

Show #1204  
"Alien Invasion"  
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THE SILENCE OF THE BIRDS  
GREEN INVADER  
THE SILKEN TREE EATERS  
DUST BUSTING

TEASE

ALAN ALDA Some time in the 1940s, a brown tree snake hitched a ride aboard a US Air Force plane in New Guinea, and it traveled across the Pacific to the island of Guam. As a result, Guam lost all its native bird life. On this edition of Scientific American Frontiers, global attacks by alien species.

ALAN ALDA (NARRATION) The European gypsy moth has been steadily transforming America's forests, and now the Asian longhorned beetle could do the same thing. An African fungus crossed the Atlantic, to cause a damaging disease in Caribbean coral. And a Caribbean weed is smothering marine life in the Mediterranean, and it now threatens the California coast.

ALAN ALDA I'm Alan Alda. Join me now for Alien Invasion. SHOW INTRO

ALAN ALDA (NARRATION) It's a tranquil scene on the coast. A couple of guys are diving -- checking out life on the lagoon floor. People are boating. Actually I know who that is out there. She's Rachel Woodfield, a marine biologist, and she's bringing in a bag of that weed the divers were looking at.

ALAN ALDA Hiya, Rachel.

RACHEL WOODFIELD Hiya.

ALAN ALDA Is that it, there?

RACHEL WOODFIELD This is it right here.

ALAN ALDA (NARRATION) But the weed is not as nice as it might seem.

ALAN ALDA We're at Agua Hedionda Lagoon, just north of San Diego on the California coast. The divers out there are trying to get rid of every last shred of this stuff that they can find. It's called *Caulerpa taxifolia*. It's an invasive weed that

has the potential to literally smother California's native marine life to death. We know that because it's already killed off thousands of acres of coastal life in the Mediterranean. *Caulerpa* is a classic example of the phenomenon that we're devoting this entire program to -- alien species.

ALAN ALDA (NARRATION) Remember killer bees? They're dangerously aggressive African bees, introduced to Brazil in 1957. Now they've spread north into California and the southwest, and beekeepers are trying to figure out how to cope with them. South American fire ants are another alien. They attack pets and wildlife, and destroy native plants. Fire ants got to Mobile, Alabama in the 1930s, probably in soil used as ship ballast. Now they're in 14 states in the Southeast.

ALAN ALDA What they all have in common is that somehow they've been transported from their home habitat, to a part of the world where they did not evolve -- where they are aliens. It's a great thing to be an alien, because in your new environment there aren't any of the predators and competitors that you originally evolved with, that make your life a constant struggle. So you can really run wild, and grow like crazy, and take over the place.

ALAN ALDA (NARRATION) Thousands of plants, animals, insects, fish and microbes have moved around the globe to become aliens. Almost always it's humans who do the moving. Asian hydrilla, for example, was first brought to the US in the '50s as an aquarium plant. Now it clogs waterways all over the south. People always have carried things with them, of course -- either by accident or design. But now with global trade, alien species are becoming an irresistible force. In the Great Lakes, many of the most common species are aliens -- including the notorious European zebra mussel. Most are recent arrivals. New Zealand now has as many alien plants as native, around seventeen hundred of each. Hawaii is the same. It's thought that right now the US has about seven thousand alien species of all kinds. Is that a bad thing? Sometimes the cost is obvious. For example, 20% of California is infested with Eurasian yellow starthistle. It's toxic to horses, and cattle won't walk on it, so huge areas of rangeland are now useless. But ecologists argue that the greatest costs are less tangible. When species get mixed up in this great global exchange, the sets of plants and animals called ecosystems can fall apart, and disappear.

ALAN ALDA We're going to look at four alien species stories from around the world. Among them they display all the classic ingredients. There's the nineteenth century Harvard professor who thought he had the key to a better silkworm. There's the disease that was blown across the Atlantic to cause havoc in the Caribbean -- in coral reefs, and maybe among people, as well. We're going diving in the Mediterranean, to see first hand the damage that *Caulerpa taxifolia* can do. And first, the story of a bird, a snake, and a small island in the Pacific...

## THE SILENCE OF THE BIRDS

ALAN ALDA (NARRATION) This is the National Zoo, in Washington, DC. I'm heading for the tropical birdhouse, in the company of Kathy Brader, the keeper. There's one particular exhibit we're interested in.

KATHY BRADER Now this is our Guam exhibit. And in here we have our Guam rail and our brown tree snake. He's curled up on the top. And he is the cause of these guys' problems on Guam.

ALAN ALDA (NARRATION) On the island of Guam, in the western Pacific, the forests are eerily silent. Guam has lost all three of its unique native bird species. Six other regional species are gone; just three others are hanging on. This is the culprit.

KATHY BRADER You can see all the different locks and equipment we have on there to make sure that he cannot get out.

ALAN ALDA Sometimes they hide a key, you know.

KATHY BRADER Well fortunately I don't think we have that problem with the snake. And, let's just back up here a little bit. For us to have him here, we had to have a special permit. You can only have males. So there's no chance that if one did get out, they can't reproduce. Because we don't need this problem here in the United States, you know on the mainland.

ALAN ALDA (NARRATION) You can be sure that if the brown tree snake did manage to get out, the Guam rail would make an easy meal. Guam has no native snakes, so the birds developed no natural defenses against them. Horatio, as he's called, doesn't even recognize the nearby snake as a danger. It's the mealworms that interest Horatio.

KATHY BRADER We use them as a protein supplement but we also kinda use them as a treat.

ALAN ALDA As a treat? You know no wonder these birds are extinct.

KATHY BRADER Yeah. Here, Horatio.

ALAN ALDA (NARRATION) Horatio is descended from the last 21 Guam rails that were brought in from the wild in the mid-1980s, for captive breeding.

ALAN ALDA Do you hope to reintroduce them?

KATHY BRADER Yes, but there's literally millions of these snakes. We can't just go and re-release them with the snakes still being the problem. When we can solve that problem, is to reintroduce these birds back into Guam. We want them in the wild.

ANNOUNCER Here in the South Pacific theater, air transport bucks fog, mountains and Japs in the routine performance of its duties.

ALAN ALDA (NARRATION) It was the disruption of war that led to the devastation of most of Guam's wildlife - birds, bats, flying foxes, and small mammals. The island was occupied by the Japanese, fought over, and became an important air transport hub. Sometime in the 1940s, a few brown tree snakes must have stowed away on flights, maybe from New Guinea or the Solomon Islands, and made it to Guam - the first snakes ever on the island. Today, Guam is infested with brown tree snakes, maybe 1 or 2 million of them - up to 20 snakes per acre in some areas. It's the highest snake density in the world, and a major nuisance for people. Their bite is only mildly poisonous - about like a bee sting - but the snakes short out power lines, they get into buildings, and attack anything - wildlife, pets, chickens and children too. Secured in double cages at the National Zoo, there's a large research collection of brown tree snakes -- including females -- collected in Guam by veterinarian Don Nichols. He's been bitten maybe half a dozen times.

DON NICHOLS You need to move quickly once they know you're here, but I'm just gonna grab the snake by the head and secure the head, which is where all the weapons are, and then pull him on out. And as you can see, these are very long and slender, which is adapted for life in the trees. And if my hand were a tree branch, then it could actually extend its body out as much as 67% out into the air. With a lot of snakes that are not adapted to life in the trees, you can actually grab them by the tail and hold them up like this. And the snakes can't get to you if you hold it away from your body.

ALAN ALDA But this snake can, huh?

DON NICHOLS But this snake has the ability...its muscles are so strong that it can actually come right back up like this, and if I were to let go of the head, it could come up and nail me, or...

ALAN ALDA Or maybe even me.

ALAN ALDA (NARRATION) Guam is still a major hub, so the fear is the snake could stow away again, and jump to other snake-free islands, like Saipan or Hawaii. There are rings of traps around the seaport and airport. Cargoes are checked constantly. But in spite of the vigilance, there are leaks. So far the snake

has been caught on eight other Pacific islands, including Hawaii - where 14 are known to have arrived. One snake was even caught in Corpus Christi, Texas. It's only a matter of time before a new population gets established somewhere. So the search is on for some way to control, even eradicate, the snakes on Guam. At the National Zoo, Don Nichols and Elaine Lamirande are working on a radical idea - find a disease, which just affects snakes. These samples all came from snakes that died from a virus infection. Called paramyxovirus, it regularly crops up in captive snakes, which live close together.

DON NICHOLS This one looks a little rambunctious, so I'm going to use the snakehook.

ALAN ALDA (NARRATION) Don Nichols had the idea that paramyxovirus could be made to spread among Guam's dense snake population. Right now they're seeing how different strains of virus, sent here from around the world, affect the brown tree snake. The snake gets a shot of anesthetic, which takes about 15 minutes to take effect.

DON NICHOLS Good.

ALAN ALDA You're gonna reach in there, right?

DON NICHOLS Give it a few jiggles to make sure there's no movement -- you can see. I still will make sure I got control of her head, but she's quite asleep.

ALAN ALDA (NARRATION) Then a dose of one of the paramyxovirus strains is injected into the snake's windpipe, causing a pneumonia-like disease within 2 or 3 weeks. Don says these viruses pose no risks for people, because they're active only in cold-blooded reptiles. Our high body temperature kills the virus off.

DON NICHOLS ...let the fluid trickle down into the lung.

ALAN ALDA (NARRATION) So far they've tested 16 strains of the virus, looking for one that will kill the snake only after a delay, so there's time for the infection to spread to other snakes. There's no getting around the fact that this project is about killing animals - figuring out the best way to give them a really bad case of pneumonia. That's something that an animal lover like Don is acutely aware of, but for him it's the lesser of two evils.

ALAN ALDA How do you answer somebody who questions whether or not you're being cruel to them?

DON NICHOLS Well, I mean, it's all a matter of your priorities and I'm the first person to admit... I actually like snakes, and I like them where they belong. But

these things are a pest species in an area and they are causing all kinds of havoc. They 're threatening other islands. And it may not be the most humane way to kill them, but it's the only way you can do it on a broad scale.

ALAN ALDA (NARRATION) There was an attempt on Guam to persuade people to eat the snakes. It never caught on, and anyway no approach involving catching individual snakes is going to make a dent in a population of millions. Don is convinced that only a biological control agent that can perpetuate itself, like a disease or a parasite, could have much effect. But could biological control carry its own risks?

ALAN ALDA Don't viruses reproduce rapidly? Don't they have a chance to mutate and attack other species eventually?

DON NICHOLS My biggest concern would be whether or not it could adapt, mutate and adapt to the native lizards.

ALAN ALDA (NARRATION) Don says that paramyxovirus has never been known to jump to lizards, and of course they'll do tests before any virus release. But biological control inevitably carries risks - and that's a measure of how difficult it is to tackle the problems created by alien species.

ALAN ALDA The original problem occurred when some snakes got on airplanes and flew to Guam. Now if you infect the snakes in Guam, and an infected snake gets on an airplane and flies to some country where that virus could hurt those snakes, isn't that a danger?

DON NICHOLS There is a chance of that happening. However, one of the key things is that these viral diseases are very density dependant. In other words, high populations, dense populations -- easy for the viruses to spread around. But, in the native range of these things, it's very difficult to find the snakes. They're in very low density, so... It's not a zero percent chance, I'm not saying...

ALAN ALDA No, no, I mean, my mind is racing because it just seems to me that every time we do something to fix something that we did wrong 50 years ago, we create a new problem for somebody 50 years from now.

ALAN ALDA (NARRATION) The hope, of course, is that we've learned how not to create new problems. If the virus project is approved, the small island of Rota, 35 miles north of Guam, may hold the best hope for the return of Guam's wildlife. It's still free of snakes, so there are birds here that are extinct on Guam. Over the last few years, more than 200 Guam rails, bred in zoos from the 21 birds captured in the 1980s, have been released here. MAN Two zero eight five.

ALAN ALDA (NARRATION) They're breeding successfully, so they can provide a wild nucleus from which Guam itself can be repopulated -- if Don Nichols' virus works. Guam's wildlife can never be fully restored, but without snakes it can return to something like the balance that once existed. And at the same time, the threat of similar devastation spreading to other islands can be averted.

GREEN INVADER

ALAN ALDA How long have you been studying this Caulerpa?

ALEX MEINESZ More than 10 years.

ALAN ALDA 10 years.

ALEX MEINESZ 10 years now, yes.

ALAN ALDA (NARRATION) We're in a small town just down the coast from Nice, in the south of France. Alex Meinesz, a biology professor from Nice University, is taking me out fishing.

ALAN ALDA ... in those ten years, how much has it increased?

ALAN ALDA (NARRATION) As with thousands of places like it around the Mediterranean Sea, this town depends on a mix of fishing and tourism for its livelihood.

ALEX MEINESZ Yes. On peut monter?

ALAN ALDA Okay, thanks. Bonjour! FISHERMAN Bonjour! Patrick.

ALAN ALDA Patrick, Alan.

ALEX MEINESZ Alex. Bonjour!

ALAN ALDA (NARRATION) We're on the Vergé family boat. The waters around here have been fished for generations. Until now, that is. They don't fish here any more. We had to persuade them to set their net out last night, just so we could film the result. And the result is this.

ALEX MEINESZ Caulerpa

ALAN ALDA Yeah.

ALEX MEINESZ Caulerpa.

ALEX MEINESZ Look. Oui, oui. On arrête un peu, uh? Look. And this caulerpa clogs the nets and the fish see the nets and there is no fishes.

ALAN ALDA Oh, I see. So it hurts fishing just because...

ALEX MEINESZ They see the nets.

ALAN ALDA ...it calls attention to the nets.

ALEX MEINESZ Yes.

ALAN ALDA (NARRATION) The weed, called *Caulerpa taxifolia*, doesn't belong here. It's a tropical plant, common in the Caribbean and other warm waters. The northern Mediterranean gets cold in the winter, but somehow the *Caulerpa* is surviving, and thriving - nothing can touch it.

ALEX MEINESZ When you broke it, there comes a kind of juice out of it, you see?

ALAN ALDA Does that juice have anything in it that keeps away predators?

ALEX MEINESZ Yes, absolutely. That are terpanes, caulerpanines. And this is a kind of toxic matter and a repellent matter. So the fish don't eat it.

ALAN ALDA So it repels fish. So in this area nothing is a natural predator.

ALEX MEINESZ No! You see all the leaves are entire. Nothing...

ALAN ALDA Nothing has been eating it!

ALEX MEINESZ No, no eating trace.

ALAN ALDA Yeah.

ALEX MEINESZ On y va?

ALAN ALDA On y va. Holy moly! He really jumps in!

ALAN ALDA (NARRATION) Alex took us into the shallow water near the town's bathing beach. Everything below was covered by the *Caulerpa* - rocks, sand, mud. There's nothing else down here, no other plants, barely a fish. It's a classic example of an alien that just takes over - like the brown tree snake in Guam. Nothing eats it, and nothing competes with it.

ALEX MEINESZ It's full, uh?

ALAN ALDA Yeah, there's a lot of it down there.

ALEX MEINESZ All the bottom is covered, eh?

ALAN ALDA There's a lot there!

ALEX MEINESZ All the bottom is covered.

ALAN ALDA (NARRATION) The Caulerpa arrived here about nine years ago. Advancing at an inch a day, it has ruined the fishing and it'll soon clog the town beach. It's the same disastrous story, spread out along 1,000 miles of Mediterranean coast. Caulerpa is easily spread. It's carried along in fishing nets, and there are millions of small boats in the Mediterranean - all with anchors.

ALEX MEINESZ A little piece like this, I put this in the water, after 6 months you have 3 square meters, with this little piece.

ALAN ALDA Any part of this?

ALEX MEINESZ Any part. Any part.

ALAN ALDA (NARRATION) With its rapid spread from fragments, and its cold water survival, Caulerpa in the Mediterranean is behaving in ways that shocked marine plant experts like Alex. After years of investigation, Alex is pretty certain he knows how this disaster happened. This is the aquarium at the famous Monaco Oceanographic Museum, where Jacques Cousteau was once director. In the early 1980s the Museum, along with several other European aquaria, started using a decorative, and easy to grow, plant in their tropical tanks. The plant was Caulerpa taxifolia. It's still used here today, as it is around the world. Alex believes that somehow some fragments of Caulerpa were released from the tanks into the sea. A museum diver first saw Caulerpa right outside the building, on the bottom, in 1984. It covered just one square yard. By 1989, when Alex first saw it, it covered 2 acres. By 1990 it was at nearby Cap Martin, next year Toulon, 100 miles away, and now it's found from Spain to Croatia. With no natural enemies to hold it back, the Caulerpa has been steadily smothering Mediterranean sea life. In the shallow areas, there's normally a complex community of over a thousand different species -- algae, shellfish, worms and fishes, all based on meadows of native sea grass. In the darker depths there's a different balance, with the grass giving way to red sea fans. This is the steep, 100-foot rock wall off Cap Martin, once a favorite spot for scuba divers. The film is from 1996, shot as the Caulerpa was taking hold. Alex has been diving here

every year since the Caulerpa arrived. As the alien plant advances, it blocks light out -- from the red sea fans, for example, which die off. Alex has seen the same process repeated all over the rock wall. Did this all originate with the Monaco aquarium? Genetic analysis has shown the Caulerpa is a mutant strain, unique to aquariums -- including Monaco -- and not found in the wild. But we'll never know for sure how it first got loose. In the summer of 1999, our underwater cameraman swam down the rock wall at Cap Martin to record the progress of the Caulerpa. The wall is now completely covered. The last sea fans are dying. The wall is essentially a biological desert. Once again we're looking at Caulerpa growing in an aquarium. But there's something else - it's a kind of slug, and it's eating the weed. The result - all over the tank, ghostly white fronds of weed, with their toxic juice sucked right out by the slugs. The slugs are being studied in his lab at the University of Nice by Alex Meinesz. In his view, they represent the single best hope for controlling Caulerpa taxofolia in the Mediterranean. We've jumped 4,000 miles across the Atlantic to the Indian River in Florida. Alex's slugs came from here, collected by Cecilia Miles, a marine biologist from Florida State University. Here Caulerpa is eaten -- and controlled -- by the highly specialized slugs, as it is further south all over the Caribbean. The hope is that slugs from Florida -- the northern extreme of their range - might be hardy enough to survive the Mediterranean winter. In the summer of '99, Cecilia collected and packed a batch of Florida slugs for shipment to Alex in Nice. The slugs had their own air supply for the flight, and were escorted across the Atlantic by a French grad student.

GRADUATE STUDENT And I see you when I get back. See you Cecilia. Bye bye.

ALAN ALDA Here you were a student of caulerpa and all of a sudden it shows up on your doorstep...

ALAN ALDA (NARRATION) Alex has been studying different slugs for years. The Florida batch had been in residence at Nice University for about 2 weeks when I visited. His work with slugs and Caulerpa is done on a shoestring budget, in a makeshift lab behind the biology building. The Monaco Aquarium connection makes this a very political subject, so research grants have been hard to come by.

ALAN ALDA ...so you've got a chance to see who's working out.

ALEX MEINESZ Yes. Come in, please. Come in.

ALAN ALDA So they're in there, I don't see any slugs.

ALEX MEINESZ Yes, here.

ALAN ALDA Oh yeah. yeah, yeah! Now is he eating now?

ALEX MEINESZ Yes, I think so, yes.

ALAN ALDA So these slugs really like that toxic stuff.

ALEX MEINESZ Yes. They need the toxic, because they take the toxins and they stock it in them and then the fishes doesn't eat it.

ALAN ALDA Oh, I see. So the slugs use the toxins to keep the fish away from them!

ALEX MEINESZ Exactly. Exactly. Exactly.

ALAN ALDA (NARRATION) The slugs have other highly specific adaptations to Caulerpa - they need Caulerpa cells as part of their own metabolism, and they have a special tooth, which matches only Caulerpa cell structure. Alex argues that the slugs are so exquisitely adapted to their one food that releasing them into the Mediterranean to control the invasion biologically would present a very low risk. I asked him about it.

ALAN ALDA How do we know the slugs that you bring in won't adapt and find some other way to live in addition to caulerpa?

ALEX MEINESZ When the slug have no more caulerpa, they can not, in one generation say, Ah, we shall change our tooth, our mouth, our toxin, to eat other things. You understand? You understand?

ALAN ALDA That takes a lot of plastic surgery!

ALEX MEINESZ You understand?

ALAN ALDA Sure, sure!

ALEX MEINESZ When there is Caulerpa, they eat Caulerpa. No problem, no problem. When they see there is no more caulerpa, it is too late. It's too late.

ALAN ALDA (NARRATION) Alex's slugs may be the only way to go. All kinds of non-biological control methods have been tried - like releasing poisonous copper from underwater electrodes... Or simply scraping the weed off... Vacuuming it up... Freezing it with dry ice... Scalding it with hot water... Or cutting off its sunlight. But there's nothing that's practical on a large scale, except the slugs. I asked Alex again, Is it really smart to release the slugs into such a paradise of food?

ALAN ALDA All of a sudden, they're dining out every night. They're going to Maxim's every night. And they're doing pretty well. Now, you're liable to have some pretty fat, happy, healthy slugs around looking for trouble.

ALEX MEINESZ No, no. You have a prairie of Caulerpa with many slugs in it and then they control the caulerpa and it is finished, that we think. But what you want? Do you want to have a Mediterranean Sea full with caulerpa without any control method? We must have a predator for this invader. Without predator, the Caulerpa -- that is a risk that we see now. We can see, you have see it when we snorkeled. You see with the fisherman. It covered all the bottom and it expands every year. So what do we do? Do we do nothing? Or do we try this?

ALAN ALDA If you can't get rid of it, if the slugs don't work, if the slugs are too dangerous, if the slugs work but governments won't let you use the slugs, what will the Caulerpa do? What will happen to the Mediterranean?

ALEX MEINESZ What happens is exactly the same that happened since ten years. It extends. It extends every year, in new country, new regions. And we think that this algae is able to colonize most of the region of all the Mediterranean Sea.

ALAN ALDA (NARRATION) Now fast forward two years and 7,000 miles. We're back at the California lagoon where we began this program. Just like in France, the alien Caulerpa here is untouched by any natural enemy. It's capable of smothering the native eelgrass. The patch of bright green Caulerpa was first noticed in 2000, suspiciously close to a storm drain outlet. Caulerpa is widely used in home aquariums, so someone probably dumped one out into a drain somewhere in the area. Getting rid of the Caulerpa here, and in one more spot near Los Angeles, is now the responsibility of Rachel Woodfield, who works for an environmental consulting firm.

ALAN ALDA Where did you first find Caulerpa around here?

RACHEL WOODFIELD The first place we found it was right out here in the eelgrass beds. We were monitoring the success of the native eelgrass beds and came across this bright green terror growing in there. We weren't sure what it was at first. We've all heard of Caulerpa in the Mediterranean. But to make the relation that this is the killer algae. It took us a little while to figure it out.

ALAN ALDA Was it widespread by the time you first discovered it?

RACHEL WOODFIELD It had spread throughout this small harbor area. It covers about five acres. So we built this boom around it to keep all the boats out and people who might want to come in and see it, and might potentially spread it.

ALAN ALDA (NARRATION) They decided to try killing off the Caulerpa a few square feet at a time - something it's too late for in the Mediterranean. Portable frames are covered with plastic tarps, which are sealed to the lagoon floor with sandbags. The underwater tent is then given a dose of chlorine and left for a few days. Everything inside is killed - Caulerpa and native eelgrass - but so long as they get all the Caulerpa, only eelgrass will grow back. After a year, it seems to be working.

RACHEL WOODFIELD We're at a manageable point right now. We have two infestations. They're deep back inland in lagoons. There's calm water. We're able to have the luxury to put these tarps down and deal with it, and keep an eye out for it before it gets offshore.

ALAN ALDA Is this the major threat or the only threat right now from an alien species in this, in these waters?

RACHEL WOODFIELD This certainly is not the first exotic species that this lagoon has seen. However, this is the first species that really has the potential to cause some serious, serious harm to our coastline and that is at a state that is manageable.

## THE SILKEN TREE EATERS

ALAN ALDA (NARRATION) We're in the New York City borough of Queens, to witness the death of a tree. One of the cemetery's prized mature maples is coming down. It was doomed anyway, and this is why.

JOSEPH GITTLEMAN What we have here is larval Asian longhorned beetle. And if we just pull him out of here, you can see they're quite sizable. They have large mandibles well suited for the environment inside a log and chewing its way through the hardwood.

ALAN ALDA (NARRATION) The Asian longhorned beetle is as big a threat to America's forests as Caulerpa is to our marine life. In late summer, each female distributes a couple of hundred eggs around several trees. The beetles arrived in the mid-1980s, in wooden packing materials from China - so as usual with alien species, they have no natural enemies here. Right now they're just confined to the New York City and Chicago areas, but already seventy five hundred trees have had to be destroyed. The damage is done in the spring, when the larvae

hatch and eat their way out, emerging as adult beetles to begin the cycle again. The tree cannot survive the process.

JOSEPH GITTLEMAN You don't see much on the outside sometimes and then when you flip it, you see what type of damage this is capable of. Our goal is total eradication of this insect from North America.

ALAN ALDA (NARRATION) Eradication means cutting up every infected tree, picking out the larvae, chipping the remains and burning the chips. And then every apparently healthy tree within 700 feet gets a dose of systemic insecticide, just in case there are larvae inside. Like with *Caulerpa*, we still have a shot at halting this alien invasion. The dominant hardwood in the eastern American forests was once chestnut, until it was almost wiped out by chestnut blight - a fungus from Japan - in the 1880s. As a result oaks took over, but they're being devastated by the gypsy moth - from Europe. So now maples are coming to predominate. But they're one of the favorite foods of the Asian longhorned beetle. It would be the worst ever pest of American forests.

JOSEPH GITTLEMAN It's a pest of about 18 different species of hardwood trees in the northeast forest, including all of your maples, your elms, horse chestnuts, willows, poplars, birch, ash trees. So your talking about a sizable percentage of the natural forest in the northeast. And the possibility of spread outside of the, if you would, the ornamental situation now, from a backyard pest to a forest pest would be catastrophic.

ALAN ALDA (NARRATION) Many people in the northeast have first-hand experience of a continuing forest catastrophe. The gypsy moth regularly defoliates and kills large swaths of oak forest, in an ever-expanding area. It's costly and destructive, it leads to large-scale pesticide use, and it's plain disgusting, too. The gypsy moth has been a classic story of alien invasion for over a hundred years. This film was made 50 years after Etienne Trouvelot, a Harvard astronomer, had accidentally released a group of gypsy moths from his home in Medford, a Boston suburb. He'd imported the moths from Europe in the hope of establishing an American silk industry. The first big defoliation took place in Medford in 1880, 10 years after the release. There were more or less constant attempts to prevent the moth from spreading, including extensive use of toxic lead arsenate sprays. But by the late 1920s it infested 40,000 square miles of New England, New York and Canada. Victory was declared several times, but the gypsy moth proved unstoppable. Today it's all over the northeast, and still on the move. From this lab on Cape Cod, the USDA continues to battle the gypsy moth, as they have for a hundred years. Inside labs sealed with airlocks, they keep gypsy moths and about 40 other aliens which might be the next invader. They even have some Asian longhorned beetles here. They're determined not to be caught off guard again.

VIC MASTRO The gypsy moth is fully entrenched in the United States. We will never eradicate it. The goal now is to slow that natural spread. You can eliminate some pesticide use, save some dollars by not letting uninfested areas become infested sooner than they would naturally.

ALAN ALDA (NARRATION) Historically, the gypsy moth spread westward at about 13 miles a year. In the last few years, that's been slowed to about 5 miles a year, with a program that's like a military campaign. They've managed to tap into the enemy's signaling system - the chemical pheromone which the darker male moths follow to lead them to the females. USDA researchers first isolated the pheromone from female moths about 30 years ago. Then a synthetic version was developed. It's contained in this little plastic tube at the head of the wind tunnel. It's a powerful attractant for any male moth that's downwind. Each spring, to detect where the moths are, half a million pheromone-baited traps are set out along the front line, from Wisconsin to North Carolina, and also throughout the western US. So now it's possible to concentrate attacks in the right place the following year, before infestations build up. This couldn't be done before. Today the insecticides are much less toxic, too, although they do kill other insects. Right from the start, people tried biological control against gypsy moths. It was understood that alien species are successful because they have escaped their natural enemies back home. So it seemed obvious that importing some of those enemies would be beneficial. A Massachusetts state lab was set up to breed and distribute many different predatory beetles and flies, and some diseases, brought in from Europe or Asia. Nothing was very successful, and it's turned out to be a classic lesson in how not to do biological control.

VIC MASTRO With gypsy moth about 40 or 50 exotics were introduced, but only about 12 of those were established. Some of those are not specific to gypsy moth and that's caused a problem.

ALAN ALDA (NARRATION) The most notorious example is this little fly, called *compsilura*, brought in from Italy. In a series of rapid, darting attacks, it plants its eggs inside gypsy moth caterpillars. Eventually the eggs will hatch into a maggot, leading to a gruesome death for the caterpillar.

VIC MASTRO *Compsilura*'s range now extends all the way across the United States, so it's far out distanced the gypsy moth. And it attacks native species throughout that range.

ALAN ALDA (NARRATION) *Compsilura* turned out to be more interested in attacking native caterpillars than gypsy moths. As a result some of our most spectacular native moths are greatly reduced in numbers and probably extinct in some areas. The lesson we've learned is that biological control agents must be

absolutely specific to the particular pest. They've taken the lesson to heart back at the Cape Cod lab. These are gypsy moth eggs, being spread onto a nutrient base. It's the production system for the latest biological control agent - a virus. When the eggs hatch, in 180 days, the cups are infected with the virus. With this timing, the virus will kill the gypsy moth caterpillars just as they reach maximum size. It's the most efficient way to produce the largest amount of virus, which is now being used in aerial spraying. The virus occurs naturally, it was isolated from gypsy moths already in the US, and it's supposed to only attack gypsy moths. The problem is it's expensive, because it can only be produced using live gypsy moth colonies. With our century-long struggle against the gypsy moth, it's clear that it's better to prevent alien species than try to cure them. But Vic Mastro believes the task is so enormous that our only hope lies in knowing ahead of time where the dangers are.

VIC MASTRO I think the problem of introduced pests is a huge problem. I think it is as big a problem as global warming. I don't think we can exclude everything. It's just a huge, huge task. And the volume of people moving around the world and trade items is so great that you can't look at everything. But I think we can target very specific things and say we'll exclude those from introductions.

ALAN ALDA (NARRATION) And right now, we're faced with two certain targets for exclusion. *Caulerpa taxifolia* and the Asian longhorned beetle are both potential gypsy moths, or worse. And in both cases, there's still time for an ounce of prevention

## DUST BUSTING

ALAN ALDA (NARRATION) The Virgin Islands. From here down to Venezuela it's a five hundred-mile loop of beautiful, small islands set in a sparkling sea. They're some of the world's most popular tourist destinations -- to find the sun... or catch a wave. Below the surface things get even better. Coral reefs -- the rain forests of the ocean -- delight the eye and the imagination. But here they are the setting for a most surprising alien invasion. It's a coral disease, which came from another continent, and a completely different environment. In the winter of 1998, I found myself being thrown around in a small boat, in the company of three coral experts -- Gene Shinn and Ginger Garrison of the US Geological Survey... And Garriet Smith from the University of South Carolina. We're off St. John -- but this is no vacation.

ALAN ALDA Caribbean, they said, we're going to shoot in the Caribbean. Nice. All these great stories, sun, surf...

ALAN ALDA (NARRATION) We found a spot that was sheltered and got ready to check out the reef. The scientists and I are going to be free diving, while our

underwater camera crew will be using scuba. Free diving's a lot simpler than scuba, and just fine for seeing shallow reefs like these, ten or twenty feet deep. The bad weather has stirred up sediment, so it's not as clear as it could be. But it's more than enough for Ginger to point out the problems. Here comes the free dive... And here's the problem. On this boulder coral, large patches -- called "white plague" -- where the living surface has died off.

GINGER GARRISON Looking pretty slick there.

ALAN ALDA (NARRATION) As we head back down, I realize that white patches of different sizes are everywhere on the boulder coral. It's one of the Caribbean's principle reef-building corals, so this is a disturbing sight, to say the least.

ALAN ALDA When I see the white stuff down there, what am I looking at?

GINGER GARRISON Well, the white area that's surrounded by the normal looking coral tissue that's brown is actually just the skeleton. What's happened is the disease, whatever the pathogen is, has evidently killed the polyp and that tissue has sloughed off. So it's as if we lost everything except our bones so that we wouldn't have any flesh on them.

ALAN ALDA (NARRATION) Next Ginger takes me down to check out the sea fans. There are clumps of them all around, waving lazily in the swells. Sea fans are one of the soft corals -- not reef-builders, but an important part of reef ecology, providing shelter for many inhabitants. But the sea fans are in bad shape. This is a typical example -- chunks of the fan rotted away, with bright purple patches. Once you know the symptoms you notice them everywhere. Garriet Smith outlines a light purple infected area. Eventually it'll die off, leaving a gaping hole in the fan. Here the process has already started. This is not just a local problem -- sea fans all over the Caribbean are affected. On the reef there are fans at every stage of deterioration. This one's lost almost all its living tissue. So out we came -- cold, wet, tired, depressed at the state of the reef. And as if that weren't enough...

ALAN ALDA I have a blister from my flipper.

ALAN ALDA (NARRATION) Then I realized that my companions don't care about working conditions. It's knowledge they're after.

ALAN ALDA Ha ha ha, I love it. Science!

ALAN ALDA (NARRATION) This is a diseased Caribbean sea fan in Garriet Smith's lab at the University of South Carolina. You can see the skeleton from which the living white tissue has died back. The brown growth is some kind of

secondary infection, and the purple is an immune reaction that shows the coral is trying to fight whatever is attacking it. So what is attacking it? The team's now pretty certain they've nailed it down. Here's what they did. Samples were taken from diseased sea fans from six different islands. After culturing for a few days, this is what they got... A whole mix of about a dozen fungi and bacteria. It looked to Garriet that only one was common to all the sea fans. It had the typical threadlike appearance of a fungus. Garriet confirmed that it caused the disease, by deliberately infecting healthy sea fans. So now it was time to identify the fungus. It's routine nowadays to map out the DNA of organisms.

KIM RITCHIE A - G - T - A - A...

ALAN ALDA (NARRATION) Garriet and Kim Ritchie mapped out the fungus' DNA, looked it up in the databases -- and got a big surprise. Sea fan disease was caused by a common soil fungus called *Aspergillus*. You could find it in any backyard. But how was *Aspergillus* getting to coral reefs in the Caribbean? Take a look at this. This picture was shot from the space shuttle over the Atlantic. The brown stain is dust -- millions of tons of it -- coming from new farmland in Africa. In drought years, when there are often dust-bowl conditions, huge quantities are swept across the ocean on the trade winds, to settle on the Caribbean. Gene Shinn suspected that the dust could be delivering a constant dose of damaging material to the water, and to the coral. And it could explain why coral diseases appear all over the Caribbean at the same time. Gene takes up the story.

GENE SHINN I got talked into presenting this as a hypotheses at the Oceanographic Society annual meeting last year on April Fool's Day, by the way, and a lot of people took it that way...

ALAN ALDA They didn't go along with this idea.

GENE SHINN I had discovered that everyone who studied dust in the past, the one common denominator is they all got laughed at one time or the other. And they were studying dust in the late 60s and early 70s and there wasn't that much dust. But it's a hundred fold greater now.

ALAN ALDA Is it pretty clear to you therefore that this rise in disease here in the coral is because of the desertification effect?

GENE SHINN Well, it was just an observation that the peak years for the dust, like '83 or '87, these were big years for the coral reefs and things changed. It seemed like there was a link.

ALAN ALDA (NARRATION) To find out what the Caribbean winds contain, Ginger Garrison sampled the air above St. John. The filter papers went to Garriet

Smith in South Carolina. And along with dust particles, he saw thousands of tiny fungal spores. So next step -- culture the spores. A few days later -- another mix of organisms. And among them -- you guessed it -- Aspergillus. So Aspergillus spores are flying 4,000 miles across the Atlantic, settling onto the reef, and then attacking the sea fans. It's an important breakthrough in understanding coral disease, and a remarkable example of how alien species can behave in unexpected ways in a new environment.

GENE SHINN The gods are with us.

ALAN ALDA (NARRATION) I'm getting to be a real pro at this now. Gene Shinn's moving on to the next phase of the investigation. He's drilling a deep core sample from a large boulder coral. The aim is to look at the recent history of the reef, to see if what happened from year to year can somehow be matched up with dust conditions.

GENE SHINN There you go, that's about thirty to forty years of growth. Not as easy as it used to be.

ALAN ALDA Do you see anything on this? Can you read this in any way now without taking it to the lab?

GENE SHINN Well, you can see this is the growth axis, these lines pointing this way, and that's each individual polyp and you can see the little polyps. It's like a little jellyfish that secretes calcium carbonate and so our plan is to take the segments, cut them out with a diamond saw, dissolve them in hydrochloric acid and then we get a residue, and that residue will be, hopefully will be, African dust.

ALAN ALDA (NARRATION) It took a lot of work, but eventually they were able to find African dust trapped in coral cores, corresponding to the recent bad dust years. Since the breakthrough with sea fan disease, the team has found a second coral type - called sea whips - being attacked by Aspergillus. And they're on the track of a second soil microbe, which may be causing "white plague", the coral bleaching disease. They've also started to look into the idea that African dust may be connected to the huge increase in asthma around the Caribbean - up 17-fold in the last 30 years. We're going to be hearing a lot more about dust in the years to come.

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