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Ecology and Greenfield Precincts: Integrating Conservation and Bushfire Exposure Risk into Urban Planning

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ECOLOGYANDGREENFIELDPRECINCTSINTEGRATINGCONSERVATIONANDBUSHFIREEXPOSURERISKINTOURBANPLANNING

Ecology and Greenfield Precincts: Integrating Conservation and Bushfire Exposure Risk into Urban Planning

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I. Introduction

It is widely accepted that continued urbanisation is rapidly converting many non-urban land-uses into metropolitan landscapes(Sheppard, 2019).Empirical satellite data reinforces this assertion(Burchfield et al., 2006; Shlomo et al., 2005). For any individual city, the footprint of urban expansion represents contested spaces; in some, urbanisation has been described as a clear "threat" to local ecosystems(McKinney, 2002, p. 1; as per: Oudenhoven & Groot, 2013). Modelling the impacts of urban expansion on ecosystem services has shown there are pronounced challenges in accommodating a larger human population which has been shown to compromise the ability of the surrounding environment in providing for food production, water retention, air purification, carbon storage and a safe environment(D. Zhang et al., 2017), or without causing localised species extinction. There are also growing concerns as to how cities accommodate increased populations; especially against the backdrop of climate change and technological innovation (Ghoniem, 2011; Jenks & Jones, 2008). Urban Planning informed by a strong evidence base is of critical value when navigating the transitions of these contested spaces, while protecting the ecological assets and human experiences of the altered landscapes. The challenge we now face is how to bring a strong evidence base into the planning and decision-making process.

One of the primary limitations to implementing effective land-use planning is the complex distribution of hazard and values in our landscapes (de Groot et al., 2010). A wide range of tools are available to urban planners to investigate the trade-offs between potentially competing land-uses and their spatial arrangements using modelling. Modelling has been used prior to inform discussion around ecosystem services and urban expansion (Deng et al., 2016), as well as discussion surrounding land-use and ecological functioning (J. Zhang et al., 2014); this modelling has then been an input in collaborative land-use planning workshops with stakeholders (Arciniegas & Janssen, 2012). However, there are currently no set universal definitions, guidelines or protocols for the majority of hazards and values likely to be encountered in the landscape(Aven et al., 2018; Beer & Ziolkowski, 1995). This extends to how such hazards and values might be weighed up against each-other from the perspectives of different stakeholders(Carey et al., 2006, p. 7). Unsurprisingly, there are few examples of urban planners drawing upon existing tools to investigate these competing trade-offs; the lack of literature in this area attests as such. Tools to weigh-up hazards and values from the perspectives of different stakeholders are found in abroad array of contexts within different industries and disciplines (DeFries et al., 2004). It is therefore difficult for planners to have the expertise to understand how to use all these available tools to assess values and hazards in the landscape. Incorporating these tools into planning practice without support from other practitioners or

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insights from stakeholders can present a significant challenge for incorporating evidence-based assessment processes into urban planning.

An example of potentially competing hazards and values in areas undergoing urban development are conservation of biodiversity and managing fire risk in areas with the wildland-urban interface(Bentley & Penman, 2017; Driscoll et al., 2016). In Australia, 30% of our threatened plant and animal species occur in major urban centres (Ives et al., 2016). Heard et. al describes one such endangered species which is sensitive to changes in its ecosystem, in the Growling Grass Frog, (2010).In the past, this species has been used as an indicator of biodiversity and environmental health (Hale et al., 2013; G. Heard et al., 2010; 2013). Ensuring the ecological health of urban landscapes is critical to the delivery of effective conservation outcomes. However, this country evolved with regular fire (Bradstock et al., 2012), which means that balancing conservation outcomes with the need to manage fire risk is a major challenge for many Australian cities(Moritz et al., 2014).

Evidence shows that land-use management decisions can significantly affect future risk to people and property(Buxton et al., 2011; Penman et al., 2015; Syphard et al., 2013). Past planning for disasters such as bushfire has been haphazard at best, as Oloruntoba notes “there is no evidence of continuity or holism” in Australian disaster planning (2013, p. 1677). This has been reflected in the failure of land-use planning to regulate for vulnerability to bushfire risk (Buxton et al., 2011); it was not until after the catastrophic 2009 Black Saturday Bushfires in Victoria (leading to 173 deaths) that it was seen as necessary to designate bushfire prone areas for planning and building regulation (Kuffer, 2011; Teague et al., 2009). This lack of coordination between different stakeholders could be remedied by incorporating the many tools available to planners, and differing stakeholder viewpoints into the urban planning process. One of these tools are computer generated models. Computer models can be calibrated to envision the consequences of alternate management scenarios (Syphard et al., 2007). They’re adopted into practice because of the ability of models to simplify a reality that is too difficult to predict in all of its complexity (Frysinger, 2002; as per: Syphard et al., 2007).Syphard et al. note that when models are coupled together “more complicated interactions” can be simulated, and this can “expand the scope of analysis” to incorporate differing viewpoints(2007, p. 4). Our research coupled two scenario simulation models together to gain richer insights, and deepen our breadth of knowledge. Whilst this combination of tools can further understand of complexity, knowing when to combine them into a planning process can be challenging.

Research has also emphasized the need for sciences to seek the early inclusion of planners in research projects (Fothergill, 2000; Jürgens, 2004), as this builds capacity to respond to changing climatic conditions. Some have argued that research results should be interpreted and opened up to planners because the participation of planners, and their evaluation of outputs makes it easier to provide robust and useful knowledge (Fothergill, 2000; as per: Lehtonen & Peltonen, 2006, p. 68).In-spite of the virtues of such collaboration, the fundamental problem remains that it is difficult for planners to balance all the competing interests whilst coordinating amongst so many different actors. It is therefore unsurprising that to cohesively structure a design response which considers all viewpoints and data sources, may seem largely unattainable to a local government planner. Coordinating across departmental siloes, technocrats, communities, local indigenous groups (and their requisite knowledge), private, public, and not-for-profit sectors seems the ideal approach, and yet the logistics of such coordination may seem insurmountable to a government planner.

Carl Steinitz's book 'A Framework for GeoDesign: changing geography by design' defines GeoDesign as a design process which adopts a set of concepts and methods to get stakeholders and different professions to collaboratively design together (2012). GeoDesign has been described as a method which "tightly couples" the creation of design proposals with "simulations [of outcome scenarios]" as informed by relevant geographic contexts (Flaxman, 2009). Primarily adopted during the design and planning phase, it is able to be used throughout the design process, including in the maintenance phase of design intervention construction(Nijhuis et al., 2016), and in facilitating the re-use of buildings and the development of brown field sites(Lee et al., 2014). Steinitz outlines that the basic framework for GeoDesignis premised on the dynamic collaboration of four different disciplines, [1]together (2012). These are the:

1. Design Professionals
2. The Peoples of the Place
3. Geographic Sciences; and
4. Information Technologies

Our research was a multidisciplinary approach which made use of practitioners from design, the geographic sciences, and information technologies. A Doctor of Urban Ecology (Geographic Sciences), An Associate Professor of Ecosystem and Forest Sciences (Geographic Sciences/Information Technologies), a Technical Laboratory Support Officer and Masters in Ecosystems and Forest Sciences Graduate (Information

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[1] Although Steinitz refers to four different collaborators which may contribute towards the GeoDesign process, these collaborators do not always represent a single individual or team. An individual or team may in fact collaborate on a project in such a way that covers two or more of the functions that Steintz describes as the four types of collaborator.

Technologies/Geographic Sciences), and a non-practicing Masters of Urban Planning Graduate (Design Professionals). All of these fields cross between design, geographic sciences, and information technologies to varying degrees; and each contributor had worked in a multidisciplinary capacity prior. Admittedly, the focus of the research as an evaluative project after the fact of approval of the Cloverton (nee Lockerbie) Precinct Structure Plan in June 2012 (Urbis, 2015, p. 10), meant that engagement of 'The Peoples of the Place' was not a possibility. Nevertheless, using data inputs from this case study, and analysis of the kind our research has produced, allowed us to test how GeoDesign could be incorporated into planning practice. It also permitted for Situation-Based Learning, as a way of further enriching the education of a Masters' graduate.

In this paper we use a rules based GeoDesign approach to investigate how two independent tools could be used in concert, to inform the planning and design of new greenfield developments on the wildland-urban interface, to ensure they simultaneously address the competing challenges of meeting conservation outcomes while reducing wildfire risk. We addressed this question using a case study approach. Case studies offer an opportunity to understand complex and dynamic systems that are bounded by location (Merriam & Tisdell, 2015), although care needs to be taken not to extrapolate findings from case studies to other situations. Conservation outcomes and bushfire risks are significantly influenced by the configuration and arrangement of features within a landscape. Adopting a case study approach ensures our research is based in reality. Therefore, we build upon a strong tradition of case study approaches to understanding wildfire risk and locational modelling of biodiversity to further advance knowledge.

This case study approach is best considered as an example of a 'rules-based change model', a distinct subset of GeoDesign model as described by Steinitz (2012). This is argued because of the similarities between the components of such a modelling approach, and because of the structure our research followed. A 'rules-based change model' is formulated as the following:

- Spatially sophisticated; behaviourally simple
- Elaborate to set up; quick to run
- Systematically and rapidly generate and test options, including sensitivity Characteristics
- Develop scenarios based on rules
- Models evaluated for potential impact
- Models used to inform debate; decision made based upon negotiated/agreed public values

Our modelling was reflective of this approach. Of the situational forms of 'rules-based change models' that manifested in our work, our model was composed of two separate models, which were coupled together. The focus of this research was to simulate different scenarios and evaluate their potential impact on both the local species biodiversity (using the Growling Grass Frog as an indicator species), and on bushfire exposure of housing in this development. The combination of tools in use sequentially was followed in our study design, and this mimicked the GeoDesign process. Due to the rules-based structure of this process (and the prescribed nature of future development), it was not able to contribute to the public decision-making process behind this development. It stands as an example of a GeoDesign process which consults various different stakeholders, although it does exclude the 'people of the place', which could be addressed in future study designs.[2]

Balancing competing risks and demands on land is a major challenge (Sharmina et al., 2016). Integrating a multidisciplinary and data driven planning process makes it possible to quantify the potential costs and benefits of alternate planning scenarios. Decisions can then be made with a quantification of the trade-offs between urban expansion, biodiversity conservation and fire risk reduction. Greater conservation outcomes, environmental sustainability and a reduction in the exposure of human-valued assets to wildfire could occur as a result.

II. METHODS

a) *The case study area*

The study area for this research project is the Cloverton Development on the northern outskirts of greater Melbourne, approximately 38kms north of Melbourne's Central Business District. The site is a greenfield development and is projected to house up to 30,000 residents. It is less than 20kms from the 2009 Kilmore/Kinglake Black Saturday Bushfire, which resulted in more than 120 deaths and over 2000 houses being lost (Gibbons et al., 2012; J Leonard et al., 2009; Justin Leonard, 2009; Whittaker et al., 2013). The Cloverton development is currently surrounded by arable farmland interspersed with scattered trees and small blocks of remnant native woodlands. There is relatively flat topography in this area, with the exception of subtle depression along two creek corridors (Kalkallo and Merri Creeks) and their associated drainage lines.

These watercourses are important habitats and refuges for the Litoriarani form is(hereinafter 'Growling

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[2] In the future these stakeholders could be included from the inception of the development proposal (identification of the need phase), and could be collaborative contributors with whom the professional designers, information technologies, and the geographic sciences engage with. Collaboration with such stakeholders could extend to prospective residents, as well as traditional owner groups (taking advantage of the Traditional Ecological Knowledge of these groups), allowing these peoples to influence output design (as per: Greaves, 2017, p. 24), pp. 24). This would overcome broader deficiencies of the planning process.

Grass Frog'), an endangered species in Victoria which is highly impacted by urban development in the broader Melbourne metropolitan area. Under Section 69 of the 'Conservation Forests and Land Act (1987)' this species has been identified as requiring 'Land Protection',[3]accorded to it by the 'Biodiversity Conservation Strategy for Melbourne's Growth Corridors' (Conservation, Forests and Land Act, 1987; State Government of Victoria, 2013). The Cloverton development is designated as a bushfire prone area by the Victorian Department of Environment, Land, Water and Planning (hereinafter 'DELWP').

The site includes provisions for a major freeway and railway along the western and northern boundaries at some time in the next 50 years. Once constructed, this freeway has the potential to influence wildfire risk and viability of the northern Merri/Kalkallo Creek populations of the Growling Grass Frog. As the Cloverton development is also identified as a Metropolitan Activity Precinct under Plan Melbourne (Department of the Environment, Land, Water and Planning, 2017) and in the Hume Corridor Integrated Growth Area Plan (City of Hume, 2015), the developers and relevant planning authority have created a Precinct Structure Plan (hereinafter 'PSP') which lays out the land-use configurations for the new development (Department of the Environment, Land, Water and Planning, 2017). These plans contain recommendations about Growling Grass Frog conservation and bushfire risk mitigation provisions and standards (City of Hume, 2012).[4]

b) Conservation challenge

Kalkallo and Merri creeks and their associated drainage lines are considered important sites for meta populations of the Growling Grass Frog. 'Guidelines for managing the endangered Growling Grass Frog in urbanising landscapes' have been developed, based on extensive research in order to inform land-use decision making where the species is known to occur(Heard et al., 2010).These guidelines are a tool developed specifically for the Victorian Department of the Environment Land Water & Planning (hereinafter 'DELWP') to understand and minimise habitat loss of an endangered species.

The guidelines recommend a minimum buffer zone of 200 m along corridors to maintain viable meta populations of Growling Grass Frog. We ran a spatially expanded meta-population model to investigate how different configurations of the riparian corridor area may impact the long-term viability of Growling Grass Frog in this landscape, as created by Heard, McCarthy, Scroggie, Baumgartner, & Parris (2013). Proposed buffers along the Kalkallo and Merri creeks range in width from 50m to 200m (City of Hume, 2012). To test how effective the proposed buffer arrangement for Growling Grass Frog meta population dynamics was, we compared between (1) the current greenfield landscape (2) the mandated PSP buffer zone width with; (3) a 50 m riparian buffer; and (4) the recommended 200 m riparian buffer (Figure 1).

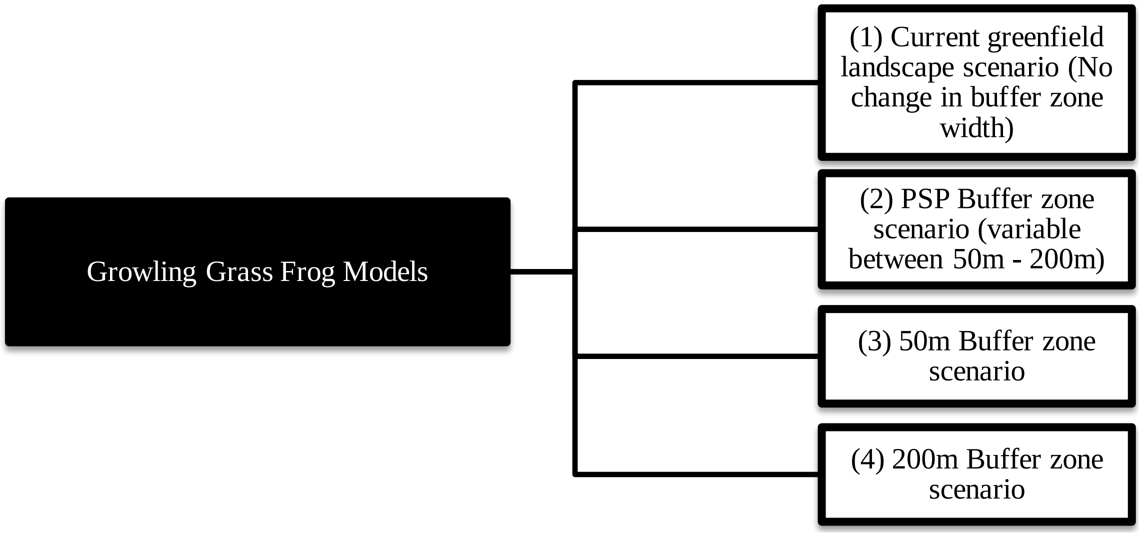

Figure 1: The Cloverton Case Study landscape and four planning scenarios

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[3] There is no specific definition for this terminology as of writing.

[4] This structure plan did not include Kalkallo Township or the most northern section of the Cloverton development.

The above named model uses statistics to run multiple simulations according to a set of inputs, to then produce two outputs. Firstly it calculates the probability of a population occurring within the wet lands, that is the minimum size required that would allow for the long-term viability of the Growling Grass Frog. Following from here, the model then calculates the probability of a quasi-extinction of the Growling Grass Frog, based on the aquatic vegetation and hydroperiod of each wetland, as well as the spatial arrangement of these wetlands(Heard et al., 2013). Data from DELWP about potential sites for wetlands and pre-existing wetlands situated along the creeks was used. Where data were not available, we assigned values for aquatic vegetation coverage and the percentage of time in each year in which the wetlands would be inundated with water by comparing aerial photographs extracted from Nearmap (2017). For the proposed wetlands, an arbitrary value of 3 was assigned for vegetation coverage, & an arbitrary hydroperiod of 60 was given, as these were the default values for proposed wetlands identified by Heard et al. (2013).

c) The challenge of wildfire risk management

To calculate Fire Risk we used the fire behaviours imulator PHOENIX-RapidFire (hereinafter 'Phoenix') (Tolhurst et al., 2008),which has been developed and tested for operational use in south-eastern Australia(Bentley & Penman, 2017). This tool considered risk of exposure of housing to wildfire, because housing loss is a tangible representation of risk that is directly relevant to urban planning processes, an observation recognised in the 2009 Black Saturday Bushfire Royal Commission (Justin Leonard, 2009; Teague et al., 2009).

Phoenix uses modified versions of two common fire behaviour models to predict the spread and impact of wildfires (Penman et al., 2014).Phoenix requires inputs of weather, ignitions, fuel type and fuel load. Weather is inputted into Phoenix as hourly values of temperature, relative humidity, wind speed and direction, cloud cover and drought factor. We used three weather streams utilised for fire risk estimation by DELWP. The weather streams are defined based on the Forest Fire Danger Index(Noble et al., 1980).The Forest Fire Danger Index (hereinafter 'FFDI') is a composite index that combines the weather on the day and long-term drying of fuels present on the landscape to estimate the likelihood of fires escaping containment and becoming uncontrolled. We used values of 50 (very high), 75 (severe) and 130 (catastrophic) to cover the range of weathers that are likely to result in house loss (Blanchi et al., 2010). Ignitions were set up on a regularly spaced grid of 1 km (to simulate the randomised nature of ignitions within the environment) and each ignition was run for all combinations of weather (FFDI values of either 50, 75 or 130) and planning scenarios (current greenfield landscape, PSP mandated buffer zone, 50m buffer zone, 200m buffer zone).Information detailing the fuel types and fuel loads was based on the current data layers extracted from DELWP materials. These values were then varied according to the planning scenario being tested meaning urban fuels replaced the grassland fuels within the proposed housing zones (for the PSP mandated buffer zone, 50m buffer zone, and 200m buffer zone scenarios). There was no such variance for the current greenfield landscape scenario. The ring road was designated as a no fuel zone. Riparian shrub land (extracted from DELWPdata) was entered into Phoenix, and then altered in accordance with the different buffer zone scenarios being tested (current greenfield landscape, PSP mandated buffer zone, 50m buffer zone, and 200m buffer zone).This was done to test if the buffer zone width would impact upon the exposure of housing to bushfire. To estimate the impact on houses we calculated the average number of houses exposed per fire under each planning scenario and each FFDI. Values were then compared between scenarios using a confidence interval approach where non-overlapping 95% confidence intervals is equivocal to a $p=0.05$ significance test (Walshe et al., 2007).

d) Rules-based change model

The data inputs for both models were spatially sophisticated as the data inputs for both models were very detailed. This extended to modelling that included the location of a future potential joint road/rail corridor, exact widths of the buffer zone along the creek (current scenario, projected PSP buffer zone, a 50m buffer zone, and a 200m buffer zone). The dynamic nature of bushfire on the landscape meant that much of the modelling had to capture this complexity; similarly, the models of the behaviour of the Growling Grass Frog populations needed to account for such complexity. As the Growling Grass Frogs modelling was conducted on the local population scale (not the individual organism level), averaging was necessary.

The set-up for both models was elaborate as it required a great deal of data from different sources to be collected, and then aforesaid data to be appropriately coded. Once this set-up process had been completed, the inputs were plugged into both Phoenix and R-Studio.

The extensive outputs from both models allowed for a systematic approach to test different scenarios, and their effects on the Growling Grass Frog populations, the exposure of housing to be built in the estate, to bushfire, and the likely impact the construction of the road/rail corridor would have upon these. Once the data had been appropriately coded, and the models set up correctly, outputs were generated very rapidly.

Of the characteristics from the 'rules-based change model', our approach was premised upon scenarios which had already been set. The subdivisions of housing have been approved by council, and the Precinct Structure Plan (which defines the strategic development of Cloverton) had also been given approval (Urbis, 2015, p. 10). The alignment of the road/rail corridor has largely been prescribed through the inclusion of a planning scheme overlay, which reserves land for this purpose (VicRoads, 2014, p. 1). As such, the simulation tools we adopted had to reflect these.

e) *Sequencing a Geodesign methodology*

The simulated scenarios are tools from a kit, and are used as an example to show how they could be incorporated into a process. This process is organised according to the relevant GeoDesign collaborators, and the timing of their contributions made throughout the project. These steps give a basic overview of the timing of different phases of our research. The timing of each phase is key to effectively operationalising GeoDesign approaches.

Step 1: In this step, the Design Professionals (Urban Planners) engage with other professionals via consulting, research, seeking data from administrative bodies, and other partnerships. Whilst their contributions are limited during the Generate and Evaluate phase may be limited, they guide the planning permit application, and more generally the GeoDesign process, especially when preparing information to be presented to the People of the Place. Dependent on the level of collaboration sought from the People of the Place, they could be engaged with here. This corresponds with the 'Identify the Need' and 'Identify Acceptable Scenarios based upon 'Needs', Constraints, and Knowledge/Best Practice' phase.

Step 2: Geographic Sciences identify and recruit Information Technologies and the people who utilise Information Technologies (as required/if not already working as part of the Geographic Sciences team). Information Technologists assisted in the production of raw data. This then allowed the Geographic Sciences to advise on scenarios that would balance acceptable levels of wildfire, and conservation risk, as well as permit urban expansion, and infrastructure construction. Furthermore, the practitioners of Geographic Sciences provided disciplinary knowledge, collaborative interdisciplinary skills, networked connections, as well as technical skills. The Information Technologists provided the same skill set, which was utilised in our approach. This corresponds to the 'Generate and Evaluate', and the 'Preparation of Information for the People of the Place' phase.

Step 3: Design Professionals, Geographic Sciences, or both, organise and host events for the People of the Place to provide feedback. This information is then incorporated into the plans (to varying degrees), and the completed plans are released and actioned. This mirrored the 'Presentation of Information to People of the Place' Phase (although our research was unable to extend to this point).

Each 'Step' described above, is denoted in Figure 2. Figure 2 further explores the significance of incorporating the GeoDesign process and 'how' the scenario modelling can be operationalised as a tool, to improve the coherency of urban planning.

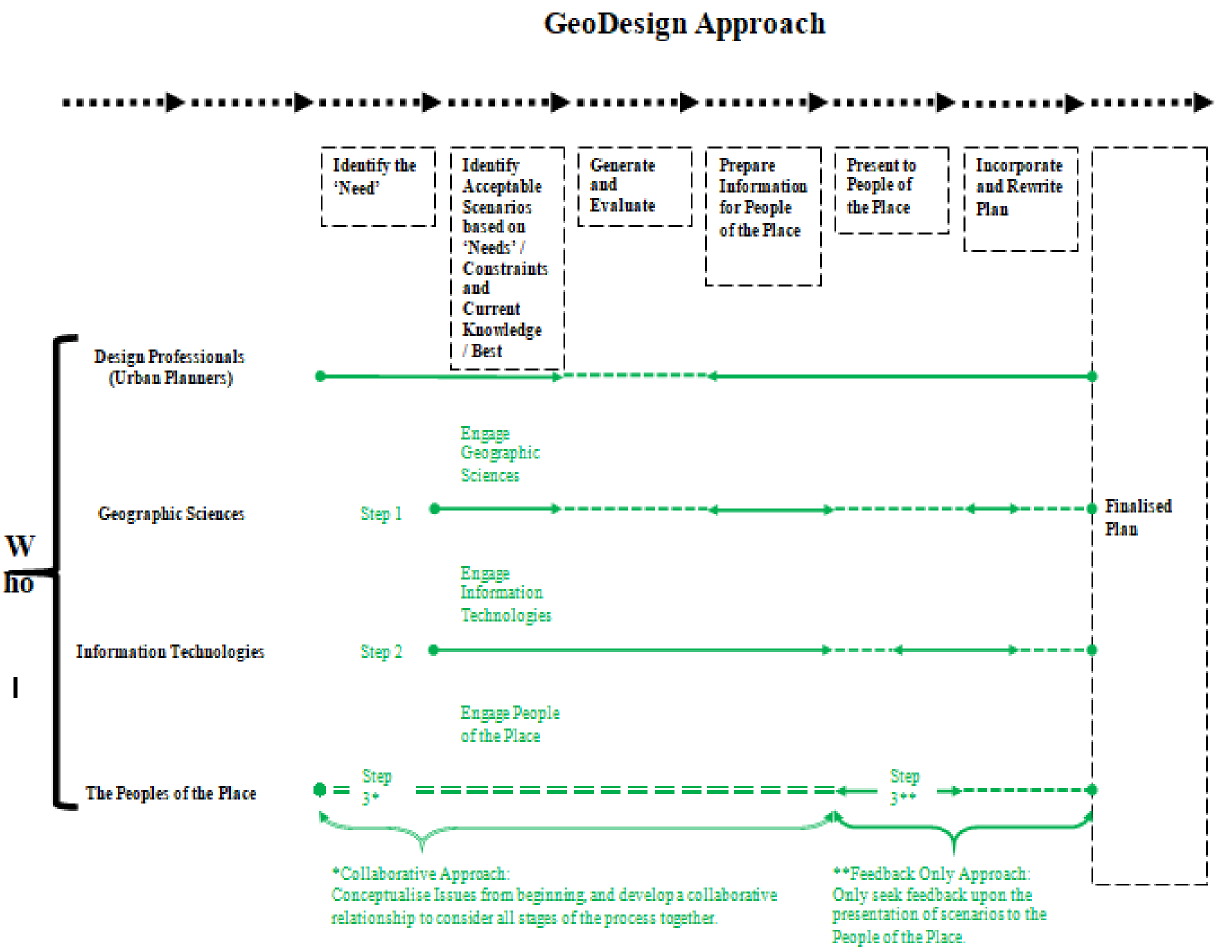

Figure 2: Sequencing of the rules-based change GeoDesign Approach as adapted from Steinitz (2012).

III. Results

a) *Growling grass frog*

The average percentage of wetlands predicted to be occupied by the Growling Grass Frog, was reduced in each of the scenarios associated with land-use change,compared to the control which is the current greenfield landscape scenario (as seen in Table 1). The control scenario had a 60% probability of there being enough wetlands occupied by frog populations to maintain the long-term viability of that population. This meant that all future scenarios would reduce the prevalence of Growling Grass Frog populations as compared to now. There was a 33.3% probability of enough frog populations occupying wetlands to maintain the long-term viability of the species in the PSP mandated buffer zone scenario. This probability reduced to 18.1% for the 50m buffer zone scenario. In the 200m buffer zone scenario there was a47.8%probability of longterm viability of the Growling Grass Frog, which was considerably higher than the PSP and 50m buffer zone scenarios, but lower than the current greenfield landscape scenario (which was the control scenario). The percentage of models in which the Growling Grass Frog became quasi-extinct also showed the same pattern with the 200m buffer zone scenario having quasi-extinctions in 3.2% of the models, increasing to be 6.8%of the simulations for the PSPmandated buffer zone scenarios, and in33.2%of the 50m buffer zone scenarios could a quasi-extinction be expected. It was only in 1% of models that the frogs would go quasi-extinct in the current (control) greenfield landscape scenario. Table 1 below presents these results.

Table 1: Average minimum occupancy of Wetlands and Proportion of Quasi Extinctions per model iteration.

	(1) Current greenfield landscape (control)	(2) PSP mandated buffer zone	(3) 50m buffer zone	(4) 200m buffer zone
Number of Wetlands	85	40	43	59
Average minimum percent wetlands occupied by Growling Grass Frog to maintain the long-term viability of that population.	60%	33%	18.1%	47.8%
Average percent of models in which Growling Grass Frog became quasi-extinct	1%	6.8%	33.2%	3.2%

b) *Wildfire risk*

The rating on the Forest Fire Danger Index has the strongest influence on the number of houses which are exposed to fire in our modelling as depicted in Figure 3; if the FFDI is a value of 50 it is considered then the combination of weather and fuels on that day then the risk of fires breaking out of containment and becoming an uncontrolled bushfire is ‘very high’. At FFDI 75 this changes to a ‘severe’, and at FFDI 130 this becomes ‘catastrophic’. According to our modelling for the ‘no Outer Metropolitan Ring Road’ scenarios, 198.3, 708.9, and 2572.8houses would be exposed to bushfire for FFDI’s 50, 75, and 130 respectively. In the ‘Outer Metropolitan Ring Road is constructed’ scenarios, these values were significantly reduced to be 155.6, 503.5, and 2193.9 houses exposed in relation to FFDI’s 50, 75, and 130. Width of the buffer zones had limited influence on the number of houses exposed within each Forest Fire Danger Index category. In contrast, construction of the Outer Metropolitan Ring Road resulted in a significant reduction in the number of houses exposed to bushfire within each Forest Fire Danger Index category.

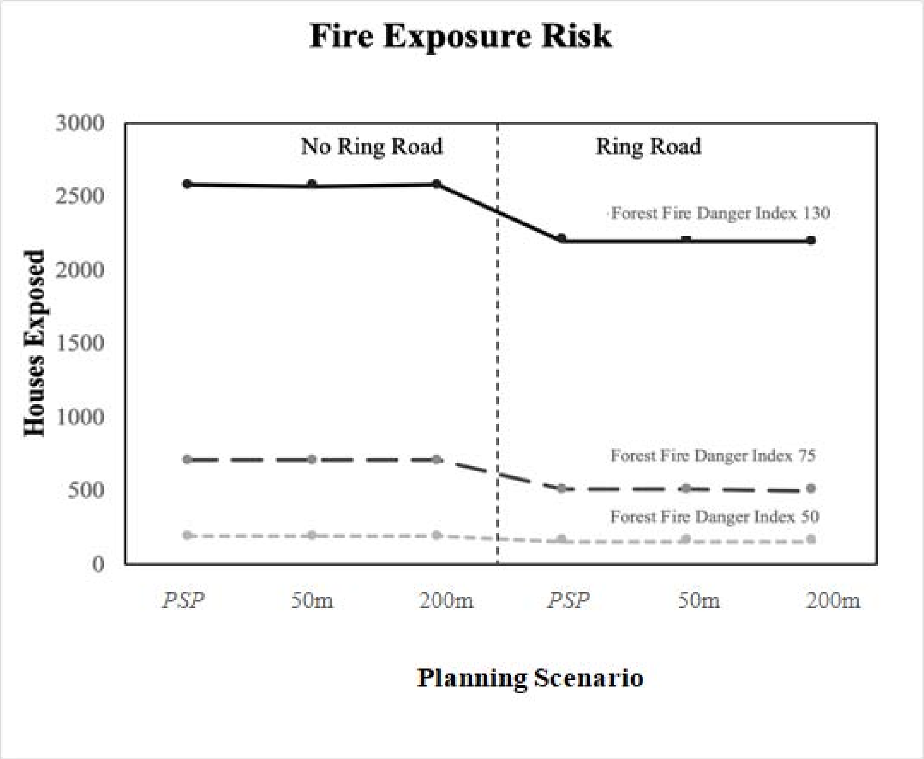

Figure 3: Fire Exposure Risk Chart depicts the different scenarios and the number of houses that were exposed to fire.

c) Comparing outputs

Models for fire and the Growling Grass Frog operated on differing spatial scales and therefore it was not possible to undertake a quantitative comparison. A qualitative assessment between the results for each scenario is presented. Fire simulations included scenarios with and without the ring road present.

Comparing conservation and fire risk outputs we found limited evidence to suggest that the wider riparian corridors would contribute to an increased risk of housing exposed to fire. The presence of the Ring Road greatly reduced the number of houses exposed to fire, although it is likely to impact on the Growling Grass Frog populations. We were unable to include the ring road as part of our simulated scenarios for the Growling Grass Frog, as the results will be dependent on finer scale aspects of the design of the ring road and associated infrastructure. In particular, the design relating to Merri Creek and associated wetlands will impact the viability of these populations. We did not attempt to include variables that would account for infrastructure design, as it would introduce too much uncertainty into our simple case study.

IV. DISCUSSION

Our case study approach compared two potentially conflicting metrics: conservation of an endangered frog species and minimizing fire risk in new urban developments. We found that whilst changing the width of the buffers along the stream had negligible impact on the number of houses potentially exposed to fire, it did have a net positive impact on the likelihood that the threatened Growling Grass Frog would persist in the urbanising landscape. By undertaking this analysis, we were able to quantify how compromising the buffer zone width from the recommended minimum widths was likely to compromise the chances of the Growling Grass Frog persisting in the proposed plan.

Results from the two metrics were complementary, however this approach would also have been useful if they had presented conflicting results. The quantification of risk from wildfire, or the risk of Growling Grass Frog quasi-extinction would have allowed the planning process to evaluate trade-offs to deliver both outcomes in a transparent and defensible manner. Such a process requires the documentation of preferred outcomes within the bounds of what is considered to be an acceptable level of risk, and can be completed informally or using a formal process such as structured decision making (Gregory et al., 2012).

We used the case study to examine how existing scientific research can be incorporated into the planning process to help support the strategic planning process. The primary contributions our research makes to the literature is as a 'proof of concept' for a GeoDesign approach to a development approval process, which can lead to greater synergies improving biodiversity outcomes, wildfire exposure risk reduction, balancing against continued urban growth. However, there are limitations which prevent the direct implementation of this exact approach into every day planning practice tomorrow, and our research responds to this. Some of the hurdles remaining to be cleared are knowledge barriers, institutional barriers, development project governance structures, and the fundamental politics that land-use planning entails.

It has long been acknowledged that modelling can be an effective tool for bridging the gap of understanding between local stakeholders and planning policymakers. Modelling of GIS data, has been proven to be a useful communication tool when recontextualised for consumption by local stakeholders, broadening the understanding of spatial phenomena and bridging knowledge gaps between planners and stakeholders (Rambaldi & Callosa-Tarr, 2001). Other researchers have noted that modelling tools are also an effective way of communicating planning concepts with specific restrictions (environmental, or spatial), from researchers to planners and policymakers themselves (Koomen et al., 2011, p. 118; Koomen & Borsboom-van Beurden, 2011, p. 136).

In a European example, spatial-planning researchers focussed on communicating the modelling of sea level rise to urban planners, and some of the difficulties when transforming data outputs from simulations into effective policy and processes (Lehtonen & Peltonen, 2006).5 Although on a different scale to our study, some of the issues identified by Lehtonen & Peltonen are nevertheless relevant to our discussion as they relate to knowledge barriers. They are:

1) That communication [of modelling outputs] needs to be made concrete [to planners]
2) That there is a need for "digested" scientific information [to inform urban] planning [decisions];
3) That there is a need for intermediaries and arenas to facilitate interaction between science, [modelling] and planning;
4) And finally, that clarity in planning regulation is important (2006, p. 66).

In relation to point 1, it is true that the efficacy of these tools as a way of communicating is a function of what information is available to be included in the models, in addition to the natural limitations that using a simplified model of reality impose. Although the negative impacts of a quasi-extinction of an endangered frog species may be considered unfortunate but an acceptable outcome for urban growth, the larger environmental collapse that this would necessarily indicate, is a more visceral image to draw attention to. Linking these in with potential economic or legal liabilities spawned from such degradation of the environment draws focus to these points more clearly. Contrasting this to the synergistic outputs we were able to create, and how our GeoDesign approach allowed for this is likely to focus the attention of planners and bureaucrats.

In a different European example of translating simulations across to real-world practice at the spatial-planning scale, Koomen & Borsboom-van Beurden highlight that an iterative and open character to modelling processes engaging with planners in workshops led to the success of such an approach (2011, p. 238).This is largely reflective of point 3, especially as they draw such attention to how workshops with planners and policymakers throughout the modelling phases were essential, because it allowed for multiple criteria (as defined by different bureaucratic representatives with expertise from varied backgrounds) to evolve and to be fulfilled(Koomen & Borsboom-van Beurden, 2011, p. 239). Koomen & Borsboom-van Beurden go on to note that this was key to ensuring that relevant and translatable outputs were produced. Additionally, planners and policymakers must have data outputs clearly explained to them if modelling outputs are to be used effectively. In instances in which workshops with planners throughout the modelling phase is not possible, the raw data outputs must be presented in a digestible manner.

The very nature of a Rules-Based Change GeoDesign method required the work shopping of information and collaboration over ideas to prioritise specific planning concepts, resulting in tangible potential scenarios. Our research was an iterative design process whereby we would convene to discuss changes to the inputs to the model (land-use, width of buffer zones, environmental layout), and subsequently tweak these, resulting in different model outputs that were considered to be more desirable. This is the definition of a facilitative arena, and it certainly facilitated the joint action of science and urban planning together. Coding which of the model outputs would be included in the results section allowed for them to be presented in a concise and easy to understand manner, and this allowed us to achieve both points 3 and 2.

To that end, Nilsson & Florgård argue for the transformation of raw scientific data into that format that is accessible, and yet comprehensive for all stakeholders involved in urban planning processes (2009, p. 555), in line with point 2. Argument is made from the vantage of wanting to see environmental and ecological concerns furthered in the planning process on the basis of rigorous data(Nilsson & Florgård, 2009, p. 555). Nilsson & Florgård warn that most scientific information is generally not easy for planning authorities to understand because of the differences between planning and science (2009, p. 555). They continue that

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[5] This was done as as part of the 'Sea Level Change Affecting the Spatial Development in the Baltic Sea Region' project.

scientists must recognise when they're promoting segmented knowledge towards planning processes, they're just another stakeholder, competing against other stakeholders who have a deeper insight into how to influence planning process outcomes (2009, p. 555). Competition between stakeholders is what Cars (1992) terms "negotiative planning", and simply cannot be avoided in modern urban planning processes(Cars, 1992; as per: Nilsson & Florgård, 2009, p. 555).

Whilst in a GeoDesign framework these contributions are sequenced into the planning approach, the simple truth is that scientists will remain as stakeholders, not decision-makers in planning processes. Therefore, to ensure the greatest amount of success in having scientific contributions incorporated into urban planning, data outputs must be translated into a comprehensive and easily digestible format (Nilsson & Florgård, 2009, p. 555).

Furthermore, Fothergill (2000) argues that the communication between science and planning should take the form of a dialogue, instead of a scientific monologue. They argue by taking such a collaborative approach, modelling results can be conveyed more precisely, but more importantly knowledge exchange between researchers and planners can be enhanced (Lehtonen & Peltonen, 2006, p. 68). This communication would lead to the further dissemination of this information from planners in their own workplaces (Lehtonen & Peltonen, 2006, p. 68).

There are however, fundamental issues in assuming that research of this kind can be directly translated into practice, and some of these go to the problems at the heart of urban planning in Western Liberal Democratic societies. Naturally, the proceeding paragraphs relate to clarity in planning regulations, and the abovementioned point 4. For one, there is contestation over what urban planning is, and questions over what values are ascribed to 'space' and 'place' in relation to planning (Davoudi & Strange, 2009; as per: Koomen& Borsboom-van Beurden, 2011, p. 240). These issues can only be addresses in the political realm.

Research of this nature cannot be expected to account for changes in direction determined by authorities. This is especially so if it is not appropriately calibrated for such changes. This extends to expectations of research to delve into areas not considered within the original bounds of possibility.

The expectations that plans (developed in either a hypothetical scenario as described in a research paper, or as gazetted government policy) would not be altered during the implementation phase overlooks the non-determinism that characterizes reality. This doesn’t even take into consideration the ever complicating role of planning at metropolitan and regional scales (de Jong & Spaans, 2009; Salet & Woltjer, 2009).

To transpose the tenets of GeoDesign presented in this research, into the Victorian planning scheme, would likely require a major overhaul of the Victorian Planning and Environment Act (1987). This is because a collective action is intrinsic to the GeoDesign approach, which stands in stark contrast to the Victorian planning scheme's development approvals process.

This process has been described as "discretionary, often contested" and "ultimately political" (Cook et al., 2012, p. 12). It would be necessary to restructure the Planning and Environment Act to ensure development approval processes were more united between sectors from the very inception of the project. This would entail greater involvement in project design and implementation through enhanced co-operation of the public, private, and not-for-profit sectors, in addition to other stakeholder groups. Design professionals, geographic sciences, information technologists, and the peoples of the place from each of the above described sectors would need to be sequentially drawn into the process. New planning approvals processes would be deployed for government planners, planning authorities, and other bureaucrats, providing a framework for their interactions. It would be necessary to educate planning practitioners, and planning authorities on these new processes and structures, through workshops and seminars.

Institutional reforms of this scale, in service of GeoDesign would likely transform governance structures for large-scale urban development projects, and this would require changes to the Planning and Environment Act. New project management regimes would be formed for big projects between multiple sectors, and this would be in addition to bureaucrats, geographic scientists, and information technologists from local, state, and federal government being engaged in projects earlier on. Naturally, the integration of planners and developers engenders a degree of scepticism of the general public.

Cook et al. note that one feature of the Victorian planning scheme is the extensive Third Party Objection and Appeal Rights (hereinafter 'TPOAR'), in which anyone can object to and appeal the approval of development projects (2012, p. 12). One advantage of this is greater "public scrutiny . . . of government decisions" in turn bringing "transparency and accountability" to the exchanges between developers and the planning approval authority(2012, p. 12). In a report on Planning, Zoning and Development Assessments, the Productivity Commission observed that strong TPOAR counters opportunities for corruption, or the general publics' perception of corruption (Productivity Commission, 2011). This is important, as the general public is suspicious of closeness between public, private, and not-for-profit sectors (an expected consequence in the application of GeoDesign). Strengthening of TPOAR may be necessary to allay this mistrust.

This research was conducted in the fulfilment of the requirements of a minor Masters thesis. This bounding ensured the project was an operation of Scenario-Based Learning. Scenario-Based Learning is based upon the use of contextual knowledge, which can bring students closer to the realities of their profession by allowing experiences which are designed to supplement rather than replace work experience (Eland et al., 2010; Errington, 2009, 2011; Mio et al., 2019; Smith et al., 2018). It fills a gap created by the growing uptake of professional work by young adults, by providing safe, reproducible, and authentic work experience (Eland et al., 2010). Although the hurdles experienced in this research may not equate to 'real world' complexities as experienced by practicing urban planners, they nevertheless represented a valuable and authentic method of learning 'through work' experience. Indeed, the very bounding of this research proved an issue as it limited the scope and therefore the detail we could provide when enquiring about the application of GeoDesign processes. Other issues we encountered in our research extended to being able to collect information from the relevant administrative bodies, appropriately weighting different values in the landscape, knowing which data-sets produced were relevant to the results, and understanding how to evaluate simulated scenarios against each other. These issues were unique to our research.

The tools in this study used different spatial scales to quantify the risk to the Growling Grass Frog and the risk of houses exposed to fire. Evidence for each risk was modelled using an appropriate scale for that value, although it reduced the opportunities to compare the two models directly. We considered this preferable to trying to alter the tools to a common spatial scale, which would have introduced additional sources of error and hampered our capacity to identify differences between treatments.

As part of our research project, we considered seeking feedback from practicing planners on the methods, results, and discussion, to further broaden the scope of enquiry, and its relation to urban planning practice. Unfortunately this was not considered within the bounds of the original research, proposal, nor subsequent iterations of this research paper as this would've required research ethics approval from our research institution.6In the future, this could form the basis for further research projects.

V. Conclusion

Given current pressures to accommodate growing human populations into our cities and towns, the need to adopt planning approaches that make use of existing tools to inform the decision-making process is critical. Within ecology and natural hazard management there are a number of existing tools available that can assist with quantifying potential impacts to a range of assets and ecological values under different planning scenarios. GeoDesign offers a new and integrated way in which disparate skill sets and disciplines can be combined together to achieve multiple outcomes. Although there remain difficulties in translating a theoretical concept across into every day planning practice, there are a number of useful starting points that our research has provided. Actively engaging in this process has provided a model example of the joint action required of a GeoDesign planning process, and given insight into how to make modelling outputs (and more broadly scientific data) clear and accessible, comprehensive, digestible (usually through dialogue) for planners, whilst also clarifying the role of planning regulation. Reflections on the necessary changes required of the Victorian planning scheme to permit this approach were discussed. One of the major hurdles to a more wide-spread adoption of incorporating scientific models into the planning process is the specialist expertise which is often required to run the models.

Overcoming this challenge will require ongoing dialogues between practitioners in many disciplines. However, starting these discussions requires knowing alternatives to the current system are possible, and our case study demonstrates how such a dialogue can proceed.

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[6] In addition, the ongoing uncertainty induced from the COVID-19 Pandemic would make expanding the scope of this research to include such feedback difficult to achieve within the permitted timeframe.

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