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RAVEN'S WORLD

SHOW INTRO

ALAN ALDA This is prairie. It's a French word meaning "meadow" --but what a meadow. The early French explorers who first used the term couldn't have had any idea what they had stumbled across. The area we call the Great Plains was once the greatest grassland on Earth, covering over a quarter of the continental US, stretching up into Canada and down into Mexico. But now there's only about one percent of original prairie left. It succumbed to the tide of railroads, steel plows, barbed wire, cattle and settlers that began to flood west 150 years ago. We lost an enormous interlocking community of plants and animals, but of course we did get something in return. The Great Plains now yield roughly 25% of the entire world harvest of wheat, oats, barley, rye, sorghum and corn. That process, the replacement of the Earth's wild places by domesticated landscapes, has been going on for about 10,000 years now, ever since people invented agriculture. Today that action is concentrated in the belt of tropical forests that girdle the Earth, and later in the program I'll be talking with Peter Raven, one of the world's best known advocates of forest conservation, about why we should care about losing wilderness.

ALAN ALDA (NARRATION) We'll also be visiting Biosphere in Arizona. It's been completely reorganized as a climate research institute, with sealed-in models of the earth's key wilderness areas. Now scientists can begin to see how those areas could react to the global climate, 50 or 100 years in the future.

ALAN ALDA But first -- the prairie. There's now a significant movement to restore some of what we've lost. To bring back to at least parts of the Plains the essential wildness they once had. Reassembling a working ecosystem is a little like trying to put Humpty Dumpty back together, but a few places are beginning to be wild places once again.

PRAIRIE COMEBACK

ALAN ALDA (NARRATION) First light, on the prairie. We're in northeast Oklahoma, to witness a tradition that stretches back all of 7 years, but with ancient roots. It's the annual bison roundup on what was once the Chapman-Barnard cattle ranch. Stampeded into the corral, by cowboys in pickup trucks, are the first of over 1,000 bison -- also known as buffalo. 5,000 years ago the stampede would have been started by Native American hunters, using a ring of fire set in the prairie grass - although probably not during a downpour like this. Today there'll be no feasts of fresh bison meat, but instead a systematic checkup of each animal to make sure this precious herd stays in peak condition. In 1989 the ranch became the Nature Conservancy's Tallgrass Prairie Preserve, the largest prairie restoration project on the continent.

ALAN ALDA I don't want to get, you know, unduly nervous, but... they're heading for us.

BOB HAMILTON Yeah.

ALAN ALDA Yeah. Well maybe we should just step inside the thing here.

BOB HAMILTON They like us.

ALAN ALDA No, I think we should step inside the corral. You want to come with me or are you just gonna stand out there?

BOB HAMILTON Oh no no… they know me.

ALAN ALDA Well, that wasn't so bad.

BOB HAMILTON No, no.

ALAN ALDA Kinda easy. They are coming back!

BOB HAMILTON They have a very strong, bison have a very strong herding instinct.

ALAN ALDA Yes, so do I. What do they do for the land? Why… why are you so concerned about bison as far as the land is concerned?

BOB HAMILTON In Great Plains grasslands, you're looking at grazing and fire, are really the two management forces that we're trying to put back into these landscapes. And bison were the primary, the premiere historic grazer in the Great Plains.

ALAN ALDA (NARRATION) But the bison were too easy a target. In the 1860s special excursion trains, riding the new railroads, brought random and widespread slaughter deep into the Plains. Most carcasses, killed for fun, were left to rot. Then in the 1870s, bison robes became all the rage, and the collapse of the great herds began. It's almost incomprehensible, but by 1900, 60 million animals had been reduced to a few hundred total, most in zoos and private herds. Settlers moved in where Plains Indians and the bison they depended on had co-existed for thousands of years. Teams of "prairie breakers" as they were known used oversize plows to expose the rich soil for the homesteaders' crops of corn and wheat. John Deere's steel plow, invented in 1835, was tough enough to bust open the tangled prairie sod - itself a material strong enough to build houses with. America's great unbroken grassland - our Serengeti - is gone forever. Parts of the arid short-grass prairie, closer to the Rockies and now used for grazing, could be prairie again. But in wheat and corn country - the Dakotas, Nebraska, Kansas, Iowa, Illinois - we couldn't bring the prairie back if we wanted to. The whole system of native plants and animals has simply disappeared. Except, that is, on the Chapman Barnard Ranch. It was never plowed, so every prairie plant is here, somewhere on its 38,000 acres. It seems strange to immediately start burning things up, but that's exactly what the Nature Conservancy did when they moved in. I'm about to find out why.

HARVEY PAYNE Well, Alan, I hate to tell you this, but the cowboy custom is, the person on the right has to get the gate.

ALAN ALDA Okay, I'll be a good cowboy. One second.

ALAN ALDA (NARRATION) Extremes of heat, cold, drought and storms are normal here -- not so comfortable for us modern cowboys, but they kept the prairie ecosystems happy. In spite of the weather Harvey Payne, the preserve director, offered to show me the secrets to prairie restoration.

ALAN ALDA Just call me Slim.

HARVEY PAYNE Okay, how about Tex?

ALAN ALDA Tex is good.

ALAN ALDA (NARRATION) One secret is size. This place is big - 50 square miles - so there's room for different things to happen in different places. Our first stop was here, in an area that was burned in late August, about 2 months ago, leaving enough time before winter for warm-season grasses to re-sprout.

HARVEY PAYNE The bison, once they're released from the corrals will utilize this area very heavily.

ALAN ALDA Because this is the new growth that they like so much?

HARVEY PAYNE Yes, it is. They will use the re-growth from a burned area almost exclusively to all other parts.

ALAN ALDA (NARRATION) Prairie plants have specially deep root systems, so they can survive both drought and fire. When the hot fire passes above, the roots below are unharmed and even stimulated by the warming of the soil. The animals will graze here all winter and into next spring. At that point there'll be a dramatic change - all the broadleaf plants, which bison won't eat, will come back very strongly, because there's no competition from the overgrazed grasses. Harvey showed me the result on this patch.

HARVEY PAYNE This area was burned a year ago last summer and it was used very heavily by the bison in the first growing season. The bison have grazed the grasses very closely to the ground, allowing the broadleaf plants to exhibit themselves much more dramatically.

ALAN ALDA (NARRATION) The broadleafs produce flowers and seeds, which in turn attract insects, birds and small mammals. Then over a few years the bison will find a new burn area, grasses will come to dominate again, and the patch will end up like this - with a thick thatch of grasses, ready to burn once again. It's this shifting interaction between burned patches and bison which is the biggest secret of the prairie. It may look tranquil and settled, but it's a jungle out there. Things are always changing, and for every slight alteration there's a plant, an insect, a bird that's perfectly adapted to the new conditions. So real prairie, they've discovered here, is not just grassland. It's hundreds of tiny subsystems, all mixed up.

HARVEY PAYNE We call this a disturbance-dependent landscape. And those disturbances are fire and grazing primarily by bison. But that's what shaped this ecosystem. And that's what's allowed the 750-plus plant species here to develop and to flourish. That's what happened to allow all the different bird species, the insects, the reptiles, the amphibians, nematodes in the soil.

ALAN ALDA (NARRATION) Already at the Preserve you can see the richness coming back to prairie life. Prairie chickens - grouse - like to feed on new growth, but nest in mature grass. Sandpipers prefer the partial shelter of young grass. Rare harrier hawks follow the mice, and the mice are where the best seed crops happen to be. Multitudes of insects are attracted to many different flowers. And it seems there's a dozen different flowering plants for every week of spring and summer, every different patch of light or shade or passing shower. Once these

constant ripples of change were flowing across millions of square miles. But now the challenge is to maintain them over just 50.

HARVEY PAYNE That patchwork dynamics took place on a large scale in the tall grass prairie as an ecosystem. We're trying to reduce that scale in size to this preserve.

ALAN ALDA (NARRATION) Here's the deliberately complicated burn pattern they're developing for the first third of the Preserve so far. About 50 different patches get either a Spring, Summer or Fall burn, about every 5 years. Manipulating the land like this is truly a return to an earlier age, because the prairie was largely created by people. For thousands of years Native Americans set fires to attract bison to the new growth, probably more fires than were started by lightning. So over time, every plant and animal became adapted to fire and bison. Nature's machinery is perfectly tuned. Seeds caught in the bisons' thick coats, for example, get spread across the land - especially when the animals wallow in the dust. Eventually the bison wallows make seasonal ponds, which attract birds and snakes, which then… Well, you get the idea. We're back on the Preserve, at the start of the roundup. 1,300 bison are out here somewhere, but where? Most of them are exactly where you'd expect -- on the newly burned patches. It takes a week to drive the herd into progressively smaller enclosures. And every year a few just can't be caught - usually the strongest, most experienced bulls, that can outmaneuver anything. Cows with this year's calves are the easiest to catch, and that's important, because the long term goal is to imitate ancient hunting pressure from wolves and Native Americans. So once they've built up the herd to the limit of about 3,000 on their 30,000 acres, they'll sell off mainly calves. Eventually the whole herd, minus a few bulls, is collected in one 50-acre pen. Then for about a week, batch after batch of animals is run through the corrals. For these cowboys, it's like working with stronger, faster, more aggressive cattle - although that doesn't prevent some pretty daring moves every now and then. This year's calves are separated out to get their vital brucellosis shot. Brucellosis is a serious cattle disease, and the Preserve has to co-exist with its cattle-ranching neighbors. The calves will rejoin their mothers later. All the rest go down the chute. Every animal has its computerized record and its place in the herd structure. So this is a simulated wild herd. But they're still wild animals nonetheless.

ALAN ALDA These guys are frisky here. Okay, go ahead. Go, go!

ALAN ALDA (NARRATION) The whole chute has to be higher, stronger and tougher than what you'd use for cattle. There are routine shots for parasites and other cattle diseases - also to be good neighbors.

BOB HAMILTON They've all got microchip transponders in their ears. These tags…

ALAN ALDA How do you get this guy's job over here?

RANCHER You make him mad.

ALAN ALDA Whoa!

RANCHER I've been a bad boy!

BOB HAMILTON As you can see, right… right there...

ALAN ALDA Aha, yeah.

BOB HAMILTON ... is the tag. It's just a small plastic tag. It has a microchip inside of it. So you…

ALAN ALDA Who gets to put the tag on his ear?

BOB HAMILTON We put them in typically as yearlings or calves.

ALAN ALDA Oh, I see -- when they're a little more manageable.

BOB HAMILTON ... easier to handle, yeah.

ALAN ALDA And what kind of information is in that tag?

BOB HAMILTON Basically kind of like a social security number.

ALAN ALDA How do you decide what happens to the animals after they leave this point?

BOB HAMILTON Well, it's all determined beforehand who stays and who goes. By knowing the complete structure of the herd, then you can sit down in the comfort of your office and figure out what the carrying capacity is for next year and the year after. As they come through then, we can identify those animals and basically they have been flagged. So, OK this is a 15-year old cow, you know this is her year to go.

ALAN ALDA (NARRATION) Before long I was wondering if it was my year to go.

BOB HAMILTON Just lean in there. Don't get too close, especially to the adults. They will sucker you in to where you think...

ALAN ALDA They'll sucker me in?

BOB HAMILTON Yeah, yeah. You think they're at their full extent…

ALAN ALDA Oh yeah.

BOB HAMILTON ... and you'll lean in and they'll lunge out and they've got another 18 inches to go and you'll get a horn in the ear.

ALAN ALDA Okay.

BOB HAMILTON You're on.

ALAN ALDA Oh great. Whoa.

BOB HAMILTON Watch out. Watch out for the equipment there. There you go.

ALAN ALDA Did you get it? Did we get it?

WOMAN Got it.

ALAN ALDA We got it. Good. Take this. I'll see ya… I'll be at the luncheonette.

ALAN ALDA (NARRATION) One surprise this year was finally catching up with this terrific 1,600-pound bull. He was not happy about it. Brought in from Montana 2 year ago, he had never got his microchip tag.

BOB HAMILTON He was a no show last year. He didn't cooperate in the round up.

ALAN ALDA (NARRATION) Regularly introducing genetic variety with new animals like this is another key part of managing the herd. The Tallgrass Prairie Preserve is a highly successful restoration project, but for it to stay wild humans will need to look after it forever. In our next story, we'll see how scientists are deliberately damaging model wild areas, to simulate the future.

THE SECOND EARTH

ALAN ALDA (NARRATION) This is the Sonoran Desert in Arizona. And this is Biosphere 2. It was built to be an earth capsule - a replica of the world, but sealed and isolated. Its mission was launched in 1991. The eight Biospherians embarked on a 2-year experiment in self-contained living, supported only by the natural ecosystems inside. It was to be a demonstration to the world of our

dependence on nature and the earth. Biosphere met that goal - but not in the way that was expected. Today, tour groups admire the futuristic décor and impressive systems that remain in place. The experiment in self-contained living, though, was a failure. The sealed-in atmosphere became dangerously unbalanced, with oxygen going down, and CO2 building up. Eventually, outside air had to be brought in, proving not only that it's hard to live in a large greenhouse, but also making it clear how dependent we all are on the availability of the earth and its systems. When the self-contained experiments ended the question was, What could be done with this magnificent, 3-acre, 150 million dollar structure? There were 7 miniature ecosystems from around the world, hundreds of plant species, an agricultural area and elaborate heating, cooling and rain systems. Happily, Biosphere's Achilles heel during the self-sufficient living experiments has turned out to be its greatest asset for doing research. Because it can be sealed off, it's possible to deliberately change the conditions inside, and measure how the natural systems respond. In 1996, Columbia University took over Biosphere and gave it a new mission - to become a center for research on the earth's climate. The main goal would be to explore how rising levels of CO2 gas in the earth's atmosphere might affect natural systems, like forests or coral reefs. CO2 comes from burning fossil fuels, like coal or oil. Already it's reached twice the level it was in pre-industrial times, and it'll double again by the middle of this century. Scientists generally agree that rising CO2 is causing global warming. It's likely there are complicated related effects going on, too - like storms or droughts or shifting weather patterns. Much of the research here is trying to get at the basics. Will extra CO2 in the atmosphere affect forests or oceans not just through changing weather, but directly - in how they live and function?

BARRY OSMOND The best view is from up by the new student village.

ALAN ALDA How many students do you have there?

BARRY OSMOND Well, we've had about a hundred and fifty in the first session this summer.

ALAN ALDA (NARRATION) The new director of Biosphere is Barry Osmond, a plant and forest biologist. I was last here in 1995, before the research goals had been worked out.

ALAN ALDA Some of these things look like they've actually either died or are on the verge.

BARRY OSMOND They've wilted. We've lost a lot of leaf on some species. One of the curious, well, important things is to discover which species do what in terms of response to drought. Sound effects are very good.

ALAN ALDA Yeah, very nice. Very mysterious.

BARRY OSMOND Right. I think you've been here before. A number of years ago.

ALAN ALDA Yeah, yeah.

BARRY OSMOND This new balcony...

ALAN ALDA This walkway wasn't here, was it?

BARRY OSMOND No, this has only been in since January of this year. And behind you, you see one of the other major reconstructions. See the plastic curtains?

ALAN ALDA Oh, yeah.

BARRY OSMOND ...that were installed to seal the rainforest off as a separate chamber.

ALAN ALDA (NARRATION) You can't do research on the model systems unless they have their own isolated climates. Plastic curtains also divide the former agricultural area into three separate, young intensive forests.

BARRY OSMOND It's the concept of enclosure and control that makes it an experimental system. And it's really the only place on the planet where you can do these large-scale experiments. These experiments that we talk about as driving the new discipline of experimental climate change science.

ALAN ALDA (NARRATION) Here's a use for the miniature ocean which the Biospherians would not have imagined.

BARRY OSMOND The rain experiment was simply a matter of putting garden sprinklers from here to there, every ten feet, turning them upside down, and making it rain with the right-size raindrops.

ALAN ALDA (NARRATION) Scientists from half a dozen institutions descended on Biosphere to create a storm at sea, more realistic than any Hollywood special effect. They know it was realistic because they measured everything imaginable - the surface turbulence, the mixing of fresh and salt water layers, the size of the drops. The goal was to see how storms affect the way CO2 in the air gets absorbed into ocean water. Right now it's believed that about a third of the globe's man-made CO2 is consumed by ocean plankton. So we need to know how the whole process works. This kind of information is essential for building

computer simulations of the global climate of the future. In this case one 2-hour storm, with 6 inches of rain, yielded a surprise result.

BARRY OSMOND We discovered that large raindrops stimulate the mixing of the air and the gasses in the ocean, a factor of ten times. The first time.

ALAN ALDA Now that's something that you wouldn't have been able to find in nature, isn't it?

BARRY OSMOND You can't do that experiment in nature. You can imagine what it's like, trying to find a rainstorm at sea and then do something like that.

ALAN ALDA (NARRATION) I'm with Guanghui Lin, Biosphere's resident rainforest expert. We're on our way to the now-sealed off rainforest. You have to go through the basement to get there. Down here you realize it may all be natural up top...

GUANGHUI LIN Just like a factory.

ALAN ALDA (NARRATION) ...but there's nothing natural about the systems everything up there depends on.

GUANGHUI LIN …gonna go through the rainforest airlock.

ALAN ALDA OK.

ALAN ALDA (NARRATION) Three hundred species were originally planted here 10 years ago.

GUANGHUI LIN A lot of banana tree around the side.

ALAN ALDA (NARRATION) Two-thirds of the species that were planted died within a couple of years, but it's now stable and steadily maturing. So it's not exactly like a real forest, but Guanghui is confident its basic processes are the same - and that's what he studies.

GUANGHUI LIN Rainforest very important system on earth. Right now people believe that a significant amount of carbon that humans put into the atmosphere was locked into the rainforest. In this so-called CO2 fertilization effect.

ALAN ALDA So it's locked in there?

GUANGHUI LIN That's correct. At least temporarily, or sequestered there, locked there.

ALAN ALDA (NARRATION) So right now rainforests are essentially growing faster because of the increased CO2 in the air. In the process they absorb about a third of the CO2 humans are generating -- about the same as the ocean. The big question is, how long can rainforests keep it up? This is the standard way to measure how active a leaf is - how much CO2 it's taking in by photosynthesizing. You can do this anywhere - in an Amazon forest or in a lab. But because this forest is totally enclosed, they can go much further. They can track what happens to all the CO2 in the system. CO2 is absorbed by growing leaves, but it's given off by decomposing leaves. It's also given off by billions of microorganisms active in the soil, or by plant roots. When he tracked everything in this way, Guanghui made a disturbing discovery. If he runs the rainforest chamber with a mid-21st century atmosphere -- about double today's CO2 -- just as much CO2 comes out of the forest, from the roots and soil and leaf litter, as goes into the leaves in the canopy. The forest reaches its limit.

GUANGHUI LIN At the highest CO2, the rainforest as a whole system reaches so-called CO2 saturation. At that point, CO2 coming into the forest will come out almost in the same amount.

ALAN ALDA You mean like if you pour enough milk in a milk bottle, it overflows. Or a bucket.

GUANGHUI LIN Exactly.

ALAN ALDA (NARRATION) If Guanghui is right, that means in about 50 years rainforests will be losing their capacity to lock in CO2. And that's without taking into account the steady loss of rainforests that's going on now.

ALAN ALDA Is this overstating it? We could once handle the rate of, the rate at which we put carbon in the atmosphere. But now we're reaching the limit of it to hold it as a sink. And the whole system is reaching a limit so that the more we put in now, the more the effects of that carbon in the atmosphere will accelerate.

GUANGHUI LIN Exactly. Exactly. That's, you... I think that statement is correct.

ALAN ALDA (NARRATION) In the last couple of years, Guanghui has also put his rainforest through a series of droughts. One prediction for global warming is that there will be more frequent droughts in the Amazon. After a drought here, the forest is revived with rain before the plants are permanently damaged. It's known that during a drought, leaves shut down - they stop photosynthesizing. So if the soil and roots just keep on giving off CO2, a drought-stricken forest could turn into a CO2 source, rather than a sink. But here they've found the soil and roots shut down too, so at least the atmosphere won't be gaining CO2 during forest

droughts. Like the ocean rain experiment, the drought and high-CO2 work would have been very hard to do out in the real world. And keeping track of all the CO2 is impossible - you can only do that in a completely enclosed system. It's been just 6 years since the Biosphere rainforest was turned into a climate research tool, and already it's yielding significant results. In future, we'll be hearing more from this little patch of forest. One thing about Biosphere is you can usually count on the weather.

ALAN ALDA Thank you. I'll see you later.

ALAN ALDA (NARRATION) I don't think there are any violent ocean storms scheduled for today, so I'm heading out to check on the coral reef, with Les Kaufman, a marine biologist. The three-quarters of a million-gallon ocean tank is not in such good shape as the rainforest. All this furry stuff is algae. There are a couple of fast-growing species which have come to dominate. The corals have to compete with the algae for light, so species that grow slowly - like this one - have a hard time. The white parts are dead. Life and death struggles are normal on reefs, and corals usually bounce back rapidly after fish or algae attacks. But here the balance has tipped towards algae. Natural reefs have more light than Biosphere's, and more fish. The fish eat the algae, allowing the corals to grow vigorously. A healthy reef can even recover from so-called bleaching events, when unusually warm water kills off the corals. Bleachings are likely to happen more often with global warming. The darker patches here are corals growing back. Designed to simulate a typical Caribbean lagoon and reef, Biosphere's ocean tank was started off with a natural diversity of corals and fishes. There were 31 coral types, 47 fish species and hundreds of individual fish. But fish began to die, it was too dark for some corals, and the water was too rich in nutrients - partly because at first the tank was connected to the mangrove swamp. In nature a reef and a swamp wouldn't be so close. The result was a plague of algae. Like the rainforest, the tank is now stable and self-contained. The fish are feeding on the algae, and the remaining corals are surviving. But Les Kaufman says it's like a damaged Caribbean lagoon, which has some pollution and is overfished. Even so the tank has turned out to be a terrific research tool. Like in the rainforest, the first thing they did was a long-term experiment on the effects of high CO2 in the atmosphere. It's easy to simulate that here by slightly changing the water chemistry - something you can't do in the open ocean, of course. The result was spectacular and alarming. At CO2 levels we'll reach 50 years from now, corals reduced their growth rates by 40 percent. The CO2 disrupts the way corals make their calcium carbonate skeletons. They're now building on that first big result. Because the tank contains a working reef community, Les Kaufman is looking at how high CO2 affects the constant struggles between competing species.

ALAN ALDA Are these the cages here?

LES KAUFMAN These are they right here. So there are four of these arrays, and at every one there's a cinderblock with exposed corals, and a cinderblock with caged corals.

ALAN ALDA (NARRATION) Arrays of different baby corals are laid out in the shallow water, where light levels are close to normal. Some samples are in the open, others in cages. The cages keep fish - which would normally graze on the algae - out. There are still enough algae-eating fish in the tank to pick the exposed coral samples pretty clean. They're finding that high CO2 tips the balance further toward the algae. If there are no fish around, the weakened corals tend to lose the battle, and become smothered with algae. Les Kaufman believes this offers a glimpse of what's happening outside Biosphere.

LES KAUFMAN All these things are going on at the same time out in the real ocean. The CO2 level's going up, coral growth is slowing down. We're over-fishing. We're taking away the fish.

ALAN ALDA The fish eat the algae...

LES KAUFMAN ...eat the algae.

ALAN ALDA So it sounds like, if what you think may be happening is happening, that it's gonna accelerate the rate of damage to the coral.

LES KAUFMAN Dead on. That's exactly right. And I think that's part of the reason why even in areas where bleaching is not a severe problem right now, corals are going under very quickly.

ALAN ALDA (NARRATION) I challenged Les Kaufman to explain why people who never see coral reefs should care about the threat to them.

ALAN ALDA So we lose the coral. What difference will that make?

LES KAUFMAN Well, of course I'm partial to coral. And anybody who lives between 25 degrees north or south latitude is partial to coral, because it protects shorelines and provides food, and tourism -- huge tourism industry. But forget about the corals as anything but a harbinger of what we're going to be feeling in the entire world ocean. I mean, one of the things people don't realize is that, even though a lot of talk now is about threats to coral reefs, all the marine organisms in the whole world ocean that build their skeletons out of limestone, out of calcium carbonate -- that's clams and lobsters and shrimp and on and on and on -- all of those organisms are going to suffer from this effect.

ALAN ALDA (NARRATION) At Biosphere they're beginning to look at ways to respond to increasing CO2 in the atmosphere.

BARRY OSMOND We've kept one of the original living quarters as a museum. And this is the one here.

ALAN ALDA (NARRATION) A big part of the original Biospherians' mission was to grow their own food. Although they were often hungry, they did manage to support themselves on a half-acre of intensively cultivated high-quality soil. Today the agricultural area has been separated into three sealed greenhouses, with CO2 at the level of today's atmosphere in one, and double and triple in the others -- where we'll be in about 50 and 100 years' time.

ALAN ALDA What makes you say that the CO2 concentration will be like that at the end of the next century? That seems an awful long way off to predict.

BARRY OSMOND There's no doubt. You know, I'm as sure about these numbers -- within a large error -- but I'm as sure about the increase as anything I know. It is clearly, that's the way it is. There is no doubt about it anymore.

ALAN ALDA (NARRATION) The three greenhouses now contain young poplar trees. They're grown around the world in intensive forestry operations, as pulp wood for newsprint. They grow 3 feet a month in season, then here they're cut back to start again the following year. The theory is that poplars could be grown specifically to absorb CO2. Then instead of going for pulp, they'd be used for furniture, or even stored in the Arctic, so the CO2 would stay locked up in the wood - or sequestered, as biologists say.

ALAN ALDA That sounds like what we ought to do is plant poplar trees all over the place and help reduce the effect of this warming that we're creating.

BARRY OSMOND This is a small component of what has to be done. It's the best that biology could do. That is, to take a fast-growing tree that produces a fixed form of carbon, which is not going to metabolize very quickly and get some degree of sequestration, effect some degree of sequestration. This is not going to answer the problem of rising CO2 altogether, but it's a useful contributing part.

ALAN ALDA (NARRATION) The Biosphere intensive forest is now in its third research year, but already there have been surprises. In year one, the high-CO2 trees grew faster than the ones with low CO2, but in year two they didn't. And because this is a closed system, they know the CO2 was still absorbed. Unless there was some kind of mistake, the CO2 must have gone below ground - into the roots or soil. That could spell trouble for the idea of forest sequestration.

ALAN ALDA We're figuring out ways to store the badness, but we're building up a bank account apparently, of that badness and it's like a time bomb. Because unless we figure out a way to do something with it, we've got all this stuff laying in the ground that can open up.

RAMESH MURTHY We don't know. We don't know.

ALAN ALDA Yeah, you don't know what the mechanics of that are.

RAMESH MURTHY Right. We don't know if it's going to be a bank account. We don't know if it's going to be a time bomb ticking down there to come out. So that's... we need to know. If we have to go forward and use forests as a, sequestration, as a policy, you need to know what happens both above and below ground.

ALAN ALDA (NARRATION) In the coming years at Biosphere, they'll be pursuing that question, and many others related to the global climate. How important are those questions?

ALAN ALDA There are a lot of people who say, we don't have to do anything about this now because scientists are really in disagreement about how really serious the question is, CO2 and the atmosphere. Are they?

LES KAUFMAN Well, there are still a few people who carry a healthy skepticism about the exact nature of what's happening and how it's happening. And we need to be skeptical about details. But if you're asking me, is elevated CO2 in the atmosphere a problem? That we need to do something about now? The evidence in my book is overwhelming.

ALAN ALDA (NARRATION) So maybe Biosphere, once an answer looking for a question, has now found its role.

BARRY OSMOND I think, on the basis of our observations, our experiments, the case will be easily made for manipulative experiments in climate change science. And that's the future.

RAVEN'S WORLD

ALAN ALDA (NARRATION) The Missouri Botanical Garden in St. Louis. I'm visiting its director, Peter Raven. We're heading for the Garden's signature half-acre geodesic dome, now a 40-year-old classic.

ALAN ALDA Now is this a rainforest?

PETER RAVEN It is up here. It's warmer and then it's cooler down there. So over here we can grow plants that are really from tropical rain forests, and as you go down towards the west here you get into plants that are from cooler and cooler places, like the islands in the Pacific or from cloud forests. Basically we try to build as much variety in here as we can, so people can get a good idea of what it's like in the tropics.

ALAN ALDA Is this place mostly for people to become educated about rainforests in general, or do you actually do research on these plants here?

PETER RAVEN It's mainly to educate people about what the plants are like in the rainforests and other kinds of tropical forests around the world.

ALAN ALDA So these plants are, in a way, in an environment that they wouldn't find themselves in the natural world.

PETER RAVEN Well, the temperature and the humidity and all are about the same. I mean, one of the funny things is it's really cooler in the tropics than it is in St. Louis in the summer.

ALAN ALDA So you have to air-condition it.

PETER RAVEN We need to actually cool the place…

ALAN ALDA …to keep it tropical. What's happening?

PETER RAVEN Vents are opening or something because the temperature is hitting some kind of a critical level. It'll be over in a minute. It's something like opening vents.

ALAN ALDA You just have to think about temperature or mention it and the windows open.

PETER RAVEN No actually, that's what I wish.

ALAN ALDA (NARRATION) In Raven's 30 years as director, the Garden's sparkling public displays have gone from strength to strength. They're comparable to the New York Botanical Garden, or Kew Gardens in London. But Raven's done something else here, that the public doesn't see. This is now one of the leading plant research centers in the world, and the headquarters of attempts to save US endangered plants. Raven has been a passionate conservationist since the 60s when, on academic field trips, he saw the reality of mass extinction developing in the tropics. Mixed in with the plants being raised

for display are some of the rarest plants in America, saved in the nick of time from extinction.

PETER RAVEN This is a medlar. It's a plant that was discovered about twelve years ago. A little tiny grove of these, with just 26 individuals was discovered in Central Arkansas. The whole genus, the whole kind of plant was unknown in North America before.

ALAN ALDA Is there something special you can learn when you have a plant like this that seems to be unique. I mean that's so different from it's neighbors?

PETER RAVEN All that we know is that since it's very unique, since its so unusual, it may have characteristics that are outstanding.

ALAN ALDA (NARRATION) Here's a unique lobelia from Hawaii, with fewer than 200 in the wild. Here's a rare member of the pea family, from Tennessee, and here's a groundnut with 25 little patches left in the Midwest. So why should we care about a rare medlar from Arkansas?

PETER RAVEN This is a plant in the rose family which has lots of plants of economic importance: apples, plums, peaches, strawberries and so forth. So it could be that the genetics of this particular plant would be of interest in relation to economic uses of the rose family directly. But we just don't know. We're barely getting the tools to even be able to think about those questions.

ALAN ALDA In a way, letting this go would be like burning down a library that had only one copy of each book.

PETER RAVEN Letting any species go is like that.

ALAN ALDA (NARRATION) One of Raven's favorite projects here is a 15-acre Japanese garden. It's vital, he says, for Americans to learn about others, and to understand what's going on out there. It's a crisis, and the prognosis is clear.

PETER RAVEN We'll lose about half of all tropical species during the course of the next century, which amount to about a third of all the species on Earth.

ALAN ALDA (NARRATION) The images are by now familiar. Tropical forests are rapidly disappearing, at the rate of about 150 square miles a day - 1% a year. Forest is fatally attractive. The timber's worth money, and the space gives room to expand. Developing countries need both, as they follow the way we in the industrialized countries do things.

ALAN ALDA Why is it important not to let species go extinct? What difference does it make? Does it make a difference to us as humans? Does it make, I mean, will we perish if a certain critical number of species become extinct?

PETER RAVEN It's not that we're not gonna survive. We're gonna survive. We're gonna survive in whatever kind of a world we build for ourselves. The question is, shouldn't we be capable of making intelligent choices not of survival but of what kind of a world do we want?

ALAN ALDA (NARRATION) In Raven's world, people acknowledge that we are part of nature, that we evolved in wild places side by side with nature's diversity, and that we have no right to destroy these wonderful things. Who could disagree with such an idea, he asks, when faced with the beauty of the forest? Raven helped coin the term biodiversity to describe the huge range of species that fit together to make ecosystems - like tropical forest or the American prairie. The problem is the forces arrayed against advocates like Raven are immensely powerful, and some would say unstoppable. Just look at our own short history.

FILM NARRATOR To make a million acres bloom anew. To build an industrial empire from the wasted power of the Columbia.

WOODY GUTHRIE (SONG) Now river you can ramble where the sun sets in the sea. But while you're rambling river, you can do some work for me. Roll Columbia, won't you roll, roll, roll. Roll Columbia, won't you roll, roll, roll.

ALAN ALDA (NARRATION) It took us only about 300 years to dam every major river from the Atlantic to the Pacific, cut down all but 2% of the original forest, and plow under a million square miles of prairie. We literally took nature apart, without really understanding it. In the process we found prosperity, and pollution. But now the tinkering is becoming global in scale. Scientists agree we're changing the climate -- and what else could we be doing?

PETER RAVEN I think we have to think of the dictum of the great American conservationist Aldo Leopold who said "the first rule of intelligent tinkering is to save all the cogs and wheels."

ALAN ALDA So you don't leave 'em out when you put them back together.

PETER RAVEN When we're learning…when we're learning what we can do, that's just the time that we ought to be concerned about saving the parts that we can do it with.

ALAN ALDA Is the developing world going to catch up with us and surpass us, do you think, in the ability to wreck things? How is that gonna work?

PETER RAVEN Well, 20% of the people in the world live in developed or industrialized countries. We have about 85% of the world's economy, use about 80% of the industrial energy, have about 90% of the world's scientists and engineers. So, that's about proportional to our impact on the world's ecosystems, about proportional to the amount of pollution that we produce and amount of waste that we produce and the destruction of natural environments. It is our pressure on the world that is really causing most of the damage, directly or indirectly.

ALAN ALDA And yet we're always worried and always preaching to the developing world that as they develop, they better not develop the way we did.

PETER RAVEN If everybody in the world lived as we do in the United States, it's estimated it would take about two more of additions of planet Earth to accommodate everybody and we haven't got it.

ALAN ALDA (NARRATION) People have to understand, says Raven, that we humans are inseparable from the natural world. We use it all the time.

PETER RAVEN When New York City wanted to purify its water about ten years ago, it found that it had two choices: it either could put about five billion dollars in new water purification plants or it could put about one and a half billion dollars in restoring the watersheds in the Catskills. It was an easy choice.

ALAN ALDA (NARRATION) More often those choices are not so easy, or so obvious. For example, we filled in or drained about half our wetlands before we fully understood how they purify water, recycle nutrients, absorb floods, and provide nursery grounds for marine life. There may be as many as 20 million insect species in the world. Most are in tropical forests, but many are right here at home, working hard to pollinate our crops. We don't know the effects of destroying a large part of the globe's insects. And we don't know how effectively polluted oceans will continue to help regulate the global atmosphere - which is just one of the things oceans do, as do forests. Biologists are now calling these natural processes, ecosystem services.

PETER RAVEN They've been estimated by some economists as worth $37 trillion or some arbitrary number like that. But actually, it's pretty easy to see that they're priceless. If we didn't have them, we'd all be dead so we wouldn't be worrying about what they were worth.

ALAN ALDA It seems to me that that points to the incredible complexity of nature, and of this system that we're all hooked into. When you talk about our

interconnectedness, that sounds like it makes it especially difficult to know what piece you can pull out without the whole thing collapsing.

PETER RAVEN That's right. It's not only incredibly complex, but it is our basic habitat. It's the resource or it's the area into which we evolved. You see, 400 generations ago, just 400 generations, 10,000 years ago, there were only a few million people in the whole world. It's really only been the invention of crop agriculture that's allowed the global population to build up to where we're cultivating an area the size of South America, producing food, producing poets, musicians, specialists of all kinds that create what we call civilization. But it all relates ultimately on the ability of natural systems to be able to support us.

ALAN ALDA (NARRATION) The nightmare that Raven foresees is growing poverty and population driving a quickening pace of ecosystem destruction in developing countries. The only possible answer, he believes, lies with new ideas - especially new science - coming from within developing countries themselves.

PETER RAVEN One out of every four people in the world get by on a dollar a day. And the women and children in those societies have no opportunity whatever to contribute to human progress, because they spend their whole time carrying fuelwood and water over great distances back to smoky, carcinogenic huts. That's a way of insuring that the human race will not make the progress that it can. What I would like to do is to be able to build up the 10% of the world's scientists and engineers that exist in developing countries, into responsible groups in those countries that would be able to advise their governments and their people how to achieve the aims that they want: sustainability, health, relative prosperity, dignified lives in which people can contribute. So a lot of our energy here in the Garden, and a lot of my personal energy, is devoted to building institutions, and to empower people in developing countries to be able to take care of their own futures adequately.

ALAN ALDA (NARRATION) And what about us in the rich countries? He says it's the same answer. We need to consume fewer of the world's resources, but we can live just as well if we get smart and use science. That's the first thing. The second may be a little harder.

PETER RAVEN If there would be a single thing that we could do in the United States that would support global sustainability in the future, and the most possible options for our grandchildren and their grandchildren, it would be to bring our fellow citizens and ourselves to our senses about the fact that we live on a single planet Earth, with magnificent diversity run by people in something like 200 different nations, and that we all are managing this beautiful planet together. Promote a spirit of internationalism in the United States. Help people understand why it is that we depend on countries all over the earth, and do

something about it -- in our schools, in all of our social groups, and in any way that we can.

ALAN ALDA (NARRATION) If that doesn't work out, our idea of wilderness may have to change. It'll be confined to places like this, or Biosphere or the Tallgrass Prairie Preserve -- and to stay wild it'll have to be managed by humans forever.

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