

Argentine ants are "unicolonial." In other words, they form large colonies of many different nests. Unicolonial species do not exhibit aggressive behavior toward other ants from different nests in the same area. This non-competitive behavior allows Argentine ants and other tramp species to establish very large, high-density colonies. The sheer numbers of these ants, along with the aggressiveness of their workers, allows them to effectively prey upon and/or outcompete many other species of ants and insects. Since Argentine ants are most often imported and not native, this ability allows them to dominate the areas they invade. In Argentine ant-infested areas, other species of ants and insects may be virtually eliminated.

What Makes Argentine Ants a Potential Threat to Native Insects and Plants on Haleakalā?

There are no native ants on the Hawaiian Islands, so most of the insects that evolved here are not adapted to defend themselves against the aggressive predatory abilities of large colonies of Argentine ants. Native Hawaiian insects are often soft-bodied and flightless—easy prey for the Argentine ant's ground forces. Argentine ants are voracious feeders and other insects are only one item on their wide-ranging menu.

In addition to preying on native insects, Argentine ants also may prevent these natives from using rocks, logs and other objects for cover. These ants often nest under objects of this type. In the extreme environment of the alpine/aeolian zone, that cover may be important refuge to the native insects to shelter them against the midday sun, the nighttime cold, and the wind.

In Haleakalā National Park, researchers who surveyed native “arthropods” in ant-infested areas and non-infested areas found that the ants reduce the populations of native species. (Arthropods are a group of invertebrate animals with jointed bodies and limbs that includes insects, spiders, scorpions, mites and centipedes.) The effects are especially severe at higher elevations, where the prey species are fewer in number. Species that are known to be severely affected by Argentine ant predation in the park include native bees and moths, which are the main pollinators for native plants such as *‘āhinahina*.

Another advantage Argentine ants have is that there are no predators, competitors, or parasites in the alpine/aeolian ecosystem. Argentine ants are well known for displacing native insect and ant species elsewhere in the world. Researchers and resource managers at the park are concerned that the same thing could happen at Haleakalā.

How Are the Ants Spreading in the Park?

Since the first Argentine ants were found in Hosmer Grove in 1967, the ants have expanded their territory each year, spreading steadily outward through the budding process described above. In 1982, a second population of Argentine ants was discovered in the park, at the parking lot at Kalahaku Overlook, further up the mountain.

Given the Argentine ant’s tendency to hitch a ride with humans, it is not surprising that the first population found in the park was near Hosmer Grove, a picnic area and campground that receives a lot of visitors. Likewise, Kalahaku Overlook is frequented by large numbers of people.

Just over thirty years after it was first recorded in the park, the Argentine ant range has expanded to over 500 hectares (1200 acres, or about two square miles). That is about 4.5 percent of the entire area of the park. Researchers believe that much of the “crater” at Haleakalā could be inhabited by Argentine ants eventually, if no way is found to control their spread. According to one analysis, approximately 50 percent of the area of the park—including the west slope of the volcano and most of the western and central parts of the crater—is potential Argentine ant habitat.

Sources

Fellers, J. H. and G. M. Fellers, “Status and distribution of ants in the Crater District of Haleakala National Park,” *Pacific Science,* Vol. 36, 1982, pp. 427-437.

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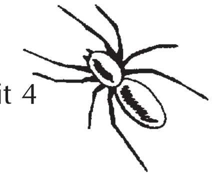


Ants Video Note Sheet

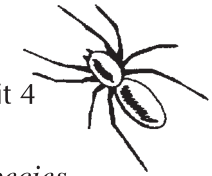
Write notes based on what you learn watching *Ants! Little Creatures Who Run the World*.

Write something you learned from the video about ants, termites, or other social insects that illustrates each of these traditional Hawaiian values.

Laulima — Cooperation, many hands or people working together on a task to accomplish a goal

ʻOhana — Extended family system, the primary component of society. Individual interests are not as important as the interests of the group.

Kuleana — Responsibilities and roles. If each member of society fufills his or her *kuleana*, all needs for survival will be met.



Write at least two similarities and two differences between Argentine ants and other ant species on the video. Here are six areas of comparison to use for ideas. There are others, as well.

Argentine Ant Characteristics and Behaviors	**Note Two Similarities and Two Differences Between Argentine Ants and Other Ant Species**
• Argentine ant colonies reproduce by "budding." The new queens walk to their new nest site after having mated in the nest. Argentine ant males die after mating. • Argentine ants are voracious predators. • Argentine ants do not have permanent nests. They may move the entire nest from time to time. • Argentine ant nests have more than one queen. • Argentine ants do not defend their nests from other Argentine ants in the same area. • Other	

Argentine Ants Teaching Teams Background

Topic #1: The Location and Spread of Argentine Ants in Haleakalā National Park

Where Are the Argentine Ants?

[See Figure 1: Argentine Ant Populations in Haleakalā National Park, 1997, p. 28.]

Argentine ants were first found in the park at Hosmer Grove in 1967. Since then, the ants have expanded their territory each year, spreading steadily outward through the budding process described in the next section. In 1982, a second population of Argentine ants was discovered in the park, at the parking lot at Kalahaku Overlook, further up the mountain.

Just over thirty years after it was first recorded in the park, the Argentine ant range has expanded to over 500 hectares (1200 acres, or about two square miles). That is about 4.5 percent of the entire area of the park.

The lower elevation population is located southwest (leeward) of Hosmer Grove picnic and camping area, the original site of introduction at 2074 meters (6803 feet). This population is in native subalpine shrubland.

The upper elevation population was first discovered at Kalahaku Overlook at 2775 meters (9102 feet). Vegetation at this site is much more sparse, as in the alpine/aeolian ecosystem. This population has expanded primarily down the crater wall to the "crater" floor, and is now advancing across the "crater" floor.

How Far Could They Spread?

[See Figure 2: Potential Range of the Argentine Ant in Haleakalā National Park, p. 29.]

Based on patterns in range expansion over the past 30 years, researchers believe it is likely that the Argentine ant is capable of colonizing large parts of the park's subalpine shrubland and aeolian zones.

Researchers have estimated the potential range of the Argentine ant within the park, taking into account rainfall, elevation, and habitat suitability (including nest site availability, vegetative cover, and estimated levels of food resources such as arthropods and nectar or honeydew sources). This predicted potential range covers the west slope and most of the west and central "crater." If Argentine ants spread to this whole range, they would occupy nearly 50 percent (5500 ha or 13,585 acres) of the park's total area.

This estimate does not account for the potential range outside of park boundaries, as you can see on the map.

How Quickly Are They Spreading?

[See Figure 3: Spread of the Lower Population, p. 30 and Figure 4: Spread of the Upper Population, p. 31.]

The two populations of Argentine ants are expanding at different rates.

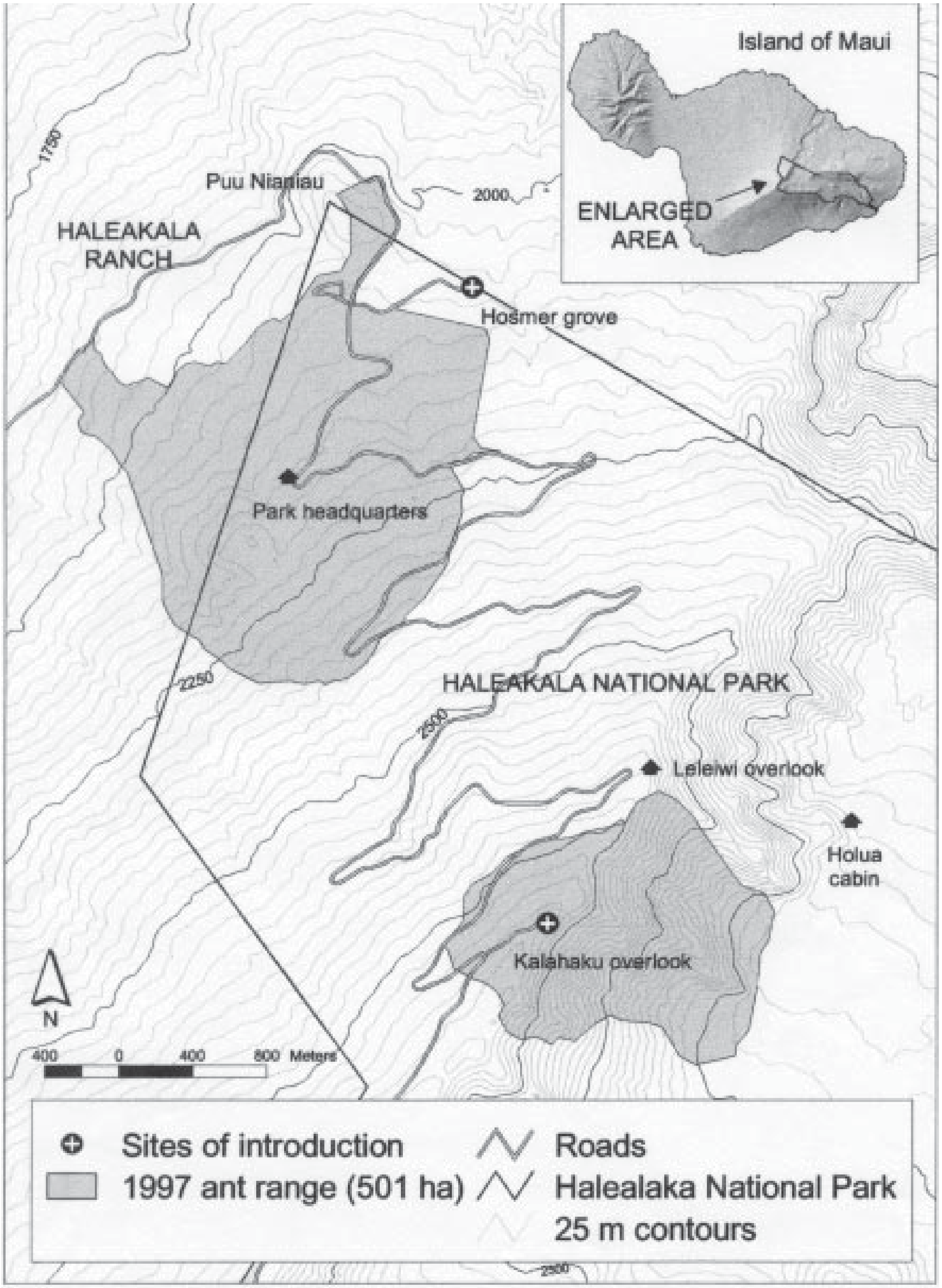
<u>Lower population</u>: The first surveys of ant distribution were done in the early 1980s, more than ten years after the ant was found at Hosmer Grove. The population's rate of radial spread (expansion of the population boundaries outward from a central point) since 1982 has averaged approximately 29 meters/year.

Upper population: Expansion of this population has been much more dramatic, with spread exceeding 150 meters/year in some areas.

- For the first seven years in which this population was monitored, it spread roughly equal distances in all directions at a rate of approximately 24 meters/year.
- By 1993, westward spread continued at this pace, but the rate of spread toward the east had increased to about 81 meters/year, bringing the upper population to the "crater" floor.
- From 1993 to 1997, peak rates of spread (exceeding 150 meters/year) occurred at lower elevations in the crater. The population spread more slowly (23 meters/year) at the higher elevations west of Kalahaku Overlook on the "crater" rim.

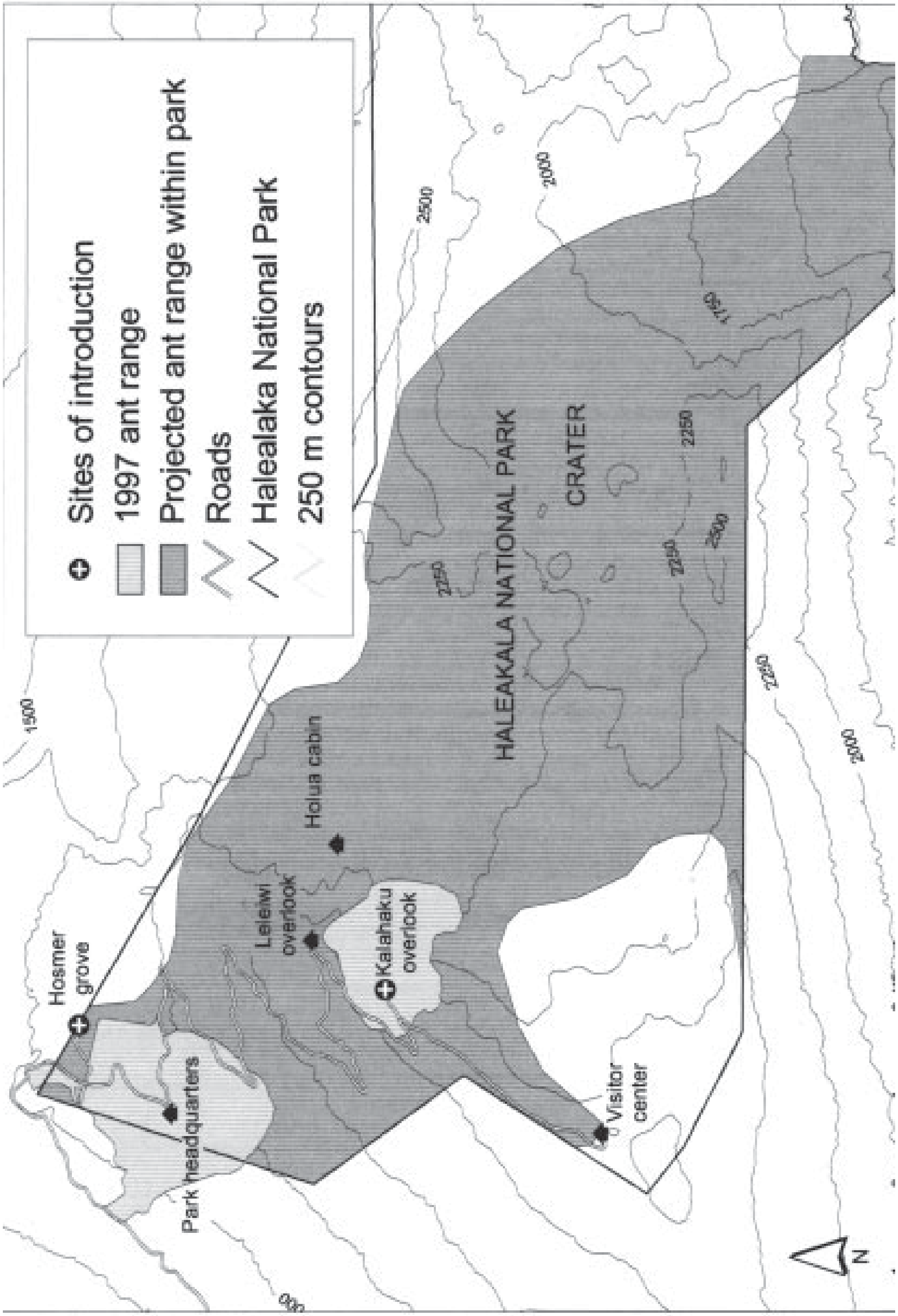
Note: On Figures 3 and 4, "pitfall sites" are indicated. Pitfall sites are the location of traps used to assess population numbers.

Figure 1: Argentine Ant Populations in Haleakalā National Park, 1997



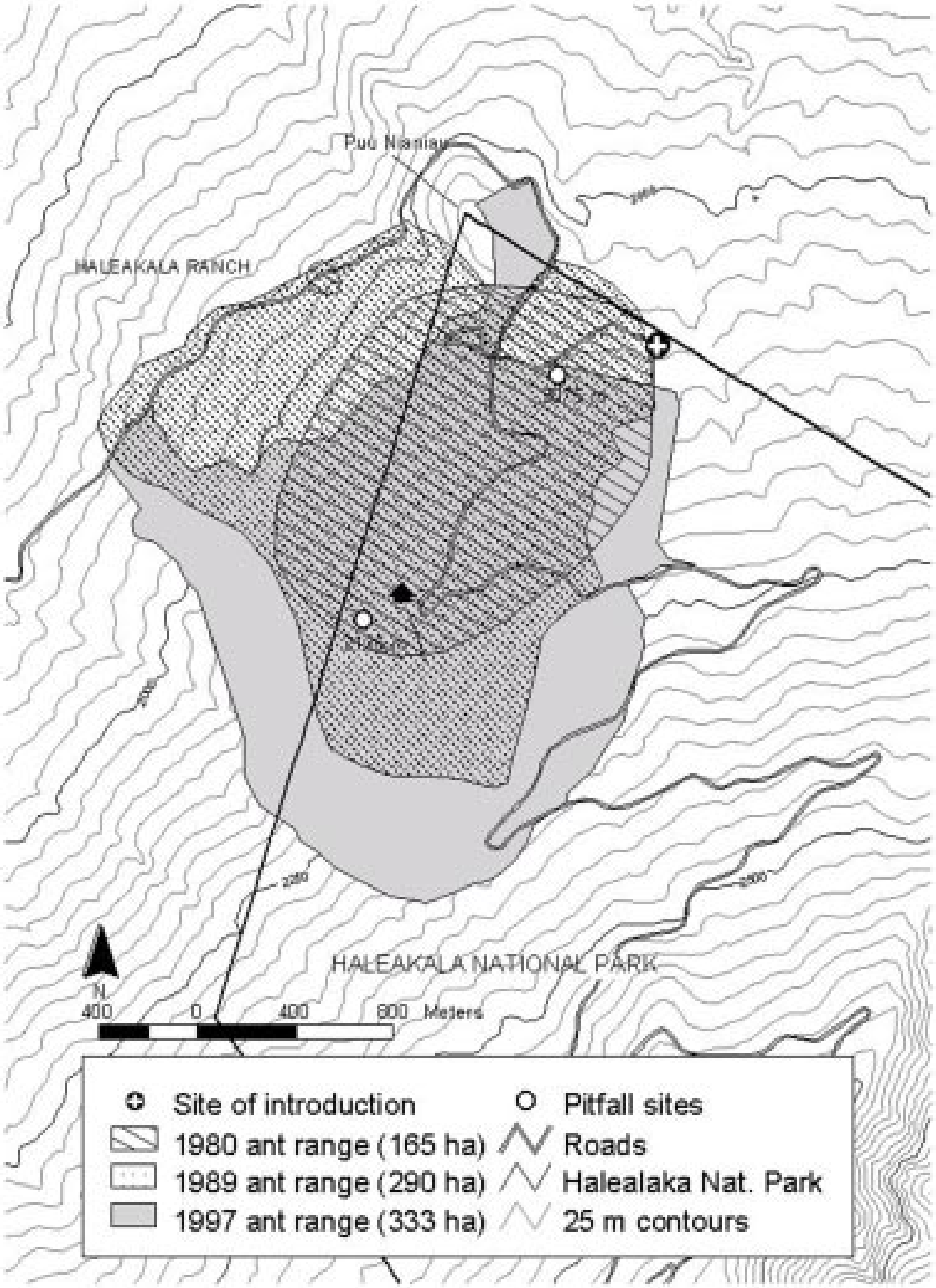
Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 2: Potential Range of the Argentine Ant in Haleakalā National Park



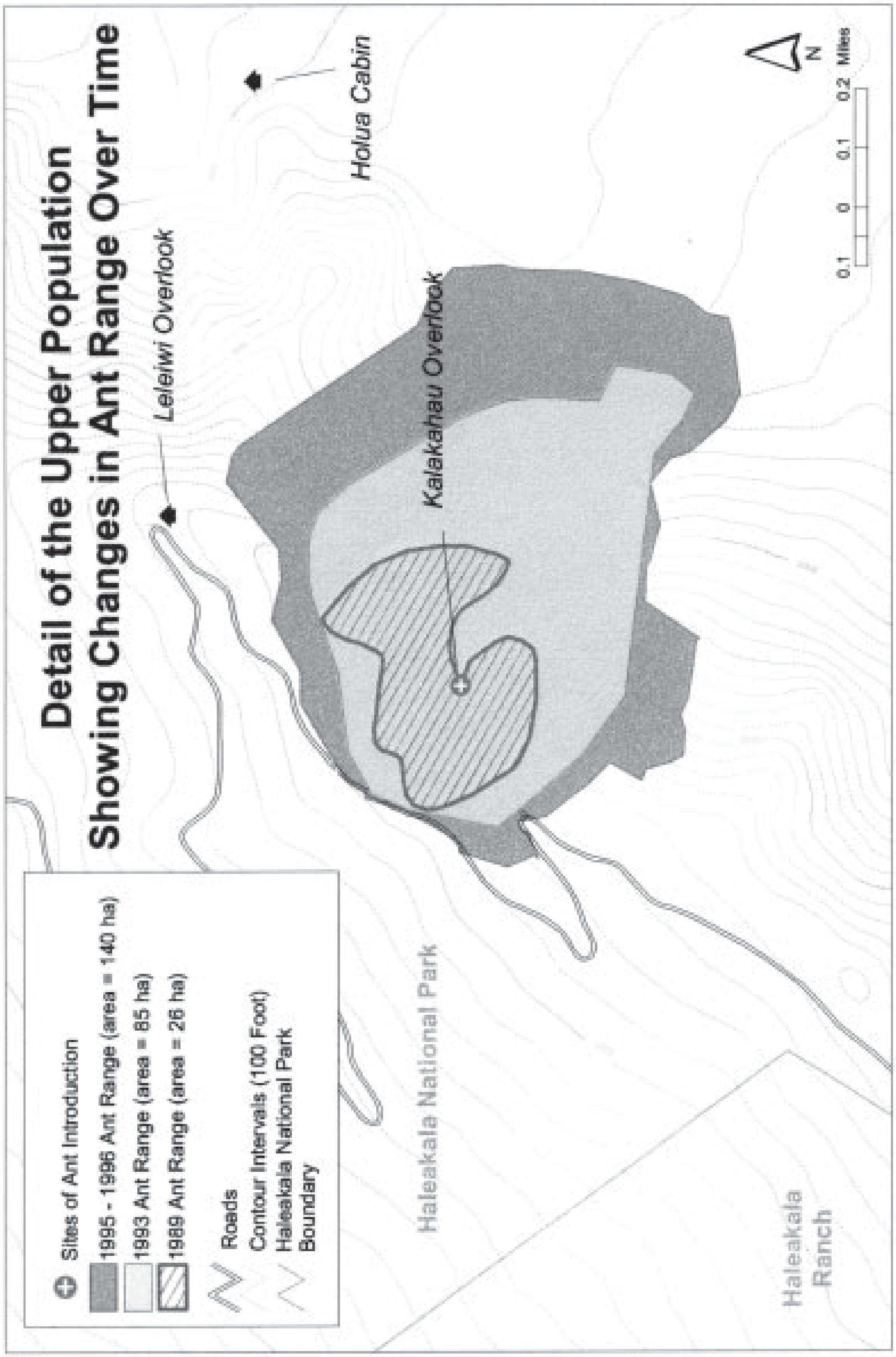
Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 3: Spread of the Lower Population (1997 range projected)



Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 4: Spread of the Upper Population



Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Argentine Ants Teaching Teams Background

Topic #2: The Threat Argentine Ants Pose to Native Arthropods in the Alpine/Aeolian Ecosystem

In 1985 and 1986, researchers did a study to determine the impact of the Argentine ant on the native ground-dwelling "arthropods." (Arthropods are a group of invertebrate animals with jointed bodies and limbs that includes insects, spiders, scorpions, mites and centipedes.)

Researchers used two techniques in this study: "pitfall traps" and "under-rock surveys." They set up two study sites within the Argentine ant range and two outside of it.

The "pitfall traps" were specimen jars and baby food jars partially filled with an antifreeze solution to preserve trapped organisms. The inside rim of each jar was baited with finely blended salted fish. These traps were buried flush with the ground surface where they attracted foraging invertebrates that fell into the preservative in pursuit of the bait. After two weeks, the jars were removed and the contents sorted and identified in a lab.

The under-rock surveys provided additional information. From plots within the study site, researchers lifted rocks and catalogued the invertebrates they found under the rocks. The under-rock surveys provided information about some types of invertebrates that were unlikely to be caught in pitfall traps (because of their food source preferences, for example).

The study suggests that many native arthropod species are negatively affected by the presence of the Argentine ant. Other invertebrate species are positively affected, while still others do not seem to be affected one way or the other. Here are the native species the study suggests are most negatively affected by the Argentine ant.

- Large Lepidopteran larvae (the young of one of the endemic noctuid moth species)
- *Nesoprosopis* larvae (the young of the endemic Hawaiian yellow-faced bees). The study suggests that ants destroy the nests this ground-dwelling bee builds under rocks and feeds on the larvae.
- Carabid beetles
- Spiders including *Lycosa hawaiiensis*, the endemic wolf spider.

[See the following pages for informational cards about the native arthropods mentioned above.]

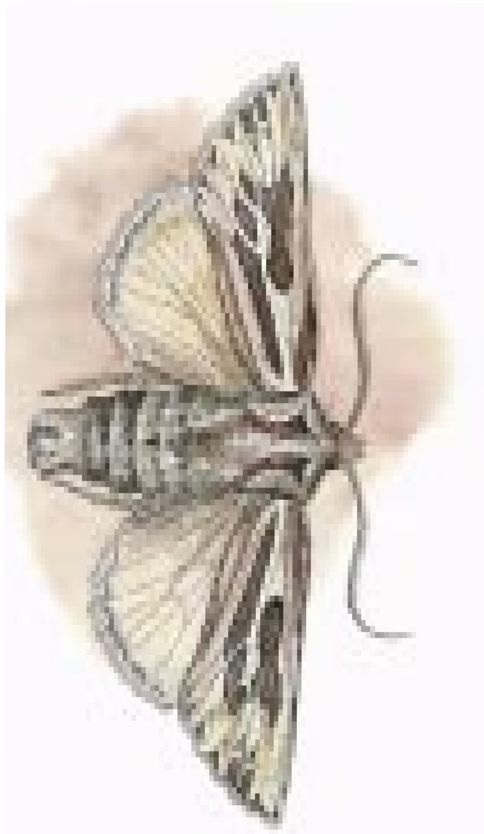


Image: Nancy Sidaras

Hawaiian Noctuid Moth (*Agrotis arenivolans*)

Order Lepidoptera, Family Noctuidae

Status Endemic to Hawai‘i.

Habitat •Larvae have been seen feeding on the leaves of the native shrubs *pūkiawe* and *na‘ena‘e*. They also feed on the seeds of the *‘āhinahina*.
•Caterpillars burrow in cinders during the day and feed at night.

Characteristics •Adults have a layer of long, thick hairs on their wings and bodies that help keep them warm, reflect sunlight and prevent water loss.
•Adult noctuid moths visit flowers at night, probably acting as pollinators for native plants.

Think about it: Noctuid larvae are abundant in the alpine/aeolian zone. But wherever the Argentine ant is established, very few of these caterpillars can be found. What do you think is happening?

Did you know? The larvae (caterpillars) of most Lepidoptera species around the world feed on plants. But the larvae of at least one Hawaiian noctuid moth species in the alpine/aeolian zone feed on other arthropods as well as on the leaves of the few plants that occur in the area. Their arthropod prey is either dead or in a stupor from the cold night air.

Image: Nancy Sidaras

Hawaiian Yellow-Faced Bee (*Nesoprosopis [Hylaeus] volcanicus*)

Order Hymenoptera, Family Colletidae

Status Endemic to Haleakalā.

Habitat Lays eggs in a winding, silken tube nest, usually under a rock.

Characteristics
•Solitary, unlike the social honeybee that lives in cooperation with other bees.
•Visits flowers to gather pollen and nectar to feed its young.
•Small—only 6-12 mm (.024-.048 in) long.

Think about it: Why would these small bees be so critical to the pollination of many native plants including *pūkiawe* and the *‘āhinahina*?

Did you know? Another species of Hawaiian yellow-faced bee (*N. volatilis*) found in the alpine/aeolian zone is a nest parasite. It lays its eggs in the nest of *N. volcanicus* or the related *N. nivalis*. It may visit flowers, as well, but only to gather nectar to feed itself.

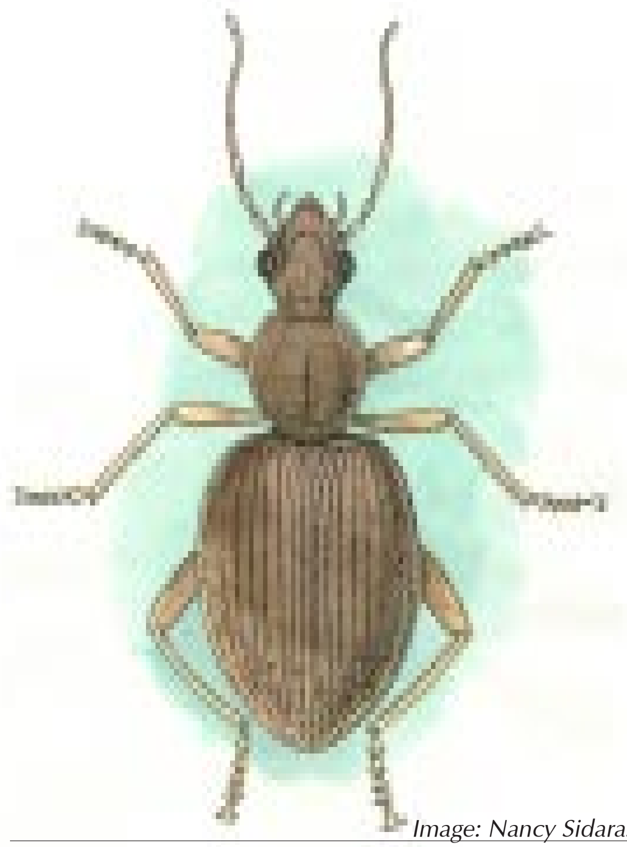


Image: Nancy Sidaras

Carabid Beetle (or Ground Beetle) (*Mauna frigida*)

Order Coleoptera, Family Carabidae

Status Endemic to Haleakalā. Of ten carabid beetle species recorded within the alpine/aeolian zone, nine are endemic to Haleakalā.

Habitat Five of the endemic carabid beetle species, including *Mauna frigida* have been found only on the upper 150 meters (492 feet) of the mountain's summit.

Characteristics

•These five species are flightless scavenger-predators.
•Thick exoskeletons protect them from water loss and extreme cold.

Think about it: These five species are extremely rare. Little is known about their current status or biology. Some of them may be extinct. How would you go about trying to find out?

Did you know? The 215 Hawaiian endemic carabid beetle species probably evolved from as few as six original immigrants.

Photo: Haleakalā National Park

Wolf Spider (*Lycosa hawaiiensis*)

Order Araneae, Family Lycosidae

Status Endemic to Haleakalā.

Habitat

•Live only at or near the mountain's summit
•Makes shallow burrows under rocks by cementing windblown leaves and other detritus together with silk. The burrows protect it from the cold, dry climate.

Characteristics

•Normally dark in color, turns silver when hunting among the *'āhinahina* rosettes.
•A predator-scavenger that hunts on the ground rather than building web.
•A large spider, measuring between 3.5-5 cm (1.4-2 in) in length.

Think about it: How might a dark-colored body and long legs help a wolf spider survive in the cold temperatures of the alpine/aeolian zone?

Did you know? Mother wolf spiders carry silk egg sacs (larger than their own bodies) beneath them. As the young hatch, they ride on their mother's back while she hunts.

Argentine Ants Teaching Teams Background

Topic #3: Biological and Behavioral Characteristics That Make Argentine Ants a Strong Invader

and

Topic #4: Characteristics of Argentine Ants That Affect How They Spread and Can Be Controlled

[For more information about these topics, see the Student Page "That Ant Is a Tramp."]

Because of the constant expansion of this species and its potential to seriously deplete endemic arthropod species (including essential pollinators for native plant species including the silversword), park researchers and resource managers began looking for a way to keep the ants from spreading to new areas.

Several basic biological and behavioral characteristics of the Argentine ant suggest that it would be vulnerable to a control strategy that uses toxicants (poisons). In brief, here are four of these characteristics and what that means for designing a control program:

1) Polygyne Colonies & Flightless Queens Disperse by Budding

These characteristics usually go together.

- "Polygyne" colonies have many queens.
- "Budding" is a process by which new queens will locate their new nests near their birth colony—usually within meters. Mating takes place within the birth nest. Afterward, along with a few workers from her birth nest, the new queen walks away to a new site and begins her own nest. She lays eggs and the workers that accompanied her in her relocation do the work of digging the nest and tending the brood.

This suite of characteristics is crucial to designing a control program. With Argentine ants, it is possible to treat the boundaries of the population to keep it from spreading further. This is because of the budding process through which the population expands slowly outward. A new, noncontiguous population will only be established if people transport the ants to a new place.

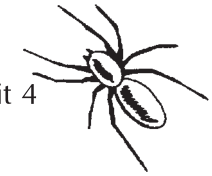
2) Unicolonial and Non-competitive

Argentine ant workers are not territorial. In other words, they do not defend territories against ants of the same species. In fact, workers born elsewhere are readily accepted into the nest. Workers often wander between nests, helping out in whatever nest they happen to be in at the time. New queens that disperse from their birth colony may also be accepted into an existing nest.

Because workers move around so readily and move the nest contents at the slightest disturbance (see the Student Page "That Ant is a Tramp" for more detail about this) there is no well-defined colony. It is often impossible to distinguish between nests. This is called a "unicolony." The population is essentially one large colony with high densities of ants. These high-density colonies often dominate their habitat and usurp other ground-dwelling arthropods.

This set of characteristics has two major impacts on a control program:

i) There is no way to control the Argentine ant population one nest at a time; and
ii) Argentine ants respond in large numbers to introduced baits. In areas of high ant



densities, researchers believe ants will quickly take most of the bait back to their nests, leaving little behind for whatever non-target species are left in the area. If that is true, the use of toxicants combined with bait is likely to have maximum impact on the Argentine ants and minimal impact on other species.

3) Seasonal Food Preferences

Argentine ants prefer different food types at different times of the year. During the summer, they are attracted to protein-based baits. During the winter, the same baits are much less effective. This characteristic is important for determining what time of year to treat using a particular bait. It is also a good reason to do a year-long bait preference test.

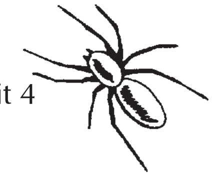
4) Trophallaxis

"Trophallaxis" is a process by which regurgitated food is passed among colony members. Food is exchanged in this way between workers, from workers to brood, and from workers to queens. The process of trophallaxis within ant colonies allows food to be passed quickly through the nest. This process is typical of most ant species.

In designing a control program aimed at eradicating ants, it is important that the workers pass on the toxicant to other ants, especially the queen, so the whole colony is poisoned and cannot repopulate itself. Since workers are the first to eat the food (then pass it on to others through trophallaxis) the toxicant needs to be slow acting, so workers have a chance to pass it on before they die. Combining a slow-acting toxicant with a highly attractive bait is a key to success.

In Contrast to the Argentine Ant…

- Many ant species have "monogyne" (single queen) colonies. Tramp species often have the polygyne colony type.
- Many ant species disperse by a process in which new queens go on a "nuptial flight" or mating flight along with winged males. In these species, the new nest can be kilometers away from the new queen's birth colony. The males die after mating, and the new queen has not been accompanied by any workers. She digs a hole in the ground and seals herself in. She raises the first brood of workers by herself and feeds them off her fat reserves. When these workers are born, they take over the work of the nest (gathering food, maintaining the nest, tending the brood, etc.) and the queen continues laying eggs.
- In species whose queens disperse by flight, new populations can be established far away from the original colony and are difficult to track.
- For many ant species, the nest and the colony are the same. The colony is distinct from other colonies.
- Colony workers in many ant species are territorial. They defend the area from all other ants, including ants of the same species from other colonies.
- Most ant species are "multicolonial." A population of these ants is made up of many separate colonies. One common control method is to exterminate an individual colony, for example by dousing the nest with a liquid that kills ants on contact.



Argentine Ants Quiz

1) Explain Argentine ants' response to a disturbance in their environment, such as a vibration, change in weather, or a manipulation of their nest.

2) How could this type of response help Argentine ants "hitch a ride" with humans?

3) How many different populations of Argentine ants are known in Haleakalā National Park today?

4) Is the size of those populations getting bigger, getting smaller, or staying about the same?

5) Give two reasons why Argentine ants are considered a threat to native insects and plants in Haleakalā National Park.

   i)

   ii)

Activity #3

Controlling the Argentine Ant

● ● ● Class Period One *Argentine Ant Control Efforts*

Materials & Setup

- Argentine ant range acetates (master, pp. 48-59)
- Overhead projector and screen

For each student

- Student Page "Designing a Control Strategy That Works: Questions From the Discussion" (pp. 60-64)

Instructions

1) Ask students to review what they learned during the last activity about where and how quickly Argentine ant populations are spreading within Haleakalā National Park. Have students from the team that worked on that topic provide a quick synopsis.
2) Using Teacher Background "The Spread of Argentine Ants in Haleakalā National Park and Recent Efforts at Control" (pp. 40-43), lead a class discussion on recent efforts to control the spread of Argentine ants in Haleakalā National Park. Use the acetates to illustrate key points.
3) Assign the Student Page "Designing a Control Strategy that Works: Questions from the Discussion" as homework.

● ● ● Class Period Two *Effectiveness of Control Efforts*

Instructions

1) With the entire class, discuss students' determinations about the effectiveness of the ant control experiment. Review their calculations and talk about factors that might make the results questionable.
2) Ask students to discuss the idea that current control efforts may be simply buying time during which alternative methods of *eradication* may be developed and tested.
3) Review the entire unit, discussing student questions and ideas.

Journal Ideas

- What can you do to prevent the spread of Argentine ants within Haleakalā National Park?
- What kind of educational program would be effective at helping park visitors learn about Argentine ants and how to stop their spread?

Assessment Tools

- Student Page "Designing a Control Strategy that Works: Questions from the Discussion" (teacher version, pp. 44-47)
- Participation in class discussion
- Journal entries

Teacher Background

Designing and Implementing an Argentine Ant Control Program

Because there are native ants in most natural areas around the world, few attempts have been made to control ants for conservation purposes. Researchers and resource managers in Haleakalā National Park face quite a challenge designing a control program for the Argentine ant. There is, however, a huge industry built around the control of ants in urban and agricultural situations and ongoing research about the effectiveness of various pesticides. Still, the number of ant control products is limited because the U.S. Environmental Protection Agency (EPA) has a strict registration process for pesticides. The EPA must separately register each product (which is a combination of an attractive bait and the toxicant or poison that actually kills the ants).

Recently, a toxicant called hydramethylnon has gained EPA approval for a variety of uses and has been found to be relatively effective against ants and much safer than many of its predecessors. Hydramethylnon was used in the late 1980s to eradicate the little fire ant (*Wasmannia auropunctata)* from Santa Fe Island in the Galapagos. So researchers began looking at options for using this pesticide against Argentine ants in the park. Here is how the control program evolved:

Step #1: Conduct a Bait Preference Test

Because the park's infested area is large and most of it is inaccessible by foot, spreading the bait by helicopter is the most feasible approach to broad-scale treatment. This dispersal method requires using a solid, pelletized bait. So researchers conducted a year-long test to determine which baits the ants preferred.

Step #2: Test the Combination of Bait and Toxicant on Small Plots

The most attractive bait was protein-based. So researchers did these tests during the summer when ant populations rise and bait retrieval is highest. During the summer, the ants' need for protein is the greatest.

Most ant-control strategies involve prolonged access to toxic bait. But the hydramethylnon formulated in the bait breaks down in the sunlight in only a few days. Researchers knew that spreading the toxic bait by helicopter over large areas would be an expensive proposition, unlikely to happen more than once a year. So they decided to test the effect of a single broadcast treatment of toxic bait, hoping for eradication, even though it seemed like a long shot.

This test application did not achieve eradication. But it did result in a 97 percent reduction in the numbers of foraging ants.

Step #3: Refine Approach to Focus on Control

Based on their test results, researchers decided that eradication would not be attainable but that controlling the spread of the populations would be possible. They hypothesized that applying the toxic bait along the borders of the ants' range would limit the population's expansion into new territory.

Step #4: Test the Control Hypothesis

In this study, planned for the summer of 1996, they would measure the effect of treating the population borders. They chose two study sites, one in each of the two ant populations.

[See Acetate Figure 5: 1996 Aerial Treatment Plots, p. 52. If you want to review the location of the ant populations and their direction of expansion, see Acetate Figures 1-4, pp. 48-52.]

The plot in the upper population was located at the "crater" floor along the border expanding into the summit basin (the "crater plot"). It was a large plot, covering over 20 hectares. The location and size of this plot were chosen because researchers and resource managers wanted to:

- Try to halt the rapid spread into the "crater" and keep the ants away from a campground located less than 500 meters (1640 feet) from the ant boundary,
- Determine whether a deeper plot is more effective than a narrower plot, and
- Test the future possibility of treating large areas.

Six monitoring sites plus a control site were used to track the reduction and recovery of ants in the "crater" plot. Monitoring sites along the border in both the treated and untreated areas were used to measure the rate of expansion. [See Acetate Figure 6: Upper Population Plot, p. 53.]

The lower population plot (the "frontcountry plot") was also located along an expanding border but was much smaller. It measured 260 meters (853 feet) long and only 120 meters (394 feet) deep. The design of this plot was chosen because:

- Researchers wanted to see if a narrow border treatment would be sufficient to stop movement, and
- It represents a small section of what would potentially be a 120-meter-wide swath encompassing all expanding ant boundaries.

Monitoring transects with bait stations every ten meters (33 feet) were established in the treated plot and in adjacent, untreated shrubland. These were used to measure rates of reinvasion in the treated plot, as well as rates of territory expansion. [See Acetate Figure 7: Lower Population Plot, p. 54.]

In August 1996, the toxic bait was dispersed in these two plots by a helicopter and a bait hopper. The bait hopper was designed and built especially for this purpose.

[See Acetate Figure 8: Post-Treatment Results for the Lower Population Plot and Upper Population Plot, p. 55.]

Study Results

- Ant numbers in both plots dropped off soon after treatment.

- By November, the numbers in the upper plot had jumped back up to 50 percent of their pretreatment levels. As the winter months set in, population levels dropped off (as they do naturally—see the control figures in Figure 8 for comparison). In the upper plot, population levels began recovering from this seasonal trend in June and July of 1997.

- In the lower plot, there was very little recovery by November, and by July (10 1/2 months after treatment), the ant numbers had recovered to only 21 percent of their pretreatment levels.

The Conclusions?

- The smaller, narrower frontcountry plot was more effective in suppressing recovery than the large "crater" plot. Researchers believe this is primarily due to the fact that it is easier for the helicopter pilot to cover narrower areas more thoroughly with the toxic bait.

- There was no expansion of the ants' territory after treatment in either of the plots, while the borders in the untreated control areas expanded significantly.

Stop Right Here!

Students will analyze what happened as a result of this treatment as part of their homework assignment. Use the remainder of the information on this sheet as background for the Class Period Two class discussion.

Step #5: Treat All Expanding Borders

Based on these results, researchers decided to treat all expanding borders of both populations in a 120-meter-wide (394-foot-wide) swath to determine if this control strategy would work on a larger scale. In August of 1997, they treated the entire upper population border and the southwest edge of the lower population border.

[See Acetate Figure 9: Population Border Areas Treated During 1997, p. 56.]

They monitored expansion of the ant population at 84 stations along the treated borders. [See Acetate Figure 10: Lower Population Monitoring Sites, p. 57, and Figure 11: Upper Population Monitoring Sites, p. 58.]

Treatment Results

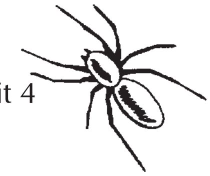
- The mean rate of expansion at these stations one year after treatment was considerably lower than mean rates of expansion calculated from distribution data for previous years. [Acetate Table 1: Comparison of Pre- and Post-Treatment Boundary Expansion, p. 59, shows the difference. Students will have calculated some of these figures in their homework assignment.]
- The lower population expanded, on average, only one meter (three feet) beyond its pre-treatment range. This expansion is only about 3.5 percent of the mean expansion rate for previous years.
- Expansion on the western portion of the upper population was similar and was only about 4.5 percent that of previous years.

Different Kinds of Research

Here is a little twist that you may want to go into with students. It helps illustrate the difference between experimental and applied research.

During quarterly monitoring of the 84 stations after the aerial treatment, researchers were able to identify areas where the treatment was not working (perhaps due to pilot error or unknown ecological factors). In those small trouble spots, researchers applied the toxic bait again by hand. So, in reality, the method that worked to slow the spread of the ants was aerial treatment of a 120-meter-wide border coupled with periodic hand treatment of small areas.

If this were a purely experimental study, researchers would not have changed the parameters of the study by reapplying toxic bait by hand. However, since the ultimate goal is to achieve a resource management objective (controlling the spread of Argentine ants), the researchers could make adjustments as they went along.



- Expansion on the eastern portion of the upper population was greatest but still only about 25 percent of the 81 meters/year (266 feet/year) calculated for the 1993-1997 time period.

Given these results, researchers and resource managers plan to use the border treatment strategy each year to slow the spread of ants in the park. Their ultimate goal is still to eradicate the Argentine ant in the park. Slowing their spread is a way to buy some time to investigate and develop different approaches to eradication.

Sources

Krushelnycky, P. D., et al, *A Thirty Year Record of Argentine Ant Range Expansion in Haleakala National Park, Maui, Hawaii*, U.S. Geological Survey, Biological Resources Division, Makawao, Hawai‘i, in preparation.

Loope, Lloyd L., Arthur C. Medeiros, and F. R. Cole, in *Proceedings of the Conference on Science in the National Parks, 1986, Volume 5: Management of Exotic Species in Natural Communities*, L. K. Thomas, Jr., (ed.), The U.S. National Park Service and The George Wright Society, 1988.

VanGelder, Ellen, Personal communication, February and March 2000.

Teacher Version

Designing a Control Strategy That Works: Questions From the Discussion

Based on the class discussion and the information provided below, answer the following questions:

1) Discuss the importance of each of the following characteristics of the Argentine ant to the design of a strategy to control or eradicate the ant:

   a) Argentine ant queens are unable to fly. They mate in the nest where they were born, and if they are leaving to establish a new nest of their own, they walk a short distance away. So Argentine ant populations expand slowly outward. Most other ant species have winged queens that may fly a long distances away from their birth nests to establish a new nest of their own.

   With Argentine ants, it is possible to treat the boundaries of the population to keep it from spreading further. This is because of the "budding" process through which the population expands slowly outward. A new, noncontiguous population will only be established if people transport the ants to a new place.

   b) Like most other ant species, the Argentine ant shares food through "trophallaxis." In this process, worker ants pass regurgitated food to other workers, the brood (larvae and pupae), and the queens. Highly attractive food gets passed quickly throughout the nest.

   In designing a control program aimed at eradicating ants, it is important that the workers pass on the toxicant to other ants, especially the queen, so the whole colony is poisoned and cannot repopulate itself. Since workers are the first to eat the food (then pass it on to others through trophallaxis) the toxicant needs to be slow acting so workers have a chance to pass it on before they die. Combining a slow-acting toxicant with a highly attractive bait is a key to success.

c) The Argentine ant forms large "unicolonies" in which it is difficult to distinguish among nests. In the park, each of the two ant populations is essentially one big colony. The Argentine ants from one nest do not defend their territory against Argentine ants from another nest. In fact, worker ants move readily from nest to nest, helping out wherever they are needed.

There is no way to control the Argentine ant population one nest at a time.

2) In the summer of 1996, researchers conducted a study in which they measured the effect of treating segments of the ant population borders with toxic bait. One of the two study areas they chose was located on the "crater" floor, on the rapidly expanding eastern edge of the ant population. One reason the researchers cited for choosing this site was that they wanted to keep the ants away from the Hōlua campground and cabin, less than 500 meters (1640 feet) away from the boundary of the ant population.

Drawing on what you have learned about the characteristics of Argentine ants, explain why researchers would be concerned about keeping the ants away from the campground and cabin area.

The main point here is that Argentine ants disperse over long distances only through human contact. If the ants spread to the campground and cabin area, which are both heavily used by people, there is a much greater likelihood that ants will be transported to uninfested areas within or outside of the "crater."

3) In August 1997, a helicopter was used to apply toxic bait to the expanding border areas of both Argentine ant populations. The entire upper population border was treated, as well as the southwest edge of the lower population border. Researchers monitored the expansion of the ant population at 84 stations along these borders.

They divided the upper study area and monitoring stations into two portions because they have different historic rates of expansion:

- The "frontcountry" or western part, where the historic rate of expansion is slower.
- The "crater" or eastern part, where the population has historically spread more rapidly.

One year after the treatment, researchers gathered the data contained in Table #1: August 1998 Ant Border Monitoring Results, August 1997-August 1998 (Student Page 5, p. 64). Use the data provided to answer the following questions, writing the formulas and each step of your calculations in the spaces below the questions. Round to the nearest one-tenth:

Mean boundary expansion = Total expansion (T)/Number of stations recording data (n)

a) What is the mean boundary expansion for the lower population?

MBE = T/n
MBE = 38/37
MBE = 1.0 m/yr

b) What is the mean boundary expansion for the frontcountry segment of the upper population?

MBE = T/n
MBE = 23/21
MBE = 1.1 m/yr

c) What is the mean boundary expansion for the "crater" segment of the upper population?

MBE = T/n
MBE = 482/23 (although there are 26 stations, 3 had no data)
MBE = 21.0 m/yr

d) What is the mean boundary expansion for the entire upper population?

MBE = T/n
MBE = 505/44
MBE = 11.5 m/yr

4) Fill in the table below, using the results of your calculations. Then answer the question that follows.

	Mean boundary expansion one year after treatment (m/yr)		Mean boundary expansion in previous years (m/yr)*
Lower population	__1.0___	(n = __37__)	29 (1982-97 data)
Upper population	__11.5__	(n = __44__)	
Frontcountry segment	__1.1___	(n = __21__)	24 (1993-97 data)
"Crater" segment	__21.0__	(n = __23__)	81 (1993-97 data)

Question

Based on the data in the table above, would you say that the effort to control the spread of the Argentine ant is working or not working? Explain your reasoning.

Park researchers and resource managers believe the answer is yes, the control effort is working. Students may support their answer in many ways; perhaps the most obvious is to compare the rates of spread pre- and post-treatment. Here are some points of comparison:

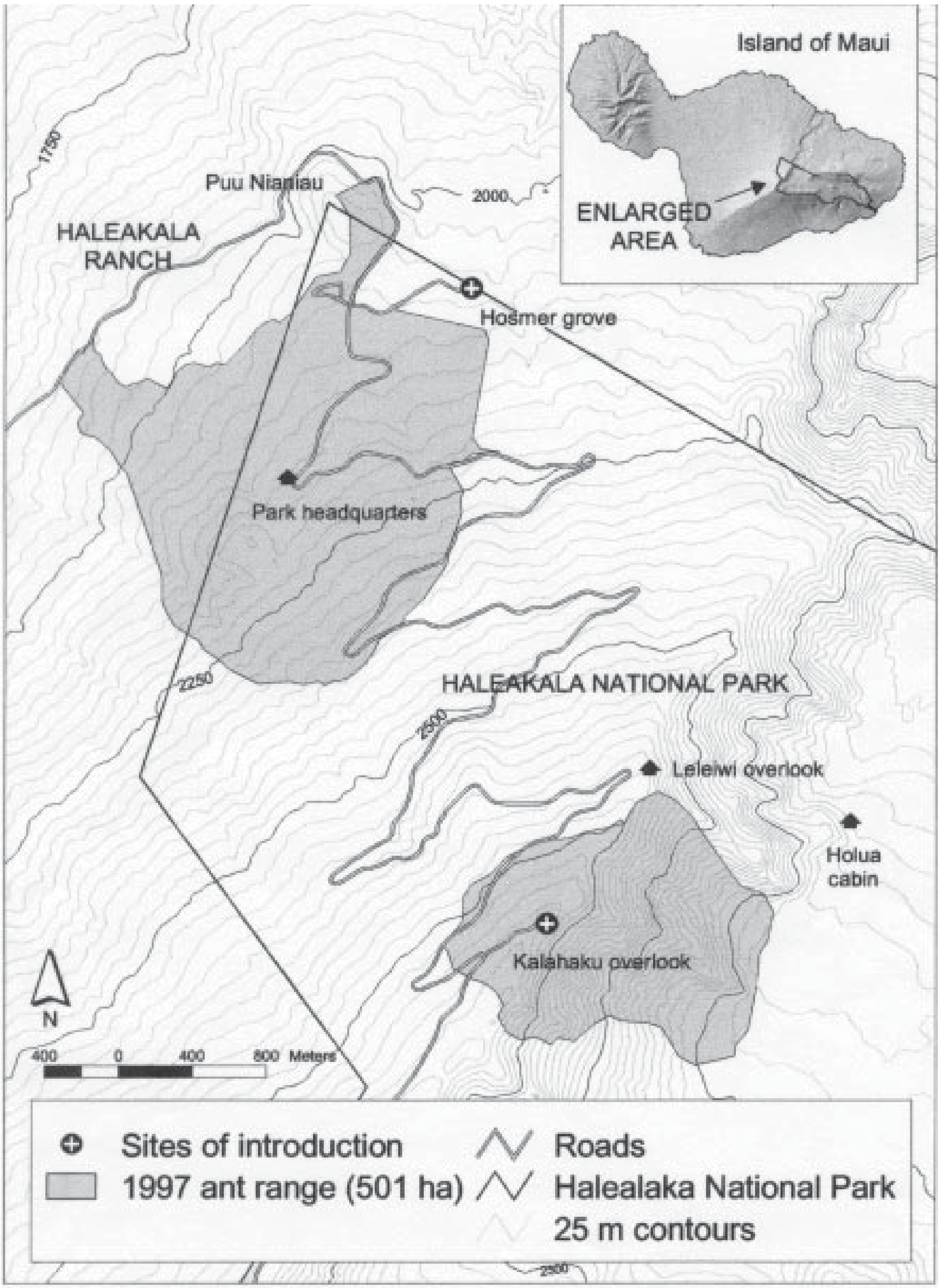
• The mean rate of expansion at these stations one year after treatment was considerably lower than mean rates of expansion calculated from distribution data for previous years. [Acetate Table 1: Comparison of Pre- and Post- Treatment Boundary Expansion shows the difference. Students will have calculated some of these figures in their homework assignment.]

• The lower population expanded, on average, only one meter beyond its pretreatment range. This expansion is only about 3.5 percent of the mean expansion rate for previous years.

• Expansion on the western portion of the upper population was similar, and was only about 4.5 percent that of previous years.

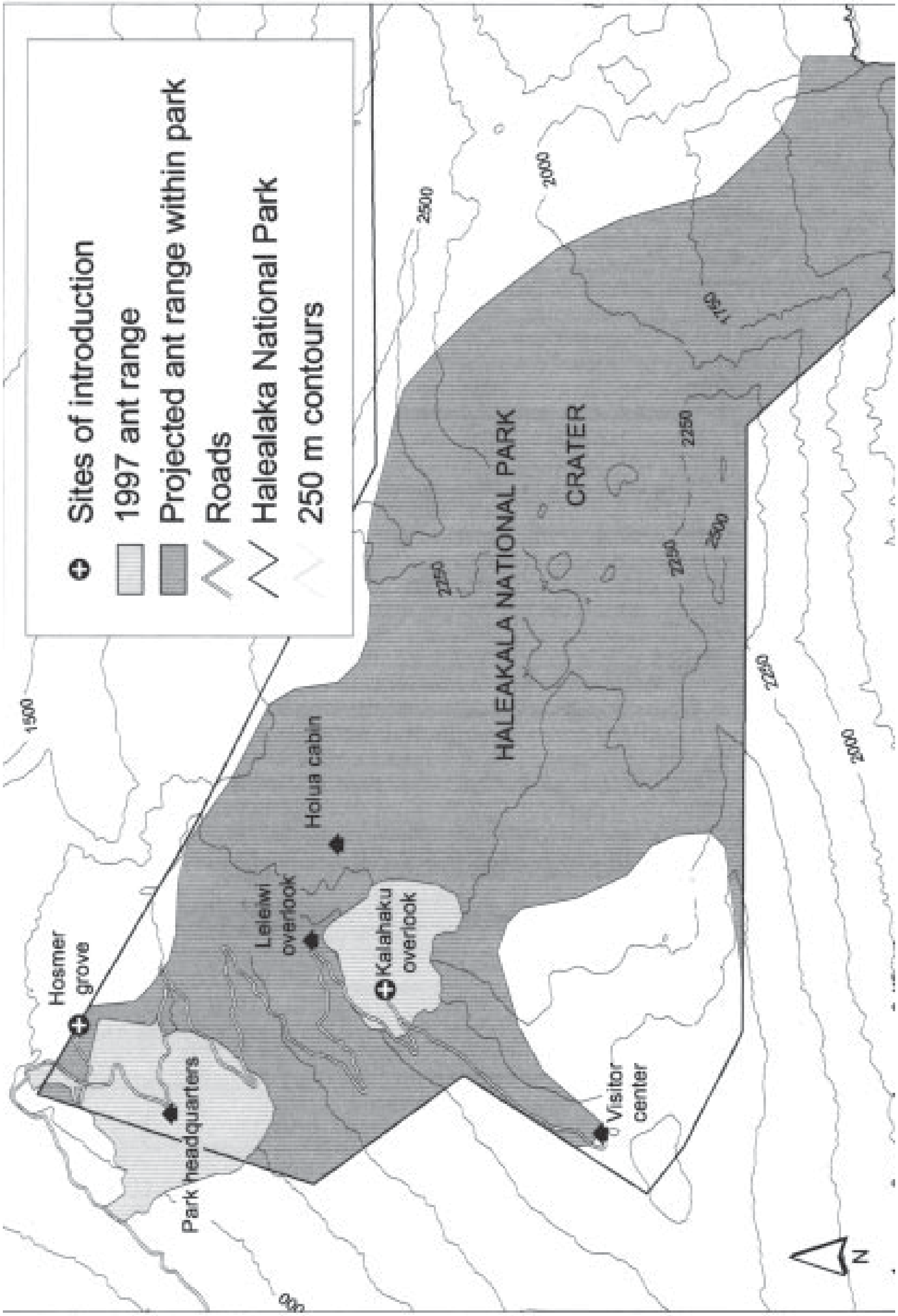
• Expansion on the eastern portion of the upper population was greatest, but still only about 25 percent of the 81 meters/year calculated for the 1993-1997 time period.

Figure 1: Argentine Ant Populations in Haleakalā National Park, 1997



Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 2: Potential Range of the Argentine Ant in Haleakalā National Park



Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

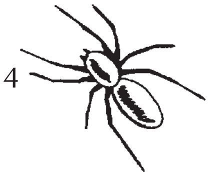
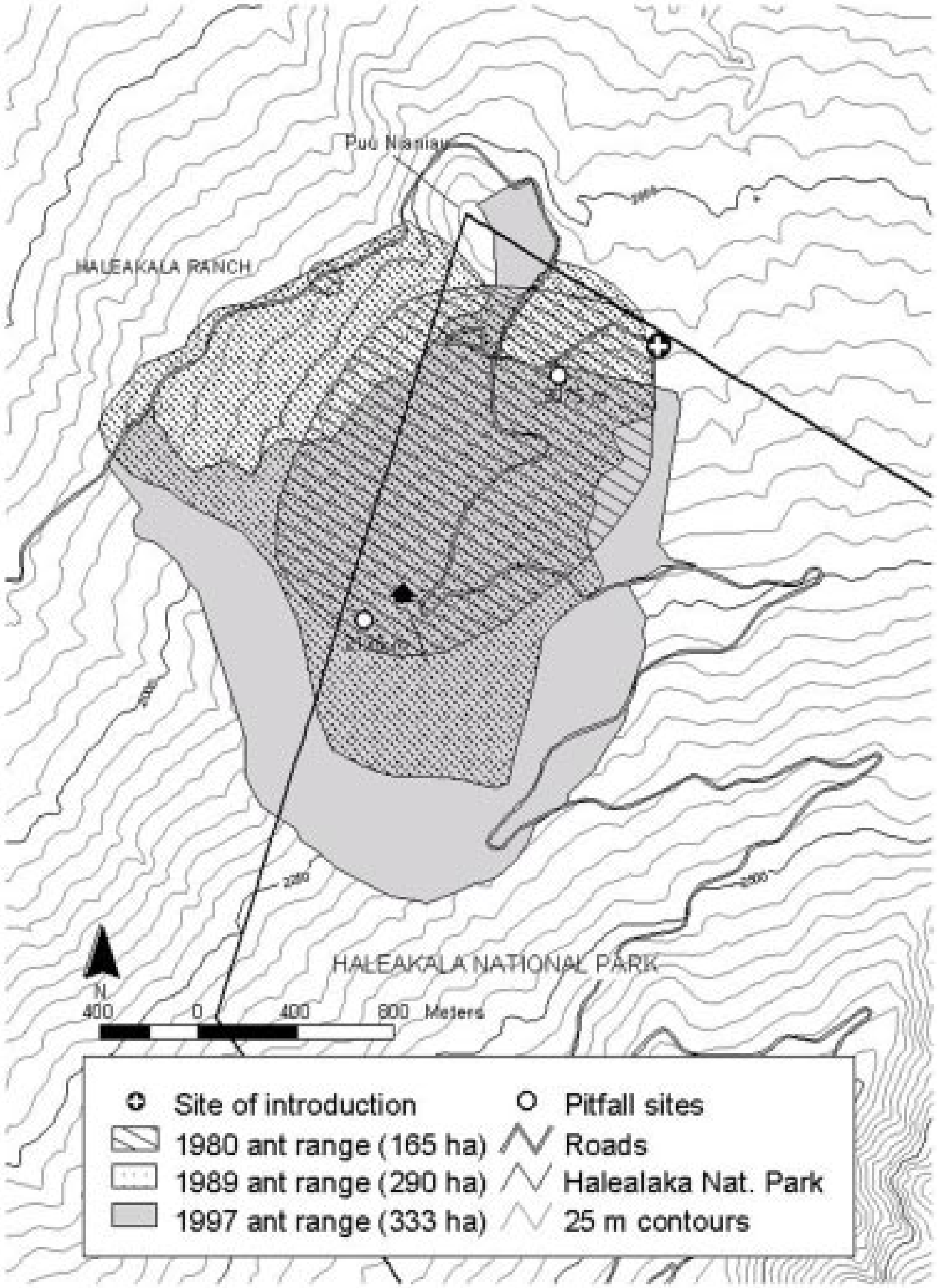
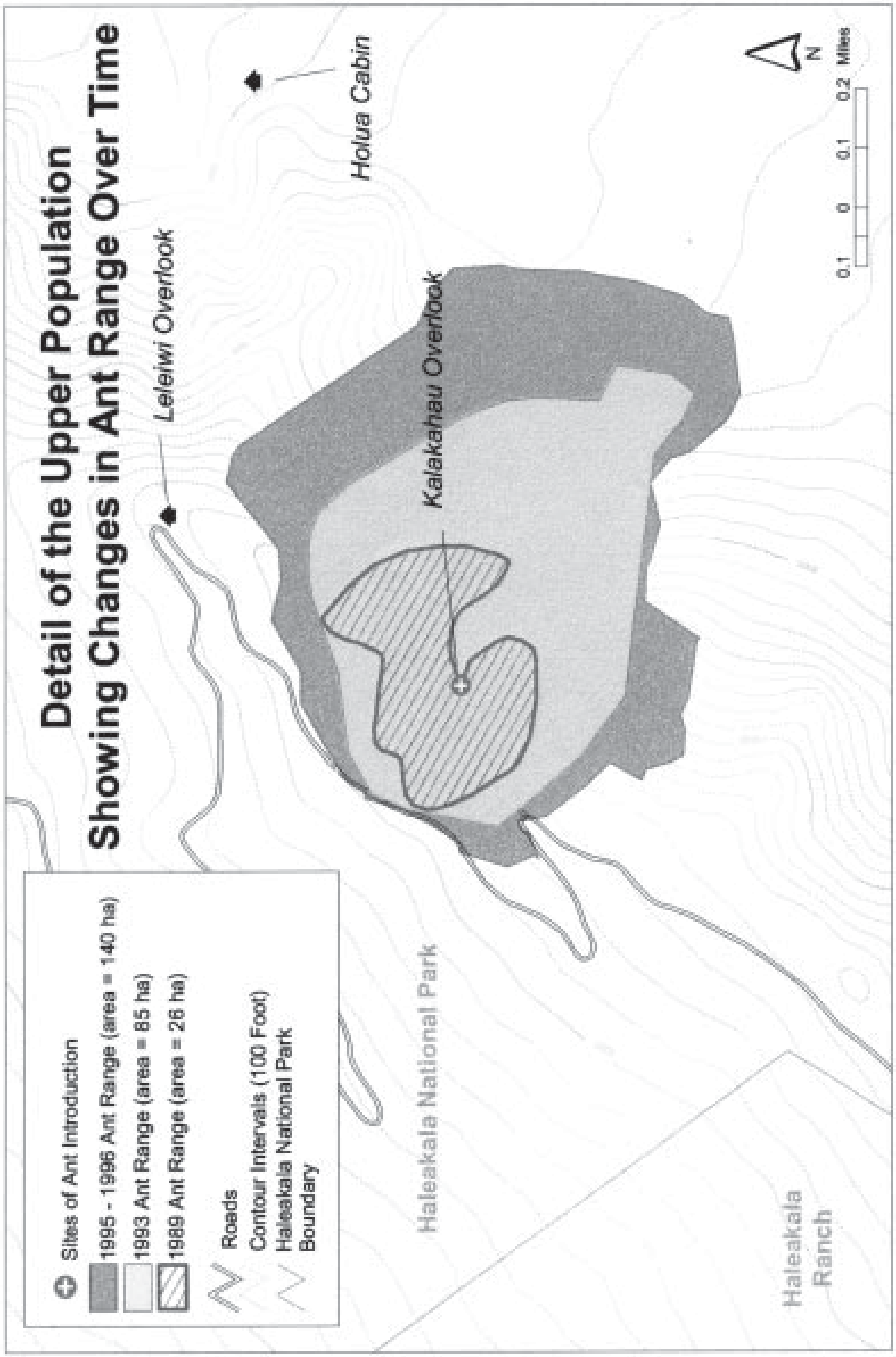


Figure 3: Spread of the Lower Population (1997 range projected)



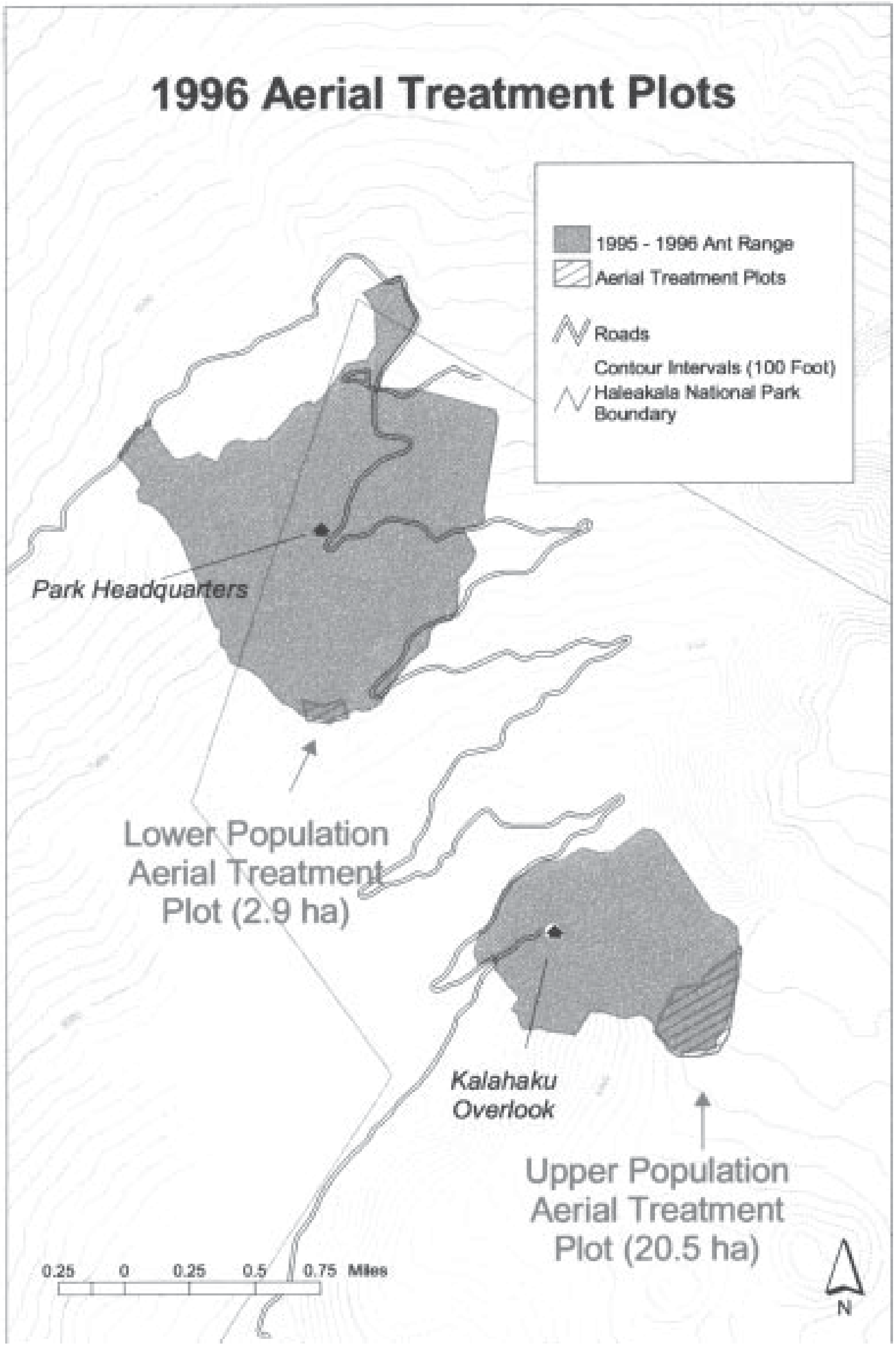
Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 4: Spread of the Upper Population



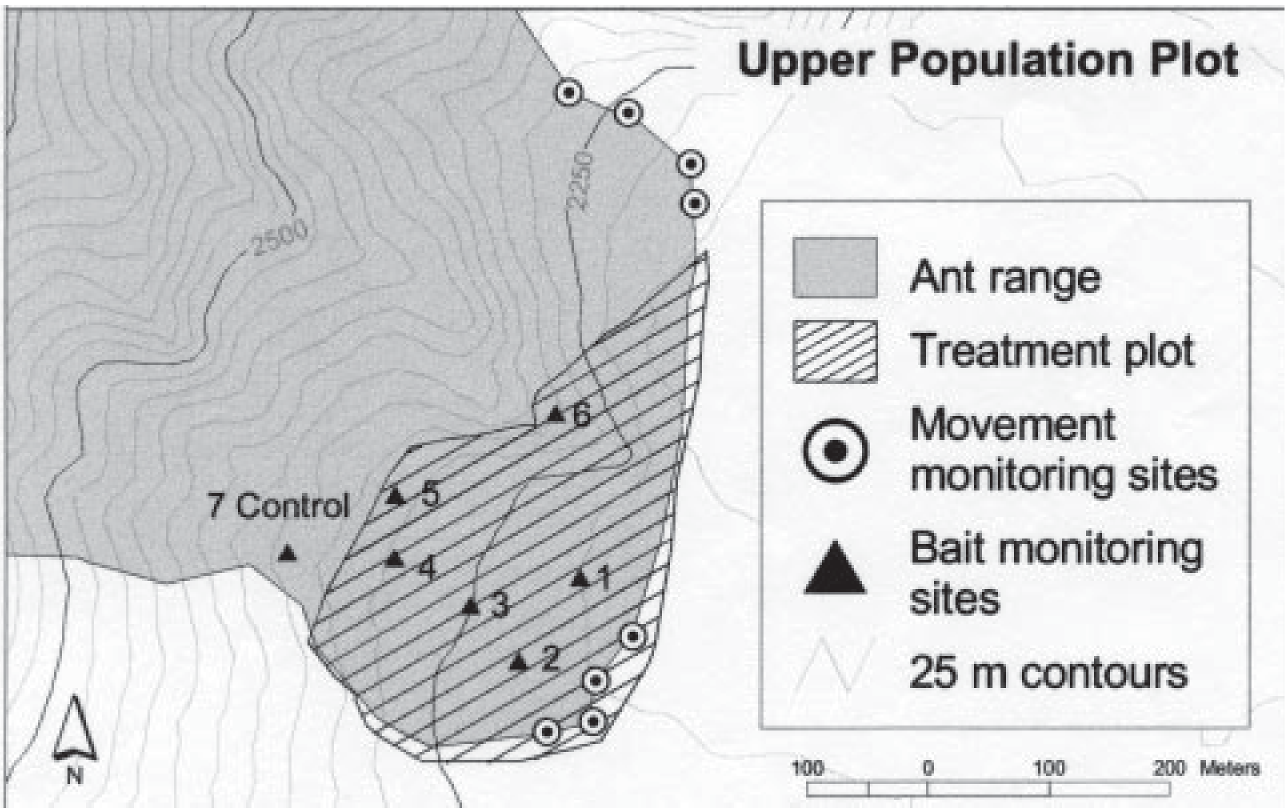
Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 5: 1996 Aerial Treatment Plots



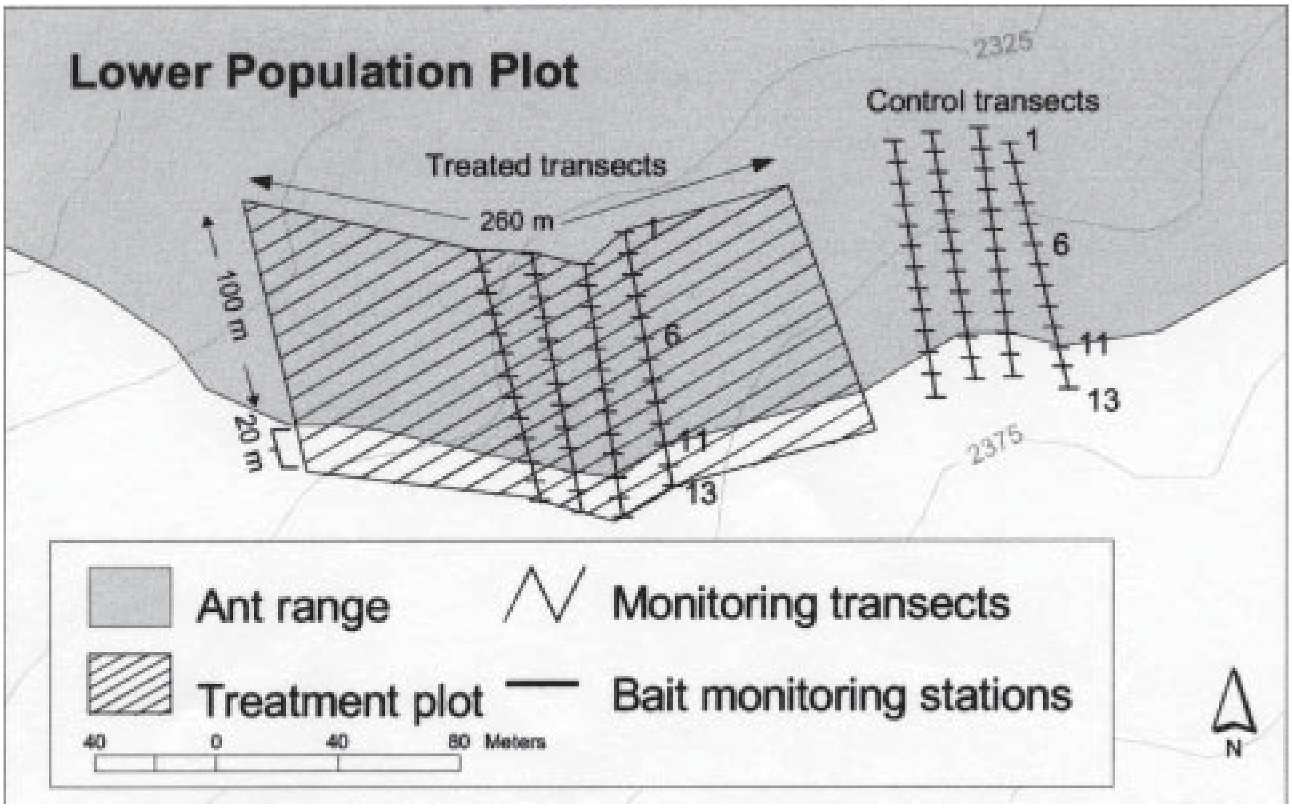
Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 6: Upper Population Plot



Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 7: Lower Population Plot



Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

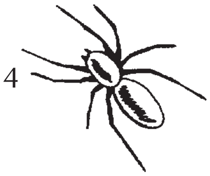
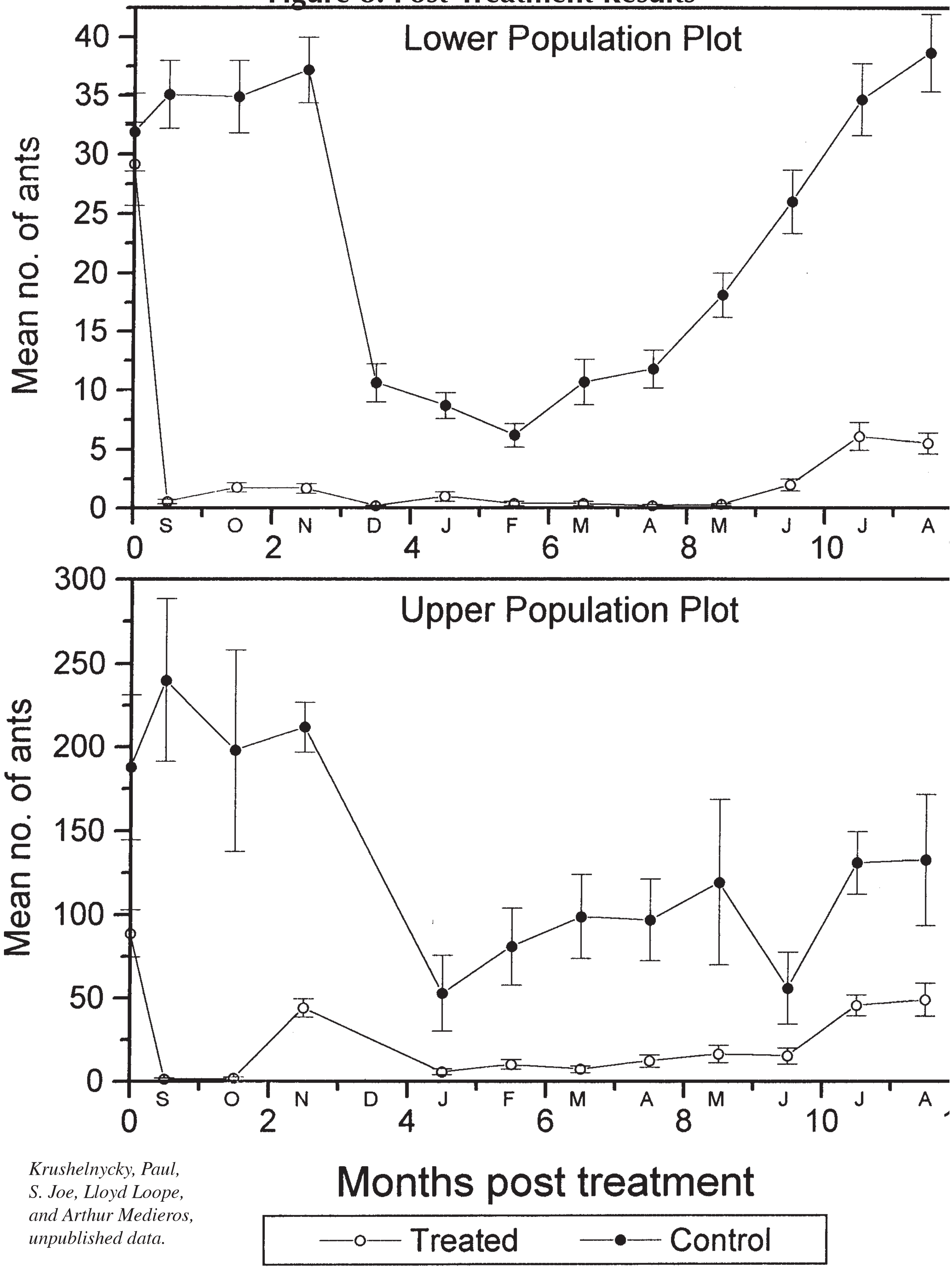
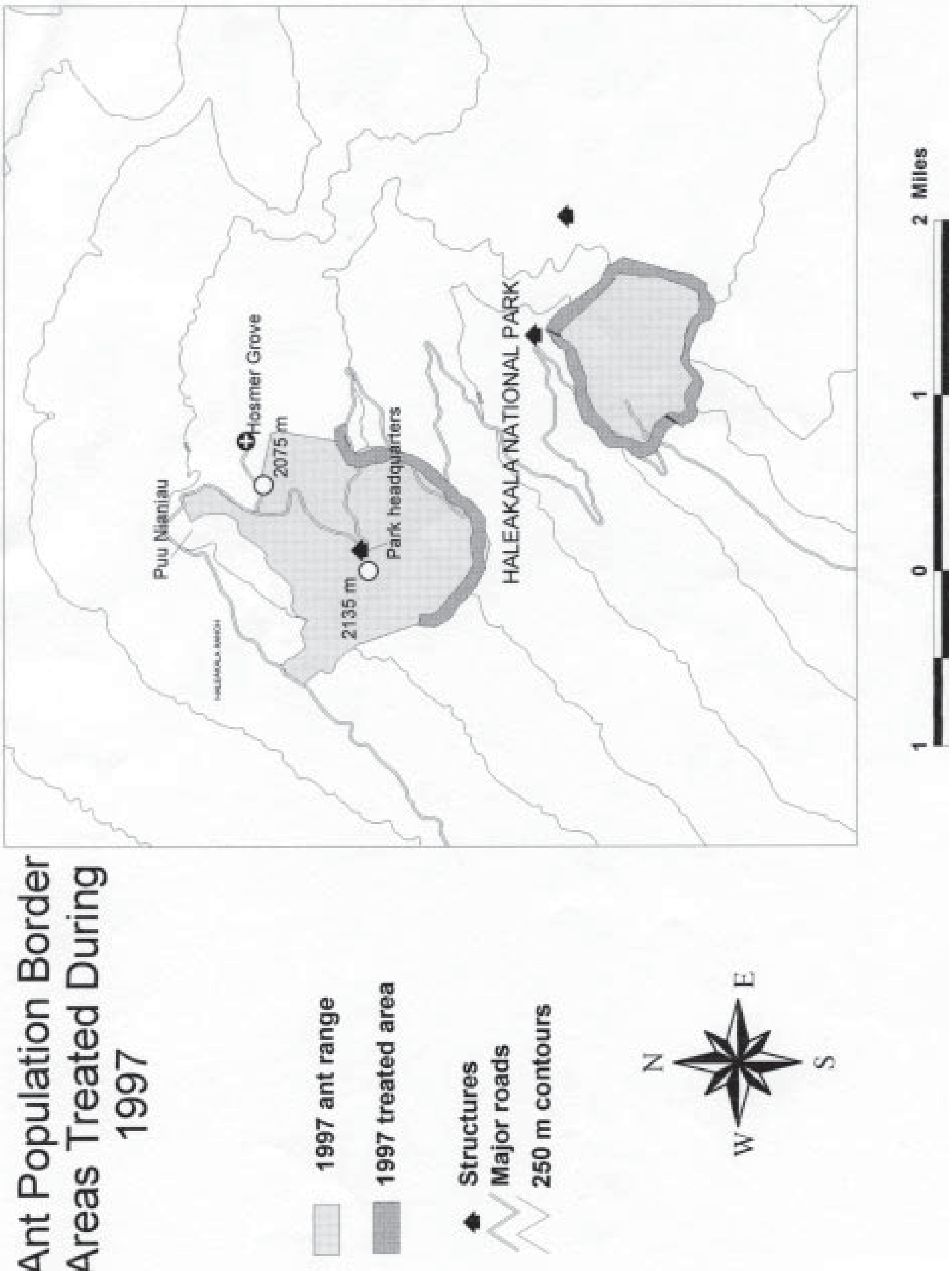


Figure 8: Post-Treatment Results



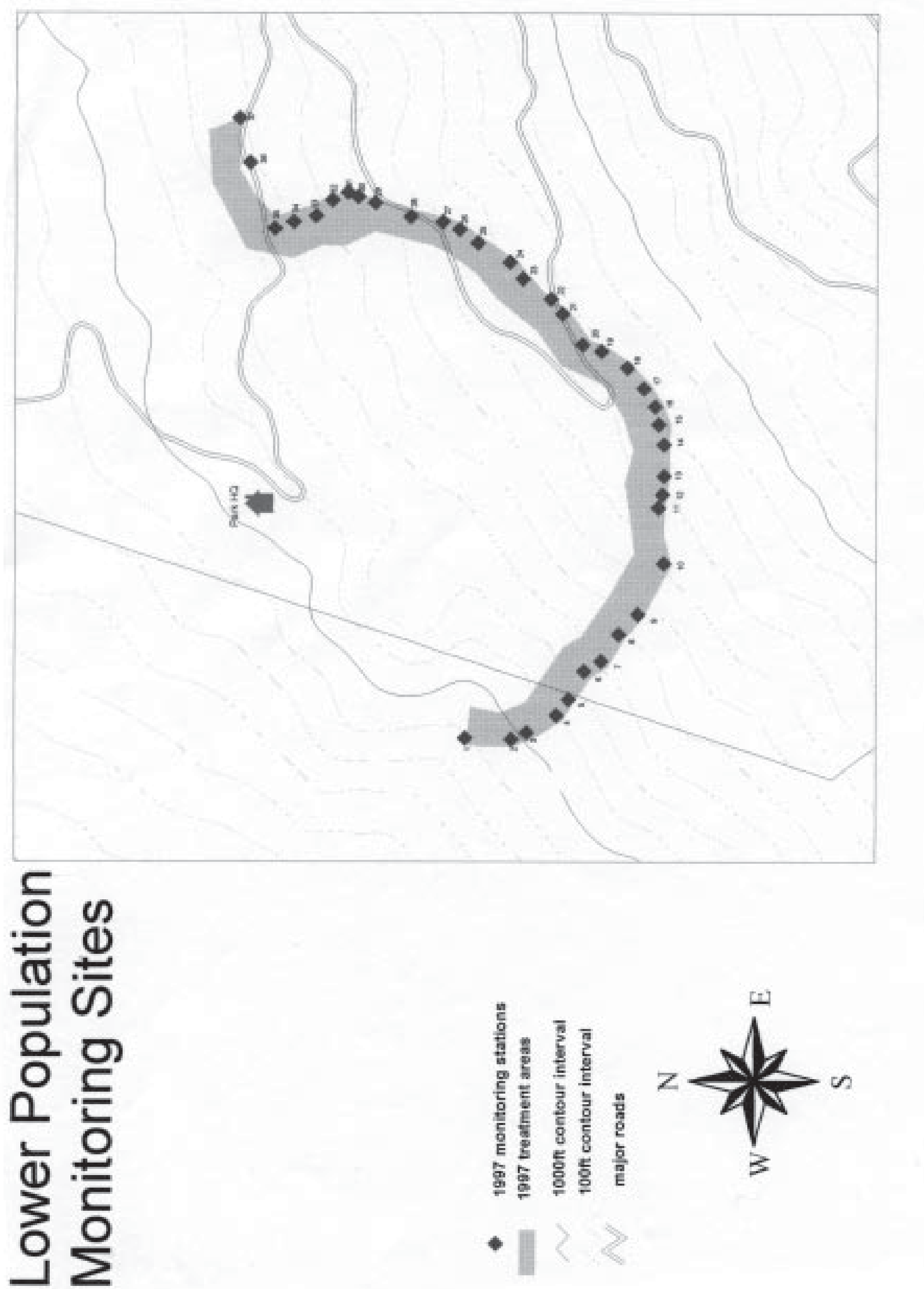
Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 9: Population Border Areas Treated During 1997



Map: Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.

Figure 10: Lower Population Monitoring Sites



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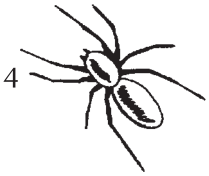
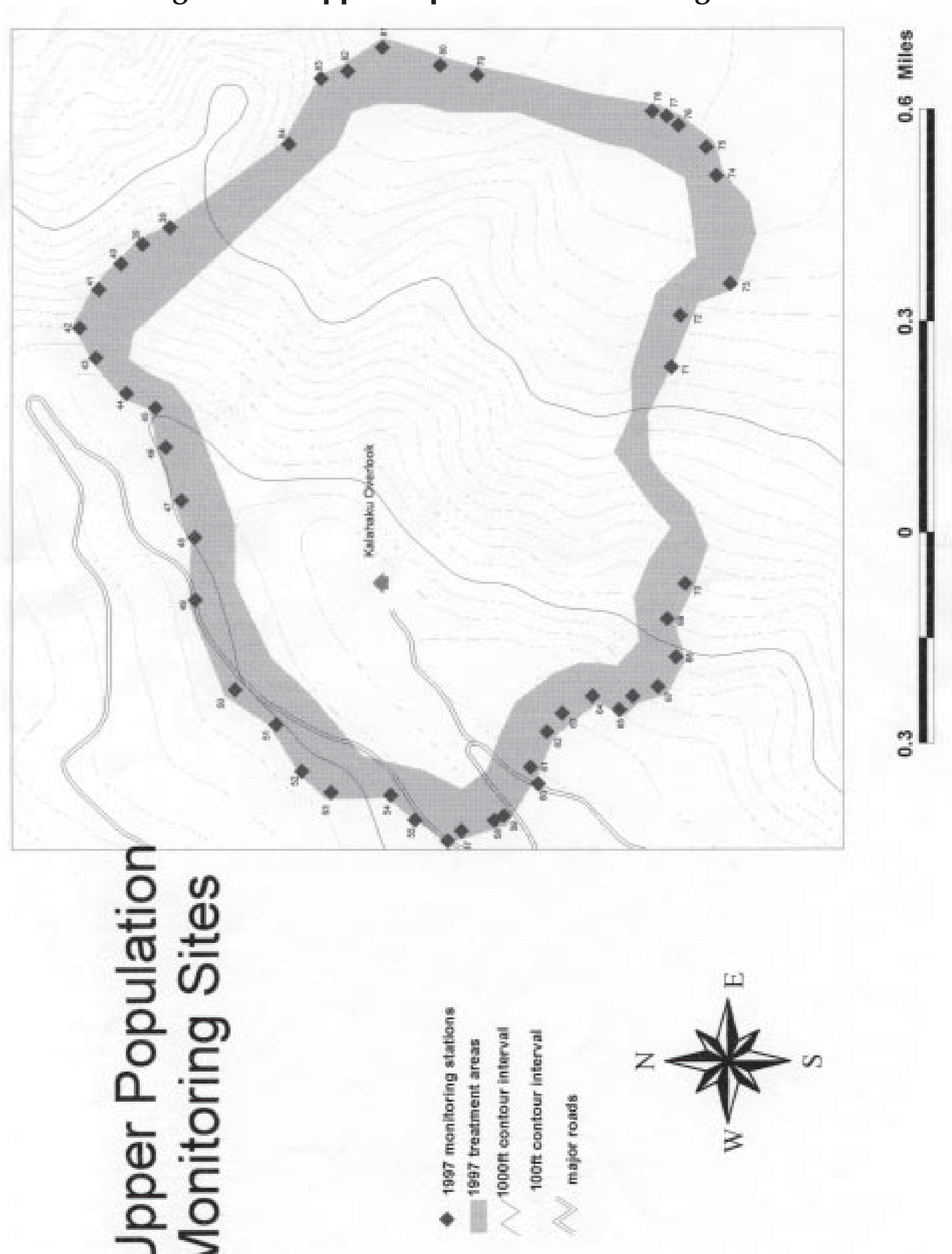


Figure 11: Upper Population Monitoring Sites



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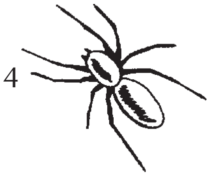

Table 1: Comparison of Pre- and Post-Treatment Boundary Expansion

	Mean boundary expansion one year after treatment (m/yr)		Mean boundary expansion in previous years (m/yr)
Lower population	__1.0___	(n = __37__)	29 (1982-97 data)
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Frontcountry segment	__1.1___	(n = __21__)	24 (1993-97 data)
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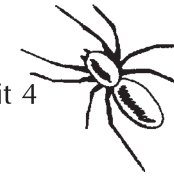
Krushelnycky, Paul, S. Joe, Lloyd Loope, and Arthur Medieros, unpublished data.



Designing a Control Strategy that Works: Questions from the Discussion

Based on the class discussion and the information provided below, answer the following questions:

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   b. Like most other ant species, the Argentine ant shares food through "trophallaxis." In this process, worker ants pass regurgitated food to other workers, the brood (larvae and pupae), and the queens. Highly attractive food gets passed quickly throughout the nest.

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   Drawing on what you have learned about the characteristics of Argentine ants, explain why researchers would be concerned about keeping the ants away from the campground and cabin area.

3) In August 1997, a helicopter was used to apply toxic bait to the expanding border areas of both Argentine ant populations. The entire upper population border was treated, as well as the southwest edge of the lower population border. Researchers monitored the expansion of the ant population at 84 stations along these borders.

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- The "front country" or western part, where the historic rate of expansion is slower.
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One year after the treatment, researchers gathered the data contained in Table #1: August 1998 Ant Border Monitoring Results, August 1997-August 1998 (page 5 of this handout). Use those data to answer the following questions, writing the formulas and each step of your calculations in the spaces below the questions. Round to the nearest one-tenth:

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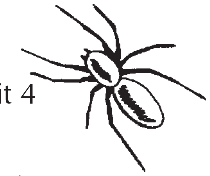
c. What is the mean boundary expansion for the "crater" segment of the upper population?

d. What is the mean boundary expansion for the entire upper population?



4) Fill in the table below, using the results of your calculations. Then answer the question that follows.

	Mean boundary expansion one year after treatment (m/yr)		Mean boundary expansion in previous years (m/yr)
Lower population	________	(n = _______)	29 (1982-97 data)
Upper population	________	(n = _______)	
Frontcountry segment	________	(n = _______)	24 (1993-97 data)
"Crater" segment	________	(n = _______)	81 (1993-97 data)

Question

Based on the data in the table above, would you say that the effort to control the spread of the Argentine ant is working or not working? Explain your reasoning.

Table #1: August 1998 Ant Border Monitoring Results August 1997-August 1998 (One Year)

Lower Population		Upper Population Frontcountry Segment		Upper Population "Crater" Segment	
Station #	**Expansion (m)**	**Station #**	**Expansion (m)**	**Station #**	**Expansion (m)**
1	0	44	0	38	12
2	0	45	0	39	0
3	10	46	0	40	10
4	0	47	0	41	35
5	0	48	0	42	21
6	0	49	5	43	2
7	0	50	0		
8	0	51	0	65	0
9	0	52	0	66	0
10	0	53	0	67	0
11	0	54	0	68	15
12	0	55	18	69	0
13	0	56	0	70	0
14	0	57	0	71	0
15	0	58	0	72	0
16	0	59	0	73	8
17	0	60	0	74	0
18	0	61	0	75	18
19	0	62	0	76	31
20	0	63	0	77	no data
21	0	64	0	78	0
22	0			79	no data
23	0			80	no data
24	0			81	156
25	0			82	74
26	0			83	49
27	0			84	51
28	0				
29	0				
30	0				
31	0				
32	0				
33	12				
34	16				
35	0				
36	0				
37	0				