SONORAN DESERT CONSERVATION PLAN

STEERING COMMITTEE

EDUCATION SESSION

September 18, 1999 (9:00 - 12:00 a.m.)
Arizona-Sonora Desert Museum (Gallery)
2021 N. Kinney Road Tucson, Arizona, 85743

CONSERVATION BIOLOGY

Basic Modeling Approaches to Species Viability
Michael Gilpin

Applying the Science of Conservation Planning to the Biological Element of the Sonoran Desert Conservation Plan
Bill Shaw

INTRODUCTION: DR. SHAW

I would like to introduce Michael Gilpin. He will present a heavy-duty quantitative analysis into the topic you see on the board which is Population Viability Analysis which is an extremely important aspect of Conservation Biology in evaluating conservation strategies. He is widely published on this topic and on the topic of metapopulations which I am sure he is going to talk about today and he is a preeminent authority on these issues and we are really fortunate to have him here today.

BASIC MODELING APPROACHES TO SPECIES VIABILITY: MICHAEL GILPIN

So I asked what is boot camp and Maeveen said, "Well you know, they don't exactly have the same background you normally speak to, " and I said, "Well at least they know calculus or at least they remember calculus." So Maeveen said, "Well, see try to keep this lecture to sound (intelligible to someone) like a real estate developer or a lawyer. I was on the recovery team for the Desert Tortoise and they said I was gambling and Maeveen said, "Yes, gambling." So I am going to give you a lecture on species viability analysis and I am going to try to do it metaphorically and graphically without any calculus. You have the Sonoran Pronghorn, Pygmy Owls and there are going to have to be some PVA's done in this process of planning for Pima County and the purpose of the lecture I am giving you today is to give you some real gut feeling for the power and especially for the limitations of PVA because PVA is not magic, it is part of the process but you guys have to be somewhat skeptical about the answers that PVA gives you. I am going to appeal to your intuition, I am assuming all of you have gone to Vegas and lost in some sense, you lost as much money as you wanted to play with or you have lost all of your money so the metaphor of gamblers or a player playing a game and losing money is what we use for the viability of small populations.

How long will a player play the tables before that player goes extinct? What is the best strategy? If a player is losing money, is there a way to change the strategy whereby to prove the odds of survival so these are some of the things I am going to point out how the mathematical analysis pertains to these things and link them up with small population biology. Now, like any computer geek pretending to be a biologist, my approach is through a website and you have access to this website, there will be a link from the Pima County Conservation Plan webpage and there is an address floating around here. This is actually coming locally off my MacIntosh so PVA introduction, we are going to think about gamblers, we are going to think about, you know, you go to Vegas there are games you can play, how long you expect to last, how many free drinks are you going to get while you play, da da da.

Now, as I said you do have access to this so even though I go over these facts you can log onto the web and as long as you are using any 4.0 level browser, you can manipulate these things.

So here is the game of craps and it is not the whole game of craps only the pass field. The way the pass works is that when the table is in the odd condition, the next throw of the dice is going to be the coming out throw. If you throw a two, a three or a twelve, it is craps and you lose your money immediately. If you throw a seven or an eleven you win immediately. If you throw one of these numbers, four, five, six, eight, nine, ten that number becomes the point , there is an ivory disk here the croupier will turn this over the on condition and place it on where the point is and then the betting proceeds. You keep throwing the dice. If you make your point you win, if you throw a seven first and call seven out then you lose your money so all bets, all pass bets are resolved with this mechanism and you can play the game by pressing this button, throw dice.

The first time you throw, ah! Bad number! Throw a three it is craps, we are a loser and our money would start at ten and so it now at nine. We will play again, throw the dice again and we get a six so this disk is now over the six and the on position now the win-loss is resolved either by throwing a six or by throwing a seven. You keep throwing, we throw a seven and we immediately lose.

In two steps, the steps are here, we have gone from ten dollars to eight dollars. Now what this program does is it allows us to speed up the investigation of playing craps and there is a button here that says "play until broke." So I played until broke and it took me 2,300 steps before I went broke with ten dollars. You can get a lot of free drinks with that.

So we reset, 900 is real good too. Reset, play until broke at 300, that is still good. Fifty-two, yeah. Now the fastest you can go broke would be ten steps, you would lose every time. So now we do this and we get a sense that there is a lot of variability of a small amount of money persisting at the crap table. It can fifty steps or it can be 2,000 steps. Which is it? We cannot put a real answer on that until we do lots and lots of these things and come up with a probability distribution. Now I am only going to do 100, the computer can do 10,000 but it takes a few seconds to do this so here is the kind of mathematical analysis one can do on the game of craps. We have now started with ten dollars each time, we just keep on playing and playing and playing. A couple of times out of 100 trials will go at least 5,000 steps before we go broke.

Most of the extinctions are early on and that is what these numbers are, each of these is a division of 100 steps. The mean time to extinction is 743 steps, however, most of the trials go extinct before the mean and this is very typical of PVA work on small populations. The expectations are that most populations is 80-90% of the cases will have gone extinct before we move onto extinction, we get a lot of the mathematics we currently have predicts mean time to extinction so you have to understand that if you are gambling on this thing, maybe half of the cases will have gone extinct in the first 200 steps. In fact, maybe 10% of them will have gone extinct in the first 50 steps and some of the rules are not rules but guidance that comes out of PVA analysis is that you want about 95% probability persistence per 100 steps or 100 years in the case of species. To get 95% you are not going to get that starting with ten dollars so you need a bigger population of money to have any chance whatsoever of getting 95% probability of persistence for 100 times that.

Now let's check to see if this a robust answer so we can do this a couple of more times. And it looks like it is a pretty robust pattern. One hundred trials is roughly enough, 600 to 800 is the mean and this distribution does not change too much, of course it is a little bit ragged out here because these are just small sample points but the general curve is the exponential decline. See, I truncate the thing and here is actually the ones that go even longer.

This is what analysis can do to the stochastic and stochastic is a word meaning involving chance and all things in nature involve chance so this is what mathematical analysis can do for a stochastic process which we understand perfectly and this is the point. We understand and can program the rules of this process perfectly. Chance comes in through the throw of the die, this chance comes in through weather events, disturbances, outbreaks of insects, all these things were chances. .It has a skew out to my right on the board. Given that we understand this perfectly, we can start to ask some questions about strategy and about change of rules.

Now I am just starting a baud experiment that we might do is that we might say, "Well, I have a carload of graduate students and we are going off to do field work and they are whining that they want to play craps with ten dollars," so what advice did I give to my graduate students? Shall I say, "Let us all be chummy and play the same bet at the same table? Or should we all play different tables?

Now if we all played the same table and we all followed exactly the same distribution we would all go extinct at the same time which may have some advantage. But if you had the excuse to play different tables, the probability that at least one of them persists is much higher so this is a hedge your bet type of approach where you spread your risk over different environments, the important fee here is that the roll of the dice is different at each of the tables. See if it were the same type of dice on the video display monitors or something like that at all the tables it would go back to being, "everyone goes extinct at the same time."

This turns out to be a very key thing in population viability analysis, are your patches seeing the same environment or are they seeing different environments? If they are seeing the same environments, it would be refining some of the rules that Reed was telling you about but the rule is, if the environment is the same everywhere, aggregate everything into a single pass. But if each pass has a different environment and a different set of prey/predator then it is better to spread your risk over multiple patches. This is a case by case analysis because each species perceives the environment in different ways.

Now, see one of the things we can do is start with more money. If I start with more money, the distribution time would lengthen out so you are always better off when you have a larger population or stop when you have a small population, that is why you are going to pay attention to those populations that are currently much reduced, those are the ones that have much higher probability of extinction.

Now what is going on here is that Las Vegas is not a charity, every gamble you play it has a negative growth on your money. So every one of these things will always go extinct. If there was the possibility of a single trial in my run not going extinct, my computer would still be running so every one of these things managed to reach extinction after some numbered steps and that is because the expectation is for each dollar you bet at craps, you expect to get 98.7 cents back. That is the mean. So the mean rate of growth is very important and now many of the species we deal with Conservation Biology, the condor is a perfect example, you can look at the graph of the condor and it is going down, down, down, down and they were long lived animals and they had to be five-years-old before they could reproduce and they were eating coyote poisoned bait, they were getting electrocuted. It is a given that they had to live forty-five years to start to have chance to have a chance of replacing themselves, they were not making it to forty-five years and here is a case of the population going down, down, down, down so if you cannot reverse that, it is hopeless. But even populations that have a positive rate of growth can go extinct and I have a demonstration here on the next screen.

Due to a ceiling, they can only get so high and once they get that high, they start bumping into ceilings and cannot escape and you still have all the land and forces acting on them so they can have a run of bad luck and go extinct from that point.

Now what I have done here, there is some text you can read if you go to the website and so see as your bootcamp assignment, I want you to do some sort of structural analysis on the game of craps and some betting analyses and e-mail your results to Maeveen.

See, this is the normal game of craps and I want you to consider three different things, each of which has an analog in the real world of biology. See the game I have been modeling is where you bet one dollar at a time.

Suppose as you get ahead, you feel excited each time you win, you have more than ten dollars you bet two dollars and when you have more than twenty dollars you bet three dollars so you scale your bet up as you have more and more money. What impact would this have on tying to extinction? Now I am not going to tell you the answer, you have to go to the website to do this, but this is more truly the way biological populations work because as the numbers get higher the total rote is higher so a condor population of 60 is going to betting more offspring population than a condor population of ten.

Another thing is, suppose our gambler is playing here and suppose every time she gets to twenty dollars, her husband comes by and asks her for money to play his games. She will never get beyond twenty dollars, what does this do to her probability of extinction? Again, this is analogous to a pairing population, a small patch that never get beyond some total density. Suppose that she is playing and her husband periodically comes by every 100 trials to ask for a few of the ten dollars and if she does, he gives her a dollar so this would be like migration into a patch. What does this do to extinction? So these things are all perfectly defined problems on which we can do mathematical analysis. Hopefully this is the gut feeling that the bet is going to be used as the basis for what I am going to talk about next which is the real world. In the real world we do not know the rules, we have to guess at the rules. Someone said do a PVA on the Pygmy Owl, I would not have a clue on how to do a PVA of the Pygmy Owl, you have to spend a lot of time learning about the Pygmy Owl and sometimes, if there is not the knowledge available today, it takes years to get the knowledge. See, the knowledge being what underwrites see the rules which is what you would go into this kind of simulation model.

Given that you do not know the rules, there are two approaches. The literature obscures the difference between these approaches so there is all sorts of stupid argumentation about PVA in the literature now.

There are two branches of PVA, one of which is a time series approach and this is exactly like chart or technical analysis in playing the stock market. You simply have a gray out of the price of the stock and that is the only thing you know, you do not know anything about what Greenspan said, you do not know anything about the economy, you are watching the value of the price of the stock and you are trying to project that value dramatically forward in time to tell you whether it is a winning or losing stock, this is a timer series approach or what you can call a "statistical approach so you have some information and you want to draw a line through it and say it is going up or down.

The other approach is to do the science and learn the rules. I am going to quickly talk about both of these approaches and show you what their limitations and relative considered advantages are. All these things are the sort of games I have my students play them.

So here is a game where a population is declining, let's think of the grizzly bear. The truth is, the population is declining but we have to make an argument to the National Park Service or to the public at large that the grizzly bear is declining. The problem is, you cannot census the grizzly bear. If we could actually get the true numbers of grizzly bears you see yesterday, today and tomorrow we could draw a valid line through these census but even with something as big as a grizzly bear, we would have a tremendous uncertainty as to how many grizzly bears each year.

See if they were all wearing radio collars that would be great, but even spending two million dollars a year it is hard to get a perfect census so what we deal with is a sample.

There are some who think that you can actually fly over and do aerial surveys on things that are out in the middle of plains and short vegetation, you can photograph them and get pretty good numbers but most things we work with, we have to sample. So here is a game that we play where we are going to take samples at two points in time and we are going to project what the population is doing. The population is really declining along the black line. See I have a 10% sampling deficiency here so this means that suppose we had Yellowstone. Suppose I go into 10% of Yellowstone and spot every grizzly bear that is there and I multiply that number times ten, that is how I estimate the total sightings in Yellowstone but the grizzly bear moves around and sometimes this area would have more dense sightings. So I have a 10% sampling deficiency, yet I have taken samples two years apart to do a trial. My real numbers are here and here, through the sampling process I get estimates of grizzly bears below and above here so after one year, I say the grizzly bear is increasing at 47% per year. But that is what I get from my sampling. I do ten trials, numbers all over the place, do 100 trials and this is not good enough.

The colors are not coming in, I can see it on my screen. See when we go back to one number you can imagine a line going between these two numbers. Now suppose I increase my sampling efficiency to 50% so I am getting a much tighter answer and one of the important things is the true growth of the population was minus 3% per year and when I sample with 50% efficiency over a five year period my sample estimates cluster around the actual estimate and it is only in the small percent, 12% of the cases am I falsely estimating the positively growing population.

Okay, this is real important. There are two things that I did to get better answers. I spent a lot more money to sample more thoroughly and I took a lot more time to do the sampling. Both of these cost you money. See the developers always scream, they say we have loans on these big plans they are developing and you know, can't you see they are paying the bank ten to twelve percent interest per year while you guys wait for this to come true but these are actual limitations. You could say, "Well go out and sample better," but some things there are reasons you cannot sample better. If you go out and sample too thorough you disturb the environment too much. These are the kinds of limitations you get when you play the project the time series game of PVA.

Now I have another game here, it is sort of the same game where you have a sampling efficiency, sampling efficiency and number of time steps over which you sample and these are in what are called text fields so you can change these numbers. See, this game works by selecting a growth rate. Now I have selected plus or minus 3% and what I am going to get here is with my sampling efficiency, see of 10%, there is an underlying trend line which is up or down at 3%, these are my sample points of one, two, three, four, five, six.

I am going to hit one of thee buttons to guess whether this is a growing or shrinking population. Now this looks easy so I am going to guess that it is growing and in fact it is growing, I go to the next one and that one looks like it is growing. This one is going down. So these are my samples which look like they were going up and in fact, the first sample was way below and this sample is a little bit above so what a six year series and what the truth was, it is going down.

Again, if I stretch out this period or increase the efficiency of sampling so I am going to increase the sampling here to 90% and start a new trial. You see here there is very little error, the population is almost certainly increasing, there is very little sampling error about these points and when I guess I am almost certainly going to be right.

This is a very common way of doing PVA, see it has the statistical limitations that I just told you about. More importantly, there is no model here, there is no understanding the mechanism. From this you do not go to a recovery plan, from this you do not go to an HCP, this only is raising the red flag, this is going up or down. You do not understand the population so I never do these things, a lot of people still do these, but I tend to go towards the mechanistic model which is actually even harder but at least if you try and develop a mechanistic model you have some understanding which allows you to do what we put in a report, what if we shoot the predators, they are eating these guys. What if we put up better feed boxes, a lot of what if things that could be put into the model and you can run the simulation. Again, I am not saying these things are perfect but at least they are a tool that allows you to come to a consensus as to what might be a good strategy for dealing with this particular case.

This is slightly complicated, but look at the red line here. The red line is the plot of the number of animals you expect in the next time period given the number of animals you have today. So here is the animals you have today, here is the animals you have tomorrow and in this range between this point and this point, you expect to get more animals tomorrow. See, if you have these few animals today, this point is preparing capacity, this is a 45 degree line. If you have this number of animals today, you get the same number of animals tomorrow, the population is at steady stake, it is at equilibrium. If you are above this point, the animals you expect tomorrow are fewer than the animals you have today because there is not enough food for these animals. Their population is going to crash so this is the famous logistic growth model, this is what is used for harvest modeling. People try and harvest animals at half their pairing capacity because that is the point where they have the maximum resilience, the hunting pressure and things like that.

What I am doing here is doing a logistic growth model with pairing capacity and I am varying the growth rate so the growth rate here is one which means that it is 100% growth rate. See a growth rate of zero means the population would not change at all so I am giving you the population positive growth rate and I am changing the environment. I note everything with the exception of I do not know what the environment is going to be from year to year. This almost exactly now I guess to the craps model. Some years we are going to get bad rain, some years we are going to get good rain so the environmental variance, this is a variance measure on the growth rate. See, this also can be changed, the higher this is the more variable the weather is so you drag the mouse over these bars, let's get the environmental stochasticity low. See, as we get this low there is very little disturbance from year to year, the estimates cluster around the pairing capacity and that is what this histogram is. The probability of distribution for observing animals is the capacity plus or minus 5% with low environmental stochasticity. Now this is very important, the only thing I am going to change next is the variability in the environment, I still have a population with positive growth and a positive pairing capacity but now I am getting worse ups and downs and if I have dramatic fluctuations, then I get two or three bad ones in a row the population really gets driven down. Changing this, see I am actually going to drop the growth just a touch and see what happens.

So changing environmental stochasticity to higher variance and what you are seeing here is a spread in the probability of distribution in animals and note that the mean of this distribution is moving to lower population sizes relative to pairing capacity. This is a strange mathematical result that very few people understand but it is easy enough to see here.

So we start to stack up the population at low densities and some of the chance occurrences drive the population extinct so out of 300 trials we are getting 20 times this before the population goes extinct. Understanding the degree of environmental stochasticity is equivalent to understanding the dice that gets rolled in the craps. The species varies for the same species in different environments, but this is a key thing. Environmental stochasticity is all the key in doing population viability analysis, understanding where it comes from, how it impacts, what you might do to mitigate it, etc. I do not have time to get more deeply into this, I am going to now going to talk about metapopulations.

I have done a lot of work on metapopulations so now imagine the following. We have a (?) here, we have it in this color which is almost impossible to see it. I have six patches, six habitat patches of different sizes and different adjacencies, different distances between them. I can keep track of distances. Now, the data that went into parameterizing this model come from South Pacific birds. Jerry Diamond and I did about a ten year series of work where I took all the information he gathered from birds and fit models of area dependent extinction and distance dependent dispersal. These things are of the character birds which might be of the character butterflies but is not at all necessarily the character of small mammals on patches of the forest floor, but it is plausible.

The point of this model if you could do relative investigations, see it would take a lot of information to quantify this absolutely but in the relative sense you can change the configuration of the patches and see what it does to the persistence time of the metapopulation. When I hit simulate, you see the patches wink on and off, see the big one winks off fewer than the small ones, the small ones this small one for example winks a lot. This graph plots the number of patches occupied, this graph which moves down the page is patch zero, patch one, patch two, patch three, patch four and patch five. The black bar represents occupancy, this point represents an extinction event and so this patch during this period of time is extinct, it is recolonized and it goes extinct and this looks like something which is not too viable. You see, most of the runs for 400 time steps are ending up with all the patches extinct. So then we can do some things, we can say "Well, what if we move this patch over here?" So now we have better connectivity and see, nothing else has changed but we do have better connectivity Persisted, persisted, extinct. See moving this patch over here, when it was sort of isolated out here it would usually go extinct and stay instinct and did not help the system. Moving it into here it first of all had a higher probability persisting. Secondly, it served as a source patch for these four adjacent patches so when this one would go extinct there would be an extra probability that conditional upon this patch being occupied you could get a dispersal colonization event that went from this one to that one.

So metapopulations are very much dependent on size and location of patches and the rules that Reed was discussing earlier are based on models like this, but this is a single species model this is not a model that is talking about biodiversity of the Amazonian Rain Forest, this is a model that you would apply to one species at a time which allows you to do this analysis. This type of model allows you opportunities to add patches so I add a patch over here and they can move it in, I can make it bigger, get this one closer.

Notice now that these black bars are more continuous so this is a tool which allows single species reserve design.

Q:Can you change the shape of that?

A.No, this is sort of a toy model that is used for student demonstrations, boot camp stuff, but the real world stuff I have done, I have ragged edges.

In fact, a lot of the work has now gone to actually subdivide each of the patches, but the rules still remain the same about dispersal over bad habitat.

I am going to finish off with a real world example. Again, I do not have time to do this fully but this is actually one of the things written up in Quammen's book, Song of the Dodo, in fact this graph is almost exactly in Quammen's book except it was a true basic program at that point, now it is a wonderful job applet. So in 1987, I gave a talk at the 1985 meeting that Soulé held that led to the 1986 book on population viability analysis which was a term that was coming into vogue and the Fish and Wildlife representative, Jim Johnson from the Albuquerque, New Mexico office said, "That is what we need, we want you to analyze the Concho River Watersnake, we have a jeopardy case, Section 7 consultation with the Bureau of Reclamation, they want to build a dam on the Concho and Colorado Rivers in the middle of Texas," San Angelo, Texas, is off here on the map and so the proposal from the politicians of the corp was to put a dam about here to create a reservoir of about this size and the biologists were saying, "Well this is bad." Because here you have a snake species and imagine this is a river, the Colorado River and this is the Concho River. So you have a snake species that used to be in about 2,000 miles of habitat in all sorts of streams that went up here but due to all of these small dams and we had a rancher question here earlier, this is one of these cases where building teeny little dams interrupted the dispersal of this snake and this is a metapopulation snake so the interrupted dispersal fragmented the species and the species went from 2,000 kilometers down to about 500 kilometers in 1987 and now there was going to be a major dispersal barrier put in here to try to trisect the current population. The biologist said, "Fish and Wildlife should be in jeopardy and you should stop the building of the dam," so they hired Soulé and me to do a PVA of this thing, we had a month to do it. We had pretty good data including a bunch of videotape in a helicopter flying over these rivers looking at the habitat which immediately made me nauseous and took three days off of my time. But surveys were done, they had a lot of graduate students out here, they have done genetics, they divided the river up into these patches because these snakes only persists in ripple habitat, it does not like smooth flowing stretches of the river. These rivers are like the ones you have around here, they are dry for one-half the year, but when they are flowing in the late summer the snake can only feed on ripple habitat where the water is going over the rocks. The snake will perch on branches over the river and strike out a little fish from these branches because that is the only way they can feed. The size of these cells is proportional to the amount of good habitat in a five kilometer strip, 500 kilometers divided up into five kilometer stretches, there are 100 patches here.

This snapshot is the occupancy in black of those patches in 1987, they had a 1983 survey where different patches were occupied so there had been extinction recolonization events between 1983 and 1987 over a short period of time so this looked like a metapopulation. It also had zero genetic heterozygosity which is consistent with being a metapopulation, but I do not have time to make that argument.

Now, we are making something that is much more realistic, it actually fits the geometry of the landscape, it has the adjacency of patches. See, the colonization is basically only 61 or 62 patches, up or down stream. You do not have snakes swimming one-hundred miles, they just cannot make it, they get predated on as they go through the clear flowing areas. To go a mile, it is pretty good in a lot of ways it is as good as it can be at that time. I am going to tell you about one huge error, but we can run the model.

This is sort of the same thing, the patches are blinking this is 300 years into the future so the answer for this is that the current configuration of the snake is viable. It almost never goes extinct in the simulation runs. Sure, it has lost a lot of range but the species was not listed at this point in time, it was listed within one year of our work, another one to be listed. Currently the analysis would not underscore a support listing because the best model is not predicting extinction. It has never gone extinct in 300 years, but the issue is jeopardy.

We can add the dam. Adding the dam permanently extinguishes all of these patches or so we believed. So now you run it and it does worse. So this line is the number of extinct patches and typically what happens in these runs is all of this system will go extinct and all of this system will go extinct. After trisection you now have two unviable metapopulations but you still have one viable metapopulation. The answer out of this model is the jeopardy opinion is not warranted because again, you are going to get further reduction in range but if you are basing jeopardy on viability, the thing is not unviable. Well then Soulé and I did not like this answer but there it was. Soulé said, "Yeah, but what happens if there is an interstate highway, or what happens if an oil tanker drops off the interstate highway and sends a bunch of nasty pesticide down this river, there is no refugia and it will all go extinct so that is a catastrophe and the Army Corp of Engineers nodded and said, "Well we will hire some graduate students to move snakes." They did go ahead with the listing and there has been further work. I was just on the phone one month talking to some of the Fish and Wildlife people in the Albuquerque office and they want to do another PVA and they said that in fact, what we were told is that the reservoir would be bad habitat because the snakes would get predated on by bigger things. The graduate students working out here now are finding snakes all along the edge of the lake where the branches come over the lake and they are striking down. The dam could still cause problems getting over the edge of the dam but at least this connection is higher. Maybe this is going to be something where further information is going to lead to a change in the predictions of the model that the trisection is not as bad here in the dam per se and retrospectively was not as bad as it was first prospectively to be.

I am going to stop here, I did not mean to take as much time as I have so these are PVA's starting from the gambling intuition, leading to some toy models and coming up to a real world case that had real implications. I mean this particular case where a lot of people were not put out of work, but this kind of modeling had the input numbers been different it could have denied San Angelo their bass fishing lake. Thank you.

We are a little bit late but I can take a couple of questions.

Q:In a couple of instances you have pointed out the importance of sampling efficiency in predicting species persistence. In your models you have shown that you can have sampling efficiency going all the way up to one. In the real world the examples are going to be biological that indicate you cannot do this, what are some of the ceilings we can expect?

A:Oh, that is a good point. That is not my area of expertise because I am the guy that takes the data the field people gather. See, it always a question of time and money, I mean to thoroughly sample Yellowstone is a lot of time and money but then as you have point out, there is sometimes just impediments to perfect sampling. In your sampling here you are disturbing the population over there, you have to let it settle down before you can go over there. There is just a variety of things since it changes from species to species. Birds can be fairly easily sampled because sometimes you can go out on territorial calling. You have a tape recorder, you play this thing and the bird comes in and displays and then you can check off the presence of the bird. Other things are pretty cryptic and hard to find, I do not know at all about the Pygmy Owl. I mean the Sonoran Pronghorn would be probably be easy to sample.

Q:Coming from San Diego, maybe you can tell us how their regional habitat conservation plan models might fit.

A:Zero. Well now that is untrue, but around 1993 the political will changed from more from doing single species analysis to doing multi-species analysis so now you have to do 100 PVA's and you want the answer sooner. There are other techniques that are coming to be used instead of real thorough PVA's so PVA';s seem at a bit of a decline because of all the demands for data and things like that, but for particular umbrella species the PVA can be very important. The Desert Tortoise, the PVA was the thing that was underlying the research design. There are other considerations that come into play. You see, the PVA 's can be more or less good, but you are probably still going to do a PVA, it is just a matter of whether it ends up being graphical on a computer or being an opinion of an expert or something like that. PVA to me is a big umbrella term that simply means "Population By Ability," species analysis. It is like financial analysis where you can go in, someone can look at your stock and real estate holdings, nod and say, "That's good," or someone can charge you $10,000.00 and give a very detailed analysis of what stocks you own and so on. So, there is a lot of variation here. My bet is always to go with good mechanistic models.

Q:Can you develop techniques for using these models?

A:Excellent question. See I am not developing this but I am now more and more incorporated into technical teams that do this. Fifteen years ago they maybe hired someone like me and said, "Run with it." Now, there is always a technical team and there is a lot of feedback correction and there is also lots of cognizance from the experts that there is uncertainty about these things. The uncertainty has to be put into these models. Now I have mechanisms that I did not explain in this short talk. That is what the craps homework exercise are about so you should never just look at one of these computer graphics and see what it is feeding you. Change the assumptions a little bit, sometimes you find that changing this assumption does nothing but changing this assumption, this other one over here the answers are dramatically different. This then informs you that the most important data you are going to need pertains to this presumption and that is where you should spend your money, or that is where you should factor in the uncertainty. You should always have a very thorough understanding of the uncertainty of these models and that was one of the points of my talk, I was trying to get across that there are some limitations of these things. This is not physics, this is something much less than physics and see the public in particular should be aware of the limitations of these things. I hate it when some academic comes in and says, "This is the answer, everyone shut up." That does not work, I mean I used to do that but not anymore.

Q:In your study, have you also been involved in with the genetics?

A:Yes.

Q:For instance, have you got these animals spread out in small pods?

A:Very much so.

Q:We have heard several comments this morning where the speaker said something about the predicament of the Oregon loggers would be in a sense extinct if they protected the Spotted Owl. The affect on the loggers was not as they had predicted. I have a question here about ranching and conservation. Are similar kinds of models being done that would look at the impact on the environmental objectivity?

A:See, I am working on the team now. We have been meeting with people in Tucson for the last couple of decades. We are doing things that are rather distant from PVA. PVA presents a parameter and they are more of a landscape approach, very, very much like what Reed is doing.

We are actually using a final computer optimization model to consider all the PVA land uses, the costs and things and then come up with a conservation landscape. We are doing it one species at a time, we are going to superimpose multiple species and try to get efficient solutions but the answer is the world is moving in this direction. My expertise still lies at the level of single species and that is a full time job sir, for several people.

Q:[inaudible]

A:You have read Limits to Growth I take it back in 1972. That is how I got into Conservation Biology, I was worried about the human species. There were these books written in the early 1970's called Limits to Growth and if you remember those things, they all went crash! They went crash because of nuclear war, because of overpopulation, accumulation, pollution, loss of Ag land and all sorts of things.

I was pretty unhappy with managed future when I was twenty-five and living in 1972. Technology was the answer that everyone mentioned at those points, I was going to save everything. That's nonsense, but if you look at what is going on with technology and productivity in Ag land and things like that it looks like we are here to stay.

If you really want to get your homework in early, you can work on it tonight.

Michael Gilpin:If you didn't get enough of that, the website is posted here.

http://insci14.ucsd.edu/~bi178s/PVA/

Thank you.

APPLYING THE SCIENCE OF CONSERVATION PLANNING TO THE BIOLOGICAL ELEMENT OF THE SONORAN DESERT CONSERVATION PLAN: BILL SHAW

What I would like to do briefly now is tell you a little bit about what the Science and Technical Advisory Team has been doing in the last six months or so and hopefully talk a little bit about how we are attempting to incorporate some of these types of techniques and this type of knowledge into the situation that we have here in Pima County. So we can just begin with the slides.

As I think most of you know, one element of the Sonoran Desert Conservation Plan involves the biological aspects of it. The Science and Technical Advisory Team for the Sonoran Conservation Desert Plan is charged with overseeing this process and ensuring that we have appropriate integration of conservation into Tucson's Comprehensive Planning. As you all know, Tucson is a city that is blessed with a very unique environment, unique biota, still a fair amount of habitat that is still available and most of us are here because we appreciate the beauty and diversity of the plants and the animals that depend upon these plants.

It is also an area that has a thriving economy and a growing economy and so we are rapidly usurping this habitat for human uses. The question we are faced with is whether the Sonoran Desert Conservation Plan is, how can we take a comprehensive look at the entire Pima County region and direct this growth in a way that will ensure that in the future we will have some opportunities to enjoy the biota and beauty of the Sonoran Desert?

Now, most people here probably share some frustration with the rate at which growth is occurring in Tucson and the places that have been lost in recent years as a consequence of this growth, but it comes as a surprise to a lot of people that Tucson is actually viewed as one of the leaders in the interest to integrate conservation into development. If you go into the scientific literature, one of the first places you will see any reference to urban biological communities is a classic piece by a preeminent ornithologist Emlin who spent a sabbatical out in Tucson in the 1960's I believe it was and wrote an article dealing how different urban landscapes affect the types of birds that are able to exist.

We go way back long before many people, especially professional biologists who were not talking much about urban wildlife issues. I have kind of a strong history, although we have not necessarily impacted the pattern of growth as much as possible. Back in the mid-80's the identification of critical habitats more recently a series of studies in Saguaro Monument addressing the affects of urban growth on the wildlife of the monument. More recently than that, a systematic inventory of land covers within Tucson in which we actually looked at the types of vegetation associated with different zoning types that put us into a position of being able to answer some questions like, when we make decisions as a community, what will its effects be on the natural vegetation and the wildlife that are associated with it?

And we can go back and say, "On average for example, the major rivers of about 405 of the vegetation that is native vegetative cover and so on and we can do this for the various land cover types. We actually have a wealth of information as Sharon mentioned, we have even attracted people most recently. We had several hundred people from around the world participating in an Urban Wildlife Conference so it got lots of information, continuing studies but what we have not had is coordination of this. We had individual projects, development projects that have been impacted substantially but we still continue to grow in a piecemeal

way without any comprehensive vision of how we want to grow as a community and what areas are most appropriate for development, what areas are most appropriate to meet some kind of objective of preserving biodiversity within the context of urban growth and development throughout Pima County.

We continue to have this lack of comprehensive vision, a kind of frustrated vision in which we desperately needed a symbol of wisdom, someone with wide open eyes but a hard nose to take the leadership and of course, that came in the form of the Cactus Ferruginous Pygmy Owl in March of 1997 which all of a sudden instead of being just local politics, this became more of a national issue because of course, Endangered Species address a national heritage, the concern of everyone for preservation of biodiversity. As a result of this, there has been the formation of this coalition that you are representing here and all the exciting things that are happening right now in relation to the Sonoran Desert Conservation Plan.

I would like to tell you a little bit about what the Science and Technical Advisory Team has been doing. We convened a group of nine scientists beginning last March and have been working with the help of Pima County staff in doing a lot of preparatory steps to put us in a position where we can begin to implement some of the science that you heard about today in the development of the biological element for the Sonoran Desert Conservation Plan.

We began by defining a mission, exactly what it is we hope to accomplish out of this which is to ensure the long term survivability of all of the indigenous species in the region. This is just some quick bullets on some of the things that we have accomplished so far. We began by talking to experts in individual groups of wildlife to get a list of which species are most vulnerable, which species are in some degree of jeopardy and in some cases, which species are the source of problems such as invasive exotic species. We have gone through several renditions of a report, a list of species of concern to make sure that out of this process we have at least on the table, a list of all the possible species that we ought to be concerned about as we go through this planning process.

It is a very dynamic list, we organized and reorganized it repeatedly with the help of Julia Fonseca and Pima County staff, we provided and developed a brief environmental history of the area with the hope that when we bring in some outside consultants to help us with this process we can get them right to work with a good understanding of this region without having to gather a whole lot of basic information so we have been trying to pull together a whole bunch of different types of information and get us in the position where we can write an intelligent scope of work that will lead to a contract for environmental consultants to come in and assist us with the natural development of the biological element for the Sonoran Desert Conservation Plan.

Three basic steps which I think as we go through this, you will see some parallels of the things we have heard earlier, particularly what Dr. Noss was describing. We did not pull together all the basic information that we need to identify which habitats are most important and then develop a biological element for the Sonoran Desert Conservation Plan.

What you will see up here is kind of a different but very similar organization of which we are trying to approach this from several different levels of analysis. It is not simply a matter of developing a plan for the Cactus Ferruginous Pygmy Owl, we want to develop a comprehensive plan for Pima County and provide biological input into that plan. In addition to

the threat of endangered species that are in some ways have initiated this process because of the economic impact of these issues, we are going to make sure we look at other vulnerable species that are not today, threatened or endangered, so we can ensure that they never reach that status in species with special social significance and then at the community level, we want to simultaneously be looking at which biological communities are most important. And then come back and address the question of whether some socially significant species or species that may not be endangered or come up but are dependent on large areas and what can we do to make sure that whatever system we develop will provide the continued existence of areas of species that require large areas.

We are pulling together the information on various species, various communities such as Honeybee Canyon here that have special significance, virtually any riparian environmental course. The Sonoran Desert has very high importance, even within the Urban Design Departments. As I mentioned, the large area dependent species such as mountain lions or mule deer, we want to make sure that we address the metapopulation issues that Mike Gilpin just described in whatever pattern of habitats that we do leave as the plan is developed.

What always happens in this process is when you start asking questions: which species should we worry about? We could draw a curve of them, the more times you ask, the bigger the list gets, it goes on and on so one of the most challenging things we have to do is boil this list down because we simply do not have the resources or knowledge to address all of these species and we are still in that process and still have a long way to go. We have focused on species that were identified as being biologically vulnerable and that still leaves us with an unmanageable list, 74 is far too many. Our next steps would be to continue to see if we can narrow this down to a number of species that is more manageable. By focusing on key species that we know that if we provide a plan for conservation on these individual species, umbrella species or keystone species that it will also serve for protection for many, many other species that are vulnerable.

Pima County is a huge, huge area. We really cannot expect to go out and gather detailed information about the entire area so we are going to need to focus on key areas that we know are of special significance if we are going to accomplish our mission of preserving the biodiversity of this region.

Just to show you some of the conversations we have had, one of the big issues of Pima County is the impact of invasive species that are not native to this area on native species. We are not going to develop a conservation plan for these but we felt it was important to provide as a foundation, to list these species and discuss them a little bit and address their significance as well on any effort we have to restore and conserve species in Pima County.

Gradually as we begin to develop this information, our challenge will be to integrate the critical habitat information, with information about the protective status of lands, regional contacts and basic fees, etc. in order to produce the biological element for the Sonoran Desert Conservation Plan which again is one of the unique things I think about Tucson's effort. We are focusing on the big picture, the Sonoran Desert Conservation Plan. One aspect of that will be the possibility of Section 10 permits to address the native species issues. We want to keep our main focus on the big picture in how we can integrate conservation in Tucson as a community. Endangered species will be one aspect of that.

I think there are some very special opportunities at this particular time that we have not had in this community in the past. Those of you who have been around for awhile have seen many efforts to get some comprehensive planning that end up sitting on the shelf. We do have this Pygmy Owl situation that has become a very effective motivator and has created a strong coalition. The realization that we do need to address some sort of comprehensive planning for this community so we are not continually fighting on a case by case situation which is really in no one's interest.

We have extraordinary backing from the Interior Department which is going to help us do this as you probably heard. The Interior Department has identified Tucson as kind of an example, it hopes to see a good example for many communities in terms of how we address these issues. There are some new aspects of state law that may make acquisitions of some of the state trust land and issues like that more feasible. That plus the fact that we have a robust economy at this time, all of these things kind of come together and create a very special opportunity that we have not seen in the past 20 years, to do some meaningful planning.

We also have some real challenges. We have rapid growth and demand for this growth to continue, we have a huge area that we are trying to address. Someone pointed out to me yesterday the size of Pima County is the size if you take Rhode Island, add another Rhode Island, add Connecticut and add Vermont, that is about the size of the area we are planning for. It is a huge, huge area which again, points to the critical importance of our focusing our efforts on those aspects of conservation planning that are most important because there is no way we can do it all in an area like this.

We do have relative to many communities a lot of biological information but certainly not enough to achieve the comfortable limits that we would like and we have this tradition within Tucson of watering down and shelving any Comprehensive Planning effort before it ever amounts to too much. We have to overcome all of these issues but I think when you look around and you see the people that show up for meetings like this, the amount of effort that is going on in this community and public attention to this whole Sonoran Desert Conservation Plan.

I think we have an opportunity now that we have not had in the past 25 years to develop some comprehensive planning so that we can continue to enjoy the environmental amenities that make it so nice to live in Tucson which include not only the common species that we live with on a day to day basis but some of the rare species that most of us are not lucky enough to see but we still care about preserving and the vehicle we are using is the visionary proposal for the Sonoran Desert Conservation Plan. That is what the Science and Technical Advisory Team is attempting to do, we do have some additional time. If you have any questions for Dr. Noss or Dr. Gilpin or any of us, we would be more than happy to answer them.

QUESTIONS AND ANSWERS

Q:We have been sitting here for several months, learning a lot and you folks have been working but I am not sure I quite understand how the two processes are supposed to come together and what input we can expect.

A:This is a Maeveen question I think.

Maeveen Behan:I think the question was -- and I am not going to take a lot of time today because we will have that discussion in the near future -- the question was, at what point do the lines cross between the public process and the technical process? They cross at meetings like this where you are introduced to the work of the technical side and they will cross more directly after you graduate from boot camp and go in to a more refined kind of land panel format. Carolyn Campbell had a good suggestion that the Board might choose to implement which is to have people with expertise in certain topics that are on the steering committee be able to produce white papers and watch the whole process. And so we will move into sort of a land panel formation, and the technical people will be protected I guess from the politics, if that is your question. I think we have heard that from every corner of the public that they want to make sure that the science remains protected and so we do want to do that, and as much as we can, have the science team report out to you and give you information, educate you in a broad sense and then go to each land panel, to each community and give that information to as many people as possible as we go forward. That is, I guess, the general sense of where the lines cross. All the technical teams, science, cultural, historic, ranch and implementation will start working with consultants as soon as we get our planning money and so right now this is all free work from the expert committees, and they have done a really great job. Usually this what with most communities would call down time, waiting for what we hope is a federal appropriation for planning. During this time, our expert teams have generated a tremendous amount of information, and that effort shaves millions off the price and years off the time of conservation planning. You will hear more from the technical teams, more from the consultants they ultimately link up with -- this is a continuing education process. Ultimately your goal and your charge is to take the work of the experts and give advice to the elected officials about what type of preserve alternative you would like to see -- and you need to know a lot to do that.

Q:To what extent will the Science and Technology input shed light on specific local issues like wildcat developments?

A:I would like to think that we will provide the community with an ability to make more intelligent decisions or understand more intelligently what the impacts of that kind of public policy issue or subdivision can occur totally unregulated. I would hope that our information would strengthen public and policy controls. Those are the types of variables that are being plugged into the models that we taught about today, or among the variables.

Dr. Shaw:The question was, with the variables in Pima County how much of the land can be subdivided and developed without much regulation such as referred to as wildcat process?

> Once the biological element has developed and goals in terms of species and communities occurs [inaudible] socioeconomic analysis of what goes on in the land so for example, we are fortunate by having large protected areas in the forest areas of the forest service in areas like this that are going to address many of our biodiversity issues already. We probably will not need a new preserve to reserve mixed comment for environments because most of those occur where there is considerable protective status already so that will help us focus things but what the community has to do, of course, is prioritize which areas are worthy of protection and to do that, they will need to know the some of the socioeconomic issues like which lands are subject to have unregulated growth which would make them [inaudible] so that is definitely part of the modeling that we are talking about doing as part of the process.

Q:While this process is developed, is the Science and Technical Advisory Committee looking at those issues?

A:Well, I think our strategy I guess is to get as high profile as we can to what we are doing on the science side, the issue of whether there will be more oriented periods of time when nothing much occurs is one that [inaudible] biology, we hope to find ammunition and assistance. I do not see as our task, that level of policy recognition.

One comment, when the gnatcatcher was listed in California that triggered a lot of this in Southern California, it was listed as threatened and the Fish and Wildlife Service anticipated what the problems might be and concomitant was the listing that they published some special rules that provided for this interim take. Unfortunately, the Pygmy Owl was listed as endangered and with endangered species, you do not have as much flexibility but my feeling is that the Fish and Wildlife Service understands the need for interim provisions and there might be a way to negotiate with them, but this is only speaking as an outsider.

Q:Dr. Noss, you mentioned corridors in passing, I wonder if you could elaborate on what experience have been in other places of wildlife corridors? What could that look like?

A:Wildlife corridors that have been studied most in urban environments and found to be effective are essentially ways to bypass barriers. There are underpasses on highways, they are in fact preparing some cover to dispersing moving animals. Wider overpasses across or underneath highways, providing riparian cover. [inaudible] they might be concerned with different types of habitats that species are vulnerable to isolation might require some contiguous form of corridor for their needs. I would emphasize that corridors have to be designed relative to the particular type of species [inaudible] subarea of your County. You cannot design a corridor automatically and expect that every species is going to be able to use it, you have to know something about the history of those organisms and what might actually serve as a barrier to them in order to get around.

Q:In reference to the food plan, if the food is not around for them and health is not maintained among the animals, the population is not going to be there. If we could provide better food for these animals, would we really be helping the animals and building the population so that we do not have some of these endangering issues? Has anybody looked at the food side of it? See what their diets are and if we could provide food for them, perhaps that could increase their population which would be better for everybody.

A:Its food, its cavities in the case of cavity nesting, it depends on what the limiting factor is but as a general rule of thumb, the best strategy of providing habitat requirements of individual indigenous species is to provide natural vegetation that has allowed those species evolve for millions and millions of years. That is the kind of foundation you need in your conservation plan, to provide the natural community plants that supplies the food covering all the other needs for a species. There are a few special cases when you manipulate environments to a high degree in order to pump up the population [inaudible] like the Pygmy Owl, the issue is almost certainly not a matter of limitation of food, it is solely a limitation of habitat availability.

Q:[question inaudible]

A:Only indirectly, in the sense that because we have converted their primary habitat with riparian corridors in areas in this region to other human uses, you take away the vegetation you destroy the habitat and not just food but all the other things. Food is not the issue with the Pygmy Owl.

Q:[question inaudible]

A:Well basically you have to go out and survey and this is one of these areas where genetic sampling can frequently indicate where there is low dispersal because over time, genetic differentiation will build up in these local populations whereas if it is not a metapopulation but only superficially appears to be patchy with lots of frequent movement between them, you will find genetic homogeneity. So the short answer is sometimes genetics which is a relatively rapid and inexpensive approach to doing the analysis. [first part inaudible] animals to see how they move over their lifetime but genetics [inaudible].

Q:[inaudible]

A:Well, remember it is in the species side. See, we cannot just look at a landscape and know what the species is going to do on it, we have to measure them over their lifetime which is a difficult thing but if you measure genetics and find that fairly close to the adjacent populations have substantial gene frequency differences, the assumption is that you do not have a lot of movement between these things and it is a presumption that it is a metapopulation.

Q:[inaudible]

A:The question was, in the past from other studies, how many other corridors work for the animals? Well this again, we have had relatively few studies of wildlife corridors and that is part of the problem but studies, for example, in Southern California by Dr. Paul Byer, he was hooked on the mountain lion and he found that certain culverts under a highway make a barrier to some species and certain culverts, they just would not go through. Some animals would not cross a narrow culvert but a wider underpass, whether it was a large area available with more cover, more vegetation available for the animal then they were more frequently used. A lot of it is consideration has to do with security, providing security to the animals.

Q:Do we have an opportunity in this situation that perhaps have some influence on the Endangered Species Act?

A:I guess the best answer to that is what we are doing here is what many, many communities are struggling with, it is learning to live with and utilize and make an effective Endangered Species Act for each of these give us a little bit of knowledge of how we might make that act work better in our society so it would be just one more piece in that direction.

Q:What is the relationship between our local Science Technical Advisory Team and the Fish and Wildlife Service ?

A:I would have to say it is somewhat intimate and from the beginning, Babbitt's Office assigned one individual here to work with us throughout it and at most of our meetings, we have had several people from the Fish and Wildlife Service local offices, they have been a resource for advice and consulting so from the very beginning they have been heavily involved and indeed, we have their one person from the Fish and Wildlife Service, Doug Duncan who is on our side on the Technical Advisory Team.

Q:What do you see from your role on the Science and Technical Committee as the major policy judgements that the steering committee will ultimately have to provide recommendations for the Board of Supervisors?

A:Well, I think our task is to provide this steering committee with vision of what we see as the most appropriate strategy for conservation, integrating conservation and all the other things that are being considered as part of this big comprehensive plan. I guess what I would anticipate is, like the way it is going to work, the biologist, we do like to gamble, we do like to win. We would like to make some recommendations that the whole world might not really be able to live with in our community. The steering committee has got to have representation from all interests and you are going to have to make recommendations and integrate them with science, ranching culture and concerns for all other issues that are part of this. My guess is that our recommendation is going to be very strong for biological concerns and your task is to make judgements on tradeoffs to make biological adjustments with other parts of the comprehensive planning.

Maeveen:One piece of information that might help -- if you look at the education series outline, I hope you will show up for one session in particular -- the all day education session at the university. We will work in smaller groups, and you will see an interweaving of each of these strands -- fiscal, cultural historic, ranching, conservation biology -- and you will see at that session, how do you draft a species conservation plan. The other overlay that you will receive at that time is what we have been working on this week with Mike Gilpin and three other scientists from the University of California. We are working to create a decision model that shows the tradeoffs involved in your decision to promote a certain preserve alternative. We will talk about that too in October. You have to preregister for that session.

Audience:November.

Maeveen:You are right, November 6th at the university and I really encourage you not to miss that session.

Q:[inaudible] have you done studies on other animals or birds to indicate their dominant within the urban area?

A:The answer to the last part is yes. And to the first part, I can assure you the coyotes will be back, populations are cyclic in coyote populations but they are naturally cyclic and you may not have seen any in your neighborhood for the last few years but go a few miles away and I think you will find different perspectives. There are plenty of coyotes. There are a whole bunch of species that have been studied. Javelina, mule deer, we have studies going on with roadrunners, bats, Desert Tortoise and lots and lots of individual pieces but as I said before, what we have lacked is being to pull all of these together in a comprehensive conservation plan.

Q:Is the Board going to be dealing with their own guidelines soon?

A:Chuck Huckelberry: Probably the answer will come from seeing what comes out of the recovery plans for the Pygmy Owl and my guess is that when we see the specifics in that recovery plan it will then be required to take before the Board, specific actions regarding an interim plan, but until we have those specifics there is not much we can do. We can do interim plans for every element, I think we can do an interim plan for ranch conservation, etc., we just have not gotten that far so I think the first interim type planning process will probably lead to discussions with regard to regulation or what we may need to do with land use will come from the recovery plan for the Pygmy Owl.

Dr. Shaw:Why don't we give a hand to the guests that came from out of town. Thank you.