T R A N S C R I P T

LEGISLATIVE ASSEMBLY ENVIRONMENT AND PLANNING COMMITTEE

Inquiry into Tackling Climate Change in Victorian Communities

Melbourne—Tuesday, 10 March 2020

MEMBERS

Mr Darren Cheeseman—Chair
Mr David Morris—Deputy Chair
Mr Will Fowles
Ms Danielle Green
Mr Paul Hamer
Mr Tim McCurdy
Mr Tim Smith

WITNESSES

Ms Jane Coram, Director, Land and Water Business Unit,

Dr Deborah O'Connell, Principal Research Scientist, Adaptation Pathways and Societal Transition Team, Land and Water,

Mr John Clarke, Team Leader, Regional Projections Team, Climate Science Centre, and

Dr Martin Cope, Air Quality Modeller, Aerosol and Chemistry Modelling Group, Climate Science Centre, CSIRO.

The CHAIR: Welcome to the public hearing. Before we begin there are some important formalities that I must outline.

All evidence taken today will be recorded by Hansard and is protected by parliamentary privilege. This means that you can speak freely without fear of legal action in relation to the evidence that you give. However, it is important to remember that parliamentary privilege does not apply to comments made outside of the hearing even if you are restating what you have said during the hearing. You will receive a draft transcript of your evidence in the next week or so for you to check and approve. Corrected transcripts are published on the Committee's website and may be quoted from in our final report.

Thank you for making the time to meet with the Committee today. Could each of you please state your full name and titles before beginning your presentation—it is very formal, isn't it? Who wishes to start?

Mr CLARKE: Okay. My name is John Clarke, I am a Team Leader with the Regional Projections team in the Climate Science Centre at CSIRO.

Dr COPE: I am Martin Cope. I am an Air Quality Modeller, and I am in the Aerosol and Chemistry Modelling group in the Climate Science Centre.

Ms CORAM: I am Jane Coram, I am the Director of CSIRO's Land and Water business unit.

Dr O'CONNELL: I am Deborah O'Connell. I am a Principal Research Scientist in the Adaptation Pathways and Societal Transition team at Land and Water at CSIRO.

The CHAIR: Terrific. Thank you, over to you guys, and I look forward to your presentation.

Ms CORAM: Thank you. If I may, I will give an introductory statement and then I guess we will be very happy to take questions.

The CHAIR: Happy with that approach.

Ms CORAM: Excellent. So first of all, thank you for the opportunity to contribute to this Inquiry.

The world's climate is changing and driving changes in global markets, policies and industries, often in ways we cannot fully predict. CSIRO is addressing challenges faced by individuals, communities, business, industries and governments through our multidisciplinary research that connects climate knowledge and information to climate adaptation and mitigation responses.

As a society we need to achieve systemic changes. Part of doing this is by understanding the change trajectories we are on—climate, ecology, population, to name a few—and developing new techniques and new technologies such as low-emission energy technologies, building materials and designs, and improving emergency warning systems.

My colleague John Clarke led a team who partnered with the Victorian Government to deliver Victorian Climate Projections 2019. This suite of reports provides Victorian communities with authoritative and up-to-date information to help them better prepare for climate change. Over the last few months John's team, together with the Department of Environment, Land, Water and Planning, and the National Environmental

Science Program's Earth Systems and Climate Change Hub, have been running a series of workshops to help the community understand how to effectively incorporate this information into their decision-making processes. The department has also allocated funding for John's team to continue to support users of the projections through expert advice, guidance and tailoring of datasets.

Martin Cope leads our work on the smoke and air quality prediction system, AQFx, as mentioned in our written submission. AQFx was run operationally by the Bureau of Meteorology extensively over the last summer for smoke forecasting, providing information to the Victorian EPA and the State Control Centre to assist with health warnings. AQFx was also used by bureau forecasters to assist with aviation visibility advisories. Both John and Martin have worked extensively with the Victorian Government for many years.

Current decision-making and planning processes, such as strategic planning, risk assessment and stakeholder engagement processes, were not designed to cope with the level of change and uncertainty we now see, and new approaches are required to be effective and robust in these circumstances. CSIRO has a number of examples of projects that span theory and practice where we provide scaffolding organisations to move from their current set of approaches to the ones that will be necessary in the future.

We know that although the technological solutions are critically important, building resilient and adaptive communities, businesses, industries and governments requires putting people and systems thinking at the centre of resilience and adaptation initiatives. Technology options need to be implemented appropriately and at scale, in line with reaching broader sustainability goals and visions for the future.

We help to catalyse the broader system change needed by, at one end, inspiring really different ways of thinking about the problem and the future while also chipping away at approachable incremental changes that can start to operationalise some of these big things in smaller steps.

Drawing on her multidisciplinary background, Deb O'Connell has been working in this area for many years, and I would like to highlight two examples. Firstly, AdaptNRM, which is a national initiative that aims to support NRM groups to include climate adaptation planning in their NRM plans. Adaptation information is delivered at a national level in scale but is designed to suit regions to complement existing NRM activities that incorporate locally specific issues and solutions. Secondly, CSIRO has also played an ongoing role in disaster risk reduction, from vulnerability to resilience. This is a national approach developed in collaboration with Emergency Management Australia, the National Resilience Taskforce and many state government agencies. Our work has contributed to national frameworks and guidance on disaster risk reduction. We would be happy to provide more details about this work in our appearance today.

CSIRO looks forward to continuing our partnership with the Victorian Government and community to help them respond to the impacts of climate change. My colleagues and I would welcome any questions you have.

The CHAIR: Thank you for your presentation. It just sort of occurred to me—CSIRO, as a lead science agency across the Commonwealth of Australia, obviously produces all sorts of different datasets for lots of different jurisdictions. I am curious to know what datasets you have worked up for other jurisdictions that Victoria at this stage has not purchased.

Mr CLARKE: That is an interesting question. In terms of the climate projections datasets, which is my area of expertise, I would say Victoria is actually ahead of the other states in that context. Everywhere, all of the states and territories in Australia, has access to a certain level of datasets that we developed and released in 2015. Some of those datasets are at 5-kilometre resolution, which is generally fairly usable for most people. What we have done in Victoria is develop a new set of high-resolution data that complements those pre-existing datasets, also at 5 kilometres but using a different modelling technique that adds more value—or has the potential at least to add more value—when there is topography, like in the mountains or coastlines, and that data has given us quite a bit of added understanding around rainfall at high elevations particularly but also some hotter extremes. Other states have done similar work, but not by us.

The CHAIR: Okay, and are there potential datasets that you would envisage could be accessed or funded by the State Government that they have not yet looked to do?

Mr CLARKE: Certainly. The data that we have developed so far, if you like, you could think of as the building blocks. There was not time to develop up some of the more specific datasets, like growing degree days or human comfort factors, heatwave indices. None of that work has been done yet. Definitely at least some of that work is likely to be done in the next 12 months under the ongoing funding that DELWP are providing.

The CHAIR: All right. We have heard lots of anecdotal evidence and evidence from local government that often when they put in place replacement stormwater infrastructure it is like-for-like replacement. Has CSIRO done any work to look at, perhaps even down to the 5-kilometre scale, whether increasing the capacity of stormwater systems to carry water is being done? It just seems to me that it is pretty ad hoc, I would suspect. What work has CSIRO done in terms of our stormwater systems to look at whether we need to rethink our engineering standards to model future rainfall and storm patterns?

Mr CLARKE: The most relevant source of information for that is the *Australian Rainfall and Runoff* handbook that is produced by Engineers Australia, and in the last edition of that, for the first time, an attempt was made to incorporate climate change information into that. It provides engineers with guidelines on what size pipes and things to use in a particular part of Australia. Obviously in a dynamic climate, one that is changing, those rules may longer apply. But it is very challenging. Scientifically this is very much leading-edge science because what is most important for drainage, particularly in urban areas, are those very short duration, highly intense events. Sometimes they occur over time periods of 10 minutes, 30 minutes, but our routine work produces projected changes at daily scales, not anything shorter, so to get to sub-daily is quite challenging. Now we have done some work in the most recent projections for Victoria that does look at some sub-daily changes, but it is difficult because we do not have sub-daily historic data to compare it to everywhere. So that is challenging.

The CHAIR: Okay, so from that early work that is being done now in that space, would there be a recommendation or an observation you would like to make in terms of how we get that level of understanding down to the civil engineer that works at a council who has responsibility for putting in place stormwater infrastructure? How do we get that down to the local decision-makers that are putting in place that infrastructure?

Mr CLARKE: Okay, so there are two parts to the answer to that. One is that the *Australian Rainfall and Runoff* handbook recommends that engineers allow for a 5 per cent increase in the intensity of a given event for every 1 degree of global warming, so for a 1.5-degree world that would be a 7.5 per cent increase in intensity. That is well understood to be quite conservative. The observations that were reported even in the fifth assessment report from the IPCC in 2013 were showing that in some cases short duration events have been increasing by in the order of 15 per cent. So it is quite conservative, but it is very robust.

The next thing is perhaps there is work happening in this space at the moment. Colleagues of ours in Western Australia, for example, are doing work on sub-daily rainfall changes. Also DELWP are funding some work in that space. I am not entirely sure, but possibly the Vic working project is looking into this, but I would have to check.

The CHAIR: Okay, so maybe there is a debate about what the percentage is, but through various either legislative or regulative instruments that DELWP have responsibility for ought there be some consideration of setting at least some form of a minimum acceptance within our engineering standards about the infrastructure that is required to be put in place when replacing old infrastructure or indeed in new, emerging communities? Should the State Government be thinking about setting some form of minimum benchmarks around some of that?

Mr CLARKE: Well, it is up to the Government what they decide to implement in terms of policies. In terms of the science, the recommendations in the *Australian Rainfall and Runoff* handbook are the current recommended levels, but we acknowledge that they are conservative.

Mr FOWLES: To what extent is there real granularity in the datasets that are available at the moment for local councils or farmers or anyone else—property developers or whatever—needing to make decisions about what a part of the world is going to look like 20 and 30 and 40 years hence?

Mr CLARKE: At the moment the highest resolution datasets we have are at 5 kilometres, which is more than adequate for the vast majority of applications. Having said that, there is a strong desire from most people to have information at a finer scale, preferably the scale of their house, block or back paddock. I am not being flippant; that is a genuine desire from the people that we work with. However, when you dig into the sorts of decisions that are needed it is very often not actually advantageous to go to such fine-scale resolution. As you go to finer scales the datasets get bigger and bigger exponentially. A 5-kilometre dataset for all of Victoria is a pretty chunky dataset to work with; 1 kilometre would be much, much worse.

Mr FOWLES: Sure. In terms of them being useful for most applications, to talk just about the public realm for a moment, there are the public infrastructure matters for local government that my colleague Darren Cheeseman has raised, there are things like how many dams you need, where are you going to put them. At sort of the more macroscale there are things about whether a deepwater port is going to remain a deepwater port or whether it is going to be usable or unusable in circumstances—

Mr MORRIS: Or a very deepwater port.

Mr FOWLES: Yes, but it might also be more subject to inundation in the existing breakwater areas and things like that, so there are any number of uses. Do you think the dataset as it stands is readily adaptable by—I will not say laypeople, but people who do not have the sophistication of the CSIRO team to be able to make some genuine predictions about their individual applications?

Mr CLARKE: Right now, no. It is by its nature complicated. DELWP are at the moment working with our colleagues in Data61 to develop a more user-friendly portal for disseminating some of the change information, but we still have challenges. The uncertainties around what will happen with greenhouse gas emissions alone mean that there is always going to be—

Mr FOWLES: There is always going to be a range, isn't there?

Mr CLARKE: It is always a range.

Mr FOWLES: Because people say we do not know what the global action is going to be in relation to climate change—and I will resist the temptation to make a political judgement on the leadership of some large Western economies. I guess what I am interested to know is, let us use the dam example: if a CMA comes to you and says, 'We think we are below the capacity we need to be, we're thinking about potentially building a new dam. All other considerations aside', of which there would be plenty, 'where do you recommend we put it?' How laborious a process is that, just from a weather and rainfall data perspective, to extract from the data you have?

Mr CLARKE: If those companies do not have their own hydrologists, they would need to work with hydrologists who can manipulate the datasets. It is not straightforward. Our colleagues in Land and Water do the detailed modelling in the hydrological space and they are working with the Victorian Government at the moment on updating that.

Mr FOWLES: Is there any value in the Victorian Government improving the base data so that it is more accessible by more entities, more people, more laypeople potentially or even scientists whose propellers do not spin quite as fast as yours?

Mr CLARKE: We acknowledge that across the board the data need to be disseminated in a way that is much more easy—

Mr FOWLES: And is there value in Vic Gov investing in bringing up the baseline of usability or accessibility in relation to the entire dataset? Is that a potentially valuable thing for Government to be considering?

Mr CLARKE: Our colleagues in the communication space would say absolutely.

Mr FOWLES: And you?

Mr CLARKE: The people I work with are struggling to deal with the datasets, so anything that helps make the data easier to understand would be helpful.

Mr HAMER: I have got another question just on the model. So even at that fine-grain level, is each square, each part of the grid, almost worked out independently in terms of the model calculates it independently, or is it approached more as a global—sort of statewide—and then extrapolated out to the years?

Mr CLARKE: We run a half-day course on this, so I will try and be brief. The modelling is done using computer models on supercomputers that solve the physics and chemistry and thermodynamics equations at every grid point simultaneously and each grid point communicates with its neighbour in that process, so it is a dynamical process. To do that the model divides the space—whichever space you are interested in, say Victoria—into multiple layers going up into the atmosphere as well as horizontally, so it is a three-dimensional matrix of cubes really. Rather than grid squares they are actually cubes, and those calculations occur simultaneously at every intersection of those cubes and then it steps forward in time and carries the data forward, recomputes and does that over and over and over. So each grid square is not calculated in isolation, every one communicates with its neighbour, but there are some limitations to the way water flows in those models. I am not a modeller, but my understanding is that that is a limitation of the computational power we have available, but it means that water movement horizontally in the soil has to be estimated rather than dynamically calculated, but the vertical movement in those columns is dynamically computed.

Mr HAMER: I guess the other reason for my question was that we had heard evidence previously about how particularly areas north of the Divide and inland Australia are warming more rapidly than closer to the coast, so that would be, what, an output of the model, is it? Because it is interacting with the other areas around it which are sort of feeding into a more rapid growth in one area versus perhaps a less rapid growth in another area. Is that a correct assumption?

Mr CLARKE: There are two things. People will make those statements on the basis of observed temperatures, particularly, and then looking forward into the future that is where we use the models. So the observations are recalculated into a gridded dataset that can then be analysed across the state or across Australia or across the world, and that information is computed into whether or not there is a trend. And we see that inland areas have warmed faster than coastal areas. That is in the observations. Then looking forward into the future, the models, because of the dynamics between the grid cubes and the feedbacks that go on, then you get more radiant heat from the soil inland, which heats the air more, which dries out the soil more, so you get this feedback loop, whereas in the coastal areas you have got that constant input of moisture from the ocean, and that tends to depress the warming. So it is corroborated. The projections are consistent with the trends that we see in the observations, and it is computed dynamically. So that takes account of all of the feedbacks that are in the system, with limitations—they are models. They are not perfect, but they are informative.

The CHAIR: Obviously a substantial percentage of Victoria's population and indeed I think Australia's population lives within a number of kilometres of the coastline, and we potentially have that set of circumstances where you have base sea-level rise and an inland storm surge that in a sense might create the perfect storm for coastal flooding. Where is the science at the moment in terms of modelling, particularly from a consumer perspective, over the next 20 years, 40 years, 60 years, 80 years, 100 years, in terms of the parts of the Australian coastline that is vulnerable, that people need to be aware of when they are making property purchases or councils are considering infrastructure they might put in place or public land managers are making considerations around where ports should be built or where publicly owned assets might be built on the coastline? So where are we at with developing tools and datasets and the like that individuals or industry groups would be able to access to make those kind of decisions about where they might purchase property or where we might put in public infrastructure on the coastline and where is a no-go—giving an understanding to the banking sector and the insurance sector and the like where there is potential risk and where there might be good justification for investment?

Mr CLARKE: Right. It is really complicated. Firstly, the insurance companies, particularly the reinsurance companies, tend to do this themselves. They have their own capability to take the projections and information and do their own hazard assessments and so forth. If we are to look at, say, the coincidence of a storm causing flooding on the land, coincident with a storm surge, that type of modelling is incredibly complicated and expensive. So it is not being done for everywhere, but for the entire Australian coastline there has been a first

pass vulnerability assessment. It was done quite a long time ago now. In Victoria we are close to completing a coastal hazard assessment for Port Phillip Bay. That is a project that is funded by DELWP, and it is a consortium of CSIRO, the bureau, Federation University—and I am forgetting someone—where they are looking at a combination of inundation events, storm surges, coastal erosion and groundwater change in an integrated assessment. That is a rare thing.

Dr O'CONNELL: Sorry, I was going to just maybe add to that from a different perspective. Are you done?

Mr CLARKE: Yes, that is good.

Dr O'CONNELL: I guess in working with many of the groups that you talked about in the national disaster risk reduction work as well as adaptation work we have done over a long time, it is really clear that even when you have all of the knowledge that you need, which is the sort of thing that John is talking about, the knowledge is necessary but it is insufficient for people to take action. And when we really try to explore the reasons why they are unable to take action based on that knowledge, which in some cases is very, very clear, it is usually not to do with getting more knowledge; it is about the fact that no-one is in charge, potentially.

There is a very complicated set of actors there. They are driven by different values and constrained by different values and also by different rules, and the rules are the formal policies, the legislations and also business plans as well as the informal rules of the cultural norms that we expect. So often the barriers to taking action, even when the knowledge is quite complete, are about people and their decision-making under uncertainty. So that is the sort of thing that we work with people to do, including all of those groups that you talk about.

In the disaster space and disaster reduction space, it is actually trying to take the focus off of the emergency response when those things happen and into that planning domain to make sure that people are not in the places where they will be vulnerable and their assets will be harmed, but that involves speaking to a whole range of people who have to collaborate and cooperate in a way that they have never had to do before.

The CHAIR: Just thinking about, say, Lakes Entrance and I think like Lake Glenmaggie—and that catchment I think drains into Lakes Entrance, if my memory serves me correctly—obviously Lakes Entrance is built around that particular lake system. You have got a potential storm surge coming out of Lake Glenmaggie if it is full and overflowing. You have got potential sea-level rise and coastal storm surge, and I am just using that as a hotspot, but there are probably lots of other hotspots around the Victorian coastline as well, let alone around the Australian coastline. So at this stage I suspect you can model exactly what the various scenarios are that might play out, but what you are suggesting, Deborah, is that does not necessarily then feed into planning scheme overlays, into various other either State or Commonwealth legislative thinking around consumer rights, property rights—all of those things.

Dr O'CONNELL: All of the choices that go into how insurance plays out for those people and when their insurance premiums go up, or in fact they find themselves uninsurable, which then feeds through to the property market. We are starting to see some of those things play out now. And I guess when we do work like that, we get all of the relevant players together and we try to help them through making decisions that are robust to a range of different futures—because they are uncertain futures. We can put some of those datasets on the table and then work together to work at how you might actually come up with something that is robust. Almost inevitably it means that each organisational unit, whether it is an organisation as a government jurisdiction or a company which might be an insurance company or a household or a local government, has got certain levers available to it but actually no one can solve the problem on their own. And sometimes the rules that are in place are not fit for that purpose. So there are two things: one is having rules that are fit for purpose that allow them to make those changes, and then knowing how to sequence those changes in a way that leads to an overall change, which means that no one actor can do it on their own. They have to sit down and work it out together.

The CHAIR: Okay, so you have identified an interesting problem. How are other jurisdictions dealing with that particular problem? Is there a jurisdiction globally or somewhere else within the Commonwealth where that level of sophisticated, coordinated thinking is actually starting to emerge? Is there an example you would like to point to that we should look at that is doing it better than others? It sort of occurs to me that this is a relatively new problem—from this perspective at least.

Dr O'CONNELL: Probably the example that is cited the most internationally at the moment is Louisiana. They are having to do relocation at a grand scale in that state. We have some members of my team working in the teams working in Louisiana. But certainly a lot of the, actually, NRM planning, resilience planning and adaptation planning does lead the way. They have mostly been focused around NRM, but the processes that they go through and the engagement processes—there is as much science in the way that you work with people to do this as there is in the collection of data and the projections.

There are several examples in NRM in Victoria and in disaster reduction in Australia at different scales and in different places where it is working quite well. So *Resilient Sydney* and *Resilient Melbourne* are starting to think along these lines. It is necessarily quite a place-based approach, but you have to be able to bring all the different actors in and make strategic choices that are robust to that range of futures. You know, John can talk about making projections that are to a backpack level for climate and then coronavirus comes along—so it is really about trying to understand all the different shocks and trends and stresses that underlie, and instead of one department dealing with drought and a different department dealing with floods and a different department dealing with something else, trying to bring them all into the room together. Because it is actually at the intersection of those things that you will find that the solutions will lie.

The CHAIR: Was that—and you may not be experts in this—10 years ago I think now when we had Brisbane flooded. I think they copped it both from an inland flood perspective—king tides—which flooded a fair bit of central Brisbane around the river there. Have Queensland, from your observation, started to align their agencies to look at these problems more holistically and across the portfolio as a consequence of that?

Dr O'CONNELL: Absolutely. So in response to that event they set up the Queensland Reconstruction Authority, which was originally an authority with a two-year task. They then, after Cyclone Debbie, made it a permanent authority. We work really closely with them as well. They have done and are doing some amazing work around bringing the forward planning not just for response and recovery but all of the mitigating planning that needs to be done. They have already substantially done the path for that. They have systems where, for example, they send in their damage assessment teams when they know something is about to happen. They have handheld devices and they can go around really, really quickly to photograph the damage hours after water recedes or as soon as it is safe to do so. Those photos and damage assessments are uploaded centrally, and it is fed out to information that goes to disaster relief payments and to insurance company assessments.

Those things are really quite sophisticated and well advanced in Queensland. We are now helping them to try and bring in some of the really early thinking from some of the players who are not normally involved in the response and recovery side of things, so departments of agriculture, some of the NRM agencies and some of the private sector players too, actually, because a lot of those actors need to take really different decisions in the 10 years leading into the event to reduce the impacts of those events. But they are very substantially down the path there.

The CHAIR: So I think the Victorian Government has responded vaguely in a similar way with respect to bushfire recovery, but I am thinking more from a flooding perspective. As far as I know, that work has not been done. Would you be suggesting that that would be something useful for the Victorian Government to think about—whether there should be that cross-department collaboration to build up our knowledge and our understanding of future emerging climate risks around that?

Dr O'CONNELL: Yes, I think what we typically find is that those agencies in any state that are involved in the response and recovery end tend to work together very collaboratively and across boundaries during emergencies and immediately afterwards. It is the strategic long-term planning—

The CHAIR: It is the strategic work that is to be done.

Dr O'CONNELL: The same level of collaboration is not there. I think that—certainly through the disaster risk reduction framework as well as many other initiatives—that is where if you can get the same level of coordination and strategic work as you get in the response work, things would go a lot better during the response period.

Mr HAMER: I have just got a couple of questions on another topic, specifically looking at health and food. I am just wondering what sort of work in that space you might have done specifically touching on climate

change, I guess, as our state gets hotter and rainfall patterns change, both from a human health and I guess an animal health perspective and also food security but also generally the range of food that might be on offer, and what help you might be currently providing and then also what recommendations you could potentially give to the State to actually assist in the transition. So it is a rather large question.

Dr O'CONNELL: It is probably a little bit like the difference between what John talked about and what I talked about. We have whole teams that do really detailed work in climate change and agriculture, climate change and food supply chains and logistics, and the same for health. The job of my team is to take the step back and look at the systems analysis. We have those experts all sitting in a room, and we look at the interaction of those systems and the vulnerabilities in those systems at that broader level.

I certainly do not feel that I could speak to—and I am not sure; maybe Jane can—the detailed work that has been done in those things. But certainly the sorts of interruptions in food supply, fuel supply, power supply, comms and implications for health were well explored at the broader scale in the Australian Vulnerability Profile work, where we did those systems analyses—how they create vicious cycles, how to turn them into virtuous cycles. We need different trade-off points. If things are so driven by the need for efficiency at the expense of stockpiling and buffering and that is creating the vulnerability, we need a different trade-off point, but we need to do more quantitative work to work out what that trade-off point would be.

It is the same if you are talking about preventative health versus response type of health. We have a lot of expertise working on the details of those, but we and our team try to bring the whole big picture together, and I could not answer those questions in detail.

The CHAIR: I just have one further—

Mr CLARKE: I could speak to one example in the agricultural sector, if you like.

The CHAIR: This might be a pre-emptor into that space. I suspect the climate science is suggesting we are going to have more intense smoke events through bushfire and more intense dust storm activity. Has there been any modelling done as to what that might mean for vulnerable Victorians or Australians? Are we going to see people dying as a consequence, not of the actual fire but the smoke that comes from it—or dust storms? Are we going to see more incidents of respiratory illness that might lead to death as a consequence of these events, and what modelling has been done in terms of what that might mean going forward with the various climate change scenarios that we are actively considering?

Dr COPE: We have done a lot of work in that area, and of course we have had to do a lot of work over this summer with the event that we have had, with the knowledge that that type of event is going to become more frequent over time. It is still early days, but the numbers of excess deaths because of that smoke is likely to be substantial. It is certainly a lot more than the numbers of people who unfortunately died directly in the fires.

The CHAIR: I think after Black Saturday—and in the week or two either side—the evidence was that there were probably several thousand Victorians that died of heat-related illness. Are you suspecting the smokiness across the whole of the eastern seaboard of Australia potentially has led to a similar number of people losing their lives prematurely?

Dr COPE: I beg your pardon?

The CHAIR: I am saying prematurely—their lives coming to an end.

Dr COPE: Certainly from looking at work that has been done where there has been smoke exposure, say across Sydney and across Melbourne, you would expect that it is at least in the hundreds across the eastern seaboard from this event, and then substantially more cases too in hospital admissions, incidents with asthma. You sort of go down this pyramid where the lesser effects hit more and more people, but yes, those direct effects are likely to be fairly high.

The CHAIR: And is dust generally considered more fatal than smoke?

Dr COPE: Smoke is much more fatal, the reason being that the particles are very small, and the smaller the particles the further you can ingest them into your system. In fact the very fine ones can go right through your system and cross the blood-brain barrier, for example. So you go from the coarser ones leading to increased incidence of maybe asthma and then the finer ones leading to inflammation and inflammation response, and if you are a vulnerable person already with cardiovascular, lung-type issues or you are very young, that then starts to have an impact on you—on the most vulnerable of the groups.

The key is to try and provide early warning and to have a population that knows what to do to mitigate the effects. That is where we are working. The work we are doing with DELWP for example on the air quality forecasting is trying to provide four days of warning to the vulnerable population groups, who in my experience tend to listen. It matters a lot to them as to whether they should be getting the right medication, whether they should be looking for a safe haven in a house. Usually with our standard of housing these external fine particles make their way into the house quite quickly, so you specifically need to set up a room that is well sealed with a high-efficiency air filter in it, or you need to go to a safe haven, which may be a library or some other public building. We are doing work in that area again with DELWP and the universities as to what are the mitigation steps that can be made.

The CHAIR: Is that information readily available on publicly funded iPhone apps, for instance? Is that information available on the CSIRO information technology systems you have or the Bureau of Meteorology or on DELWP? Is there somewhere, if I am an asthmatic, where I can simply bring it up? I know there is going to be smoke around, I have read the news, but I want to actually get that information firsthand—is that information easily available?

Dr COPE: It is becoming easily available. For example, we work with the University of Tasmania, and they have built this app called AirRater, where people can report on their symptoms and they can see what the smoke levels are and what they are likely to be. Over this last event we had 50 000 downloads of that across Australia, so it is really making its way into the population. But also EMV's wonderful app has a lot of that information on it as well. The only real challenge of course is you have a different app for different states, and smoke does not see the state boundaries. So that is an area we will all work together on to see if we can improve to ensure we have common messaging. I suppose the other challenge is we have been used to working with short-term smoke events where these types of intervention activities work—do not exercise for a day or so, stay indoors.

The CHAIR: Close your windows, put your air conditioner on—things like that.

Dr COPE: But if the event goes on for months, then that is a whole different ball game which we have got to work up into thinking about how best we can deal with it.

Mr MORRIS: Places like Bairnsdale probably had two months of smoke.

The CHAIR: I suspect their local emergency management plans are possibly silent on it, I guess.

Mr FOWLES: Are there any other agricultural smoke impacts other than for grapes? Does it affect the productivity of any other ag products?

Dr COPE: It does. I would have to take it on notice in terms of the specific ones, but I was hearing some discussion the other day about various agricultural types. Smoke grape taint is of course a big deal. We are talking with industry at the moment, and their problem of course is it can just wipe a crop out in just two or three days. And also then they have the issue with their competitors—say, in the European market Australian grapes are tainted. The other thing is it is not just the fine particles of smoke; it is ozone. Ozone is a secondary gas that can get produced in smoke plumes, and that is damaging to crop yields as well. So it does tend to—

Mr FOWLES: Is that because it crowds out the O_2—crowds out regular oxygen, the ozone—or is it because it is actually blocking sunlight or something?

Dr COPE: It is because it is very reactive, and so it damages plant tissue—so the yields go down. It is a little bit multifaceted in terms of the impacts. I guess the other thing is dust. Dust is an issue too, particularly if it has got bacteria or lichen on it. But normally that is the sort of thing that will get you with asthma, because it is very

coarse and it stays in the upper part of your respiratory tract. So they are two different types of issues, but often they occur at the same time.

The CHAIR: I was going to ask: so it is true that the science is suggesting we are going to get more frequent dust storms. I can recall, I think it was, 1983 when Melbourne was blanketed in it. Was that a one-in-40-year event? I have got no idea. But are we likely to see those type of events that have been relatively rare during European settlement occurring more often? And what does that mean for the communities that are losing their topsoil, and what does it mean for us being potentially the recipients south of where the wind is coming from?

Dr COPE: It means having agricultural practices in play that protect your soil.

Mr CLARKE: Certainly a contributing factor, we understand, is that soil drying in a drying climate is more likely to become airborne. The other thing about the health impacts of smoke is that it is usually coincident with heatwaves or at least hot weather, and if it is coincident with heatwaves, then you have got the health impacts of the extremely high temperatures happening at the same time, which is a double whammy effect.

The CHAIR: So you could have high temperatures, a north wind, bushfires, smoke and a dust storm potentially all occurring at the same time.

Dr COPE: It is not uncommon.

Mr CLARKE: And then you might get a flood, which has happened in New South Wales.

The CHAIR: Yes.

Mr MORRIS: If I can ask a question that I have been asked frequently in the last couple of weeks but is not really part of this Inquiry: with an event like the bushfires we have had over the summer, what sort of impact does something like that have in terms of emissions, in terms of what it does to the national emissions profile for the year?

Mr CLARKE: I might have to take that one on notice.

Dr COPE: It is enormous, but it does not go into the accounting because it is not anthropogenic.

Mr MORRIS: Well, I guess that is arguable, isn't it? It is not directly.

Dr COPE: I know, yes.

Mr FOWLES: There is a causation issue here, which I think we are all kind of grappling with—by 'all' I mean Government generally. But clearly climate change is human induced. That climate change is producing far more savage and broad bushfires, and yet the bushfires are not counted. Well, I would argue that there ought to at least be a formal kind of take-note process. But I can only assume that 1.3 million acres, I think we got up to—or was it hectares—vast amounts of bush being burnt is going to release—

Mr MORRIS: Just in Victoria.

Mr FOWLES: Yes, just in Victoria alone. But that is gigillions of tonnes of CO_2.

Mr MORRIS: I guess the point is that whether it is carbon or not, it is going to impact on warming. It is going to impact on whether we are at 1.5 or 2 or 2.5 or whatever we finish up at.

Dr COPE: You can see it in the Cape Grim record for the Southern Hemisphere: the CO_2 has gone up because of it. We could take that on notice if you would like.

Mr FOWLES: Was there much of a response to the Amazon fires that were burning a while ago in terms of the amount of carbon in the atmosphere, do you recall?

Mr CLARKE: I do not know.

Dr COPE: I do not know. All I know is our team have been talking about what they have been observing in the Southern Hemisphere, and the question now is: how long is it going to stay there?

Dr O'CONNELL: And the Amazon fires were a fraction of the area of the Australian fires.

The CHAIR: Can I just ask, and this is my last question, what level of data, modelling and mapping has been done—and the species mix and all that—across continental Australia, including Victoria? Do we know what percentage is made up of mountain ash, do we know what percentage is made up of all of the various kinds of species that might exist—I will use Victoria as an example—and do we know what biodiversity changes will occur, maybe even what ones we should encourage to occur, to enable adaptation, for want of a better term? We can go hell for leather stopping climate change as best we can, but there are going to be some changes in the landscape. What level of mapping has been done around that and what science is underpinning that? I know that is a very big topic.

Mr CLARKE: It is a big topic. Certainly vegetation is well mapped across Australia, because it is relatively easy—it is still not easy, but it is relatively easy—and you can distil a lot of information from satellite imagery, aerial photos and things like that. You do need to work on the ground as well to proof it. Distribution of animals is more difficult, but it is still quite well understood in Victoria, New South Wales and Queensland, in the arid zones. Our colleagues in Canberra have done quite a lot of work in the types of changes that can be expected to occur in vegetation communities, particularly in response to the changing climate. It is not something I know well, but certainly there has been quite a bit of work done on that. Some of our colleagues from Canberra, Mike Dunlop and co, working with the Ramsar management body in the Commonwealth, have been tackling the problem where you have a parcel of land that is gazetted for a purpose—in this case conservation, or identified and mapped for conservation purposes—but with the changing climate the habitats and the vegetation communities are moving, while the parcel of land is static, so the values within that land are changing.

Dr O'CONNELL: Alongside that, a lot of the legislation is focused around the conservation of single species or threatened species, and yet we know that for some of these species, no matter what you do it is probably not possible to conserve them, because of the reasons that John has been talking about. Their habitats are moving, and actually the conservation objective there is possibly no longer fit for purpose in some cases. We need to start rethinking the objectives of conservation. Is it about a functional ecosystem? And then how do you do that if that functional ecosystem is no longer pegged in space in terms of the biophysical characteristics that define it? There is a lot of thinking right back to: what are the objectives of conservation and are they fit for the future, given what the future holds?

The CHAIR: What level of work has been done in a Victorian context around that thinking?

Dr O'CONNELL: Well, DELWP is fairly across all of these ideas—there is no doubt about that. Our work has done some work on NRM. I do not know about you—

Mr CLARKE: No, I have not worked specifically with the Victorian Government.

Dr O'CONNELL: No, no.

Ms CORAM: I think there has been actually decades of work tackling how to conserve species and ecosystems across the continuum of land from national parks through to state forests and through to private land. There is a vast body of work, and Victoria has led the nation in many ways, but in terms of specifically in response to predicted climate change impacts, we would probably have to take that one on notice, because one of the challenges is that we have modelling of the raw impacts of climate change in terms of temperature and rainfall, but actually mapping it out to 'What does it mean for this ecosystem or this species and how is their optimal habitat going to change and how can we actually transition it so that this particular ecosystem can thrive as the climate changes?' is a huge piece of work. But it is an integration between private and public land management. But certainly we could take that one on notice.

Dr O'CONNELL: AdaptNRM do a lot of work with conservation objectives, and that is all available.

The CHAIR: You are right that conservation policy has often been about a particular geographic location and recognising its values, but if the science of climate change is suggesting that habitat is no longer viable there, what do we do?

Dr O'CONNELL: That is the work that needs to be done and the conversations that need to be had.

The CHAIR: Yes.

Mr CLARKE: There has to be a policy response. The science can tell you what is happening, but it is up to our—

The CHAIR: I suspect that is the bit that we are missing to the extent that we need it—the policy response in that perspective. Well, I have exhausted my questions. Thank you, I appreciate it. I think we have kept you 15 minutes longer, so sorry about that.

Mr CLARKE: It was a pleasure, thanks. If you like, I can table some documents, many of which address the topics that have come up.

The CHAIR: Yes, if you just leave them with the secretariat. Fantastic.

Witnesses withdrew.