Ricardo Carvajal (UNIT 2)

(1) I'd like to keep this as informally as possible. As we go through this if you
(2) want to ask a question, please feel free to ask a question. And if at any point
(3) and time if you can't hear what I'm saying or you don't understand a word that
(4) I use, let me know, okay? And we can go back and look it over. My name is
(5) uh Ricardo Carvajal. I'm a doctoral student in the Department of Biology. Let
(6) me right my name out for you in case you're curious about how to spell it. In
(7) Spanish it's pronounced (instructor gives the pronunciation) but we don't
(8) expect everybody to be able to roll those Rs that way, okay? Um, now of
(9) course the department of biology here is very large and that's because the
(10) discipline is very large. Uh, a lot of the news you've been hearing from
(11) biology in the last few weeks has come from the microbiology side of the
(12) discipline. So, if you have money invested in the stock market and your
(13) looking your biotechnology stocks, well all of that is dependent on the
(14) research and the discoveries that are taking place in microbiology. Uh, you
(15) might have seen the story about how they're mapping out the human
(16) genome and that's supposed to lead to all kinds of advances in human
(17) medicine and what not. Well, to be completely honest with you, I really don't
(18) understand that side of biology any better than any of you do. Ok, that is not
(19) what I do. I come from another uh branch of biology that's called ecology
(20) and that is a word that you're probably familiar with. H-How many of you
(21) have heard the word ecology before? Alright. I-I'm curious to know what you

(22) think ecology is. So please, anybody? Don't be embarrassed this is not a
(23) trick question. I'm really just, I'm really just curious to know (student gives an
(24) answer that is difficult to hear). So so it's about relationships between living
(25) things. That's that's really a pretty good definition, you know. And I'm
(26) surprised because before I came to study biology I just I would go to the
(27) bookstore and I would walk down through the bookstore and I would start
(28) picking up books that had the word ecology in the title. And after I got here
(29) and started realizing started uh studying ecology I realized that none of
(30) those books had anything to do with ecology, you know. Some of them talk
(31) about a spirit like a spiritual movement or others talk about environmental
(32) activism I don't know if you've heard about ya know people chaining
(33) themselves to trees so that the trees won't get cut down. Well, I mean that's
(34) environmental activism, but it's not ecology. So at least here in the United
(35) States people have a lot of misconceptions about what ecology is and it
(36) isn't. So we can start by by giving it a definition. Um, and we'll go with the
(37) scientific study of factors that determine distribution and abundance of
(38) organisms. So distribution is you know where things are located in space
(39) and abundance is of course how many. So if we go out for a walk in the
(40) woods here and we see pine trees in one place but not in another we wanna
(41) know why. Why are the pine trees only here and not over here? Ok, very
(42) very basic kind of question. Um, now in order to give you an idea of how
(43) complicated this can get, I'll give you an example that's important here in
(44) Michigan. Um, there's a little organism ca- it's about the size of my

(45) thumbnail very small okay, called the zebra mussel. A mussel is a mussel is
(46) like a kind of clam, you know. Where they have they live in the water, they
(47) have the two shells, and they open and close a little bit, and they eat
(48) whatever is suspended in the water, okay. It's called a zebra mussel
(49) because it has stripes on it sort of like a zebra. Um, now fifteen years ago
(50) there were no zebra mussels anywhere in the United States, anywhere in
(51) North America. The zebra mussel is from Europe. And in 1988 we found our
(52) first zebra mussel in a lake here in Michigan called Lake St. Claire. And now
(53) twelve years later there are zebra mussels throughout the entire central
(54) part of the United States. They're in all the Great Lakes. They're in almost all
(55) of our rivers and all of our major lakes and streams. And they have been
(56) both an economic and an environmental disaster for this region, okay. Um,
(57) because what they do they stick to anything that's hard, okay. So if you look
(58) at all of our cities around these lakes, they all have pipes going out into the
(59) water to pull in the water that they're that that we used to drink for our
(60) drinking water. And these little guys get inside all those pipes and clog all
(61) the pipes up. So you have to shut the whole plant down go in and clean all
(62) that out. That's also true for our power plants and the nuclear p- plants that
(63) draw in water and depend on on the water for cooling. Um, they've killed off
(64) a lot of our native clams and are also leading to the decline of a lot of our
(65) local fisheries. And we'll talk about the way that that's happening in a little
(66) bit. Um one of the s-so we can start asking questions about how this one
(67) little organism has managed to create so many problems for us, okay. And

(68) as an ecologist I can ask questions about each individual little clam. So I can
(69) ask well what does this clam eat? Right? Very basic question. The clam eats
(70) uh little um microscopic organisms that are suspended in water. You know,
(71) Algae? You know little plants and little animals that are suspended in the
(72) water that sort of give that the water sometimes that green color. These
(73) that's what they eat, okay? And I can uh ask how they reproduce and it turns
(74) out that you have male and female clams and they both put out eggs while
(75) the female puts out her eggs the male puts out a sperm. They spawn into
(76) the water. And they do this very frequently. And hundreds of thousands of
(77) eggs and sperm. So they re- reproduce very rapidly, okay. So that helps me
(78) to understand a little bit about why this one muscle is so successful here in
(79) this region. Um I can also look at questions that are sort of one level up of
(80) organization. So we start with the individual organism and then we can move
(81) and ask questions about population or populations of these clams. So how
(82) many if I have a lake that doesn't have any clams in it, how many of these
(83) little clams do I need to put into that lake in order to have the population just
(84) explode and take off and have the population grow, okay. That's helpful to
(85) me if I'm trying to control this kind of an organism. And I can also ask
(86) questions then at an even larger level which we call the community level.
(87) And that is what is the interaction or what is the relationship between this
(88) species and other species. So what's the relationship between zebra
(89) mussels and a species of fish? Or one of our native species of clams? It
(90) turns out that I mean these things are very very very good at reproducing,

(91) okay. Uh, to give you an idea you know a square meter is a square roughly
(92) this big, okay. And once these guys get growing and reproducing you can
(93) get one million muscles in just a little square this big on the bottom of a lake.
(94) So that's that's the way that they kill off the native clams. Because you have
(95) a clam sitting on the bottom and the little muscle comes and gets attached.
(96) And then another one gets attached and then another one gets attached and
(97) pretty soon that clam is blanketed with zebra muscles. And then more zebra
(98) muscles come and they attach themselves to the zebra muscles that are
(99) already there. So you have one layer and then another layer and then
(100) another layer and what happens is that that clam underneath basically
(101) starves to death. Or basically got suffocated because it's cut off from the
(102) water flow, okay. So that gives you an idea of how the relationship between
(103) the muscle and the clam works. Um, I mentioned that it's leading to the
(104) decline of our fisheries also. And that relationship is a little bit more
(105) complicated cause we know that the zebra muscle eats the plankton, right.
(106) Those microscopic plants. Um, so if we put if we put our plankton down at
(107) the bottom here, right. And think of that as as food. Well the zebra muscle
(108) (laughter) the zebra muscle eats the plankton, okay. Now that plankton is
(109) also supposed to be food for small fish. So right away you have a
(110) competition now between the zebra muscle and the small fish. And as the
(111) population of zebra mussels grows, they start eating up all the food and
(112) there's very little left over for the small fish, okay. Now what eats the small
(113) fish? Uh oh,this thing doesn't wanna work. Uh, well big fish, right? So as

(114) these guys as a population of these guys goes up. The population of your
(115) plankton starts to go down. The population of the small fish starts to go
(116) down. The population of the big fish starts to go down. And that puts
(117) fisherman out of business and it takes food away from our table, basically.
(118) So here we have this this one little organism that was introduced into our
(119) waters by a ship coming from Europe if you guys know how commercial
(120) ships work, they take on their cargo and then they take on water to hol- to
(121) sort of balance out the ship. And they go across the ocean, they unload
(122) their cargo and they dump all the water. Well in that water were little larvae
(123) of zebra muscles. That's how they got here and in twelve years they've
(124) created all of these problems for us. So these are the questions that you try
(125) to ask and answer hopefully as an ecologist by trying to understand things
(126) at the level of the individual and at the level of the population of individuals
(127) and then at the community level understanding the relationships between
(128) the different organisms. Um, probably the most important consequence of
(129) this invasion of zebra muscles has been an overall loss of what what we
(130) call biodiversity. And you all may already be familiar with with this term. But
(131) biodiversity roughly just means the number of species, okay. So you go to
(132) one island and you find one species of ant and one species of bird and one
(133) species of turtle. And then you go to another island that's the same size
(134) and you find five species of ants and ten species of birds, five species of
(135) turtles. Obviously this island over here has higher biodiversity and we place
(136) more value on that um. Largely because we don't really understand what

(137) all these different species do in a natural system. So the fact that we're
(138) doing things that are destroying a lot of species and leading to species
(139) extinctions, before we really understand how they work and what kinds of
(140) benefits they provide to us, is something that has a lot of people very
(141) worried. Okay. Um, now the kinds of questions that I'm most interested in
(142) as an ecologist, tend to revolve around sort of and a a part of ecology
(143) cause ecology is also a very big field, okay. Um, and one part of ecology is
(144) agro ecology which you might guess just means or you can take it as
(145) meaning ecology of agricultural systems. If anyone of you have had a
(146) chance to drive around Michigan you see a lot of corn fields. Uh, almost all
(147) the cornfields in Michigan are what we call a monoculture which is just one
(148) species, right. Now if you go down into the tropics in Central America and
(149) in South America you still see a lot of farms that have polyculture. And in a
(150) polyculture you can have many many different species I mean you have
(151) more than one so a polyculture could just be two. But you could have three
(152) or four or five different species of things all planted together in the same
(153) field. So here we we always only plant corn together. In the tropics they
(154) tend to plant both corn and beans, okay. Now the reason that they do that
(155) is because a lot of their farms are still small and so they can do a lot of
(156) work by hand and so they can manage two different crops that are planted
(157) together. And those two crops corn and beans tend to dro grow very well
(158) together. Here we plant only corn because almost all the work we do is
(159) done by big machines. And a big machine ha it's much harder to design a

(160) big machine to handle more than one kind of crop at a time. So here you
(161) have a case of the the kind of agricultural production method being sort of
(162) dictated by economic considerations, okay. Now you know why why are
(163) these kinds of questions important well if you you know you go up for a ride
(164) in an air plane and you look down and all you see at least around here is
(165) agricultural production. You see a mosaic sort of a patchwork of different
(166) fields. Well anything, any practice that covers that much area is gonna
(167) have very important ecological consequences. Um, now for me the thing
(168) that I've elected to focus on is coffee. Um, you guys ran a search maybe
(169) some of you ran a search for shade coffee over the Internet. What kinds of
(170) information did you get? Did you find any any references to what shade
(171) coffee is? Not really? Well how many of you know how coffee is
(172) produced? How many of you drink coffee? Let's take a step back. How
(173) many of you drink coffee? Yeah, I drink coffee, okay. Six months ago I had
(174) no idea really how coffee was produced. And it turns out that it's really it's a
(175) pretty interesting crop okay because the the native coffee plant, uh the one
(176) that we have traditionally worked with, is a plant that doesn't like to grow in
(177) sun. If you try to grow it in the sun, it does not do well, okay. So it's a plant
(178) that likes to grow under shade. And so historically, traditionally, all coffee
(179) was shade coffee. You didn't have to call it shade coffee people
(180) understood that when you talked about coffee, you were talking about
(181) something that grows in the shade. Um, now in modern times we've started
(183) to grow coffee in the same way that we grow any other kind of crop, right.

(184) Which is why planting big fields of nothing but coffee. I just want to show
(185) you in a diagram sort of the the range of of production methods. I don't
(186) know how easy it is to see if your all the way in the back so I'll point to the
(187) different figures in the graph to give you some idea. This up hear at the top
(188) is the traditional way of growing coffee and the way that it's done is you go
(189) into the native forest an existing forest, you pull out the plants so the small
(190) plants close to the ground and you plant coffee bushes, okay. And so
(191) everything that you see up here are all the native tree species, which in the
(192) tropics it could be fifty, seventy species of trees, okay. All up here in the
(193) canopy. Then you have a whole lot of other range of species of trees
(194) that are shorter and grow sort of here in the middle and then down toward
(195) the bottom you have the bushes. Um, to give you an idea of the height, this
(196) is forty meters here, okay. So these these trees these trees are forty
(197) meters tall that's that's a long way up. And that provides a lot of living
(198) space for different kinds of animals and for insects, birds, frogs, you name
(199) it. Um, now if you want to make your agriculture sort of more productive
(200) and you're willing to put in more work and have it be a little more intensive,
(201) then you can start taking out some of these trees here in the middle and
(202) putting in other things that you like to eat. Avocado, uh, citrus, banana, so
(203) you give yourself other foods stuffs aside from the coffee. And if you really
(204) want to start getting into intensive production then what you do is you chop
(205) all of this down, right? And you just plant in a few species of things that you
(206) know have a high commercial value. Now notice that that there's still shade

(207) because we still have trees and they're much smaller trees now. But the
(208) coffee is still shaded. Um, the next level of simplification is now you just
(209) have two species. You have one species of tree providing shade and giving
(210) you some kind of agricultural product and then you have coffee underneath
(211) that. And finally the most intensive system is just coffee. So now a days we
(212) call this this system right here we call this sun coffee and then anything up
(213) from here we're still trying to decide what what to call all this. I mean and
(214) in- all of these systems you see that there is shade, right/ But they're not
(215) the same. I mean here you have here you have a system where the
(216) canopy goes up only to fifteen meters of altitude and here's a system
(217) where the canopy is up at forty meters of altitude. That's a big difference in
(218) height and in the kind of environment that animals are going to experience,
(219) animals that live in that system, okay. Um, now currently more than fifty
(220) percent of coffee production in Latin America is sun coffee. So they've
(221) gone in and cleared everything out and they've put in sun coffee. Um, from
(222) an economic perspective you might say that that makes some sense
(223) because a lot of these countries are poor. They can get loans to put in
(224) modern agricultural practices. They can take that coffee and sell it to us
(225) here or anywhere else in Europe. Um, you know, to drink. And we pay a lot
(226) for coffee. Those of you who drink coffee know that you know it's, you're
(227) paying more than a dollar per cup for coffee. So that's a lot of income going
(228) into these countries. Now the downside of that is that as you move away
(229) from the shade coffee and you go to that sun coffee and you eliminate that

(230) shade and you eliminate those trees, you get a big big drop in biodiversity,
(231) what we had talked about before. So a lot of the work that's being done
(232) here at the University of Michigan in agricultural systems, is focusing on the
(233) effect of that conversion in production from shade coffee to sun coffee.
(234) What effect that's having on other species. Um, now th you kn- you can
(235) start with the trees. Obviously if you cut down all the trees, well like I said if
(236) you have sixty or seventy species of trees, boom! They're all gone. Um, if
(237) you lose all your trees then you of course you lose anything that is also
(238) dependent on the trees. Uh, and one of the most important groups that
(239) people have been looking at a lot are birds, uh we started to notice that
(240) here in the United States in the last twenty years we're seeing fewer and
(241) fewer and fewer of our bird species. Uh, I kn how many of you have
(242) already been here through a winter? Hardly anybody! Who's gonna be here
(243) this winter, just out of curiosity? A number of you, okay. Your gonna find
(244) (laugh) out why birds run away for the winter (laughter) ya know (laughter)
(245) it's a miserable environment, ya know. It's freezing cold and these guys
(246) aren't gonna be able to find food. They're not going to be able to survive if
(247) they stay here. So a lot of our birds migrate and fly out of here and go
(248) south into the tropics, into these coffee-growing areas. And that's where
(249) they spend the winter. And uh, ya know, I would do that if I could, but I
(250) can't. It's a very smart thing to do. Uh, so they go down there and when we
(251) started seeing the decline in in the birds that kept coming back for the
(252) spring, well we started to wonder if it was something that we were doing

(253) here. And of course we are doing things here that are disrupting our bird
(254) populations. But a lot of what is happening um that is bringing these bird
(255) populations down is happening in the tropics in Central and Latin America,
(256) where coffee is grown. And one of the biggest problems is the cutting away
(257) of these forests. Forests are cut away in order to provide pasture for cattle
(258) so it you know they can produce beef and forests are cut away in order to
(259) make it possible to grow the modern variety of sun coffee. // Um, another
(260) group so we've talked about trees, we've talked about birds, we can talk
(261) about insects. Uh, so insects, spiders, centipedes, all those little bugs. It
(262) might be a surprise to some of you that if you look at if you if you took all
(263) the species in the world and and we're we're excluding bacteria here
(264) because bacteria are special (laugh). There are there are uncountable, we
(265) don't even know, we can't even guess at how many species of bacteria
(266) there are because we know so little about bacteria in general. But if you
(267) talk about things that you can see with your naked eye, most of the
(268) biodiversity in the world is among insects. And within insects most of that is
(269) just in beetles. If you guys are familiar with beetles, you know. Beetles are
(270) uh you know they they usually they have I'll draw you my best example of a
(271) beetle. It has a shell back here and has sort of a dividing line between the
(272) two wings and then the six legs and the little head, okay. That's a pretty
(273) bad drawing (laughter) okay. That's pretty bad. You're not aloud to video
(274) tape that, okay? Uh, now one of the studies that was done by somebody
(275) here at University of Michigan, she went down into one of these coffee

(276) farms and she sprayed a weak insecticide up into just one tree, okay. And
(277) out of that one tree she was able to get thirty species of ants and 126
(278) species of beetles. Out of one tree, okay. Um, that same kind of study has
(279) been done just in forests and undisturbed forests where there is no
(280) agriculture or anything. And the numbers are actually comparable, close to
(281) the same. So you have the potential for a lot of biodiversity in these coffee
(282) farms, especially when you look at the insect life. Um, the last group that I'll
(283) talk about is sort of the one that I've started to focus on because we don't
(284) know too much about them. But they're epiphytes. And you all probably
(285) know epiphytes, you just don't know the epiphyte term. But if you know
(286) orchids, right? That beautiful flower that people are so fascinated with. You
(287) can go to orchid shows and people collect orchids and whatnot. A lot of
(288) orchids are epiphytic, is the adjective form. Um, what an epiphyte is it's it's
(289) a plant that grows on another plant. Without the benefit of soil, so an
(290) epiphyte does not have roots growing into the soil. You'll have a tree and
(291) and you won't see them around here because we don't the climate that we
(292) have makes it impossible for them to live here. But if you go to a tropical
(293) area and you look up into the trees, in some areas you will see the tree
(294) completely blanketed, completely covered by epiphytes. Now those
(295) epiphytes um they're not drawing things out of the tree, that's something
(296) we would call a parasite, you know. When it's actually drawing resources
(297) and drawing food out of the tree and we call that a parasite and we we we
(288) usually don't include that in the group of epiphytes. They just live on the

(289) tree and every thing that they need to live in terms of water and food, they
(290) get from the air or from rainfall, you know. We look at the air and we don't
(291) see anything, but if you start to analyze air there's actually a lot floating
(292) around in air. A lot of really tiny tiny little particles of nutrients that these
(293) plants are capable of absorbing and using. Um, and to give you an
(294) example of of ya know the biology of these things again starting remember
(295) we talked about organisms and then populations and communities. Well
(296) starting sort of at the things that you'd be interested in if your looking at an
(297) individual epiphyte. Here we have a tree and it's you can split a tree up
(298) into zones of sort of climate and in the outer part of the tree canopy which
(299) is the upper part, right. You have a very very different kind of climate
(300) then you have here more toward the center. And that's a very different
(301) climate than you have down here closer to the ground. So you have
(302) epiphytes that are specialized for this kind of climate way out here at the
(303) branch tips. If you think about it, way up here they have full exposure to
(304) sunlight. They also have full exposure to wind. So that's a plant that could
(305) dry out very easy imagine the wind blowing on you all day, you know. And
(306) that wind is carrying away any moisture that you have on your skin. That's
(307) gonna dry you out very quickly so in order to deal with that kind of a of a
(308) climate you have to be one type of plant, okay. Um, whereas down here
(309) you have very high humidity which is nice, but you have very little sunlight.
(310) Most of the sunlight gets blocked off by the other part of the tree. So we
(311) can look at, you know orchids growing along here. Um, we can look at then

(312) another group that are called bromeliads and I don// I// you// don't get too
(313) hung up on the different terms, you know there are different classifications.
(314) Um, you know pineapples, right? Pineapple is from the bromeliad family so
(315) you those little spiky leaves at the top of the of the pineapple. You go the
(316) tropics and you'll see lots of plants that have that sort of form. Not the
(317) big ball that's the pineapple, but just the spiky leaves growing up in the
(318) trees, okay. And then ferns which uh you guys probably know but you
(319) don't know them by that name. They're just they have very fine little
(320) leaves. You know something like that. And you'll have many many of those
(321) growing on these trees as well. Now why should it matter uh you know
(322) whether we have epiphytes or not? Well it turns out that they're really pretty
(323) interesting. You have like some of the ones some of them have a a cup
(324) form. They grow on a cup form and so whenever it rains that cup fills with
(325) water. And it turns out that there are little frogs that live in the trees that
(326) need that pool of water in order to carry out parts of their life cycle. So if
(327) that cup of water isn't available for that frog, it won't be able to reproduce
(328) and that species goes extinct. You have other species of insects who also
(329) need that little pool of water. And then you have birds who like to come in
(330) and drink the water. What if it hasn't rained in two weeks? Where are you
(331) gonna go to find water? Well you can go to one of these little cup shaped
(332) plants and drink the water out of that, okay. Um, orchids produce nectar.
(333) That's a lot of energy for birds. So birds will come to an orchid and drink
(334) the nectar. Um, bromeliads and then there's another group that I won't

(335) even give you the name of. They produce these seeds some of them are
(336) nice, big, round seeds, okay. And birds come and eat those and that's an
(337) important source of food for birds. So all of the sudden you know we start
(338) to see this this very complicated picture building building up where the
(339) coffee production method has an impact on the trees. And they kinds of
(340) trees that you have determine what kinds of epiphytes you have and they
(341) also determine what kinds of birds you have. And they also determine what
(342) kind of insects you have. And then it starts to look like all these things are
(343) related to one another. And so we're trying to figure out is how all these
(344) relationships work and these systems that are sort of more natural um
(345) because the one thing that seems clear to us is that the way that we're
(346) doing agriculture, the modern techniques that we're using with all these big
(347) machines and all of the fertilizers and all the pesticides that that is not
(348) sustainable. We can't keep doing that for very long, okay. Um, one it
(349) consumes a lot of energy and it consumes a lot of resources. And second,
(350) it results in a lot of adverse effects especially pollution. Pollution of ground
(351) water um, I I don't even know if you guys have heard about this because
(352) here in the United States we've been using so much in the way of fertilizers
(353) and pesticides and things here in the Midwest around Michigan, that it's
(354) starting to flush out through our rivers going all the way down through the
(355) central part of the Unites States and out into the Gulf of Mexico. And it's
(356) started to create this huge area that's completely dead. Where there are
(357) no fish. Where there basically is no life. And we've started calling that the

(358) “dead zone” and we’re starting to do some ex uh investigations of how it is

(359) that that area has developed. And that is all a consequence of of our

(360) modern agricultural practices. So we’re trying to stay take a step back and

(361) start to look at how some of these natural systems function so that we can

(362) start maybe trying to be a little smarter about the way we grow food and the

(363) way we grow our crops.