# Trojan Horse attack on native lupine

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The endangered Tidestrom's lupine (*Lupinus tidestromii*) lives life on the lowdown producing stalks of fruits, like those in the foreground that lie on the sand. A mouse looking for a meal just snips off the stalk at its base and drags the entire cluster of fruits to its nest. Credit: Tiffany Knight/WUSTL

At Point Reyes National Seashore in Marin County, Calif., a fierce battle is taking place under the oblivious, peeling noses of beachgoers.

It's a battle between an invasive plant and a native plant, but with a new twist. The two plants, European beachgrass and Tidestrom's lupine, are not in direct competition, and yet the beachgrass is helping to drive the lupine over the cliff.

European beachgrass provides cover that allows a timid deer mouse to get close enough to the lupine to snip off stalks of lupine fruits without being nabbed by overflying birds.

The native deer mouse (*Peromyscus maniculatus*) consumes large volumes of lupine and beach pea seeds in California coastal sand dunes. Dear mice voyage onto the open dunes only on moonless nights. This rare photo of a baby mouse eating a lupine seed in broad daylight was taken by Washington University graduate student Steve Kroiss. Unfortunately, a mouse that risks foraging during the day is probably starving. Credit: Steve Kroiss/WUSTL

In the August issue of *Ecology*, biologists at Washington University in St. Louis report on the interplay between these species in three lupine populations over a period of four years. Emily Dangremond, Eleanor Pardini and Tiffany Knight used field data to construct a mathematical model of lupine populations. The model predicts that if things go along as they have been so far, all three populations of lupines will be driven to extinction.

But it also predicts that if the mice eat just a few less seeds, the largest population of lupines, which is under the greatest pressure from seed consumption, will remain stable.

The scientists will have a rare opportunity to test the fidelity of their model to the living communities. Point Reyes National Seashore is removing the beachgrass from the prime lupine site as part of an effort to restore native dune habitat. Will the lupine population in the restoration site recover as the model predicts?

## Trouble in paradise

Point Reyes, an anvil-shaped peninsula north of San Francisco that separated by the rift zone of the San Andreas Fault from Marin County, includes spectacular coastal beaches and headlands, estuaries and uplands. When it was threatened by residential development in 1962, Clem Miller, a U.S. Congressman sponsored a bill to preserve it.

European beachgrass (*Ammophila arenaria*), seen encroaching in the background, was introduced in the mid-1800s to stabilize sand dune. (Ammophila means sand lover. And in fact the grass requires regular inputs of fresh sand to stay healthy, apparently because the sand lets it escape from soil pathogens.) In western North America, the grass completely alters the profile of the first rise of sand on the beach, turning a low, hummocky foredune into a steep, continuous ridge, a change that has severe repercussions for the entire native dune community. Credit: Eleanor Pardini/WUSTL

Maintained by the National Park Service, Point Reyes includes areas where ranching and oyster farming are still permitted.

Tiffany Knight, PhD, associate professor of biology in Arts & Sciences, chose Tidestrom's lupine as a research project because "it is endangered and yet has close relatives that are doing just fine. There's even a lupine in the northern California, the yellow bush lupine, that is really common and, in fact, is expanding its range. It's all the way up into Canada and it's been introduced to New Zealand and is doing well enough to be considered invasive there.

"So you have these lupines that are performing very differently and the basic ecological question is why? What makes some species vulnerable and others not?"

Eleanor Pardini, PhD, a research scientist in biology, points out that Point Reyes has 49 rare plant species and several groups of plants that have a suite of rare to common or even invasive species — a perfect setup for ecological research.

Knight, who is studying several different groups of plants at Point Reyes, says northern California is a biodiversity hotspot even by global standards.

## Life on the down low

Tidestrom's lupine (Lupinus tidestromii), which is named after the botanist Ivar Tidestrom, doesn't look much like the ornamental lupines found in gardens (or featured in Monty's Pythons "Dennis Moore," the sketch where the eccentric highwayman demands coach passengers hand over their lupines.)

Instead of standing tall, Tidestrom's flowering stalks lie on the sand. The

species looks like a lupine with its sails reefed and the hatches battened down for a big blow.

From a coldly practical point of view, the lupine would seem to be inviting consumption by displaying its fetching fruits so enticingly on the sand.

But Knight says the plant's slouchy morphology makes sense, given its habitat.

"It's a terrific morphology for a plant that is living in an early succession sand dune where it's very windy, very harsh," she says.

"Historically, dunes were dynamic. There were native grasses, but they weren't as dominant as the European beachgrass, so a big storm would blow out the dunes and the grasses with it.

"But Tidestrom's lupine has this absolutely amazing seed bank. The seeds can live a long time in the sand.

"During a pilot project for the dune restoration, the park's biologists dug deep into the ground and overturned the sand. Lupine seeds a meter under the ground were brought to the surface and they germinated! Those seeds must have been buried for decades," Knight says.

"So if you got one of these storms, the lupine seeds would be scarified by the blowing sand, breaking their dormancy, and so they'd germinate.

"There's no other vegetation around right after the storm, so there's not a lot of mice around either, because the mice need cover. They don't like open sand. The lupines would do really well in this windy, but mice-free zone after a storm.

"The plants hug the dune, clinging to the sand, so their flowers and fruits don't get blown around. To me this plant makes perfect sense.

"If there's a storm-free interval, the grasses will come in and the mice will come in and this plant won't do as well. But that's OK because it has already produced a bunch of seeds that are now in the seed bank waiting for the next big storm."

"I think that historically this species did just great, but we've destroyed dune habitat or modified it so much that you never get these natural dune blowouts and the species doesn't have an opportunity to shine.

"Instead, it's on the endangered species list."

## The low down on lupines

Less is known about invasive species than one might think, given the media coverage they receive. The scientists conclude their *Ecology* paper by saying that even though invasive species are the greatest threat to biodiversity after habitat destruction, "we have little quantitative evaluation of their effects on decline and extinction of native plants."

Was it really the case that the beachgrass increased the pressure on Tidestrom's lupine by providing cover for the deer mice? To find out, the three biologists conducted both observational and experimental studies.

They followed 102 fruiting lupines for two seasons in the spring of 2008 and 2009, scoring plants as "consumed" (any fruiting stalks consumed) or "not consumed" (all stalks intact).

Dangremond, then an undergraduate at Washington University in St. Louis, also placed fruiting stalks at varying distances from the

beachgrass and then scored the stalks four days later for consumption.

To avoid sacrificing fruits of Tidestrom's lupine, she used the fruits of the silver dune lupine (L. chamissonis) instead. This common lupine has fruiting stalks that "look fairly similar, although the fruits are slightly bigger," says Pardini. "They're a pretty good proxy for the rare species."

Both the observational and the experimental studies confirmed their hypothesis that the closer lupines are to beachgrass the more they are ravaged by deer mice.

## Projecting the future of a population

The scientists then set up a mathematical model of lupine populations that consisted of the stages in the plant's life cycle (such as seeds in the seed bank, seedlings, nonreproductive plants and reproductive plants) and equations that described the annual transitions between these stages.

The equations were based on demographic data from three populations of lupines at Point Reyes in which individual survival, growth and fecundity were monitored for four years (from 2005 through 2008).

"People often don't study the entire life cycle of an organism," says Knight. They'll just study reproduction and seed consumption rate and conclude that if seed consumption rate is high it must be hurting population growth.

"But that's not necessarily true.

"The rate limiting step could easily be somewhere else in the life cycle. Maybe seedling survivorship is very low. If that's the case, it doesn't matter how many seeds you produce or consume, survivorship will drive population growth."

## Running the model

Once they built the lupine population model, they could experiment digitally to better understand what might cause a population to grow or shrink.

"Suppose the consumption rate in the field was 70 percent," Knight says, "as it was in the case of one population. The model then allows us to ask what would happen if it were 60 percent, or 50 percent. What if it were zero? What if none of the seeds were consumed; how would this population perform?"

According to the model, all three of the lupine populations will eventually disappear. On the other hand, the simulations also offer some room for optimism.

"Abbotts Lagoon was the biggest population we were modeling," says Pardini. "And the model says only a small reduction in consumption would result in a stable population size."

## Will the lupines make it?

That's a tantalizing prediction because Point Reyes is about to undertake a dune restoration project that should remove some of the pressure on the Abbotts Lagoon lupines.

"All along the West Coast," say Pardini, people are trying to take out the European beachgrass and restore the native dune structure and plant and animal communities. Point Reyes National Seashore is conducting a large restoration at Abbotts Lagoon. They're taking out about 110 acres of beachgrass in a 300-acre area."

The biologists will know in a few years whether their prediction is accurate and the restoration removes enough consumption pressure to allow the Abbotts Lagoon lupines to recover.

In the meantime, the biologists have begun to monitor other populations of lupines. "There are 15 really good populations left," says Pardini, "and we're monitoring 13 of them."

"So basically we're monitoring the entire species," says Knight. "And we're getting a good feel for population-to-population variation and to what degree mice and other factors are responsible for it."

But it's not all good news.

"This article focused on the threat of seed consumption," says Pardini. "But Tidestrom's lupine is also threatened by hybridization with silver dune lupine. Historically the two lupines grew in separate locations, but people brought the silver dune lupine to the Monterey Peninsula as an ornamental plant. The two species produce fertile hybrids, which are now competing with Tidestrom's lupine.

In 2008, Knight and Pardini received National Science Foundation funding to study additional populations of Tidestrom's lupine and to incorporate hybridization risk into models of its population viability.

Life, for the Tidestrom's lupine, it would seem, is one cliffhanger after another.

Unfortunately, that is true for many plants. According to the World Conservation Union, one out of every four plant species on the planet is currently under the threat of extinction.