US Fish and Wildlife Service | Making Decisions Under Risk _Part 1_

Welcome back. We're on Module I, Making Decisions Under Risk. So in the last few modules, what Sarah has laid out for you is some of the tools that we have from the field of Decision Analysis that can help us at the analytical phase of a structured decision-making problem. And Sarah talked to you about multiple objective trade-offs and all of the tools that are available for multiple objective trade-off analysis. I'm going to talk now about another set of tools, a set of tools that's useful for making decisions under risk. There's decision trees, and there's ways of handling uncertainty that's associated with those. And I'm going to talk through and give you a sense of some of those tools.

OK "Deal or No Deal." So, 29th of October, 2008, the show "Deal or No Deal," this woman, Tamara Rodriguez, was playing. And in round six, I don't know if you know how this game works, but they start out with something like 16 briefcases and they have certain amounts of money in each of the briefcases. And there's a briefcase sitting right next to her. And then all these other 15 are being held by these models. And she has to decide which ones to eliminate, bit by bit.

And so she's reducing the number of cases. She knows the amounts that are left in all the remaining cases, but not which is in which case. And so her game is to try to, obviously, end up with the most money by eliminating cases. But there's an interesting twist, which I'll explain here. So in round six, after a whole bunch of elimination, there were five cases that remained. Three of them had a $1 million in them, one had $400, one had $300. She has a choice at this point. She's got a decision to make. She can keep playing, which means she picks one of the suitcases to eliminate, that gets opened, and then that number gets crossed off the list.

What she's trying to do is, if she gets to the end of them, then she gets the case that's sitting next to her, that's been sitting next to her at the beginning. But at any point, she can opt out of the game. The banker is going to offer a deal at every turn. And in this particular case, the banker offered her $423,000 to stop playing. Think about from the banker's standpoint. The banker is thinking there's some risk she's going to end up with $1 million. The banker would rather not have that happen. He's willing to pay her $423,000 to stop playing. But she's got a question to ask herself. Should she take that deal, the $423,000 and go home, or should you keep playing and have the chance of winning $1 million, but also having the chance of ending up with only $300 or $400? What should she do? What would you do? Why don't you pause the video, stop and talk to your friends for a few minutes, and see what you might do in that situation. Would you take the deal from the banker or would you keep playing?

OK, you've had some time to think about it. Let's look at this from a decision analysis standpoint. One way to think about this, I've drawn here on the slides a decision tree. She's got a decision that's shown by this rectangle on the left. The decision is does she take the deal or does she not take the deal. If she takes the deal, then the outcome she gets is $423,000. That's the lower branch of this decision tree. If she doesn't take the deal, she gets to keep playing. Now if she keeps playing, one of the five cases has $300 in it. So it could be there's one chance in five that the suitcase sitting next to her is the $300 briefcase and she ends up with $300. There's another 20% chance, one in five chance, that she'll end up with $400. And then there's a 60% chance, because three of the briefcases have $1 million, 60% chance she'll end up with $1 million.

We can actually analyze this. We can say, well, there's a 60% chance of $1 million, there's a 20% chance of $400, and 20% chance of $300. What does that give us? That gives us an expected value, an average over those three outcomes, of $600,140. So if she keeps playing, her expected value is $600,140. If she takes the deal, the expected value, which is known, there's no gamble here, is $423,000. So she's got a choice. Does she take the thing that has a higher expected value but some uncertainty to it, or the lower expected value that doesn't have any uncertainty?

And so, in some ways, this is exactly the dilemma that we face any time we're making a decision in the face of uncertainty. There are choices that we have to make, but the outcomes might be unknown to us. There may be some uncertainty, some variability that we can't control, in this case, and we still have to make the decision in the face of that uncertainty. And so what do we do? So that's the nature of the kind of problem that we're talking about here in this module is decisions made in the face of uncertainty.

So a little outline of this module. I'm going to talk a little bit about human intuition and risk and how we think about probabilities. And then we're going to talk about, actually in this module and the next one, is what we do in the face of uncertainty. Well, sometimes we make decisions anyway, even in the face of that uncertainty. Perhaps because we don't have any other choice. Sometimes we can't reduce that uncertainty and so we have to make the decision in the face of it. So I'll talk about approaches to risk and I'll talk about this concept of utility, in particular.

And then, in the next module, what I'll talk about is another way we deal with uncertainty is if we can reduce that uncertainty, sometimes what we'll do is we'll conduct research to reduce the uncertainty, and then make the decision later. And a useful technique that I'll talk about in the next module is called the Value of Information. And that tells you whether it's worth your while to conduct that research to reduce the uncertainty. And then the other thing we do is sometimes we make decisions and we reduce uncertainty at the same time. So we simultaneously do both of those. And that's really the idea behind adaptive management. And we'll talk about that in the next module, as well.

But let's go on and talk about, in this module, what do we do when we have to make decisions in the face of uncertainty and don't have the chance to reduce it? So let's begin by talking about human intuition and risk. One of the first challenges with decision-making in the face of uncertainty is that we actually don't understand probability very well. We, as humans, don't understand probability very well. We've got a lot of inherent tendencies towards biased estimation of probability. We talked about those in an earlier module when we were talking about descriptive decision-making and the psychology of decision-making. So that's certainly a challenge there, that we don't understand probability very well.

The second challenge, of course, is that even if we can quantify the risks probabilistically, we often don't know what to do in response. There's another part of this that has to do with how we manage risks. Not how we estimate them, but how we manage them. And there are some challenges to that, too. And I think often we struggle with how to do that, as well. And so there is a component of decision analysis that really provides some guidelines for these kind of issues.

So let's talk a little bit about probability and how we express probability typically. So I've got a number of terms here, and they're in your notebook on page I-2 that are expressions of uncertainty. So terms like there's a high probability of this event, or this event is not very probable, or this event happens seldom, or it's quite likely, or it's rare, or it's rather likely, or there's a good chance of it happening, or it's uncertain. What do those terms mean?

So there was a study done in 1967, the reference is given in your notebook, and they asked people to put probabilities, numerical probabilities, associated with these different phrases. So I'd like you do the same thing now. There's a place in your notebook. Just that one column there, on page two, that says "Numerical Probability." I'd like you just write in, for each of these phrases, what probability you would assign to that particular phrase. I'll give you some time to do that. Why don't you stop the video and then we'll come back and we'll discuss the results of this study a little bit.

OK, so, this study done by Lichtenstein and Newman in 1967. They asked the same question that I just asked you to a number of people. And they got some interesting set of results. Shown here on the slides now, it's not in your notebooks, you could jot it down if you'd like, are the ranges of probabilities that they received from the people that participated in the study for each of these terms. So, for instance, "high probability" means to people something like between 60 and 99%. Already that's kind of a wide range, right? "High probability," OK, it's at least 60%, but it could be as high as 99%. "Not very probable," somewhere between 1% and 60%. "Seldom," somewhere between 1% and 47%. "Rare," somewhere between 1% and 30%. "Quite likely," someplace between 30% and 99%. Or "uncertain," someplace between 8% and 9%.

So the point here is that these are the terms we use in everyday conversation and they don't have a precise meaning. What we hear and what we understand about these terms can be really quite different. Somebody might say there's a "high probability" of this happening. If they mean 60%, but you think they mean 99%, that's a very different interpretation of the likelihood of that event. And it could be that this is all context-specific, that the same person, when asked this question, if thinking about different kinds of events, thinking about different contexts, might estimate these probabilities differently.

So the point is that the language we use in everyday speech that expresses uncertainty is imprecise. And I think that's because, in part, our notions of probability are fairly imprecise, as well. So it's not just our colloquial language it's not just how we use these terms and everyday speech.

Here are some phrases from the Endangered Species Act. So these are phrases from a US federal statute. "In danger of extinction," "likely to become endangered." These are actually in the definitions of what it means to be endangered or threatened. Those are probabilistic statements, "In danger of extinction." There's the implication that there's some risk of extinction there. There's some likelihood of extinction. Well, what likelihood? How likely it does extinction have to be to say that it's "in danger of extinction?" Is that a 1% probability? A 5% probability? A 50% probability? And over what time frame? These things aren't clear. It's not stated in the law. We're using colloquial expressions that are imprecise with regard to probability. "Likely to become endangered." What does likely mean? Does likely mean there's a 90% chance of it happening? Or a 50% chance of it happening? Or a 10% chance of it happening?

The point is that it's not just in everyday speech that we use these imprecise probabilistic terms, but it's in our laws, as well. And so this is a challenge. This is a challenge when we're making decision in the face of risk. And the guidance we've got about how to manage that risk is stated in terms that are imprecise.

There is a little bit of hope. There's some work that's been done that says, basically, that people have a tough time with probabilities, with straight probabilities. If you say, "The probability is 0.47," it's hard for people to relate to that. The average person can't really relate to what that means. But they do better if you talk about odds. So it's familiar to think about odds, maybe because of betting and sports and stuff like that. So if we say there's 100 to one chance of something happening, what that means is there's 100 losses for every one win. OK, so that's slightly less. To translate into probability, that is 101 total chances. A hundred of them are losses, one is a win. And so the probability of a loss is 100 out of 101. So it's a little bit more than 99%. Just a shade more than 99%. The probability of win is what is one out of 101, so it's a little bit less than 1%.

I think the other reason that odds are easier or more intuitive people for people to understand is they actually convey sort of a graphical or pictorial representation. If I say there's a 100-to-one chance of something happening, you can think of, well, there's 100 black marbles that represent loss and one white marble that represents a win, and you can kind of see that. You can kind of imagine what that would look like. And so maybe that's why odds work better for people to have it more intuitive sense of it.

Well, the thing is, there's benefits of thinking in terms of probability rather than odds, and that's because there's a rich theory and a set of tools that work with probability. In other words, it's easier to work with probabilities quantitatively. But odds it might be easier to work with from an intuitive standpoint. Well, fortunately we can translate between these relatively easily.

So actually, I've got a quick exercise that's in your notebook, as well. You've got three questions here that ask you to translate the following odds into a probability of success. So four-to-one odds against you, what is that what's that as a probability of success? 19-to-one one odds against. What is that as a probability of success? And then there's four questions that ask you to take the following probabilities of success and translate them into odds against you. So take a few moments, pause the video, and jot in some answers for these exercises.

OK. How did you do? Let me walk you through these things. So the first question says, "translate the following odds into probabilities of success. " so the first one says there's four-to-one odds against. That means there's five total chances. Four of them are losses, one is a win. So the probability of winning is one chance out of a total of five. One chance out of five, that's a 20% probability of success. 19-to-one odds against. There's 19 opportunities to lose, one opportunity to win. There's 20 total opportunities. One of those is a win. One chance out of 20. That's a 5% probability of success.

Two-to-five odds against. These are the kind of odds you see on the favorite at the race track. There's seven chances total. Five of them are wins, two of them are losses. So five chances out of seven of winning, that's a 5/7 probability of success.

What about the reverse? "Translate the following probabilities of success into odds against." Well, if the probability of success is 0.5, then there's an even chance of winning. So there's one chance of winning for every one chance of losing. So that would be one-to-one odds. Those are even odds.

A 25% probability of success. That's one chance of winning out of four. So there's three chances to lose, one chance to win. That's three-to-one odds against. What about a 75% chance of success? 75% chance of success, there's three chances of winning for every four chances total. So three chances of winning and one chance of losing. So the odds against are one to three, one-to-three odds.

You might notice that when you're doing the odds against, if the first number is bigger than the second number then the probability of success is going to be less than 0.5. If the first number is smaller than the second number, then there's a greater chance of winning than losing, and so the probability of success is greater than 50%. Finally, 0.10, OK, a 10% probability of success. What is that in terms of odds against? Well there's one chance of winning out of 10. So one chance of winning, nine chances of losing. So that's nine-to-one odds against.

OK, so the point here is that if you're working with some groups and you're trying to talk to them about probabilities and they're struggling a little bit with probabilities straight up, then you might translate that into odds and have them think about odds and think about sort of the pictorial relationship that's conveyed by odds, or what it would mean if they were betting, or something like that.

All right, so there's some challenges, then, in how we think about probability. Let's move on to thinking about how, even if we understand the probabilities, how do we make decisions in the face of that uncertainty that's represented by them? So here's just a little thought example here. I want you to think about two games. Game one is I'm going to flip a coin. And in game one, if it's heads you win $30 and if it's tails you lose $1. Game two, if it's heads you win $2,000 and if it's tails you lose $1,900. Which of these games would you like to play? Which would you prefer to play? Or are you in different to these?

Well, it's kind of interesting. In one sense, if we look at the expected values, the average payout, in game one, 50% chance of winning $30, 50% chance of losing $1. So the expected payout is, if you average $30 and negative $1, that comes out to an average of $14.50. So the expected value of game one is $14.50. One way to think about that is if you played a whole lot of times, on average you would win $14.50 per time that you played.

Game two, you win $2000 with 50% chance and lose $1900. So it's the average of $20pp and negative $1900. That comes out to be a positive $50 average. So actually, game two has got the higher expected value. So why wouldn't you just choose game two? Well, you wouldn't choose game two because you look at and you're like, wow, I don't have $1,900 to pay out if I lose. The downside risk is pretty worrisome to you, well, to most of us. The downside risk is pretty worrisome and isn't offset by the upside gain. So the risks associated with this, you can't just average these things. That doesn't really express how you feel about it. Whereas in the first game, I've got $1 in my pocket. OK, if I lose that, that's OK. I The chance of winning $30, that's pretty great. Now, people may have different views about this. Somebody else might actually prefer game two. They might say, hey, I've got $1900 in my pocket, but I sure would like to have $2000. If you've just got a lot of money in the bank, maybe don't care about $1900 and you like that gamble.

The point is, that this is kind of the issue that we're faced with. When we don't have control over the outcomes and we're faced with this kind of uncertainty, how do we make decisions? Well, it turns out the decision-maker's approach to risk is part of the values judgment, the values decision that the decision-maker has. How do we make decisions in the face of risk? Well, there's a value judgment there about how we manage that risk. And I think that's an important thing to convey. And what we really need to do is get decision-makers to be able to think better about how they need to manage that risk.

Now in the context that I think about this for my work in the Department of the Interior, and I think that most of you taking the course probably think about this if you're working on problems that are tied to public values, this risk issue, the values associated with risk is often a public value. Who decides the approach to risk? Interestingly, we do have some guidance. There are some legal mandates that tell us something about risk. We talk about the Endangered Species Act and we say that the Endangered Species Act contains some guidance that says in the face of uncertainty, you need the err on the side of the species. So that's a not precise statement of a risk tolerance, but it does give you a direction. It gives you some direction about how to approach risk and where the weight of evidence needs to be in a risky situation when you're dealing with endangered species.

Do we have other guidance? Well, I'll tell you, it's interesting the conversations that I have with decision-makers about this. A lot of times we'll talk about risk thresholds and risk judgments and people would bring up 5% and 95% as thresholds very often. Well, where does that come from? That comes some from Western science, and particularly from the statistical analyses that we all learn in grad school.

Well, it's interesting if you trace back the history of the 5%. Why do we have 5% as a cutoff value for statistical tests? It turns out that that comes from a tradition out of the late 1800s when modern medicine was emerging. And surgeons and doctors we're testing out, in particular, new surgical techniques that had never been tried before. And they recognized, look, there's obviously some risk to the patients in trying out some new surgical technique. What risk can we tolerate? And in that discussion they sort of came to, I don't know exactly the history of this, but in those discussions they came to sort of a guideline, a rule that sort of said well, look, if there's 19 chances of success against one chance of failure, namely death of the patient, then those odds are OK. Then the risk we're taking is worth the benefit that may accrue. One chance out of 20 is a 5% cut-off value for that risk threshold.

Well interestingly, for some reason, as statistics started to develop, formal statistics in, say, the 1920s, that risk threshold that came out of the early stages of modern medicine in the late 1800s kind of got inherited by the statisticians and has been passed along since. Well, here's the important question to ask, is that risk threshold relevant to problems about endangered species? To problems about refuge management? To problems about habitat conservation plans? I think it isn't. I think we have to rethink these risk thresholds in each new context. Because it really is about the particular context and how we value the outcomes in that context. So this is just a caution because I think people are going to anchor on 5% or 95% pretty often and what we really need to realize and help decision-makers see is that their approach to risk is part of the values that they're being asked to express in the decision making.