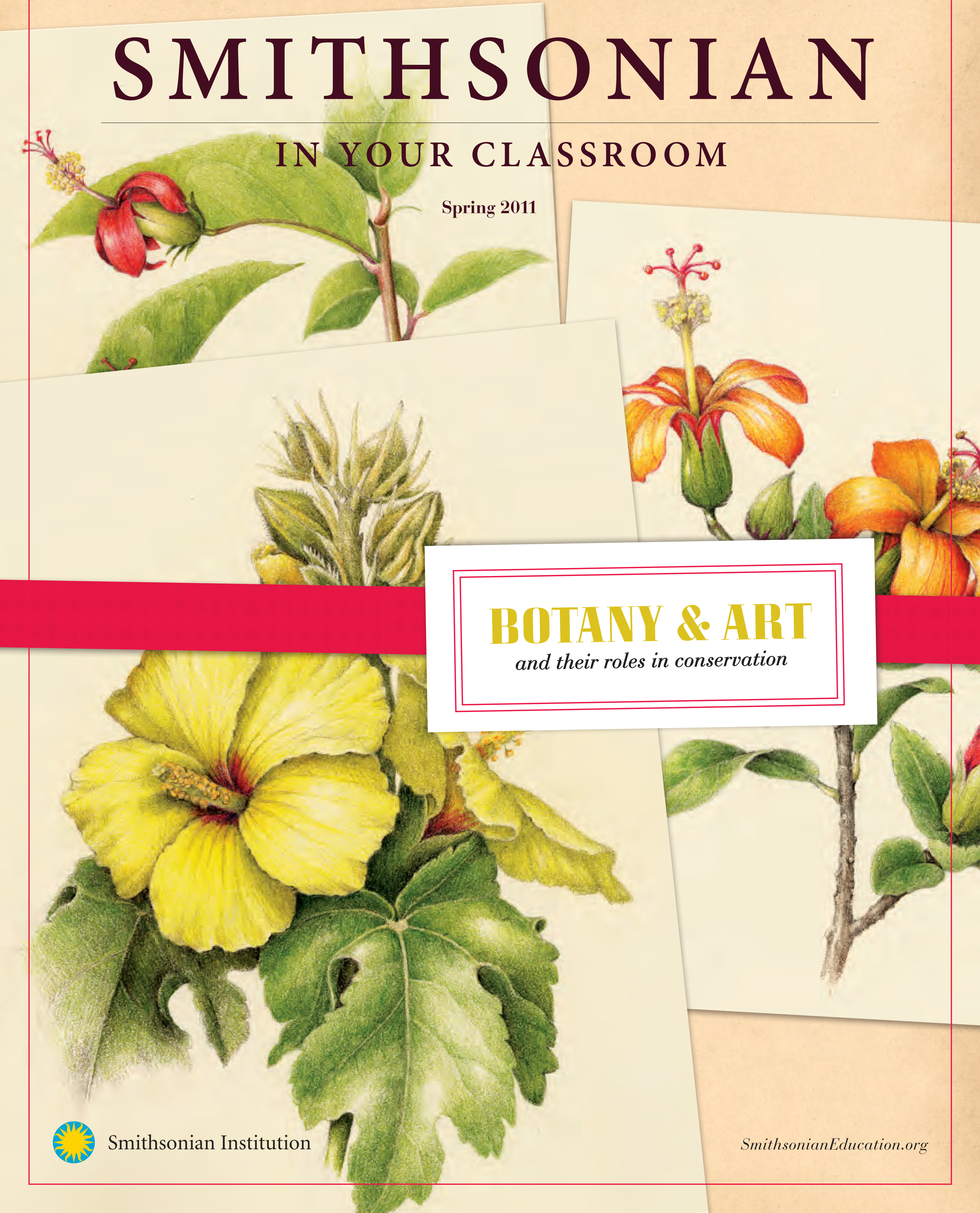
SMITHSONIAN

IN YOUR CLASSROOM

Spring 2011



BOTANY & ART

and their roles in conservation

Smithsonian Institution

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CONTENTS

Smithsonian in Your Classroom is produced by the Smithsonian Center for Education and Museum Studies. Teachers may duplicate the materials for educational purposes.

NATIONAL STANDARDS

The lessons in this issue address NAS National Science Content Standards for understanding characteristics of organisms and National Standards for Arts Education for recognizing characteristics of works in two or more art forms that share similar subject matter.

STATE STANDARDS

See how the lessons correlate to standards in your state by visiting smithsonianeducation.org/botany.

ILLUSTRATIONS

Cover: Details of colored-pencil drawings of Hawaiian hibiscus species © 2008 Wendy Hollender. **Inside cover:** Detail of watercolor of glade mallow *(Napaea dioica)* © 2008 George Olson. **Page 2:** Oil painting on paper of golden barrel cactus *(Echinocactus grusonii)* © 2008 Ingrid Finnan. **Page 3:** Chip Clark, National Museum of Natural History. **Page 5:** Illustration © Julie Martinez; photo by W. S. Justice, Smithsonian. **Page 6:** Illustration © 2008 Jee-Yeon Koo; photo © 2010 Yuichi Momma. **Page 7:** Illustration © 2008 Gillian Harris; photo by Guy L. Denny, Smithsonian. **Page 8:** Illustration © 2008 Wendy Hollender; photo by D. R. Herbst, Smithsonian. **Page 9:** Illustration © 2008 Gillian Barlow; photo, Richard A. Howard Image Collection, courtesy of Smithsonian. **Page 10:** Illustration © 2008 Kathleen Garness; photo by J. D. Ripley, Smithsonian. Dried specimens and all other photos, National Museum of Natural History.

CREDITS

Stephen Binns, writer; Michelle Knovic Smith, publications director; Darren Milligan, art director; Design Army, designer

Thanks to Gary Krupnick and Alice Tangerini of the National Museum of Natural History and Carol Woodin of the American Society of Botanical Artists.

BACKGROUND

FRAGILE BEAUTY

More than 20 percent of the world's 350,000 known plant species are in danger of extinction, according to the estimates of conservationists. Thousands of these plants have never been described by science. If any are lost, they will be lost even to human memory.

Botanists around the world are racing to make records of threatened species, the first step in any conservation effort. Working along with them are botanical artists, who provide "visual descriptions" of plants. Some of the artists use the latest illustration software. Others, like Alice Tangerini of the Smithsonian National Museum of Natural History, continue working with pen or brush.

But what can an illustration tell us that a written description cannot? And why draw or paint a specimen when you can just take a picture?

Students consider these questions in the first lesson of this issue. They compare representations of endangered plants in three forms: illustration, photograph, and dried specimen. In the second lesson, they try their own hands at botanical art, using some of Tangerini's methods.

Along the way, as they look closely at plants, they consider questions that conservationists themselves must ask. Are some plants more valuable than others? Is plant life as valuable as animal life? Are all species of life equally worth saving?

All of the illustrations in the issue appear in the traveling exhibition *Losing Paradise? Endangered Plants Here and Around the World*, organized by the American Society of Botanical Artists in collaboration with the Smithsonian. To see an online version of the exhibition, including video interviews with Smithsonian staff featured in the issue, visit **smithsonianeducation.org/botany**.

How a Plant Becomes Endangered

"All habitats on the Earth are constantly subjected to alteration and change," says Gary Krupnick, head of the Plant Conservation Unit at the Smithsonian's National Museum of Natural History. Habitat alteration leads to species extinction. "Severe alterations by human activities," as Krupnick puts it, have led to a rapid rise in the extinction rate—as much as a thousand times the natural rate.

Among those human activities, Krupnick lists forest clearing, agricultural expansion, suburban sprawl, dam construction, the introduction of invasive species, and, in the case of aquatic plants, commercial fishing. Along with these is the burning of fossil fuels and the overarching threats of climate change.

The details of habitat alteration and the endangerment of plants vary from habitat to habitat and from plant to plant. To take just two examples out of thousands:

Remya kauaiensis, a member of the aster family with no common name, is native only to steep cliffs on the Hawaiian island of Kauai. One of the main threats to its survival has been the degradation of the cliffs caused by feral goats and pigs, which were introduced to Hawaii in the nineteenth century. A more recent threat has been wildfires ignited by weapons practice at a nearby army base.

Another member of the aster family, Schweinitz's sunflower (*Helianthus schweinitzii*), is native only to the Piedmont region of North and South Carolina. As its name suggests, it requires full sunlight. As late as colonial times, its natural range in an otherwise wooded region was a miniature prairie, complete with bison. Prairie fires and the grazing of the bison provided necessary "disturbances" for its survival. Today, with its prairie gone, it thrives only where human activity has paradoxically provided similar disturbances—along the clear-cut paths of power lines or in the margins of roads.

So, in the case of one: goats and pigs and too much fire. In the case of the other: no bison and not enough fire.

This, however, is an oversimplification that leaves out many links in the chain reactions of species loss—the interconnectedness of death as well as life. In the case of the Hawaiian plant, for instance, the degradation of the cliffs has paved the way for invasive plant species, which bring new competition. One of these alien species, molasses grass, provides a fuel for the spread of wildfires.

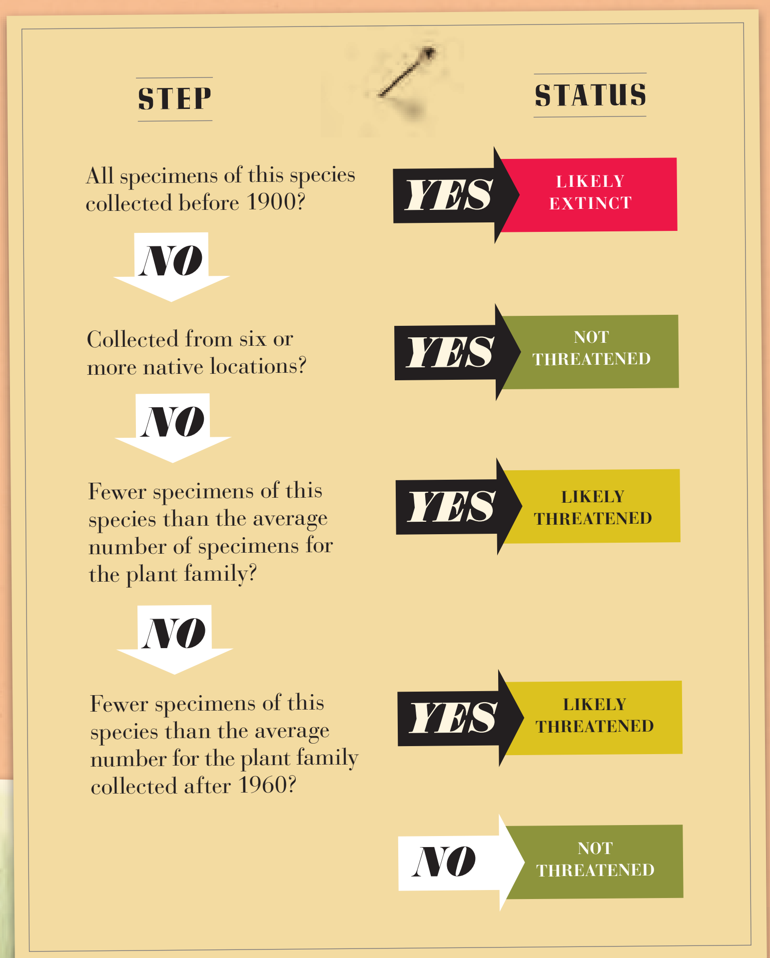
The golden barrel cactus (Echinocactus grusonii) *has a very small habitat in Mexico—about fifteen square miles—that was made even smaller by the construction of a dam in the 1990s. Smithsonian botanists used this and other rare species to test a method of prioritizing the study of plants—the flowchart seen on this page.*

Where Botany Comes In

"To save endangered species we must know about their basic biology," says Krupnick. "On a greater scale, to save biodiversity, we must first know what it is and where it lives. This task of discovering, identifying, and describing plants is the central work of botanists at museums and botanical gardens."

Krupnick and his colleagues use data from the Smithsonian's herbarium, a collection of nearly 5 million dried plant specimens, to determine which plant species may be endangered and to identify habitats of greatest biodiversity. It is all a matter of priorities: if a species or a habitat is about to disappear, it should get the most urgent attention.

As a means of prioritizing, the Smithsonian uses a flowchart that places a species into one of three categories—"likely extinct," "not threatened," or "likely threatened"—on the basis of answers to a series of questions. (See below.)



The Smithsonian's flowchart put the golden barrel cactus into the "likely threatened" category on the basis of two answers: there are only two specimens of the species in the herbarium—less than the average of five specimens for cactus species—and they were both collected at only one location. The "likely threatened" finding agreed with the IUCN's listing of the species as "critically endangered." It is estimated that only 250 golden barrels remain in the wild, a number smaller than the number of surviving California condors.

Scientific organizations around the world are similarly involved in determining the health of species, though each has its own method. The Smithsonian has tested its method by asking the questions about species already deemed endangered or extinct by the International Union for the Conservation of Nature (IUCN), the largest environmental network in the world.

The IUCN has no power to grant legal protected status to a threatened species. In the United States, this status is assigned at the federal level by the U.S. Fish and Wildlife Service, which administers the Endangered Species Act of 1973. Other countries grant protection under similar laws. But it is the work of scientists that gives a basis for all conservation action.

"Governments generate policies to save threatened and endangered species," says Krupnick. "Historically, plants have been ignored in favor of the 'charismatic megafauna,' such as pandas, bald eagles, or orangutans. When high school and college students are asked to name an endangered species, less than 5 percent will name a plant species. It is up to museums and botanical gardens to raise awareness and draw attention to endangered plants."

ABOVE: *"Very little of the world's flora has been fully studied, and time is running out," says botanist Gary Krupnick. He uses the example of the orchid family when discussing the size of the task ahead: "Worldwide there are more species of orchids than species of mammals and birds combined, and yet far fewer orchid specialists than mammalogists and ornithologists."*

RIGHT: *The Smithsonian's herbarium, one of the largest in the world, contains nearly 5 million dried plant specimens. The collection began with the acquisition of specimens collected in the around-the-world United States Exploring Expedition, 1838–42.*

Where Art Comes In

A good scientific record of a plant species requires pictures as well as written descriptions. That is where artists like Alice Tangerini come in. Tangerini is the staff botanical illustrator at the Smithsonian. Her task is to depict plants with more accuracy and detail than even the latest digital photography can offer.

"What a digital camera always produces is a digital image made of pixels," she says, referring to the smallest elements of an image. "The larger these images are projected, the more visible the pixels become. An illustrator viewing a subject through a microscope may keep enlarging the subject to see detail without the interference of pixelation."

An illustrator can also emphasize specific details—the details a scientist is studying—and eliminate the details that are irrelevant and perhaps distracting. And while a photograph of a plant shows one member of a species, with all of its individual traits, an illustration can better represent a *typical* member of a species.

While many scientific illustrators do all of their work on a computer, Tangerini continues to work with traditional tools. The drawing stylus of computer illustration is less sensitive to her touch than the fine pens and brushes she uses. Then, too, the software is less time-saving for her than it is for other kinds of illustrators. Someone using software to draw an insect, for example, can complete one side of the specimen's body and then copy and paste to fill in the other side. Insects have a bilateral, or two-sided, symmetry; plants do not. Drawing a plant this way, says Tangerini, "will introduce a false interpretation."

Bringing an artist's eye to science is one of the satisfactions of Tangerini's work. The flip side is that she can't help bringing a scientist's eye to art. In an art museum, she finds herself homing in on the depiction of plant life in paintings—a bit like a geologist seeing Leonardo's *Virgin of the Rocks* and going straight for the rocks. She can't help looking for simplifications and inaccuracies.

"I'm reminded of seeing the movie *The Last of the Mohicans* with botany friends," she says. "Although the setting was supposed to be upstate New York, all of us noticed the presence of magnolia trees, which do not occur naturally north of Virginia. The movie then became only interesting for its botanical errors!"

LESSON ONE

A LOOK AT DISAPPEARING PLANTS

This lesson introduces the subject of plant conservation with a look at six endangered species. It begins with a simple identification game and ends with students making the kind of big decision that conservationists must make: *Which of these species would we try to save first?*

STEP 1

On each of the following six pages is an illustration, a photo, and a dried specimen of an endangered species. Go to **smithsonianeducation.org/botany** to print specially formatted PDF versions of those images. Cut out the images and arrange them into three sets: illustrations, photos, and dried specimens.

STEP 2

Ask students to match the images of the six species. With young students, focus attention on the plants' most salient features—the leaves. When the matching is complete, begin a discussion of the students' reasons for their choices. To equip them with some vocabulary for the discussion, display the leaf chart on page 11.

STEP 3

Hand out copies of the six pages so that students can better compare the illustration, photo, and dried specimen of each species. As a class, consider: *If a scientist can take a picture of a plant, are there any advantages in having an illustration?*

One of the major advantages is the depiction of details seen only through a microscope, such as the seeds of the Atamasco lily. The illustrator can also emphasize specific details (such as the roots of the goldenseal), eliminate distracting details (such as the other species seen with the lady's slipper), and show many of the parts of a plant at once (as in the hau kuahiwi illustration).

STEP 4

Let students know that plant conservationists must often prioritize their attempts to save endangered species. Ask them to imagine that they are conservationists. As a class, use the information on the six pages to decide: *Which of these species are most in need of attention? Do any seem more worth saving than others?*

The students' considerations might include the number of surviving specimens, the size and vulnerability of the natural range, and even the plant's value, or potential value, to people.

Follow-up Discussion:

As a class, consider: *If an endangered animal like a panda goes extinct, is it a greater loss than if a plant goes extinct?*

If students answer yes for emotional reasons, let them know that scientists often respond in the same way. As British naturalist Colin Tudge writes: "the big, showy animals [are] the most intelligent, and intelligence is a rare biological quality that we surely ought to respect."

Also consider: *Is animal life dependent on plant diversity?*

In the view of Smithsonian botanist Gary Krupnick: "Each species has a place in the world for a reason. It's food for an animal. It's a host to a fungus. It's a cog in a wheel, and when you take out one little piece the whole thing falls apart. Alternatively, each species might also be useful for humans."

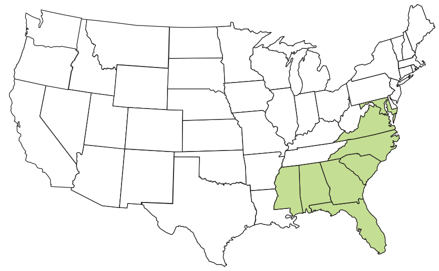
As an example of usefulness, he cites the case of the rosy periwinkle. Medicinal properties of this plant helped to increase the survival rate of childhood leukemia from 10 percent in 1960 to the current 90 percent. Today, the plant's native habitat in Madagascar is almost completely gone.

"There might be the cure for AIDS or cancer in any species," says Krupnick. "Before that species goes extinct, we should do everything we can to understand it."

ATAMASCO LILY

(Zephyranthes atamasca)

Also called "rain lily," this fragrant (and poisonous) flower was described by colonists at Jamestown. Scientists are now finding promise of anti-cancer properties in its bulb. While flourishing in several states, it is threatened at the edges of its range: in Maryland, where it has been found in only one site, and in south Florida, where it shares a diminished habitat with the Florida panther.



ARTIST: *Julie Martinez* | MEDIUM: *Gouache, colored pencil*

BOWL FLOWER

(Cypripedium japonicum)

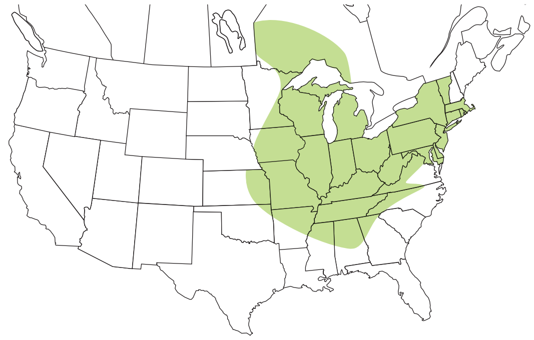
Only 200 individual specimens of this orchid remain in the wild in South Korea, where it is a protected species. Numbers are higher in China and Japan, but recent genetic studies indicate that it is a naturally rare plant. In China, it shares bamboo-grove habitats with the giant panda.

ARTIST: *Jee-Yeon Koo* | MEDIUM: *Watercolor*

GOLDENSEAL

(Hydrastis canadensis)

The root of the goldenseal is used as an herbal remedy—it contains antibiotic and anti-inflammatory alkaloids. Thriving in the shade of the eastern forests, it was threatened first by loss of forestland and then by global demand for its root. State governments began listing it as endangered in the 1990s. The roots of cultivated plants are sold legally, but tend to be expensive. The collection of wild plants, therefore, continues.

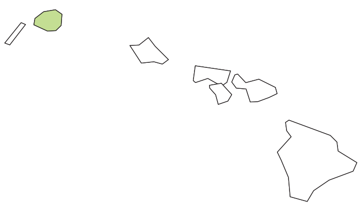


ARTIST: *Gillian Harris* | MEDIUM: *Watercolor*

HAU KUAHIWI

(Hibiscadelphus distans)

This is one of the world's rarest trees. Only 20 specimens are known to exist in their native habitat of Kauai, Hawaii. The genus name, *Hibiscadelphus*, means "brother of hibiscus." Of the seven species of the genus, three are extinct. Threats to the survivors include tree-climbing, seed-eating rats, introduced to Hawaii by the original Polynesian settlers, and cliff-climbing goats, introduced by Europeans.



ARTIST: *Wendy Hollender* | MEDIUM: *Colored pencil*

MARSH GENTIAN

(Gentiana pneumonanthe)

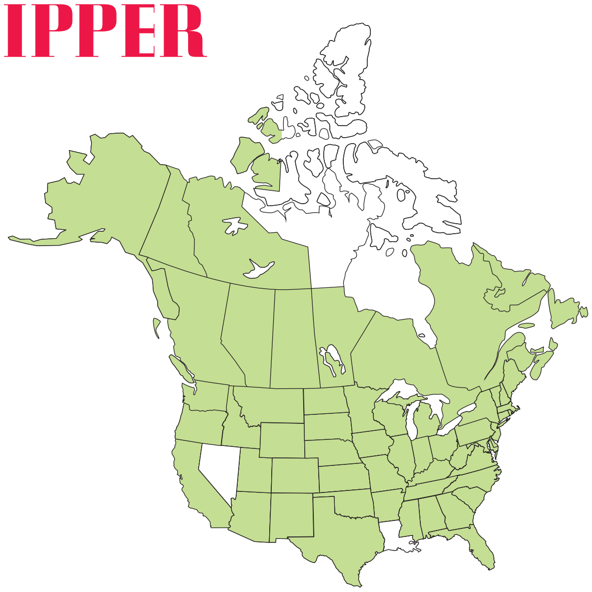
The rare Alcon blue butterfly depends on this plant and an ant species for survival. The butterfly's caterpillar has a smell similar to the ant's larvae. The caterpillar feeds on the plant until found by ants. Mistaking the smell, the ants carry the caterpillar back to their nest to raise it as if it were one of their own. When the caterpillar becomes a butterfly, it beats a hasty exit from the nest—before the duped ants can kill it! Both plant and butterfly are threatened by the shrinking of European marshland.

ARTIST: *Gillian Barlow* | MEDIUM: *Watercolor*

YELLOW LADY'S SLIPPER

(Cypripedium parviflorum)

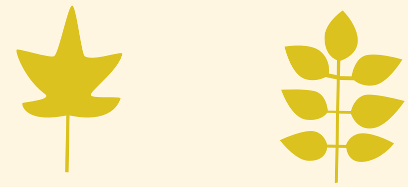
According to a 1920s guide to botanical medicine, the root of this orchid was used to treat disorders ranging from "muscular twitching" to "gloom." Valued today for the beauty of its shoe-shaped flower, the plant is protected against "orchid poachers" by several state governments. For reasons not yet known, its numbers are declining drastically even in protected areas.



ARTIST: *Kathleen Garness* | MEDIUM: *Watercolor*

COMMON LEAF TYPES

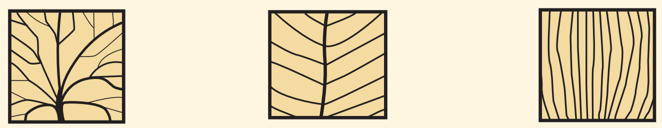
ARRANGEMENT



SIMPLE
one leaf "blade" connected to stem

COMPOUND
several leaflets connected to stem

VEINS

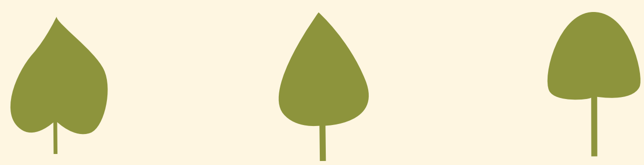


PALMATE
veins diverge from a central point

PINNATE
veins diverge from "midrib"

PARALLEL
veins run alongside each other

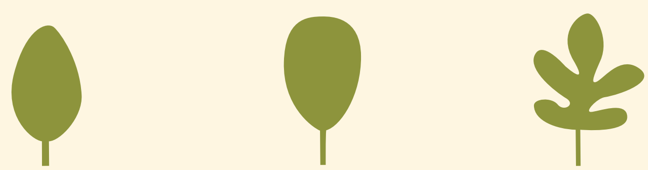
SHAPES



CORDATE
heart-shaped

DELTOID
triangular

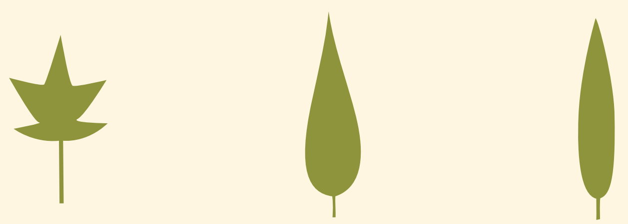
FLABELLATE
fan-shaped



OVATE
egg-shaped

OBOVATE
egg-shaped, but upside-down

PINNATELY LOBED
projections (like earlobes) arranged in a line

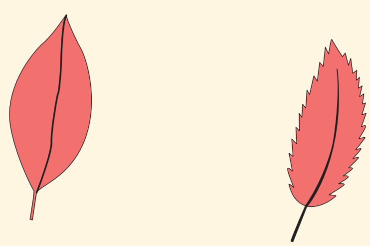


PALMATELY LOBED
projections arranged like the palm of a hand

LANCEOLATE
shaped like the head of a lance

LINEAR
long and straight (like the shaft of a lance)

MARGINS



ENTIRE
smooth edges

TOOTHED
little zigzags around edges

LESSON TWO

BOTANICAL ILLUSTRATION

BY ALICE TANGERINI

Alice Tangerini has illustrated more than 1,500 species of plants for the Smithsonian. Here she adapts her methods for a classroom lesson. Because color is superfluous to the recording of a species, she works only in pencil and ink. All that is needed for the lesson are pencils, fine black markers, tracing paper, photocopy paper, and access to a photocopier.

As a botanical illustrator, I am the eyes of the botanist. My illustrations describe the plant and its parts in a visual form. Let me tell you how I do it.

First, I make a full-size photocopy of a herbarium specimen. I use this to trace the overall outline of the larger parts of the specimen, such as the leaves and how they are attached to the stems.

Next, I make several pencil sketches on translucent drafting film of the various parts of the plant. Throughout this process, I consult with the botanists who are publishing the scientific description.

Once the final pencil sketches are approved by the scientists, I arrange them in a 12" x 15" composition. Sometimes I scan the sketches into a digital file so I can resize them to fit.

Lastly, I place another transparent film over my sketches and trace the final image in ink. At this stage, I add many fine details that show the visual texture of the original specimen.

Through the years I have demonstrated a modified version of this method at schools in the Washington, D.C., area. In just a few simple steps, your students, too, can make a botanical drawing.

STEP 1

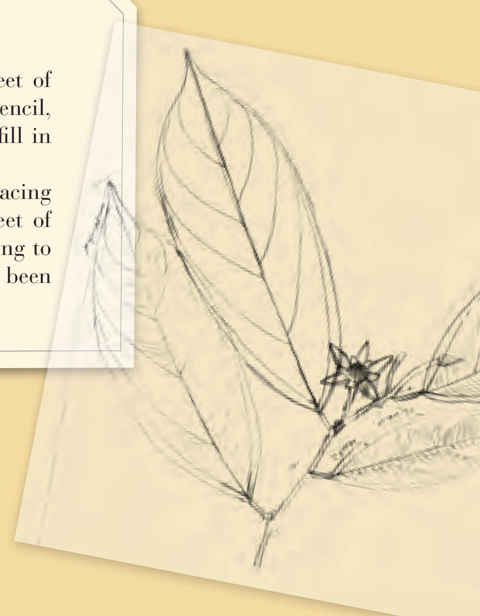
First, the class will gather real plants and photocopy them. Choose plants or part of plants (such as leaves or leafy or flowering branches) that will fit within an 8.5" x 11" copy. Make sure that each specimen can be pressed down fairly flat against the glass. Cover the specimen with a sheet of white paper. Make the copy using the photo or halftone setting to pick up the subtle tones of the plant and the pattern of the veins of the leaves. Experiment with darker and lighter exposures.

STEP 2

Use the photocopy as the "master." Place a sheet of tracing paper over it. Trace the plant outlines in pencil, focusing on the shapes of the structures. Then fill in details such as leaf veins.

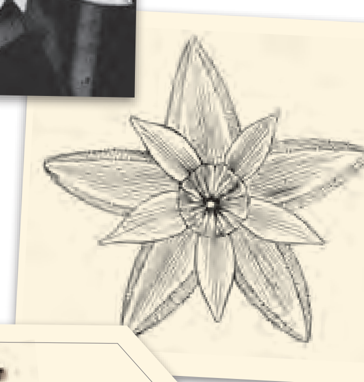
To better see the drawing, remove the tracing sheet from the photocopy and place it on a sheet of blank white paper. Refine the drawing by referring to the specimen itself. Add details that may have been overlooked in tracing.

Alice Tangerini often works with a microscope to draw tiny details of a plant.

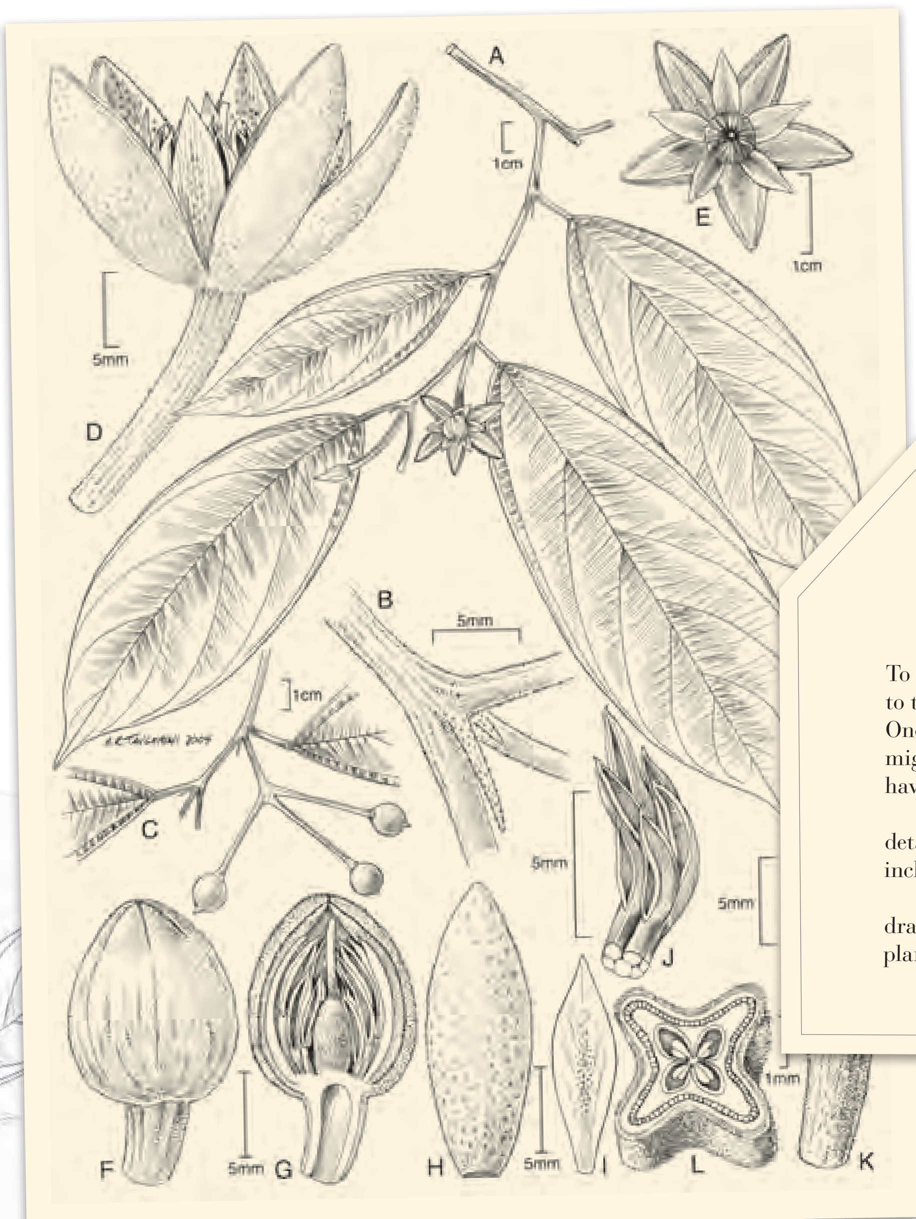


STEP 3

For the final drawing, use an ultra-fine black marker. Place another sheet of tracing paper over the pencil drawing. Secure the sheets with tape at the corners. Trace the previous tracing with the marker, but leave out any of the sketchy pencil lines. The plant structures should be neatly and clearly defined.



Seen on these pages are Tangerini's drawings of Mortoniodendron uxpanapense, *a newly described tropical tree of Veracruz, Mexico. At left is her final drawing.*



STEP 4

To draw any detail of the specimen that is too small to trace—a small flower, for instance—go back to Step One and make an enlarged photocopy of the detail. You might include a ruler in the photocopy so that you'll have a measurement of the detail in its actual size.

Repeat the steps, but include this drawing of the detail on the same sheet as the final tracing. Be sure to include the scale of the enlargement.

As this point, apply any finishing touches to the drawing, such as line shading or stippling, to give the plant a more three-dimensional appearance.

You now have a botanical illustration!

To see Alice Tangerini and botanist Gary Krupnick in a Smithsonian online conference, visit smithsonianeducation.org/botany.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Maui, Sandwich Islands [Hawaiian Islands]
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centimeters
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U.S. National Herbarium
Hibiscus kokio Hillebr. subsp. kokio
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