Ecological Succession: Change is Good - Crash Course Ecology #6

Crash Course: Ecology
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===== Introduction (0:00) =====

You remember back in the days right after the Permian-Triassic Extinction Event, when that giant flaming asteroid and those methane explosions killed almost all the organisms on the planet? No, of course you don't, because that happened 252 million years ago when mammals weren't a thing yet.

But that's kind of the point of this episode: that asteroid was a disturbance to the ecology of the planet. The flora and fauna and soils were largely wiped out, leaving a blank canvas for the organisms that survived--and there weren't really all that many of them--to fill in as they could. What happened after the Permian-Triassic "disturbance" is a dramatic example of ecological succession, how the makeup of a community changes over time, starting from, like, the day after a disturbance. Just, usually the disturbance is a little less...disturbing.

The study of how ecological communities change doesn't just look at huge, long periods of time or the effects of some apocalypse, succession can easily happen over a season in a park or in just a few days in a patch of land as small as your garden. And this might come as a surprise, but disturbances that shake up that status quo within a community actually serve to make that community better in the long run. Because much like life and the entire universe, succession is all about change and change is how a universe full of nothing but hydrogen came to include a planet full of life.

[Title Sequence]

===== Types of Ecological Disturbances (1:21) =====

Disturbances happen in ecosystems all the time, every day, a fire, a flood, a windstorm. After these unpredictable events, ecologists kept seeing predictable, even orderly, changes in the ecosystem. How life deals with these disturbances is an important key to understanding ecosystems.

First, let's note that a tree falling in the forest and a comet falling in the forest, while both disturbances, are different levels of disturbance. Likewise, there are a couple different types of succession. The first type, the one that happens after the asteroid hits, or the glacier plows over the landscape, or the forest fire/volcano burns the verdant ecosystem into pure desolation--that's called a primary succession, when organisms populate an area for the first time. The jumping off point for primary succession is your basic, lifeless, post-apocalyptic wasteland.

===== Primary Succession (2:05) =====

You're probably thinking, "That place sounds terrible, who would ever want to live there?" Well actually, there is one tremendous advantage to desolate wastelands: no competition. A lot of organisms don't mind settling down in the more inhospitable nooks and crannies of the planet; these pioneer species are often prokaryotes or protists, followed by non-vascular plants then maybe some extra-super-hardy vascular plants.

There are tons of organisms that make their living colonizing dead places; it's their thing. Like before the Permian-Triassic extinction, there were these dense forests of gymnosperms, probably full of species a lot like the conifers and ginkgos and cycads we still have today. But after the asteroid hit, the big forests died and were replaced by lycophytes, simpler vascular plants like the now-extinct scale trees and today's club mosses. While they might have had a hard time competing with the more complicated plants during the good times, the rest of the Paleozoic flora barely survived extinction. Of all the dozens of species of ginkgo that were around back then, only one still exists, completely genetically isolated--a living fossil.

It's important to remember that when we talk about primary ecological succession, we're talking about plants pretty much exclusively. Because plants rule the world, remember? Without plants, the animals in a community don't stand a chance, and primary successional species are almost often plants that have wind-borne seeds, like lycophytes, or mosses and lichens that have spores that blow in and colonize the area.

And the outcome of a primary successional landscape is to build or rebuild soils, which develop over time as the mosses, grasses, and tiny little plants grow, die, and decompose. Once the soils are ready, slightly bigger plants can move in, at which point we move on to secondary succession, and then it's game on; a whole redwood forest could develop out of that!

===== Secondary Succession (3:42) =====

But primary succession takes a long, long time, like hundreds, maybe thousands of years in some places. In fact, the recovery of these big gymnosperm forests after the Permian-Triassic Extinction Event took about 4 or 5 million years. Dirt may seem unglamorous to you, but it is alive and beautiful and complicated, and making good soil takes time.

Now secondary succession isn't just the next act after primary succession has made a place livable after some disaster, it's usually the first response after a smaller disturbance like a flood or a little fire has knocked back the plants that have been ruling the roost for a while. Even a disturbance as small as a tree crashing down in the woods can make a tiny patch of forest more like it was 50 years ago, before that one tree got so huge and shady. In that tiny area, there will suddenly be a different microclimate than in the rest of the forest, which might have more sunlight, slightly higher temperatures, less protection from weather, *et cetera*.

And just like every other ecosystem on Earth, this tiny patch of forest will be affected by temperature and precipitation the most, which will be different in different parts of the forest. So as a result of the fallen tree, the soils will become different, the mix of plants will become different, and different animals will want to do business there because that little niche suits their needs better than other little niches.

===== The Climax Community Model (4:50) =====

So the question becomes, when does succession stop and things get back to normal? NEVER. Because change doesn't end. Change is the only constant, people! You know who said that? Heraclitus, in 500 BC, so it's been true since at least then. Consider it a lesson in life.

And as ideas in ecology go, it's actually a pretty new way of looking at things. See, back in the early 20th century, ecologists noticed a tendency of communities to morph over time, but they also saw succession in terms of a community changing until it ultimately ended in what they called a climax community, which would have a predictable assemblage of species that would remain stable until the next big disturbance.

===== Stochasticity (5:27) =====

Well, maybe that's what seemed to be happening, but ecological succession is actually a lot more complicated than that. For starters, there's a little thing called stochasticity, or randomness, which prevents us from ever knowing exactly what a community is going to look like 100 years after a disturbance. Stochasticity is basically your element of unpredictable variability in anything.

So you can predict with some accuracy what plants are going to take over a glacial moraine after the ice has receded because the seeds of some colonizer species typically make it there first. But unpredictable things, like weather conditions during early stages of succession, can end up favoring another species. The point is, scientists' attempt to predict what a community ends up looking like in 100 years should always be thought as probabilities, not certainties.

===== The Myth of Ecological Stability (6:06) =====

Another difficult with the whole model of a climax community has to do with the idea of an ecosystem eventually stabilizing. That word "stable," whenever it's used in a sentence that also includes the word "ecology," you can pretty much be sure it's being used wrong, because stability never happens. There are always disturbances happening all the time in every ecosystem. A small portion of the forest might burn, a windstorm might take out a bunch of trees, some yee-haw might rent himself a backhoe one weekend and clear himself a little patch of heaven on the mountain beside his house because he's got nothing better to do; who knows? Stuff happens!

So instead of ending in some fixed, stable climax community, we now know that an ecosystem is in later successional stages if it has high biodiversity--lots and lots of biodiversity. And the only way biodiversity could be high is if there are tons of little niches for all those species to fit into, and the only way there could be that many niches is if, instead of a single community, an ecosystem is actually made up of thousands of tiny communities--a mosaic of habitats where specific communities of different organisms lived.

===== Intermediate Disturbance Hypothesis (7:07) =====

Such mosaics of niches are created by disturbances over time, with everything always changing here and there, but it's important that these disturbances be of the right kind and the right scale. Because it turns out that the kind of disturbances that have the greatest effect on biodiversity are the most moderate disturbances. When ecologists figured this out, they decided to call it the Intermediate Disturbance Hypothesis, because it hypothesizes that intermediate disturbances--not too big and not too little--are ideal.

See, just a little disturbance, like a falling tree or something, isn't really enough to change the game. On the other hand, a really severe disturbance like getting covered with lava would take the community all the way back to asteroid-wipeout level primary succession. But every nice mid-level disturbance creates its own habitat at its own stage of succession with its own unique niches. More niches means more biodiversity, and more biodiversity means more stability and healthier ecosystems.

Even if two disturbances happen in two different areas with roughly the same climate at the same time, the stochastic nature of ecosystems mean that the two areas might recover in completely different ways, leading to even more niches and more biodiversity.

Now, this does not mean that you should go rent a backhoe tomorrow and cut a swath into the wilderness. It's just suggesting that a medium level of disturbance is natural and normal and good for an ecosystem; it keeps everybody on their toes.

===== Importance of Disturbance (8:20) =====

And like I said, disturbance happens, and by and large we should let it happen. This too is a relatively new idea in ecology; in fact, for most of the history of public land management in the US, great swaths of forest were not allowed to burn. People considered the purpose of forests to be wood production, and you don't want to burn down some trees that are going to make you a bunch of money. But because of the lack of intermediate disturbances over a long period of time, we ended up with catastrophic fires like the one that torched Yellowstone National Park back in 1988. A single lightning strike totally annihilated almost 800,000 acres of public forest because the ecosystem hadn't been allowed to indulge in a nice, leisurely burn every now and then.

But now, those forests have undergone more than 20 years of succession, and some parts have even re-burned at a more intermediate level, creating a nice, high-biodiversity mosaic of habitats. And it's gorgeous, you should come visit it sometime.

And that is ecological succession for you--how destruction and disturbance lead to beauty and diversity. Just remember what my main man Heraclitus said and you'll be good: the only constant is change.

===== Credits (9:22) =====

Thank you for watching this episode of *Crash Course: Ecology,* and thank you to everyone who helped us put this episode together. If you want to review any of the concepts that we studied today, there's the table of contents over there. And if you have any questions or ideas or comments, we're on Facebook and Twitter and of course, down in the comments below. We'll see you next time.