Field Notes

Participants:
Sam (SAM), a mathematician and population modeler in the ecology department at the University, and co-leader of the Wildlands adaptive management (AM) project
Val (VAL), a statistician and population modeler in the ecology department at the University, and co-leader of the Wildlands adaptive management (AM) project
Logan (LOG), a field ecologist in the ecology department at the University, and a participant in Wildlands adaptive management (AM) project
Alex (ALX), a field ecologist in the ecology department at the University, and a participant in Wildlands adaptive management (AM) project
Pat (PAT), researcher in the ecology department at the University, participant on the field trip
Riley (RIL), Masters student, participant on the field trip
Rowan (ROW), Wildlands site staff member
Tony (TON), Wildlands site staff member
Simon West (SW), participant observer

Location:
Wildlands National Park

Transcribed notes:

Day one

Group meeting on the first afternoon on arrival in Wildlands (at the hostel), 15:00:
We met Tony, one of the Wildlands site staff, at the gates. Sam told Tony that we were in the Park to do some vegetation surveys of ironwood and pine. Tony drove us through the Park to our hostel, showing us areas of pine and ironwood as we went. We arrived at the hostel and took our things to our rooms. Sam and Logan then asked us all to sit outside to have a meeting and decide what we would do for the rest of the afternoon and the next couple of days.

LOG: There were no pine seedlings among the exclosures, all younger pines were planted. Do we want to include those [in our survey]? Or is that not part of our remit?

SAM: If it's being grazed, then yes it is part of our remit.

LOG: It depends on what questions we ask. If we … My feeling is that there are a few different vegetation states that could be sampling targets. But we will not see any seedlings – just understory under adult trees and the relative density of trees. Driving through the park we only saw three ironwood states – large trees well-spaced out (forty to fifty meters between trees, no shrubby understory). Then there was a denser version, still older trees, no understory (ten meters between trees). Then there was a

third one, lower down in the valleys and shrubby. For the pines there was more of range – tall spaced out trees, denser thicket (old plantings), and towards the end of the drive was another one.

ALX: Wasn't the pine at the end a different species of pine, the smooth pine?

[Group discussion – aren't we looking at both species if they are in the same area and soil? Which one was which? The group pull out ID guides to try to identify the differences between the target pine and the smooth pine]

SAM: Of the two it is the [target] pine that the management are concerned about.

LOG: But we are gonna get zero information on density. So more about variation in understory and tree density – which is remaining information to collect apart from location etc.

VAL: What about smaller trees – can they still be eaten by desperate kangaroo? (or is it just seedlings?)

ALX: They would be safe except for browsing of low branches – unless that causes them to get diseased.

SAM: Another researcher has done studies on how munching of low branches changes structure as they grow.

ALX: I'm not sure what the supposition is with ironwood – are they recruiting? Or are they recruiting and then getting chomped?

SAM: The story from the Authority is that they are recruiting naturally but then getting eaten – that is the pines but I'm not sure about ironwood.

LOG: The most logical thing is for them [the Authority] to do exclosures. These were three years old and then getting eaten. So you need over five years of good rain to recruit naturally without exclosures. They need five years to get away from the roos.

[Group discussion: Is there any possibility of getting five years of good rain? What about the rich stands of young pines that were spotted? Were they in exclosures when they first grew? What about further back in time – how did the stands of mature trees that we saw today get there in the first place and establish themselves?]

LOG: I think we should do surveys across the range of stages of vegetation that we've seen. Wherever there are adults. Full range from low to high density. [Here Logan described the veg types again spotted earlier from the car]. Have a go at sampling, pick a spot, do the easiest space first – this will be open, with not many other species.

Do detailed sampling with both methods: quadrat and twenty-meter square, and the rapid sampling. We should focus on trying out the method, don't worry about doing too many. We could do this now and check methods and experiences later – what would be hard, what might be easier, what might be feasible?

ALX: What about doing a 'recon' now and getting familiar with the types of veg? We can sort out which pines are which and make sure we're not confusing things?

VAL: And we can run through sampling methods for those that weren't there [at the University when we developed them] later so everyone is clear on the methods.

Decision: The group goes to do a 'recon' now to see what is happening in the Park and then to gather in the evening to talk through what should happen over the next couple of days. There is discussion about where to go for the recon – nearby or the dense stands of young pine spotted from the car earlier. The decision is to go and look at the nearby trees because the group had a good look through the car window at the young pines spotted earlier.

Recon trip, 16:00:
The group went to an exclosure site on the sandy ridge to check young pines that had been planted by site staff (circa three years ago). They had all been eaten to some extent by kangaroos but were all relatively healthy looking. Kangaroos could get into the exclosure now (kangaroo skeleton and droppings found inside the exclosure).

The group then walked over to the adjacent, unfenced sandy ridge where there were mature pines perhaps thirty to forty years old. There was a patch of perhaps hundreds of very young pine seedlings on top of the ridge. Logan said that this was a completely different story to the one told to the group by the site staff (who said that the kangaroos were eating all of the seedlings that came up and therefore prevented recruitment). Alex, the plant ecologist of the group, checked the seedlings and told us that the plants had been nibbled by roos but were persevering. He told us that the kangaroos might not be the primary factor inhibiting recruitment but rather it might be the soil conditions (there were fewer seedlings down the slope where the soil changed to a heavier clay based soil), the wind (there was a wind blowing towards the sandy ridge, which may have blown the majority of falling seeds there), or the sun (the sun was catching the spot where the seedlings were, creating a sort of incubator).

Logan pointed at a stand of mature pines on the floodplain (where the soil is heavy clay), and hypothesized that in these stands of trees there would be no seedlings. Logan based this hypothesis on the drive to the hostel earlier, where Logan had seen no young seedlings in the mature pine stands. Logan said that given the existence of seedlings on the sandy ridge, it didn't seem like kangaroo grazing was the only or major problem, so perhaps soil condition was also a factor. Logan then frowned and

said, however, that the conditions must have been right for pines to grow in the lower plains at some point, given that the mature pines were there now.

Discussion in the car on the way back to the hostel, 17:30:
The discussion on the way back centered around how to use vegetation sampling methods to obtain effective representation of the range of likely vegetation states of pine and ironwood habitat.

SAM: We need to try out range of possible sampling methods to obtain greatest diversity of possible states of pine and ironwood. There will be a trade-off between the time that the site staff have to implement ongoing monitoring and the level of detail and accuracy that they need or want.

Evening discussion after dinner at the hostel, 20:00:
The group discussed how each sampling method is useful depending on what questions you want to answer, such as, for instance, the rate of 'natural' regeneration in different environments/contexts, or the likelihood of success of exclosures. The group pointed out that the central issue they face is: what questions do they want to explore on this trip?

ALX: The way I see it is we can ask questions that [more directly] get at what is driving changes in system or we can ask questions that contribute to the objectives of management and what they want to learn [right now]. These two *may* be quite different.

SAM: Well the management want to regenerate pine and ironwood and they want some indicators that will help them knowing what is happening in system.

LOG: But what is the spatial distribution of pine-ironwood – is there no clear answer on what areas they want to regenerate?

ALX: Are there areas they are happy with and want to extend? Or does the whole thing need to be re-done?

[Group discussion: What do the management want to do, and what do they want to learn? What are their objectives?]

SAM: The management opinion is - "underneath these trees that we have left, we want to see if there is regeneration." The aim for us is therefore to capture the variation that exists in pine and ironwood communities. If they [the Authority] want that vegetation type to continue to be healthy they need regeneration of canopy features, but also structural factors. Detailed surveys are important because they characterize an area's vegetation.

ALX: Is the point of the surveying to find out how long it takes to do sampling and how simple it is? Or is it an example of what you would do as part of a broader campaign, to find out where trees are and aren't recruiting?

SAM: Both! Us doing the surveys over the next couple of days is designed to clarify if the surveys are a sensible method, does it take forever, is it a stupid design? In this way it is quite a good thing that there are only two ecologists or botanists among us seven people, so we can see if the methods are easy for beginners. The other part is marking on the GPS where things are, and characterizing the density of adult trees, the existence of shrubs and open ground, so we can get an idea of the location and range of vegetation. Management need to know there are very different states of this vegetation type, rather than pretending it's all the same thing.

ALX: But the management have already got maps – do they need to lay out variability in key structural layers? Do they know all the sites where there has been recruitment? What I'm getting at is how much information is sitting there that they just haven't been bothered to lay out – or how much do they not know at all? This will affect how we lay the sample out because we need to know what information they need… For instance, whether we should look at other dune caps to see if there is recruitment on them? But we need to know if this is the target?

SAM: The pine sandy ridge is in an earlier report on pine recruitment sites. The map in the report is extrapolated from a number of points – the points are nicely selected but the maps are only based on a few points – so you get straight lines and the zones of pine recruitment are effectively guesses.

[Group discussion: what data has management already got? What data exists and who has generated what data?]

SAM: The Authority should, in theory, monitor all sites where pine and ironwood are through time and see what happens.

VAL: What management actions do they do? Shoot rabbits, shooting kangaroos, locally fence and plant …

ALX: Wasn't one of the ideas we had to encourage management to set up exclosures where they thought there might be recruitment?

VAL: This relates to the two aims of learning for management. First they want to monitor long-term progress in re-vegetating the park, and second they want short-term feedback on their practices – culling kangaroos.

LOG: Yeah, for me though if they want to expand this to getting the landscape in general as good as it can be then there is a whole load of other stuff to bring into this.

VAL: Yes, and this is why we have the surveys with two different levels of complexity. The more complex one could be done over five years by researchers or botanists but we also need to provide something quicker for them to be able to do to get immediate information.

SAM: Well I think there really has to be exclosures – the decision is where these should be placed. The other thing is how we keep canopy trees going in the landscape. So the question is: do we put all our efforts into exclosures and try to figure out where they should be and what we want to see in them? Or should we focus on the vegetation type as a whole?

LOG: Well either way it doesn't seem like we need to change the methods we came here with. I think the more important thing is where we target with the surveys and how many we do in each vegetation condition state. Do we go to each condition once and do a detailed survey in each? Or do we try to go as many sites as possible? We could play this by ear – we pick one in the morning that we think is important and go there first, and then go from there. The key question is: do we need to change anything drastically based on new information we gained today where we saw all those young seedlings coming up?

SAM: I think we prioritize low sampling numbers but based on as many different vegetation conditions as possible – because this is primarily a scoping exercise. We're supposed to provide indicators, not highly profound inference about regeneration in different places. They're not asking us to do that.

LOG: And the data we already decided to gather could be used to inform a whole range of things – understory, mid-story, tree distribution and density. The thing we would lack is a targeted search – e.g. we think the pines prefer the dune ridges so let's go to all the dune ridges and check the hypothesis – we would lose this. But we could potentially do both – go to dune ridges on the third day to check for seedlings?

Decision: Agreement on going with the original methods.

LOG: So the way the surveys will work is we will have two groups – two pairs doing the rapid survey, and three people doing the detailed survey together. The detailed survey goes like this: we pick a species (pine or ironwood), pick a location and a candidate tree that looks representative of the site, draw out a twenty by twenty-meter square around the tree. One person puts out tape along transect lines, and the other person writes down site details and takes photos of the site. There is no point doing the detailed survey method on sites with no seedlings because we won't get any data – unless the point is to become familiar with the method. Our hypothesis was that there would be less seedlings close to the tree as they will be outcompeted, and more further away where there is more room.

VAL: How will we define a seedling?

LOG: At the moment anything under chest height, but we can change this if we need to …

VAL: And how do we pick a suitable tree?

LOG: It can be any tree but has to be one of the target species.

VAL: We don't pick a tree based on how many seedlings we see?

LOG: No it can be any tree.

[Group discussion: should we pick a tree based on how many seedlings we see? Are we trying to characterize the proportion of trees with seedlings or the spatial distribution of seedlings under trees? If the first, then we should just select random trees, if the second, we should only pick trees with seedings]

VAL: So will the trees that we pick now be the ones chosen by the Authority to monitor for the next few years, year on year?

LOG: The aim now is just to build up some numbers on the more detailed sampling units. This information builds up the idea of what we expect to see over time to give to the Authority in our report.

Decision: We need to see if exclosures work, to know this we need to know the spatial distribution of seedlings. So we need to sample trees with seedlings.

[Group discussion: Are there trees to big or old to have seeds?]

LOG: At the moment this whole discussion sounds like lots of little side projects or hypotheses – for instance, the idea that once seedlings get to a certain size they are safe from kangaroos – but they are hard to put together into a whole.

VAL: So the size of exclosure, where to locate the exclosures – that's what your suggesting we get at with your lots of little studies?

[Group discussion: what stories can you tell with particular types of data, what can you say to management? What will this data enable us to tell the Authority?]

LOG: So as we planned – we maintain distance from tree structure in rapid and detailed surveys in hope of finding seedlings. The only change is that the rapid survey people look around and try to find any interesting things nearby. Through these

surveys we will have lots of biological information, spatial information, time and effort information (to do the survey), do you [indicating Val and Sam] think that these methods will give you the right information to make a good recommendation to management?

VAL: [Laughs] It's hard to tell in advance.

LOG: Also of course I guess this depends on the degree of confidence with which you want to tell it.

VAL: We don't have enough samples to be able to make a really strong recommendation. We want to be able to recommend some sites for exclosures. But it's hard if we only see two sites in these two days … To what extent can exclosures be based on the knowledge of site staff? I don't know how many exclosures they are willing to put up … I say we do our best, and this will be instructive at least. It'll be a rise in knowledge from zero. And let's not worry so much about sample size – going from one to two or three will not be any different, you need to go from one to ten for it to make any difference …

LOG: Will the information we gain allow decisions to be made any different than ranger intuition? It probably won't. But it will allow you to be more confident about the decisions that you make because you have at least some data to back it up … What about this hypothetical situation: we have data on one site with seedlings, and nine sites no seedlings. This will tell them changes in vegetation structure (useful if they want to know about vegetation condition going into the future, but nothing about exclosure success, if that's what they want to do. For that you would need to know where the seedlings are and how many there are).

At this point the discussion finished, but the question remained: do the team search for trees with seedlings? Or do they sample trees in general across a range of sites?

Day two

On the way to the pine seedling site on the sandy ridge in the car, 08:00:
We arrived at the sandy ridge in the morning in order to count the seedlings we had seen the day before. In the car on the way the group discussed again whether to sample only trees with seedlings or whether we need to get a broad range of possible states (perhaps a random sample). Val stated that at the very least just running through the methods – the quick and detailed surveys – would give us information on the time needed to carry out the vegetation surveys and the level of expertise needed (e.g. whether the site staff would be able to carry out the surveys unsupervised by researchers). The group asked what data would be needed – what would be useful for management – what do the Authority want? What do they want to learn? Sam stated that the management of the park want to base kangaroo culling on sound science.

There is public pressure on the Authority to avoid kangaroo culling (because of its iconic native status), and they want to avoid culling unless it is based on science. They want to have some justification for their actions. Sam said that there have been a number of vegetation surveys carried out in Wildlands over the past few years by researchers that have not been suitable for site staff to do themselves.

Discussing the methods at the sandy ridge site, 08:30:
We arrived at the sandy ridge and Logan began to demonstrate the vegetation survey methods to those who had not been present at the pre-trip planning meeting at the University. We did the methods as a group, and talked through the issues that arose.

No. 1 Detailed Survey Method
Issues discussed:
[Group discussion: where to lay out the transect – with the tree in the center? Or with the tree at the edge of the transect (to capture as many seedlings as possible)? Logan argued that the tree should be in the center to get spread of seedlings, if we were thinking that slope, or prevailing wind, or soil condition around the tree would have an impact on seedling success rate. Alex argued that if we wanted to get an accurate image of how many seedlings there were around a tree it would make no sense to have tree in the center and miss out on lots of seedlings lying just outside the transect. Logan responded that if we were to have tree on the edge of transect it would need to be on the same side for every tree, and this was not appropriate given the different situations of the trees we would be sampling (i.e. they are not all on same hill in same position).]

Decision: To have the tree in the center of the transect – because of the hypothesis that prevailing wind and soil condition (sandier on upward side, implying better access to water for plants, clayier on the lower side, implying less water access to plants) may have an impact on spread of seedlings, and we need to be consistent throughout the sampling in different locations.

[Group discussion: How long does the transect have to be? Twenty meters? The formal method laid out by Sam, Alex and Logan before the sampling stated twenty meters, but when laid out in practice it looks too big.]

Decision: Fifteen meters, because it is more practical.

SAM: What tree do we pick to sample? Are we doing a random sample or are we picking trees with seedlings?

LOG: We should do a mixture of both, so I reckon pick a tree that seems representative of the assemblage.

[Group discussion: Where do we lay out the tape for the transect? Do we go from North to South for instance or some other method? Logan said that this would be important if there was some specific hypothesis we wanted to test or some variables that we particularly wanted to pick up – for instance type of soil (sandy to clay down a gradient) or direction of drainage/wind – because marking direction of transect would allow you to represent and interpret the data visually/spatially afterwards.]

Decision: From North to South because we may want to test hypothesis that the pines currently prefer the sandy ridges.

[Group discussion: How do we characterize what matter/vegetation we hit with the pointing stick in the transect method? (The method requires you to point the stick every meter and record what it hits before it touches the ground. What is characterized as 'litter' or 'bare ground' or 'germinating plant' etc. varies in each ecosystem/location and has to be defined by the researchers at the time of doing it. This means that doing the pointing method is much easier in an arid or desert landscape than a rich grassland because it is easier to see what the stick is hitting.) Are there any new categories that we have to add in this site because they are especially interesting?]

Decision: Logan establishes what counts as 'dry litter' for the purposes of this site (bits of dead woody matter and dry grass), and adds the category of 'kangaroo poo' because the pointing stick hit poo several times. Logan noted that this would give a measure of kangaroo grazing pressure on each site.

At this point Alex noted that, "I hate this bit of setting up field sites, it just seems so arbitrary. I prefer it when you have the data rolling in from field sites and you can just work with the numbers [in the office]." Then Rowan – a member of the site staff at Wildlands – arrived at the site, and the researchers gathered round to have a discussion. Rowan was surprised by the number of seedlings at the sandy ridge; however, Rowan said the seedlings look small but most likely are at least five years old because they are continually being nipped back by the roos before re-sprouting. Rowan said it takes about ten years for the seedlings to grow to a size to ensure that they "get away" from the roos and survive to adulthood. Logan asked Rowan for a hypothesis about the success of seedlings on the ridge: Rowan replied that the pines prefer the sandy soils and there was less competition on the ridges from other plants for resources. Alex asked Rowan about the seedlings in the exclosure – were they planted or natural? Rowan replied that they were natural seedlings that had been exclosed, but that the exclosure had been erected before Rowan began working in the park. Rowan was surprised at the number of seedlings on the sandy ridge. Rowan's expectation was that there would just be bare ground. Rowan then said that the last five years had seen sixty percent less rain than usual but the seedlings still came up because the rain was at the right time – so timing is crucial. Rowan then left and the group continued to address the details of the methods.

VAL: And where do we measure the diameter of the tree?

LOG: The diameter of the tree should be measured at chest height.

SAM: Yeah, but whose chest?

LOG: About 1.3 meters.

SAM: That's not the height of my chest! [general laughter]

VAL: What if the tree branches off into multiple stems before 1.3 meters? Loads of the trees here are shrubby.

LOG: OK well we should measure the main branches in that case.

VAL: But how do we characterize the main branches? You can't really tell with those ones.

LOG: Well not the thinner stems – just look at the tree and decide what you think are the main ones.

[At this point there was a decision to measure the diameter at knee (circa 50cm) rather than chest height because of the shrubby nature of the pines]

ALX: How do you measure the base diameter with the calipers on this slope? The diameter changes according to the angle I measure at.

LOG: Why don't you take a couple of measurements at different angles and average them?

At this point a number of questions were raised about the method: In any transect it will be impossible to make any conclusions about whether the seedlings came from the tree in the middle. Are we getting at the dynamics driving vegetation change through the vegetation surveys (e.g. rain, fire, flooding, kangaroo numbers)? Because if we just put exclosures where we see seedlings we will never find out how those seedlings came to be there in the first place – so the exclosures are mainly for conservation rather than controlled experiments. These questions were discussed with no resolution and then Logan explained to the group the rapid survey method.

No.2 Rapid Survey Method
Issues discussed:
The rapid survey method is a more basic analysis of the ground cover and seedlings that exist around a particular tree. It involves drawing a circle around a tree and

dividing the circle into eight segments according to inner and outer and North, South, East and West. Seedlings and understory are then estimated for each segment.

[Group discussion: What size circle should be drawn around the tree?]

Decision: The formal method specifies a twenty-meter circle but this survey is supposed to be rapid so that site staff can do it themselves without expert help, so the decision was made to have the circle only ten meters on each side of the tree.

[Group discussion: Should we specify the direction of the segments (e.g. North, South, East and West)?]

Decision: Yes, because we want to test our hypothesis about sandy/clay soil etc. and the direction can be used with the GPS data to recreate the slope/site spatially. Alex mentioned that at this point in doing a survey there is a temptation to "include everything at the start, including everything we might be interested in and address too many questions."

[Group discussion: Should we recommend avoiding male ironwoods in the "real survey" that will take place in the park over time?]

Decision: Yes, because there will be no seedlings under the male trees – the females are essential for reproducing.

[Group discussion: What happens if we miss seedlings in the counts? For instance, there are lots of trees surrounded by broken branches, stumps, and understory, and it not always possible to spot the seedlings.]

Decision: The most important difference to mark is the difference between 0 and 1 seedlings; because in an eventual model the seedlings will be categorized into broad categories of 'none,' 'few,' 'many.'

Walk to older pine community in the floodplains, 10:30:
After we had done a couple of rapid surveys on the sandy ridge, Alex, Val, Pat and myself went to take a look at the old pine communities that we could see in the plain. Alex told us he wanted to get a sense of whether these trees had any seedlings. Alex's hypothesis was that there would be none (because the kangaroos like to feed on the plains and the soil was heavier clay-based soil rather than sandy ridges).

We found a very old stand of dying and shattered pines (one hundred years plus), with no seedlings visible to the casual observer. Alex suggested that the trees had been shattered by lightning or split through age, and there was little understory which suggested heavy grazing by kangaroos. We then found a younger stand of pines (thirty years plus) that were also younger than the mature trees on the sandy ridge, but

there were still no seedlings. Alex told us that 100 years ago the conditions here were obviously very favourable for pines, given the extent of the old trees, but obviously not any longer – whether this was to do with grazing, soil conditions, rainfall, or so on. Alex said that there was most probably a convergence of factors – including climate, predation by kangaroos, soil type and so on that, if brought together at the right time in a particular place, would enable germination of seedlings.

Lunchtime discussion among the group back at the hostel: 12:30:
Logan described the process of doing the detailed survey method and told us there is a need to adapt the methods to the particular circumstances of each ecosystem or habitat, to best reflect/answer the questions you are trying to answer. Logan said that one has to tailor the methods to the questions that you want to answer and the things you want to learn. For instance, in doing the transects with the pointing stick, we found that the stick landed on kangaroo poo only once or twice, whereas in the quadrat method (where you draw quadrats at different points along the transect and count what is in there), we were getting kangaroo poo counts of one to two hundred in a two by two-meter quadrat. So each method would paint a very different picture of grazing pressure.

LOG: I think we all have lots of ideas and hypotheses about what is going on in this system – the areas that the seedlings prefer (soil/location), the effects of kangaroos – maybe we should draw out some of these conceptual models later on tonight at the hostel?

[Group discussion: What should we do for the next two days, given what we have learned this morning? Should we look for more sandy ridges, where we think that there will be more seedlings? Or shall we do a wider sampling of sites, some with seedlings, some without, and get an impression of the general state of pine-ironwood populations in the park (but without so much data)?]

LOG: The way I see it is we have two options: we can either go ahead with the methods and test them for time and practicality, or we can try and find more sites with seedlings.

VAL: For me, for the time we are in this place, the priority is to find more seedlings. Because we could really practice the methods anywhere or at any time on a site that means nothing.

[Group discussion: Conversation turned at this point to a detailed discussion about the detailed and quick survey methods – and in particular how to merge the tasks of the people involved (e.g. the scribe and the pointer, the laying out of the quadrats and transects) to make the process as quick and efficient as possible. For instance, the scribe could also count the kangaroo poo at the same time as writing down the pointer tallies. Then the conversation turned back to what exact questions we were seeking to

answer through these methods, with a view to discerning the most useful aspects of the methods.]

LOG: It really doesn't make sense to me that there were so many seedlings at the top of the sandy ridge and absolutely none elsewhere. It is baffling – we know they *can* exist there because they do, there are lots of old trees. But for some reason they are not recruiting there anymore. With such a complex situation you really need loads of time and high intensity research, but we are just scratching the surface here.

VAL: But isn't it really quite simple in terms of management problems? There are too many kangaroos and too little germination of trees …

LOG: Yeah, but there are crucial uncertainties. Firstly, under what conditions do pine germinate at all (e.g. even if kangaroos stopped eating them, are soil conditions not right in certain areas)? Secondly, will exclosures do anything to help germination (e.g. if there is a problem with germination itself then exclosures from kangaroos will not make any difference)?

[Group discussion: Discussion then turned to whether exclosures could be expected to help germination, and what we would expect to see in the exclosures with regard to vegetation growth etc. Given that there would be lots of growth of other species also affected by kangaroo grazing (for instance understory shrubby and herby species), would the pines be outcompeted? The group was unsure. Logan would expect to still see pines.]

VAL: Hypothetically, some researchers have suggested that there is a "switch" affected by rainfall, the availability of plant matter and the population of kangaroos, where kangaroos suddenly turn to grazing pine seedlings. In theory this switch can be modeled and predicted given certain data. So if we had exclosures and then some control sites, we could test these models to see if such a switch occurs, year on year. For me, I'm skeptical of whether there is a switch, I imagine it is much more of a gradual thing, with the kangaroos eating some things here, some things there.

[Group discussion: Talk then turned to what – given these speculations – we should do in the afternoon.]

VAL: I think it would be good to see another site. We are still learning, and it would be good to go and see whether there are seedlings at other sites.

LOG: Would this be an observation trip or a monitoring trip where we do surveying?

VAL: It would definitely be good to get more data so we have some numbers to back up our recommendations to the Authority …

[Group discussion: The researchers now study a map generated by an earlier vegetation survey of the park which identifies areas where the pine-ironwood community is regenerating, and identify a site to go and visit in the afternoon.]

Decision: To combine data gathering with exploration – we go to a new site, see what is there, and make measurements of whatever we find.

Drive to new site on the border of the Park, next to agricultural fields, in heavier clay-based soil, where the earlier vegetation survey had identified recruitment of pine-ironwood, 13:30:

At this site we found a stand of old pine trees (one hundred years plus), with a number of smaller saplings (ten to fifteen years) interspersed with them. Despite the existence of saplings, there were very few young seedlings. Alex and I did a number of rapid surveys where we found one to two seedlings or none at all. Alex expressed uncertainty with our sampling strategy, suggesting that we had not definitively decided as a group whether to sample trees with seedlings, or just random trees, so we were caught between doing both. Alex expressed concern that we were just sampling what we thought looked like "likely looking trees to find seedlings" based on our own intuition, and that such methods were not repeatable or objective. We completed three rapid surveys at about twenty minutes each (timing each survey on Alex's phone) before meeting up with the team members practicing the detailed methods and heading back to the hostel.

Evening discussion at the hostel, 19:30:

After dinner the team gathered again to talk through the day's activities and decide our next steps.

[Group discussion: The group talked about the time it took to do the detailed survey, including the individual variation in speed/length, and wondered how long would it take the site staff? They guessed it would take around forty minutes to one hour.]

VAL: We've timed each method. Are we happy that these methods will help towards both long-term monitoring of success towards the Authority's broad objectives of regeneration of park vegetation types, and short-term success of seedlings inside/outside exclosures? Or does something need to be added or removed?

LOG: A kangaroo scat count would be a good addition to get a measure of grazing pressure …

SAM: There is evidence of reduced grazing pressure within exclosures, so we could compare grazing pressure in and outside.

LOG: I really like the pointing method – it is more objective because there is less variation between researchers – so easily repeatable with different people. But there

are two main outstanding issues: there is no spatial reference within the twenty by twenty-meter square so we don't pick up on the North-South gradient.

ALX: But there could potentially be a spatial reference, if we recorded the start of pointing and then model this afterwards to extract the gradient information.

[Group discussion: was the first site similar enough to the second site to give good information about the practicalities of the different methods?]

VAL: How would we choose where to put an exclosure and a test treatment site outside the exclosure? If we think about first site on the sandy ridge for example…

LOG: If you pick the first one the aim of the second one is to be as similar as possible to the first one. But how to pick the first one…?

[Group discussion: Exact replication is not an option for exclosures – not enough similar sites].

VAL: A clear thing is that we have to separate conservation from experimental exclosures. The sandy ridge site should be fenced for conservation, but it is completely different to the other sites we have seen, so it should probably be excluded from an experimental site.

[Group discussion: What sites to include in an experimental set-up? How to ensure comparability?]

VAL: I'm also thinking more about the size of the survey methods. With twenty by twenty-meter quadrats you will get more seedlings in, but with ten by tens (which is quicker), if there is something wrong with the tree you will be able to cover many more areas spatially to get insights from other trees. What is our measure of heterogeneity – is it sites? Or is it locations around tree? With regard to what we are going to recommend to the Authority – if you have exclosures, and nothing happens inside, you would never get the wrong response with respect to management, because you just realize that nothing else happens. So one possibility is to concentrate on finding places with seedlings, and how to they appear to be distributed spatially. This would help to inform our understanding or where to place exclosures if we did not have seedling sightings to guide us. This is not random sampling, I'm trying to optimize how many seedlings I get in the exclosure. So is it worth us trying to find more seedlings tomorrow?

ALX: I think it is. To get a feel for what is going on – with regard to soil, slope.

LOG: I agree. I think you'll get much more information that way than recording more sites with no seedlings.

VAL: However, I think that recommending exclosures would right now be quite random, we don't have the hypotheses or data to do it.

RIL: Do we need to do more work with the methods, and figure out what we want to include, whether we need to add anything?

VAL: We are not sure what we want to analyze right now – it's good train ourselves and see different sites, but I don't think collecting more data is worth it. I think we can learn more from generating hypotheses about what is going on with the seedlings, and where we would place an exclosure if we are to recommend it.

[Group discussion: agreement that tomorrow it will be more worth it to find new sites. If we find interesting site then we get out and measure it]

RIL: Perhaps go out tomorrow morning, scout for sites, then meet up for lunch and draw up shortlist of potential sites to measure in the afternoon?

VAL: Another option is that we walk through in a line of seven in each site – so far at each site we have wandered around everywhere, and looking at it on the GPS is horrible. So we could do it systematically in a line of seven and cover the site so we don't miss anything?

LOG: So it will be a mix of looking at sites on dune-caps that we think might be exciting, and then also stands of adult trees to see if anything is happening. We do as many [sites] as possible through the day ...

[Group discussion: the group talk about the likely sites that they have seen throughout the day, and which might be good to go and see tomorrow. The group decides on likely sites through what they have seen from car windows on our drives through Wildlands, and from the maps done by earlier vegetation surveys]

Decision: "Let's go find stuff!"

[Group discussion: together or apart? The group discuss splitting up into teams to maximize the number of sites visited]

LOG: And if we see any good sites then we sample them.

RIL: What do you mean by 'good?'

LOG: 'Good' means sites with seedlings. And we keep searching until we have a really good mental model of what is happening.

Day three

Site 1:
The first site we visited was a lowland plains site with old ironwoods and pines but no seedlings.

Site 2:
The second site was a second sandy ridge that had lots of seedlings (one to five years), lots of medium saplings (five to fifteen years) and some mature trees (one hundred years plus). This was the first site at which we saw a broad generational mix of trees of all ages and timescales. The interesting thing here was that the kangaroos had built their 'scrapes' to spend the night in underneath the saplings and more mature pines – some were completely hollowed out and covered with scat – yet the trees were very healthy. Even more surprising was that there were some young seedlings in amongst these dugouts that were untouched by the kangaroos. Logan and the others modified their assumptions – the kangaroos liked seedlings but would not *necessarily* eat all of them, there seemed to be greater room for uncertainty in this regard. This countered the received wisdom of the site staff and the host at our hostel, who both suggested that the kangaroos eat the seedlings straight away.

We looked at a neighbouring sandy ridge that also had a broad range of seedlings, saplings and adult trees. Val asked Logan whether the saplings had grown enough to be "safe" from kangaroos. Logan said that yes, they had, and suggested that therefore the ridge would be "safe for another hundred years or so."

So far, since the first day, we had looked at five sites overall. The first sandy ridge site (yesterday morning) had lots of very young seedlings (one to five years), but little intermediate growth of saplings (five to fifteen years). The second site (yesterday midday), was a mature stand of trees on floodplain clay-based soils with mature trees (one hundred years plus) and no saplings of intermediate age or seedlings of young age. The third site (yesterday afternoon), next to agricultural fields, was a stand of mature trees with saplings (five to fifteen years) but few young seedlings. The fourth site (this morning), was a stand of mature trees (one hundred years plus) with few saplings or seedlings. The fifth site (just now), the second sandy ridge, had a range of older trees (one hundred years plus), saplings (five to fifteen years) and seedlings (one to five years). All seem to represent differrent convergences of ecological factors at particular favourable times.

Alex: Why not pick two sandy ridges with seedlings, put exclosure on one and leave the other one open, and see what happens to the seedlings? This would help us understand the effects of the kangaroo population on seedlings by eliminating the factor of tree germination uncertainties (the seedlings are already there so germination evidently can and has occurred).

[Group discussion: We were picking the sites today based partly on the sites we had seen from the car windows that looked "likely" (i.e. sandy ridges with pines on), and partly based on maps from previous vegetation surveys that had identified areas of high and low regeneration. But the maps did not appear to be accurate: the second sandy ridge appeared in the maps as an area of low recruitment but when we visited it was covered in saplings and seedlings. Alex wondered "on what basis have they extrapolated? Why would there be straight lines in the maps? That appears suspicious… They might have divided the region up by landform and a few sampling locations?" Val promised to check the method later in the day. This would reflect uncertainties in the kangaroo census data that would emerge later on (see below). Following this questioning of the data of previous surveys the group became concerned that we were in the wrong locations – maybe we had got the wrong ridges in the first place? Alex was unsure of our location in the final site we sampled last night and then the site we were in first thing this morning. If the old maps are showing low recruitment, maybe it is *our* fault for being in the 'wrong' locations?]

Site 3:
Lowland plains – older pine trees (one hundred years plus) and saplings, but no seedlings. Mature ironwood trees.

Site 4:
Dense thickets of pine saplings all of a similar age (five to twenty years old), almost plantation style. So thick the light would not penetrate. The saplings surrounded two or three enormous old trees dense with seeds. According to Logan this was the "perfect site" where the old trees were showering the area with seeds year after year, and at one moment the conditions were right (rainfall, grazing, soil etc.), and thousands of seedlings emerged at the same time. Logan said that the management would not want this plantation style all over the hills, but perhaps it is a good thing to have patches of this density throughout the landscape to ensure that seeds and trees remain (refugia).

Logan: This site paints a picture of opportunistic or response-driven recruitment to some chance event.

Sam: We need to capture this range of conditions – this unpredictability in time – and vegetation types in our model. The idea would be to say to the Authority that the next time you experience this particular conjunction of conditions (e.g. rain for three years around mature pine trees seeding heavily), you need to put up exclosures around these particular trees to ensure widescale recruitment. This model building is an iterative process of landscape observations and conceptual hypotheses of seedling recruitment, using each to inform the other.

Site 5:

At the next site neighbouring the plantation style thickets, we encountered evidence of continuous recruitment of pine, with a range of age classes (mixed with ironwood and eucalypts). The area gave an impression of the 'desired state' of Wildlands – representing a "healthy" landscape.

Alex: The condition of this site gives the impression that the previous site was just a chance event where reduced grazing pressure over a few years (for whatever reason) coupled with favourable rain and climatic conditions, to prompt mass recruitment – rather than because the conditions were generally 'better' there.

Logan: It is difficult to untangle whether the thickets of saplings on the previous site were driven by reduced grazing pressure over a few years or driven by rain events.

[Group discussion: the group talked about the location and use of exclosures in the park – apparently Rowan who met us the previous day had told Sam that there were a number of exclosures in the southern part of the Park. This was news to Sam, who had been led to believe by Park contacts that there were no exclosures there]

Site 6:
A large sand dune fringed by pines that Alex had spotted from the hostel. There were some medium aged pine saplings (fifteen to fifty years) but little evidence of seedling recruitment. There was evidence of rabbit habitation at densities larger than the one per kilometer claimed by Rowan from the Authority. Further along the ridge there was evidence of recent (last few months) fire damage with no evidence of re-growth of pine seedlings or saplings; the fire-damaged swathes were fringed by medium-aged (fifteen to fifty years) saplings but with little evidence of seedling recruitment.

Car ride back to hostel for lunch, 13:00:
Across the northern part of Wildlands there was often an interspersed landscape of grassy plains and dense stands of eucalyptus, with pine-ironwood assemblages in some areas. I asked Sam in the car journey back to the hostel why there was such strict demarcation in the landscape between plains and woodlands. Sam replied that the eucalyptus woodland was largely flood driven, as the floods carried the seeds around to new locations (and the seeds needed sustained moisture to germinate). Floods had a big role in driving changes in the landscape, but they had been curtailed by the massive irrigation works in the area in the twentieth century, so it was doubtful whether floods would reach these parts of the landscape again. However, the irrigation system is currently being completely overhauled – and conservationists in the area are hopeful it will allow more flooding and more water to enter the system.

Discussion over lunch at hostel, 13:30:
Val: Can you really have adaptive management here without exclosures? What other ways are there to learn about the system? I suppose you could plant seedlings in

different places and see if they get eaten by kangaroos – that would be a poor man's exclosure …

Sam: The problem with exclosures is that there is resistance to them in the Authority because of the time and the resources needed to build and monitor them. We really need to make a strong case for them.

Logan: I'm wondering whether you want to think about negotiation techniques when you write your report to the Authority recommending adaptive management ways forward. What if you ask for some big figure – like twenty exclosures – and then settle for something like ten. Because you'd probably be much more likely to get that than if you started off asking for like two or three exclosures, where you might end up with nothing. Would this be something to think about?

Val: [Laughs] I don't know [shakes head] …

[Group discussion: Conversation then moved on to the existing model of kangaroo populations – the Rainfall Model – used by the Authority to drive their culling practices. Sam said that the Rainfall Model is good at predicting the slow growth and decline of kangaroo populations according to rainfall patterns, but is bad at predicting rapid crashes and sudden events. In addition, the numbers that go into the model are often based on faulty data. The way the data is gathered is through hiring of consultants to do an aerial survey in some parts of the Park (where the landscape is more open allowing estimates from the air), and ground quadrat surveys in other parts (where a more closed landscape with lots of trees and canopy cover prevents air surveys). Sam said that there has only been a kangaroo cull once in the last four years, even though the site staff 'know' the kangaroo numbers are massive. Sam noted that the Rowan had said that the aerial survey last year had been done on a sunny day when the kangaroos were all hiding under trees and in long grass, and so came up with a gross underestimate. The "right number" (in Rowan's words) did not consequently come out of the model]

Site 7:

We then drove on to a couple of sites indicated on the previous vegetation surveys indicated as 'high recruitment' areas for the pine-ironwood vegetation type. The second site had been affected by a recent bush fire and was denuded of all understory plants. We found some very old ironwood trees (one hundred years plus) and about fifty to sixty seedlings/saplings that were very small but seemed to have been trying to come up for a long time (very gnarly and chewed). They had survived the fire and were re-sprouting from the bases of their trunk and branches. These were the first ironwood seedlings we had found during the trip. The researchers asked themselves: have we seen these ones only because the understory has been burned back? Would we see ironwood seedlings at the other sites we've visited if there were fires there? Or are these really the only ones that exist?

[Group discussion: What should the group do with its final afternoon? What was the major priority?]

Decision: It was decided that there should be some numbers behind the ironwood seedlings, because the researchers would not be able to recommend something to the Authority without some numbers to back it up.

[Group discussion: What form should these numbers take?]

Decision: It was decided that there was no use doing the rapid or detailed surveys for the ironwood seedlings – laying out the transect etc. – because there would be little information in them. Alex suggested that he could measure the diameter of the trees and saplings and measure the distances between them, to get some numbers behind any recommendations.

[Group discussion: Should the group all stay to help, or should the group split up and get some more data on the second sandy ridge that we spotted earlier?]

Decision: It was decided the group should split up, with me and Riley, and Sam and Logan, going to do some rapid surveys on the second sandy ridge – in order to get as much data as possible to put into the report.

Rapid surveys on the second sandy ridge, 16:00:
When we arrived back at the second sandy ridge, Logan told us to go and do as many rapid surveys as possible in the hour or so before sunset, to get as much data as possible in the report. Logan told us to focus on trees with seedlings, and trees with other trees in the twenty-meter circle around its base.

Riley and I picked our first tree, a youngish tree (fifteen to thirty years), with many seedlings and younger trees in the diameter. However, the central tree had many sprouting branches from its base, which made measuring the diameter difficult. Because of the time it would take to measure all the branches, we abandoned the tree and moved on to the next one, which had a single main trunk. We counted the seedlings in the circle – but there were some problems with identifying seedlings. Some of the very young seedlings had a spiny/spiky stem – we had not seen this on the other seedlings, and were unsure of whether it was the same species, perhaps it was a closely related species, or something else? We took photos of the seedling and told Logan about them when we returned to the car. Logan told us that they were seedlings that were very new and had not been chewed by kangaroos (the chewing causes a ´woodier and less spiny re-growth).

Day four

***Drive with Tony through the southern parts of Wildlands, 08:00*:**
This morning Tony, the member of the site staff who had greeted us the first day, came to the hostel to pick us up and drive us through the southern parts of Wildlands. These parts were much bushier and had much more of a canopy, and much less grassland, which apparently put off the kangaroos from staying there for too long. Consequently, there was much higher recruitment of pine and ironwood in these parts. We looked at the exclosures that the site staff had mentioned the previous days, and found signs of intense recruitment with one exclosure looking like the dense thickets of pine that we found yesterday. In one exclosure we witnessed a kangaroo that had managed to get in, but was struggling to get out, running up and down the fence, and aborting several attempts to jump the fence at the last second. In another exclosure, erected to protect some understory plants, there was evidence of native grass re-growth and seedling understory plants.

Logan was driving in the car with Tony, and after Tony had left, Logan told us that they had been talking about the general state of management in Wildlands. In Tony's opinion the aerial surveys of the kangaroo populations were defective because they were done in the wrong conditions (sunny when roos were sleeping) and the kangaroo numbers in the Park were much too high. In Tony's opinion exclosures would be a good idea to keep out rabbits and kangaroos (combination fences with chicken wire at the bottom for rabbits and electric fences at the top for kangaroos). Tony thought it might be a good idea to get a volunteer group to come and erect these exclosures without too much extra expense for the Authority. Tony also told Logan that the changed flood regimes in the second half of the twentieth century were also severely affecting vegetation recruitment in the Park, but that the proposed changes to the flood regime may mean more water getting into the Park and more chance of flooding in the future.

Site 8:
We then took a look at a patch of ironwood close to the Wildlands exit gate. We saw some evidence of recruitment with some small (fifteen to thirty years) saplings. After this site, we drove out of Wildlands and back to the University.

[End of field trip]