

US Fish and Wildlife Service | Why Structured Decision Making__Part 1__

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Hello, and welcome to an overview of structured decision making. My name is Sarah Converse. I'm a Research Ecologist with US Geological Survey at Patuxent Wildlife Research Center in Laurel, Maryland.

And my research program at Patuxent is focused on the ecology of endangered species, and I work regularly with managers to develop decision frameworks to help them manage endangered species. I, along with my colleagues, developed this two day version of the structured decision making course in order to give people, like managers, an introduction to the concepts of structured decision making.

In this module, I'll give you an overview of the concepts of structured decision making, and I'll hit many points that will be followed up on in later modules by my colleague Mike Runge, and by myself. And I want to acknowledge that this module was developed originally by Mike Runge.

So let's start with an example to illustrate some of the concepts. Let's talk about understory management. So, we can imagine being a manager who is in charge of managing ponderosa pine forest say in northern Arizona. And that manager might be motivated to develop a management plan for the forest.

The first kind of thoughts that manager might have would be along the lines of, what is it that I'm trying to achieve? What do I want to get out of managing my forest? And a manager might break those objectives into two different kinds.

We might first think about fundamental objectives. And fundamental objectives are the basic, most value-based objectives that we have. So these are the things that we really just care about for their own sake. And when we're managing a forest, we might, for instance, care about maintaining populations of the native vertebrates and invertebrates in the understory of that ponderosa pine forest in northern Arizona.

And, as a means of getting there, we might realize that what we need to do is to maintain the open-canopy pine stand with the appropriate understory vegetation. And so we might call that means objective.

So we have a fundamental objective of maintaining healthy populations of native vertebrates and invertebrates, and we have a means objective of maintaining an open-canopy pine stand with the right kind of understory vegetation. So now we know where we want to go. We might next think about, how is it that we could get there?

What are the different alternative actions that we could take to develop a pine stand that looks the way we want it to look? So we might consider prescribed understory fire as one alternative, or we might consider mechanical thinning of the understory as another alternative.

We might also need to think about aspects like how frequently we would burn or mechanically thin the forest, or maybe under what conditions. If it's a particularly dry year or wet year that might change how we think about what's best to do. So those are our avenues for getting to where we want to go.

We might next think about making predictions about how different alternative actions will or will not get us as close as possible to the objectives that we have. So we think about making predictions in the broadest sense using models.

we might need to make predictions for instance about how the basal area and the vegetation composition in the understory would change as a function of the different alternatives, like whether we do mechanical or prescribed fire, and how often we do those treatments, and so on. And that will help us think about how our different alternatives will help us achieve our means objective.

We also would want to understand how that would help us achieve our more fundamental objective. So how will the native animal communities change as a function of the habitat conditions that we create with different alternative actions? And it's important to note that these models of our system that we used to make these predictions could take many different forms.

They might simply be mental models, they might be conceptual models, or ultimately we might build quantitative models. But the key point is that those models, those models that we use to make predictions, explicitly link the alternative actions that we have to the objectives that we have. They make links between where our alternative is for getting somewhere, and where it is that we ultimately want to go.

Once we know these pieces, our objectives, our actions, and our predictions or our models, we have to solve the problem. We have to looking at our different options or different alternative actions and say,

which one is the smartest? Which one's the smartest thing that we can do, given where we want to go, and given what we know about the system that we're trying to manage?

So we find an optimal solution by integrating our objectives, our actions, our models, to identify the action and its timing that best achieve the objectives. We're going to have multiple different modules throughout this course that talk about different methods for locating optimal solutions.

In this case, we might say that an optimal solution would call for thinning whenever the basal area of our stand exceeds 85 square feet per acre for example.

So what is structured decision making? We've given you a basic overview of some of the steps in structured decision making, which we're going to go back to through this module and through other modules in this course. But at its most basic, structured decision making, we can think of it as a formalization of common sense for decision problems which are too complex for informal use of common sense.

And I take this quote from Ralph Keeney, who is one of the preeminent scholars in this area of decision analysis. So really, structured decision making is about common sense, but we use it in fairly formal ways, because we are working in decision settings, which are very complex.

We have lots of objectives, we have lots of different actions, and we often have a fairly complex understanding how systems work, as well as an uncertainty about how systems work. So let's pause now and take a minute to, before we continue on with the concepts of structured decision making, to make a distinction between two kinds of decision science and two different ways of talking about decision making.

First, is the field of prescription decision making. This is the focus of this course. Prescriptive decision making is a rational framework for how people should make decisions, and the study of an application of techniques to aid them in making decisions more effectively.

We have to contrast this with descriptive decision making, which is the science and the study of how people actually do make decisions. There's lots of popular literature about this concept of descriptive decision making. The book *Blink* comes to mind for instance, which you may have seen on the newsstands.

But we're going to focus primarily in this course on the concept of prescription decision making. How people should make decisions. But we are going to have one module and my colleague Mike Runge is going to introduce one module on descriptive decision making, which considers our natural tendencies and biases and limitations in making decisions as human decision makers.

Being aware of those tendencies, and biases, and limitations is very useful as we do go into the realm of prescriptive decision making. So we can see where our natural pitfalls might occur.

So let's take a minute and have a little discussion and think about some concepts individually. After I introduce this concept, you can just briefly pause and think about some of these ideas, maybe write some notes down. And we'll discuss them with colleagues if you're taking this course with colleagues. And then we'll revisit those concepts through the rest of this module.

So let's think about the house or the apartment that you now live in, and ask yourself how, and why, did you pick that as a place to live? Consider things like what was the source of the initial stimulus? Why did you have to make a decision about where to live? Were you moving for your job? Were you just moving to a new city to because you liked it? What was the reason?

Maybe you had outgrown the house that you were currently living in. What sequence of steps did you go through? What did you do first, and second, and so on, to make a decision about where to live? Were there any constraints that you were aware of, or did you have some objectives in particular that you thought about? How did you establish what those were?

Did you have some uncertainty about some aspect of your decision, and how did you deal with that uncertainty? How did the alternatives of where to live become available to you? How did you seek out different options? And how did you settle on the final option? And, what was important and the final choice?

Pause the video for a minute, and take some notes about the decision that you made to come to live in the house or the apartment that you live in now.

OK, welcome back. So hopefully you've been able to write down some ideas about the different aspects and different thoughts and different issues that came up when you chose the house or apartment that you now live in.

And so let's now go through the steps of PrOACT. and PrOACT is the acronym that we use to describe the steps in the structured decision making process. I'm going to introduce the steps now, but we're going to go through each of these steps in a lot more detail in modules to follow.

The first step in developing a decision framework and using structured decision making is to define the decision problem. What is it that you actually have to decide, and why? When it comes to buying a house for instance, you might state your decision problem as, I have to buy house because I'm moving to a new city to take a new job.

And I'm going to be moving there in six months, so I have six months to make this decision about what house to buy. I have to make that decision in collaboration with my spouse, for example. So you've defined what it is that you have to decide, when you have to decide it, who the decision makers are, and so on.

So that's the process of defining the decision problem. Once you understand that, you might next want to think about, what are your objectives? What is it that you're trying to achieve? And this is the second step in PrOACT, my objectives. So when it comes to buying a house, obviously I have lots of objectives.

I want to be close to my work for example. I want to have a house that's big enough for my family and the people that will be living there. Maybe I care a lot about particular things like, for instance, for me, I live in Washington DC, so it gets very hot in the summer. I might really care about making sure I have central air in the house that I live in.

Objectives are really personal. It depends on your particular situation, what you care about. If you have elderly parents living with you, you're going to have very different needs for a house than say a single person. So objectives are really particular to the decision maker, and they really drive the process. We need to know where we want to go before we can think about how we might get there.

Next actions, and we're going to talk about alternative actions in Module D, and I'll come back and cover these concepts in a lot more detail. When it comes to buying a house or an apartment, you have different options. You have the house on Main Street. You have the house on First Street. You have the house on D Street, or you have multiple different apartments.

And maybe the real estate agent introduces you to those, or maybe you search online on Craigslist to find different alternative actions. And those are the different options you could consider. And one of

those should be the best one that you can choose out of all those available. And you'll get there, understand which one is best by building models to predict the consequences of different options.

So for example, if that house or apartment on Main Street is very, very expensive. It's not going to do very well if one of your objectives is to keep your costs down. But, it may do very well if it's big enough to hold the number of people comfortably who are going to be living there for example.

So we build models to make predictions about the consequences of taking different actions. And, again, those models could be pretty simple, they could be pretty complex. And we're going to talk more in a couple of different modules through this course about how to make predictions about the consequences of different alternatives.

And last, in this PrOACT sequence, we have to think about the trade-offs, or we also often say optimization. Now, often, when we're thinking about buying a house, we do have multiple objectives. It's not just price. Its price and location. Price, location, and size. Whether or not our dog is going to be comfortable there for example.

So, we have to weigh those trade-offs and consider that the more expensive house is going to have more room, and the cheaper house is going to have less room for example. And how do we make that trade-off decision? And, with single objective problems, we often think in terms of optimization. Where we're just looking amongst the different options to see which is the best.

We're going to have a couple modules that talk about this concept of optimization. And then we have some additional steps often. For instance, we might need to think about risk and uncertainty and my colleague Mike is going to talk about those concepts in the last two modules of this course.

And ultimately, where we want to get is, we want to get to the point where we make a decision about which of our alternatives is the smartest alternative that we can choose given where we want to go, and given what we know. The predictions that we've made about the problem that we have to make a decision about.

So we can also think of this PrOACT sequence as sort of a circular sequence. We take these steps in turn. We need to understand what our objectives are before we can think about how to make the predictions of how our alternatives will affect those objectives for example.

But we also often find that, as we go through the process of understanding our problem, understanding our objectives, laying out our alternatives, making predictions, and so on, that when we get all the way to the end, we've missed something. We've left something out. We haven't properly characterized our decision problem. We've missed an objective.

We didn't consider some alternatives that may be available to us. Our models are incomplete. And so often, we'll go through this process a couple of times. And so we think of it as sort of a circular process before we get to the point where we feel comfortable that we've characterized our decision correctly and that we can go ahead, make a decision, and take action

Feeling like we really have done the best job we can in capturing all the important elements of the decision.

And it's important to note that this process of making decisions, structured decision making that we're going to be talking about, is really a planning process. It's a process that we use to get to the point of deciding what to do, and when we're going to do it, and so on. But then, we also have to go through the process of implementing that decision.

Now these two steps coupled together, both planning and implementing, come within a larger framework of project management. We're going to focus here on getting to the point where we have a plan, we know the smartest thing to do, and implementation is another topic.

Now let's go through another example to further illustrate these points. So, say we've gone through the process of choosing which house we're going to buy, and we now have the task of choosing which mortgage to take to buy that house. Say a bank offers us two possible fixed rate mortgages. They're both 30 year mortgages.

One mortgage has a 0.0525% interest rate. The other has a 0.0425% interest rate with two points. Which should we choose? We need to go through this process, this PrOACT process. So first, what's our problem? Well, we need to choose a mortgage. And maybe we know who our decision makers are. Maybe it's I and my spouse.

We're the decision makers, and we need to make this decision say, in the next month, because we're in the process of actually making a bid on a house. We then have to figure out what our objectives are. Well, maybe in this simple example, we know that our objectives are to maximize the proceeds from the

ultimate sell the house less the costs what we invest in it when we buy and during the time that we own it.

The actions are fairly simple in this case. We have two different alternative actions available to us. We can take the 0.0425% with two points, or we can take the 0.0525% mortgage. And then we need to make predictions of the consequences.

So in this case, we're going to use financial formulas which are readily available to calculate the cost of the ultimate sale, and the proceeds that we can expect at the time of the sale. We're going to use those financial formulas as our model of the system that we care about. In this case, the trade-offs step, or the optimization step, will be pretty simple.

We can directly compare the consequences for the two actions that we're considering. We have only one objective, so we just know that we want to take the alternative that maximizes the proceeds less the costs. So, at this point, let's switch over to a spreadsheet and look at the components of this financial example in that spreadsheet.

We're looking at the spreadsheet that we're going to use to evaluate our two different mortgage alternatives. In cell C2 and D2, we see the different rates for our two different mortgages. Our first mortgage has 0.0525% and our second mortgage has 0.0425%. Now, they're both 30 year term mortgages.

In cell D4, you'll see that the second mortgage has two points associated with it, whereas in cell C4, you'll see that the first mortgage has no points associated with it. Now we also see our purchase price, \$250,000. That's the same, of course, for both alternatives. And we're going to make a 20% down payment. So we're going to put \$50,000 down.

So what that means then, is, for the first option, the total loan that we're going to need is just the difference between the purchase price and the down payment. So in cell C7, you'll see \$200,000. Now in cell D7, we're going to actually have to borrow just a little bit more than that, because we're going to have to borrow enough to pay the two percentage points. So an extra \$4,000.

So our loan is going to be just a little bit more money. Now, if we continue scrolling down, we know a little bit about what our loan amount is going to be. Now we have to figure out, what is our monthly rate payment? So we can look in cell C9 for example, and realize that it's just the overall rate for the

mortgage divided by 12.

It's a 30 year mortgage, so we're going to have 360 payments over that time, and we can then calculate our payment using the formulas that are actually readily available in Excel to calculate based on the loan amount and the interest rate, and so on. The number of payments, that's going to be our payment amount, in cell C11 for option a, and cell D11 for option b.

Now we have to make some assumptions. So say, in this case, in our simple example, we know for sure that we're going to spend three years in that house. Maybe it's a situation of being a federal employee and knowing that you're going to take a three year position someplace, and after that three years you're going to be leaving. So you know for certain how long you're going to live in that house.

So over that time, you know how much your total payments are going to be over that three years' time, and then you'll know the balance on the loan amount after that time. And so you can see those numbers in cells C15 and C16 for option a, alternative a, and D15 and D16 for alternative b.

Another assumption we need to make. Let's say that in this case, we actually know how much we're going to sell the house for. So again, this is a very simple example. We're going to ignore any uncertainty we might have about that. Again, maybe we have some kind of an agreement with our employer that they'll buy the house from us at the end of the three years for \$300,000.

So C18 and D18 show the ultimate sale price. Well the proceeds then, are just the difference between the sale price and the balance on the house. And so, we can calculate then, the proceeds less the cost, and you can follow through the spreadsheet on more detail on your own. But, remember that our objectives were ultimately to maximize proceeds less costs.

So we see that, in cell D20, the proceeds less the costs are larger than they are in cell C20. So that indicates to us that the option that's the smartest option for us to take is to take the 0.0425% mortgage with the two points, and pay the two points. And we do better, we look in cell F20, by almost \$1,500.

We're now ready to say, the smartest thing that we can do is to take the 0.0425% with two points, and that would be then, the mortgage that we would choose.

OK, so we made a decision about which mortgage to choose, and it seemed incredibly easy. Well, why was it so easy? Well, we had a simple set of actions. We only had two actions that we were choosing

between, and we had only one objective. Also, in this case, and that was probably a little bit hard to believe, but we knew the system dynamics with certainty.

We knew exactly how long we would be in the house, and we knew exactly how much we would sell the house for at the end of the three years. And so the choice of the best action to take was really pretty transparent. But, what if, more realistically, we had a larger array of choices for mortgages?

What if we had a one year ARM mortgage, or, in fact, the realistic situation, as many of you probably know, is that there's a bewildering array of choices of mortgages from many different lenders on the market? What if, more realistically, you don't actually know for certain how long you'll be in the house? What if you don't know how much you'll sell the house for at the end of your time there?

What if you have a bunch of other objectives or constraints that impinge on this decision? For example, what if your monthly payment needs to be less than \$1,000? That would change the predictions that you would need to make, change the models that you would need to build, because ultimately that would change the objectives that you have.

So, in most cases, our decision problems, the ones that we care about, are more complex. And certainly in the kind of decisions that those of you taking this course are involved, oftentimes there's lots of different objectives, there's lots of different actions available to you, and there's lots of different complications and uncertainties in building the predictions about the systems that we're trying to manage.

And we're going to spend a lot of time over the following modules in this course on, how do we deal with all those different complications and challenges in decision making. [MUSIC PLAYING]