Transcript 1

Participants:
Simon West (SW), interviewer
Sam (SAM), a mathematician and population modeler in the ecology department at the University, and co-leader of the Wildlands adaptive management (AM) project

Location and timing:
A meeting room at the University, soon after the field trip

Transcript:
SW: Yeah the first area that I wanted to talk about was your involvement with the project and the process building up to the pilot study – like how you became involved in the project, who you were approached by and what the scope was for your role within the project?

SAM: Yep. So my understanding is the history of the project is that there is a research funding agreement between the Authority and the University and there are two people from the University – Blair and Jackie – and they're named on that grant. And I don't know the specific history of how the – I think probably the Authority approached Blair and said, "hey, we've got this issue, can you help us out?" But I'm not certain. I'm not sure who approached who in that initial situation.

SW: Do you know when abouts this was?

SAM: 2010 or 2011 – 2011 is written on the research document that I have, so presumably the talks started probably six months before the document was signed. And then – let me think, I've got to get my years right, we're currently in 2014 – so at the beginning of 2012 Blair hired me and hired Val also. Blair hired six Post-Docs at once, and me and Val were part of that group, and allocated the [Wildlands] project to us to carry through. And while Blair and Jackie remain interested and involved [in the Wildlands project], they made it clear that it was Val and my responsibility to direct the project.

SW: And how was it allocated to you? What did you have in particular that they thought you could help out with?

SAM: Yeah, I think probably when Blair interviewed me, there were a few different skills that I described in that interview. One is that I have a strong background in the mathematical aspects of adaptive management – I have a history of publishing research in the field of adaptive management, but particularly the mathematical modeling side of it. And in addition to that in the past few years – the couple of years prior to that interview, I had a lot of involvement in an Authority project to do with weed management, so I'd done a lot of interaction with a Public Authority. So I was

able to demonstrate I was good at communicating with a Public Authority and able to deliver the kind of work that they were interested in. So it was a combination of my mathematical adaptive management knowledge and my communication skills with a Public Authority I think, that Blair was – that Blair saw in me and thought would be useful for the project.

SW: And the previous project with the Authority – that wasn't adaptive management was it, that was something else?

SAM: No it wasn't. That was a weed management project that involved mathematical modeling in helping them with survey design, and I guess I would describe it as structured decision-making. So it fits in that idea of decision theory, but it wasn't adaptive management in particular.

SW: And in regard to the workshops – or your introduction to the Wildlands project – how did that begin, what was your initiation to the project?

SAM: My initiation would have been meeting Robin [at the Authority] in particular, quite early when I began my contract. I think even before Val moved to Australia I got to meet – Jackie introduced me to Robin and we had a one to two-hour meeting to just discuss what the Authority wanted out of the project. Then in those first few months as Val arrived we started talking about the workshops and it took us probably six to eight months before the workshop actually occurred, but that was the first thing we were working towards. So that – because Val, I think, was also hired because of their statistical skills rather than – neither of us had background to this particular ecosystem and Blair understood that, so the workshop was the first chance for the two of us to meet people who were experts in the ecosystem, and to build a picture of how they saw the problem.

SW: So was the idea that a formal model would be useful around right at the start of the project?

SAM: Yeah. And I think they – a formal model already existed for [the Authority], this was the one that Jo had done previously [the Rainfall Model], and they saw that there was room for improvement. But [the Authority] seemed to be happy with the modeling process and they were seeking an improved formal model because they were already happy that a model had been created … There were people in the Authority using that model and making decisions based on that previous model.

SW: And what was the need for the workshop – you said that it was good for you to meet the people that had knowledge of that ecosystem?

SAM: Yeah that's right. I just realized I forgot to say that in between the two – so the workshop occurred in May of 2013, I think, and in December of 2012 we also had a

meeting with some of the Authority staff – Val and I travelled to [a small town near Wildlands], and we met with the Authority managers there at that time. So we met Taylor, who wasn't yet in their current role, so we met Taylor's predecessor, whose name was Blake, and we met Taylor as well, [because] Taylor was about to take [Blake's] role on.

SW: And what was that meeting to discuss?

SAM: That's a good question! [Laughs] Again I think probably the very first meeting with Robin was very project focused and [about], "what does the Authority want from us," whereas the meeting in December with the Authority managers was asking them questions about – just learning how they saw the system, and that was definitely a beginning for Val and I to learn about the ecology of the system. I remember Val and I talking about rainfall patterns and kangaroo response and vegetation response and those kinds of ecological aspects to the problem. And also about the feasibility of management actions for them, I think that was probably the first time that we talked about, "would it be possible to measure rainfall like this?" "What if there were exclosures?" "Could you maintain exclosures or is that too hard?" Those kind of questions about what kinds of management actions would be feasible on the ground.

SW: And had you an idea of these practical restrictions from your previous work with the Authority? It's interesting what you can do as a scientist sometimes and what you can do as a management organization – had you operated with these kinds of limits before?

SAM: Yes I had, definitely. And, um …Let me think about that. Yes I had definitely had experiences in my previous projects where we had had ideas, [the] researchers, that sounded pretty easy and sensible but surprised us when we talked about them with managers that some of them were harder for them to put into practice than we expected.

SW: And were there any things that came out of those meetings that were surprising for you to find out?

SAM: Mmm, that's a good question! Um … Maybe I'd have to look back through my notes from those meetings. Yeah sorry, I don't have them with me right now.

SW: That's alright. Can you remember your initial impressions of the problem – what were you kind of thinking after those meetings?

SAM: I remember being really impressed after those meetings that one or two of the managers had – were able to bring very specific stories about response to rainfall, for example, and that they, through their personal observations, saw that rain – not just rainfall but the season in which rainfall occurred would affect what vegetation was

springing up and how the wildlife would respond. So they also had different contrasting stories of how the kangaroos would respond to the vegetation versus how rabbits would respond to the vegetation. And at that point because it was just exploration and new learning for Val and I, I took written notes but I didn't try to formalize the model at that point. I was just listening to the stories and taking notes about what they were sharing.

SW: Were there – can you remember any kind of specific points where the theories differed? Were there any that stuck out to you?

SAM: No – I didn't notice too much disagreement among them. I think mostly that was because they agreed. I think sometimes with Public Authorities hierarchy can come into play – if your boss says something then you might not feel comfortable disagreeing with them … You might be able to disagree with them in a private Authority meeting but in front of someone else it might not be acceptable. But I didn't get a strong sense at that particular meeting. Everyone seemed quite comfortable to say what they thought, yeah. I think possibly as a naïve researcher some of my questions were coming at an angle that not all of them could immediately connect with. So some of them probably held back because I'd ask a question that they didn't know what I was going on about! [Laughs].

SW: Was that kind of related to kind of formal or technical aspects?

SAM: Yeah, I was probably trying to avoid the technical terms but in my mind I might have been trying to work out what their objectives were, and I didn't use the word objectives but I was just asking questions about, "what would look like a good system to you?" Or, "what would look like a bad system to you?" And they just didn't connect with that way of thinking about the situation.

SW: Why do you think that was, do you know?

SAM: Aw I think my training is very much grounded in this structured scientific approach to a decision problem. And many people don't think about making decisions in those terms. And I was trying to – I've got these little compartments in my head about how different bits of a problem need to fit together to come to a … You've got to put the pieces into these compartments and fit them together and come to a good decision. And not everyone sees problems that way. So I was probably skipping ahead a couple of steps in logic and wanting people to put things into my compartments.

SW: So moving through this process did you meet with these managers again throughout the next year or so?

SAM: Yeah, so we invited everyone who was present at that meeting in December to a workshop in May and more than half of them would have come along. And for

those who were absent, different Authority people would have come in their place. So I think we had at least four representatives from the Wildlands regional area at the workshop. And then about six months later Val and I went back up there and Rowan, who is one of the site staff [at Wildlands], took the two of us on a tour of the Park, so that was another connection. So I guess on average we would have been having in-person contact up there with at least one person every six months.

SW: Did you kind of change the way you were asking questions throughout that process?

SAM: Definitely. And I guess it helps to do – that first meeting in December was in a meeting room [in a town near Wildlands], whereas when we saw Rowan in October and he took us on a tour, we were in the Park and looking at stuff, so that changes the way I ask questions too because I'm not sitting there with my notepad thinking about my decision compartments. I'm actually there looking at trees and grasses and thinking about what they do and how they fit together in the environment.

SW: So what kind of – just think of an example of the types of, the ways that you changed – would you … I don't know … How would you have changed do you think? From the compartments to …

SAM: Yeah, I guess by the visual cues of seeing the environment it's – when I'm in the office, because I don't have the ecological background, I can't bring to mind these different dimensions of the environment. So trees versus shrubs versus grasses and so on – those things don't naturally come to my mind, so I don't ask very specific questions about them. I might ask general questions and hope that someone will give me that information, but I don't have the background knowledge to bring that to mind and ask people specific questions. Whereas when I was in the environment and Rowan was giving me a tour I could – Rowan might point out some trees and name them and tell me some history, and I could ask things … That served as a conversation point for both of us to structure things from. But likewise, I would notice things that I would never have anticipated in the environment and could ask questions about them too.

SW: Yeah. Can you think of any of those things?

SAM: Yeah. I guess certainly something that happened in our field trip specifically [the monitoring methods field trip], but probably that I noticed a bit on previous trips was how patchy the environment was. So although we have this – on paper we have this idea of this woodland we're trying to regenerate, it's not a big space that all looks the same. Some bits are almost all grass, some bits are all trees, some bits are a mixture of different trees. And so asking questions about, "how did that come about?" "What combination of natural processes and management choices have brought about what it looks like at the moment?"

SW: Yeah. I wanted to ask you about that, because that was interesting thing in the interview last time with you and Val, was talking about the patchiness of the landscape and how that changed your perceptions of the system you were dealing with. And I wanted to ask you about, you know, as a statistical expert, how did seeing that change your understanding of what your practices would be in that [landscape]?

SAM: Yeah certainly. I guess if we had a big expanse that was all relatively homogenous then statistics tells us that we can take a small subsample of that area. And trust that within a certain error margin, that will give us a signal of what is going on for the entire space. But because we have this patchy environment, and we saw that even within those woodlands the profile can be very different, so we saw that some places with only pines, all the pines were of a certain age, and then we went to other places and saw the pines were all sorts of different ages. So we need to ask ourselves pretty carefully whether it's OK to treat them as the same thing or whether we need to treat them differently to each other, and the more things that we notice – the more things we think are different and need to be treated differently, the more sampling you need to do to capture all of those things that are going on, those different profiles.

SW: Yeah, because that was one of the things that was interesting on that monitoring trip was that discussion about what to actually treat as a sample. And how your selection of what the sample is relies on going back to the objectives of your study. I was wondering how that played out and how you dealt with that?

SAM: Exactly. So, I guess if you are trying to catch a snapshot of the entire system then you need to make your selections in the landscape relatively randomly, so that you're capturing some places where there are absolutely no seedlings, some places where there are seedlings, and going to a place where there are no seedlings makes for a pretty boring survey to carry out. But if you want an overall survey of the entire landscape you need to perform those surveys so that you get an accurate representation of what the seedling pattern is over the entire system. But because that trip was a sort of scouting trip and not a complete scientific survey, or a self-contained scientific survey, our secondary – I guess our objective for the entire project is to get that picture of the total landscape, but in some ways our small objective for that single pilot study was to practice the methods and work out how they interact with seedling density so in that case we would not be obtaining not much information if we performed a survey where there were zero seedlings. So it had – so potentially focusing on places where seedlings existed served our purpose for that pilot study, even if it was not a statistically valid design to get a landscape-scale picture of what was happening. And that was probably what a lot of our nighttime conversations were about – trading off our short-term objectives about learning the sample method first with our long-term project-level objectives of learning about getting a whole landscape picture of seedlings. And I think quite rapidly we gave up

on that – we gave up that large-scale thing and thought we've got to keep it small and short-term for the pilot study.

SW: Yeah and were you also thinking about the report that you have to present [to the Authority]?

SAM: Certainly. And, um, I guess we – I think we realized within that first day or two that it would not be possible in that report to give the full landscape picture, and that probably it's not our job to do that. That's not what Val and I were hired to do, and that understanding the survey method and how it interacts with seedlings was important because we could give them advice about the effort – in the report we could give them advice about how much effort it takes to complete a survey and then extrapolate and say if you wanted to do a big landscape-scale survey in the future, here are some expectations on the resources it would require to do that. Because I think it's really our responsibility in that report not to carry out the monitoring for them but to give them good advice on how they could do that monitoring in the future.

SW: Yeah I was wondering whether that experience of the pilot study changed your perception about your role within the project as advisors or as experts, and whether you reconceived what adaptive management would be for you or for the project after that trip?

SAM: Yeah, I think it did change my expectations about what we could supply them in that report. About the level of detail and the statistical analyses – it certainly reduced my expectations about what we could offer in that report. I don't think it altered my perceptions of the adaptive management aspect too much. I think I called on the – I used the adaptive management philosophy … As you noted before that we continued to have this conversation about what are our objectives and what activities will help us to fulfill these objectives. And so I did call on my adaptive management skills to answer that, and help make the day-to-day decisions during the course of the trip.

SW: Yeah, and what aspects of adaptive management do you feel useful for framing your thinking around those kinds of things? How does it frame the types of questions that you ask in that context?

SAM: Yeah definitely for reviewing what our objectives are and trying to build a path – working out what actions are available to us and how we can make best use of them to meet our objectives. I think that's the bit I call on repeatedly. And I think we certainly have this mental idea too – I don't think we verbalize it as often – but the adaptive part that we try to, at each step we try to record the right information so when there's an opportunity to improve it in the future we can build on what's there and improve on it rather than starting from scratch with each new field trip, or each

new data-gathering exercise. We try to create records that can fit together and can be used together in the future.

SW: And what in your work, as a statistical expert with knowledge in that field, what are the qualities you need as a statistical expert – like, what is a statistical expert?

SAM: I think, um, a statistical expert is someone who understands that there can be biases in the data collection process and builds plans to minimize the biases. So, for example, when we were thinking about that patchy environment and how to select the sites that we were going to measure, site selection is a process that can bring biases into your work if you don't do it carefully. And it's almost always going to bring biases into your work but a statistician has the ability to recognize what those are and address them as best they can, so the data we are getting is creating the kind of – is receptive to the kind of ecological signal that you're seeking.

SW: And is there a difference between the qualities of a statistical expert in general and the particular type of skills that you need to apply in the adaptive management project?

SAM: Yeah, I think so! A more pure statistician will always be focused on what data are available and how to minimize error or confidence bounds around their estimates. I think that's how a pure statistician tends to focus, whereas in this kind of adaptive management and environmental management you need to be much more mindful of what are the objectives and the decisions the manager is faced with. And sometimes there will be some things that you could estimate and they don't have to be perfectly accurate, maybe knowing whether the, for example, maybe just knowing 'is the kangaroo population big or small?' – maybe that's, that kind of simple binary signal is enough information for the manager to make a good decision and achieve their objectives. I'm not saying that this is the case for this particular project, but sometimes a coarse signal is good enough for the manager to make an adequate decision, and so that's what a statistician in this environment needs to recognize: when accuracy is important to making a good decision and when accuracy is not so important to making a good decision. I think it also carries the challenges of what the realities are – that you do need to interact with managers and work together to understand, to work together to develop data collection protocols that are realistic and carry out our intended purpose. A pure statistician often doesn't concern themselves too much with the collection methods or what mistakes a person could make with the – I think when you get out in the environment it becomes very clear that you could miss plants or you could misidentify plants, and likewise with animals, and that those are processes worth thinking about, and not all pure statisticians are in the business of thinking about those human errors in the process I think. Some are, like there are certainly ecological statisticians who do occupancy modeling and so on who have built excellent models and literature to deal with those kind of mistakes, but I think if

you walked over to the maths and stats department in this Uni, for example, you wouldn't see too many people thinking about the human error aspects.

SW: And is it also – I'm just wondering about … We've talked about the human errors in collecting data, but when it comes to things like the uncertainties within the ecological dynamics as well, is that something that's different in terms of whether you can actually get a signal or not on the things you're trying to do the statistics on?

SAM: Yeah absolutely, and there's a lot of conversations too that have to happen with both statisticians and ecologists and managers involved about what are the variables that we should be measuring and whether – and for the vegetation stuff in this project is a pretty clear example of: "do we need to understand every single species and count every single species perfectly? Probably not." That's almost certainly not realistic for the managers to do and it's probably more detail than they need to make a decision. So if we're not going to count every species perfectly then what do we do instead? Is grouping things into shrubs and trees and grasses enough? And even if we do that, how do we go about measuring them? We tried different things like estimating cover, and counting individuals, and the pointing that Logan did as well, so there are different – even if we agree that shrubs are an important variable, we could think of – I imagine that Logan could easily imagine three or four methods off the top of their head for measuring shrubs. And that's a – yeah, I think it's challenging to come to that decision because it's at this intersection of statistics, ecological surveys, and management interests. All three come into play to try to derive an answer, and so there's no-one in the project who is a perfect expert in all three things. Most of us are good at one of those things, and can speak the language of the other two, but you would almost never find someone who was a detailed expert at all three of those things, I would think.

SW: Yeah, and that leads really nicely onto the questions I have about the role of other expertise within the project. I wanted to ask you about the value of other participants, like Logan and Alex, and what kind of questions they really helped you on, and what kinds of questions you turned to them for?

SAM: Yeah, so initially in the couple of weeks leading up to that field survey they were extremely useful simply for knowing survey methods on the ground. So what are those three or four different ways by which you could measure shrubs? You can put tape measures in a cross, or you can imagine circles, or you can do parallel transects and do pointing – just those different physical layouts of data collection is something that Logan and Alex have a knowledge of, whereas mine is very limited and picked up as I go. They also have a stronger knowledge of – although neither of them work, [neither] of them are experts in that particular part of the state [near Wildlands], they have a knowledge of the general vegetation [in the state] and can make more educated guesses than I can about what species are there, how it might respond to rainfall, and some of those environmental considerations that help you to

decide what are the important variables. So they were – although they weren't familiar with this very specific ecosystem they had the right language and could ask smart questions about rainfall patterns and which species, plant composition, and all that kind of stuff.

SW: Were you involved in the – when you were discussing the types of survey method you were going to use, did you also have to be aware of how the uncertainties or the assumptions or choices behind those survey methods would affect any future model that you were going to make in the future?

SAM: Yeah. So I did have to continue thinking during that process. I would have probably always had our skeleton model of the system in my head – that flow-chart that I'm sure I would have shown you or sent you at some point. I can re-send that if you'd like? To think about what kind of data might come out of those survey methods and whether I could visualize how that monitoring would fit into the kind of model I had at the moment, whether I might need to restructure it, or whether it would take a lot of effort to formalize that link. So some of those methods such as the pointing for example generate hundreds of points of information and it probably wasn't immediately clear to me how you would condense that into a one or two number measure that would feed into the formal model structure. So I probably didn't interrogate that too deeply at the time but I would have been thinking about it and aware that conversations would happen – we'd need conversations in the future to create those links.

SW: Yeah that was interesting as well in the interviews and focus groups and the field trip, we were talking about what kind of constitutes a good method, or what method is good, and I was wondering what you had in mind when you were thinking about a good method for this situation? What that would be for you?

SAM: Yeah. Certainly from the statistician perspective you want it to be something that corresponds to the true state of nature, to the true state of the ecosystem in a reliable way that you – even though there will be error around your confidence intervals and uncertainty around the true state of the system, that we can feel confident that we understand the nature of that error. So we want a consistent signal out of the method, that it is representing the true state of the system. Certainly I think about – although it's not my personal area of expertise – I think about whether it's feasible on the ground. So who is the person who would actually be conducting – actually be doing the method in the field, and what kind of training and knowledge and expertise will that person have, and can we – what kind of instructions can we give them so that we can trust them to carry it out consistently? And obviously it's not going to be just one person, so what kind of instructions can we issue to twenty people or to a trainer, so we can trust that whoever it is who ends up responsible for doing the survey, that they won't accidently get the tape measures backwards or be

counting the wrong thing, or any number of mistakes that someone could make if we communicate it poorly.

SW: And is it necessary to – or are you thinking about these kinds of trade-offs when we are out in the field or when you are doing the monitoring? Are you thinking about, say for instance if you had the pointing method which – as we discussed in the focus group it turned out fairly objective, in a sense – but you're thinking about whether that data will be useful in your model, and also whether it's feasible for site staff to do that. Are you thinking about those kinds of trade-offs?

SAM: Exactly, yeah. I was thinking about those things as we were doing it in the field. So I guess one of the very coarse ways of thinking about was just within the group of us we had quite a variety of experience within the people in our group, so if a method was described in our plan, sure we know that Logan could do it, [but] could I do it if someone gave me the instructions? Could Riley do it? Could you do it? And those were good tests. And I don't know – I couldn't anticipate exactly what the site staff's abilities would be, and in fact just during the time that we spoke with Tony [a member of the site staff] during that trip I developed different expectations about what they might be good at and what they might not be good at. And Tony is just one member of the site staff, I don't know what the other dozen site staff in that region might be capable of or what might not be willing to do. So yeah, I didn't have a full picture of what we could expect the Authority staff to do – we need to continue consulting with the Authority to work that out – but I was certainly thinking about the different methods. And so the pointing for example – laying out the measures with the pointing tape was very repeatable. Whether – but the decision about identifying the thing at the end of the stick might be quite variable from person to person. Some of us would recognize a weedy grass from a native grass and some of us would not among the group, and so we need to think later about whether that was important or not. And meanwhile the method of just looking at the – I think it was a two-meter by two-meter square and just saying, "aw, that looks like five percent litter." Logan has done that a lot so had some confidence – Logan certainly verbalized some confidence in the estimates but some of us would struggle. Or some of us would have lower confidence. And that method in the scientific literature has been shown to be pretty unreliable I think. Even – if you got six people who thought they were experts doing that you'd still see a lot of disagreement among their estimates, so … So certainly the pointing method is more repeatable but it's still got this ID'ing error, whereas I think the cover thing has got ID'ing and estimation errors all over it.

SW: And in the interview, I think, or the focus group, you mentioned that there were moments where you had to compromise on the idealism of statistics. And I was wondering if you could just expand on that a little bit? What the idealism – the idealistic parts – are, and where you had to compromise? I think we spoke a little bit about it earlier, but …

SAM: Yeah so imagine that I was … What I recall from that trip is – probably the patchiness is the issue that kept coming up for me, and about how to deal with that, so … Yeah, the idealized version would be to randomly select locations in space, perform the methods, and get this landscape-level estimate of how many seedlings are out there, and the reality was that seedlings were very difficult to find at all, so if we wanted to take any seedling measurements we kind of had to target our efforts exclusively to places where we found seedlings. And so that was a departure from my original statistical ideal of getting a landscape-scale estimate and instead focusing on places with seedlings. So if we took the data that we collected from that experiment and built some estimates of seedling density there'd be a massive overestimate of the true density of seedlings in that Park. Because we were just going to places with seedlings – it was a very conscious bias in the way we selected our sample.

SW: And thinking about resolving that in the future – where will that decision be made to address that?

SAM: Yeah. I think – so something that I … Again, it goes back to what your objectives are, and I think it seems to me that we all come up with different answers to serve different objectives. So for example if what we want is to estimate the overarching state of the landscape, so we can make an overarching decision about kangaroo culling or other management actions, then you'd need a randomized sample. So you'd need to select our patches randomly across that entire space and accept whether or not there are seedlings in there. We need to collect those zeros as well to get that overall picture. But if your purpose is to take a protective action – so for instance if you want to put guards around individual seedlings or a fence around individual seedlings to try to protect them from grazing, then you need to find them. And so again that would be doing a survey where you focus on places where there's lots of seedlings, so you can take photos of them and measure them and point, and say to the managers, "there! There's something worth protecting in that spot right there." So those are two different purposes that I think we need to review with the Authority staff. And possibly offer two or three different survey designs in the report, so they can understand and have the option – the flexibility themselves of deciding what their objective is at any point in time, and what they need to do to fulfill it.

SW: Yeah, and that will be – will that be what you discuss in the meeting with Robin in July, this month?

SAM: Yeah, so we haven't set a date for that meeting yet, I'm waiting for Val to get back from travelling. But I think that's something I want to raise at that meeting … I guess there's a third purpose for monitoring as well, and that third purpose is to trigger other actions … So I guess the first purpose I was thinking about was getting that landscape-scale picture, and so that's the question of has our management strategy overall been yielding results that we like? And the second thing I talked about was about taking conservation actions. It could be that we need monitoring to

develop particular other signals. So maybe a kangaroo cull would need to be triggered by evidence that woody plants are under threat, so people see a certain rainfall pattern, they want to go out and measure: is there enough grass for kangaroos to eat at the moment or not? That's just a proposed – I'm not sure whether that would be a meaningful survey design for them or not, but that might be something that they're looking for as well, is evidence of an immediate threat to the – not just a generalized, 'hey, we know kangaroos and rabbits are grazing on seedlings,' but at this point in time is there an immediate threat of grazing on the seedlings? Do we need to act now or do we feel comfortable that there are enough other food sources?

SW: Yeah, and that brings up a question that I wanted to ask about the possible tension or trade-off between basing your management regime on monitoring if you do desire to have that reactive process in place. Whether there is a slight trickiness between monitoring seedlings, but then if you're trying to pre-empt threats to those seedlings you almost need to do the action before you record any of that happening actually in the landscape?

SAM: Yeah that's right, and that has been shown to be a tension in this project. That that kind of response, it might be too late – by the time you've seen grazing evidence on the ground, it's happened! [Laughs]. And the seedlings are in threat right now, and the permitting process to enact a kangaroo cull is too slow in order for you to stop that grazing that is happening right now. That was certainly something that the managers have communicated to us, and so for example it might be that monitoring – on-ground monitoring – is not the answer to that at all. It could be that Bureau of Meteorology rainfall data is enough that, or is the best opportunity we've got to predict kangaroo densities, and therefore predict the threat at a particular point in time. And that's obviously got more error attached to it because you're translating a rainfall into a kangaroo population growth number. There are more steps along the way and more error propagating, but it might be that it's something you can do much more quickly and therefore the management can swoop in and take effect more quickly. So I guess that's one of those cases where as a statistician you are not looking for the most accurate method necessarily, you are looking for one that comes in at the right time, and allows management to respond at the right time.

SW: Yeah. And I was wondering whether you see this project as more of a passive or active adaptive management in the sense that perhaps depending on these different approaches you could take there might be a slightly different emphasis on either a more proactive style or a more reactive style?

SAM: Yeah absolutely. And I think the ongoing discussions that we've had about exclosures are at the crux of that. I think what we would communicate in this first report would mostly – we want to help them set up the framework to do passive adaptive management in the first instance. But there could be – it could be possible for them to accelerate their learning if they do things like setting up exclosures. So I

would see that we are trying to offer them a passive adaptive management framework, but giving them hints about what the opportunities would be for active adaptive management for them to think more about.

SW: And have you thought about other potential ways that you could do active adaptive management without exclosures? With other tools that you could use?

SAM: Yeah it's possible depending on what the key uncertainty is, if the key uncertainty was about vegetation it might just be that you've got to wait for the right rainfall pattern, and when the right rainfall pattern happens you can do extra monitoring and learn more about the vegetation response to rainfall. If the key uncertainty is in the kangaroo population response, then you could alter the harvest rates, the cull rates, to learn more about the kangaroo population response to culling. If the key uncertainty is about kangaroo movement, then putting radio collars on some kangaroos might be the way to resolve that. We're not anticipating that the kangaroo population is where the uncertainty is going to be because there has been lots of research about kangaroos in Australia. There's lots of systems to draw that kind of information from. Now I could be mistaken, but I think at this stage it's anticipated that the kangaroos are one of the better understood bits and the vegetation is what we're unsure of. But that hasn't been confirmed with a formal model at this point.

SW: Yeah, I'd like to fit that in before you head off, is where you see the process for building a formal model and how you're conceiving of that after you've gone to the pilot study and talked about the monitoring methods and stuff like that?

SAM: Yeah. So we have this sort of flow chart at the moment that is the overarching framework – just about what the different components are in the system and how they interact with each other, and it doesn't have any … So it has arrows and it has connections, and it has ideas about the causal relationships – but it doesn't have any numbers or articulated quantities – there's no quantitative response attached to it at this point. And so I think the next steps would be to break down into subsets of that model and work out those relationships. So the model is, I think, a bit too complicated to put the whole thing in front of someone and say, "fill this in!" So I think it would be more achievable to break it down into small components and first understand, "how does this rainfall affect vegetation if there are native grasses present? When do they grow? When do they die back? What are the rainfall patterns that affect that?" And so on. And we can do that by a combination of asking experts again, the people that were at our workshop, and in the second instance just going to the literature, the existing literature. And I imagine we'll do a combination of those two things probably. Start with the literature to come up with some ideas, take it to the experts and find out if we've got the right idea or not, whether there's anything we're missing.

SW: And which experts were they? Were they the participants in the workshop?

SAM: That's right, yeah. So a number of – there would be half a dozen people within the Authority that would be suitable experts, but there are also a couple of academics at universities and other research institutes that know the system well.

SW: And would these be people that have personal knowledge of the actual ecosystem or would they be people with conceptual knowledge?

SAM: Yes. They'd be people with a working field knowledge, mostly. So yeah, site staff who spend time in the Park, or who have spent time in the Park in the past, so Robin for example sits in an office in the state capital now but spent five years out in a town near Wildlands, so Robin knows the area. And the university experts would have conducted field work out there, yeah.

SW: And so in the process of going back to the experts – is it a process of asking them whether the model fits with their understanding, or their conceptual model of how the system works?

SAM: It's something I grapple with and I haven't worked out the best approach yet. I think there's – in some ways I'm reluctant to go to them with a blank page … [laughs] …

SW: Why is that?

SAM: I think it's important to assure them that we've thought about it, and we're not completely stupid. But at the same time any information you bring them can potentially bias the way they look at the system. So I'm really – I'm quite unsure still of the best ordering of combining research literature and what's in people's heads, what the experts think.

SW: How might it work to bias the way people look at the system?

SAM: I think there's reasonable evidence of anchoring in the social science literature. If you give a person a piece of information, even if they agree with it their response to you is likely to be closer to the value you've offered them then if you gave them a completely blank page. And so I'm mindful that I could be doing that if I feed them too much, they might just go, "yeah that looks about right." Or, "make the number a bit higher."

SW: And where will this model fit with the existing models that are being used in that management process at the moment? We have the Rainfall Model and then we also have Jackie's model, the catch-per-unit-effort – I'm not actually sure if it was trialled this cull or not?

SAM: No, they didn't enact it during their cull so they went about their cull in their usual way, and one of the tasks for Val and I to hand in with this report is to sort of run Jackie's analysis on top of that data and discover would Jackie's model have told them to stop culling at a different point compared to what they – what decision they made.

SW: And what will your model – or the potential model – what gaps will it fill in?

SAM: Yeah, so I think the intention, if we can work it out and develop something that everyone thinks is worthwhile, it would replace the Rainfall Model, so it would be a different way of predicting how the kangaroo population changes. Jo's model doesn't say anything about the way vegetation changes at all, so it would, in addition to making predictions about kangaroo population change it would give us bonus information about vegetation response. We haven't – we're too far away at this point to talk about changing the cull strategy itself, although I imagine that if we can build a formal model that the Authority likes then we'll begin a conversation about how they make the cull decisions. When and how many kangaroos to take. So we'll be able to play around with our model and try different scenarios and explain more whether the current strategy is the best way to go about meeting their objectives or whether there might be other strategies. And that's the kind of thing that Val and I are pretty good at and like to do. I think we could happily play around with the theory inside the model for a while and then take some alternatives to the Authority. A small selection of ideas once we've done that.

SW: And what kind of things will you be thinking about during that process about the factors that come into the way that you'll build that model?

SAM: I think something that will come into that is whether we'll have this extra layer of vegetation that's now introduced into the model, that has not been in Jo's Rainfall Model. It might tell us that, well, I think it's fairly logical to say, "if there's no seedlings on the ground, grazing doesn't really pose a threat because there's nothing to protect." And so having that extra layer of information about vegetation in the model might be able to tell us something about when there are seedlings that need to be protected. And tell us something about whether kangaroo culls do protect seedlings or not. The model at the moment – Jo's Rainfall Model – assumes that by keeping population growth down to a certain level that a consequence will be seedling protection. But that's not formalized in Jo's model.

SW: And when you say formalized you mean …

SAM: … it's not a variable that's – it's not a variable that evaluated quantitatively at all. If you read Jo's initial reports it will verbalize that logic, that less kangaroos means more seedling regeneration.

SW: And with the time aspects of monitoring, it is interesting that we were just talking about, you know, if there are no seedlings then the cull is not useful – is there a potential that the model might address when you actually need to think about doing monitoring? Like whether you do monitoring on a three-year or five year cycle?

SAM: Exactly, that's right. So there might be times where monitoring vegetation is crucial and other times where it is not. So if the kangaroo population is low and grazing pressure is low, then maybe you don't need to know about seedlings because you can trust that the ones that are out there are adequately protected. And likewise, there might be times when knowing the kangaroo population size is very important, and there might be times when knowing the kangaroo population size is not very important. If, yeah, if there's no seedlings to protect, then maybe you don't care about grazing pressure that year, and so it's not important to know exactly what the kangaroo population size is. There might be other – thinking about time – there might end up being long-term benefits to maintaining that monitoring, so even if we trust that seedlings are, there's no threat to seedlings this year, knowing the kangaroo population size helps us to project one and two and three years into the future about what might happen. Yeah, and so having an iterative time-dependent model, that might help us predict things dynamically through time, [and] will be important for us to evaluate the benefits right now in this season and the longer-term benefits of management over multiple years.

SW: And what do you foresee as the main difficulties or challenges to building this model? Particularly thinking about the sporadic nature of this system.

SAM: Yeah, I think one of the – the big challenge that we're grappling with is identifying what those vegetation variables need to be. How it is that we characterize this complicated landscape into a few different compartments that we can measure on the ground, that we can keep – where we can characterize the change in them from year to year … I think it's a challenge because they're the crucial link between the on-ground measurements and the formalized model, and the kind of decision-making that happens in the model space.

SW: Yeah. I'm more or less finished, I'll let you get on in a second, I'll just check and see if there's anything we haven't covered.

SAM: It's OK.

SW: Yeah so we've spoken about the importance of objectives to the design of the monitoring and the design of the project, and I think you mentioned in the interview that you were sometimes unsure of the ones that were still important to the Authority, because there was this – there have been different people in charge at different times with different objectives?

SAM: Yes.

SW: And I just wanted to pick up on that bit and I wondered if you could just describe how that makes life difficult for you? [laughs]

SAM: [Laughs]. Yeah absolutely. Yeah, and I mean essentially I've been hired to deliver something to the Authority, to deliver a report to them, and I want the information in that report to be what they're seeking from us. And so I need to be really clear with my colleagues in the Authority about what their expectations are, and how we can meet them. But also as a scientist I need to think about, "well, they have this management problem, what do I think are the kinds of solutions that they need?" For example, maybe they want me to deliver one type of report, and I think that they're missing a crucial – as a scientist I might think that there is a crucial piece of the problem that they're just not thinking about, and so sometimes I might try to show that to them as well. But I would certainly always try to show that to them with ongoing discussions and work out if we can come to an agreement rather than surprising them with something in the final piece. But I think in both cases the confusion with this project has been about whether it's more important for them to receive the formalized model, or to receive a monitoring plan. And so different people in our group – different researchers in the university group had different impressions in the past, and in fact when we had a meeting with our Authority colleagues, the message we got was the thing that they want the most is the adaptive management framework – the details of the monitoring plan, or the details of the formalized model are secondary to us providing them with an adaptive management structure.

SW: And what do they mean, do you know, by 'adaptive management structure'?

SAM: Well yeah, you know – I'll continue, I started sketching out some headings for the report and sketching out what might go into each section, and the way I'm visualizing that at the moment is we need to break it into, 'what are the objectives of the project?' 'what are the actions available to the managers?' 'What are the state variables that need to be taken into account?' 'What kind of model will link these things – what kind of model do we recommend and what kind of monitoring do we recommend to link these things together and help them to make decisions?' And so obviously the formalized model fits into that bit at the end, and the fieldwork and the monitoring talks we've had fit into the state variables and the linking model aspects as well, so those are all important supporting information, but that's how I envisage the overall structure of adaptive management for this project and how the report will look as well. But, um, I'll share that with Robin when we have a meeting later this month to check whether that meets their needs.

SW: And you might not feel that you're placed to answer this question, but I was wondering where you think that drive or that desire to have that adaptive management structure is coming from?

SAM: Yeah, I think there's certainly a drive within the Authority to do that, and I think they've got some official documents fairly high up in the organization that want to see adaptive management rolled out for all, almost, of their decision-making issues. And I'm pretty sure that Leslie has voiced that, particularly for that broader Wildlands region, so we've got that bird project and also this kangaroo project. These are – these we hope will set an example for how adaptive management could be carried out and serve as templates for other people to get ideas from and carry out future adaptive management work.

SW: Yeah I wanted to follow up on that actually because you mentioned Leslie in the interview – that you were talking with Robin and Leslie – and I just wanted to check who Leslie was?

SAM: So Leslie – yeah I think you're spelling the name correctly there – is Robin's boss. I'm not exactly sure what Lesley's job description is, but it seems to involve a lot of, sort of, research – not personal research, but Lesley's in charge of a lot of the research interactions …

SW: So Lesley might be …

SAM: I can look up their email signature and forward that on to you perhaps.

SW: I think Lesley might be potentially the person who is the head of the research department of the Authority.

SAM: That sounds about right, yeah.

SW: And was it a difficulty for you, or was it difficult that you'd been handed the project from someone else? That you didn't participate in the design of it at the very beginning?

SAM: Yeah I think that is certainly a challenge with this kind of project, that there was obviously a history, a range of discussions and an agreement developed prior to my entering the project, and so not being involved in those discussions meant that I felt a step behind as to what the expectations were, but at the same time Blair [at the University] has given Val and I a lot of autonomy and a lot of space to make it into what we want. And also Jackie made it – if we look at the initial research agreement, and in speaking with Jackie also, their choice to hire Val and I meant that what is written in the original research programme is quite different to what Val and I are actually doing. So for example a lot of the funding in the original contract was about buying fences and about getting a masters student to put up exclosures. And Jackie and Blair changed their expectations about what the project would be before they even hired Val and I so they made it quite clear that what was written in that

description was not exactly what was expected of us, and that they were OK with that. So I think perhaps even if Jackie had been running the project instead with Jackie's full knowledge and relationship with the Authority, I'm sure they [the University and the Authority] would have had to have repeated negotiations anyway to – as the project evolved – to check that it was meeting everyone's expectations.

SW: Do you know why that funding, for instance with the exclosures, why that changed?

SAM: I don't know. I think perhaps they had someone in mind to do that work, and then that person was no longer available to do that masters project. I think that fell through. But yeah, there were other aspects within the description that were about running workshops and developing structures, and those are the things that Val and I are doing. So I guess the budget and the way we've spent the money looks very different to what the original agreement was but we're still supplying a lot of the same intellectual research that was described in the original proposal, just the field research has been less and quite different.

SW: Yeah. And finally I just wanted to ask what you think the key decisions have been that you have made in the project so far, the key points where you had to decide to do something or not, or have done different things perhaps, and where you think the key decisions will be in the next few months?

SAM: Certainly leading the workshop was a big point early in the project, and so making a decision about what topics to talk to the experts about, and to what extent to let them carry the conversation in directions that they liked versus insisting on them covering certain topics that we wanted, that was a big point. So for example there was, I think there was a big discussion at that workshop about … Val and I as population modelers always think about extinction possibility, for the kangaroo population for example. We know that they don't want the kangaroo population to get too high because that results in grazing pressure and reduced survival and fitness for the seedlings. But we figured that they probably – you know, kangaroos are a native animal – and they probably don't want them to be wiped out from the system entirely, and so we wanted to talk to them about, "well, how would we know if kangaroo population density got too low, could we put a number on that, is that something we could measure?" And they just did not want to talk about it. They thought it was a stupid idea because kangaroos would never – could never get hunted to extinction in this area, and so that was a real, just kind of – I don't know how to describe it – a real mismatch between the way that population modelers conceive of the system versus how a pragmatic ecologist observes the system. And so it was – we really had to think carefully about how to reframe that problem as a result of that discussion. So we wanted to have a discussion about probability of extinction or measures of low kangaroo density that they would worry about, and they just didn't want to talk about it in those terms.

SW: So how did you reframe that?

SAM: Well I think a couple of members of the group helped in that process, so one of the Authority managers noted that there is a – tourists do have an expectation of seeing kangaroos in the Park, for example, and so there would be a point at which tourists not seeing kangaroos in the Park would be a problem for them. And Leslie said, "well, from their perspective, with animal welfare considerations and so on, they don't want – they want to be culling the minimum number of kangaroos possible while still meeting their objectives." So rather than putting it in terms of low kangaroo numbers on the ground, Leslie put it in terms of low kangaroo numbers in the cull. So that was a really useful rephrasing for us. Let me think about other big decision-making moments … For me, creating the flow-chart, which is the model structure, the first start of the formalized model, was a big decision-making point. So making decisions about how to characterize the vegetation in that model was, for me, quite challenging. So I put boxes with names like, 'native grasses,' 'exotic grasses,' 'shrubs,' 'pine seedlings,' 'ironwood seedlings,' 'mature pines,' 'mature ironwood,' and circulated that with our Authority contacts to work out whether they were comfortable with that kind of characterization. And they said yes, so that's kind of what we're going with at the moment. But it will be kind of be interesting to discover as we try to put quantities on that model whether those are still useful or not.

SW: And so the flow-chart is important because it frames the structure of your activities?

SAM: That's right, so when we think about monitoring we'll be trying to develop monitoring that looks like it feeds into that model. When we're developing quantities and management decisions it'll be in terms of that framework. And we might discover along the way that it's not the best decision and we need to adapt it and change it. But by having that – it's good because it's a common communication tool, but it also means that it is going to direct our future work. And so it may or may not – hopefully it directs us down a useful path, but there's a risk that it'll direct us down a frustrating, not useful path as well.

SW: And what do you think could be the big points in the next couple of months?

SAM: I think that obviously we've got this report due in two months, so completing that and handing that in, and I think the big challenge for creating a good quality report will be whether we can – I know I have an idea for what this overarching framework is going to look like – and whether we can look at the field study we did and fit that in a logical way, and communicate that well, and likewise with the model we're still formulating. Whether we can communicate the right story to the Authority about how all these small pieces fit together. So the fieldwork and Jackie's model, and playing with the new data with Jackie's model – we've got three or four little bits

of work which all fit into this adaptive management structure but it'll be a challenge to communicate that I think, to fit that all together.

SW: Why do you think that'll be a challenge? Is the last question …

SAM: I guess because we have embarked on them as these little, different components of the work. So I did talk about having the flow-chart in mind when we were doing the fieldwork, but with the fieldwork we focused on some short-term monitoring objectives rather than the overall landscape long-term objective for example, so we'll need to work hard to convince the Authority that we've got insights that will help them with their long-term monitoring, out of that small piece of work, I think.

SW: Right. Yeah thanks so much for taking the time. It's been great.

[End of interview]