Spring Plains Watershed Repair

Project Plan (Phase 1)

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Front page image: Swift Parrot, Photo Chris Tzaros

Spring Plains Watershed Repair – Phase 1 Plan

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Summary

The '**Springs Plains watershed repair'** project is a landscape–scale restoration pilot project that has emerged through the Heathcote **Local to Landscape** system – **Biolinks Alliance's** novel approach to catalysing community action for ecologically–informed environmental restoration. The pilot takes a local hotspot for Threatened Woodland Birds and aims to repair landscape health and build resilience to Climate Change by scaling–up measures like ecological thinning and soil amelioration that help make watersheds more absorbent and productive.

The project aims to demonstrate how to repair past environmental damage and why the approach is urgently needed more broadly in the region. Phase 1 of the pilot will develop a detailed prospectus including strategies, technologies, stages, costs and time frames for one watershed within Spring Plains Nature Conservation Reserve or NCR ('Peters Gully') just south of Heathcote in central Victoria. An integrated range of ecological monitoring will be established prior to the proposed restoration and compared against post–implementation as well as with an adjoining reference/control (no restoration) watershed ('Whites Gully'). Importantly, the pilot is strongly supported by the local Heathcote (Wild Duck and McIvor Creek) community who have been consulted and will be actively involved with implementation (Funding from chuffed campaign and Volunteer Innovation Fund has been secured for delivery of volunteer programs in 2022). The project also draws on three lines of historic research and practice: forest silviculture, wildlife habitat manipulation trials (by Parks Victoria or PV), and Landscape Function Analysis or LFA – all with varying degrees of connection to the Goldfields.

Beyond the planning and preparation phase (i.e. operational plan development, securing approvals and funding, cultural heritage assessment and baseline monitoring), the pilot will have the following elements: Contour ripping (soil water infiltration), Direct seeding (natives grasses for understorey regeneration), Kangaroo grazing pressure management (maximise understorey regeneration), Ecological thinning, and Gully hydration and ponding with targeted planting. The baseline monitoring will target: Bird assemblages, Arboreal mammals (nest boxes), Kangaroo surveys (exclosures, cameras and pellet counts), Vegetation cover/biomass/abundance, Canopy and understorey productivity (remote sensing), and Soil condition assessment.

Biolinks has widely consulted during the development of this plan including with PV, North Central CMA, DELWP, City of Greater Bendigo (CoGB), TLaWC, NGO's, the private sector, philanthropists, various experts and the local community. Approvals have been or will be sought from relevant authorities and agencies, concerning: Planning Scheme regulations; Cultural Heritage and Land Use Activity Agreement compliance; Works on Waterways permit; Occupational Health and Safety standards; and Wildlife Management.

The total estimated budget for the project (over three years, including Phase 1 planning) is $360,000. The first year (2020) is largely a set–up phase with planning, approvals, funding and some limited baseline assessment. The bulk of the cost will occur in the second year when most of the intervention works will be undertaken.

While it is expected the interventions will drive immediate improvements (e.g. soil water infiltration), it is anticipated the full ecological benefits will take up to a decade to manifest and thus Biolinks is committed to managing the project over at least this time frame – (a hypothetical Phase 3 again subject to funding and relevant approvals both in terms of follow–up interventions using an adaptive management framework as well as longer term ecological monitoring). A range of other social, operational and economic benefits are likely to also result from the project.

Typical present day (mid to upper slope) dry forest structure that is widespread across central and northern Victoria showing dense canopy regrowth (on average ~20 cm DBH multi-stem coppice) with little or no understorey or ground cover and where top soil is more or less absent resulting in poor water infiltration and slow rates of litter recycling (hence its accumulation). This system is locked into a highly dysfunctional (desertified) state due to a history of gold mining, and over cutting of timber etc. that is only being exacerbated by Climate change and further imperilling many threatened species such as Swift Parrots.

Remarkably some areas have managed to escape the worst impacts of these human disturbances and represent **living benchmarks that likely approximate prior condition** and higher ecological health (resilience). Although in this case the large old trees are obviously missing, the ground layer has a very high cover of a diverse assemblage of indigenous plants that reflects better wildlife habitat and relatively good soil condition capable of absorbing and using rainfall for local productivity and food webs (instead of quickly "flashing off" down gullied drainage lines and creeks as is now endemic in the widespread degraded scenario above). Is it possible to quickly and cost effectively convert the degraded bushland into the improved benchmark condition? We believe it is and the Spring Plains Watershed Repair project has been designed to provide this proof.

Although especially rare, there are some **less modified valley bottom (alluvial terrace) drainage systems** still left across the region. This particular site (near Greytown) is far from pristine, but remarkably has retained (or reinstated) a series of minor flood plain scours or ponds that fill up following significant rain to produce seasonally productive wetlands of amphibious and aquatic plants (including the large robust Tall Sedge Carex appressa under Red Gum and Yellow Box plus some taller wattles and tea-tree) that provide vital refugial habitat for wildlife. The flanking terraces (subject to occasional floods) are typically full of diverse grass and herb rich flora. Such productive valleys were often recorded in pre-goldrush historic accounts and the Spring Plains Watershed Repair project has been designed to show how this structure can be quickly and cost effectively rebuild in a degraded minor valley to help repair past damage and buffer the landscape against worsening Climate Change.

Typical present day valley bottom in the same dry forest (previous pages) showing an incised gully which has washed away much of valley's original alluvium and colluvium that once supported productive grassy woodlands and minor wetlands (ephemeral ponds). In some cases the original canopy of Red Gum and Yellow Box has been completely replaced by dryer species such as Grey Box and Yellow Gum and the cascade of minor ponds has completely been lost. Today, following substantial rainfall, these gullies quickly "flash off" within hours instead of diffusing slowly through healthy soils so that it is available to local food webs, creating a near permanent steady hydrological flow similar to its original state.

1. Local 2 Landscape Heathcote – Background

Project genesis

Members of the Heathcote community, with Biolinks Alliance, embarked on a **Local to Landscape** planning process to develop a plan for ecological restoration in the region, funded by a two–year grant from the City of Greater Bendigo. Local to Landscape is a conservation planning system that empowers communities to lead projects that create genuine, lasting change for Central Victoria's native plants and animals by connecting those communities with the knowledge, networks and resources they need to return health and resilience to our landscapes. The Local to Landscape system allows us to listen deeply and ensure stewardship of a shared vision before projects begin. At Biolinks, we recognise that the unique offerings of local communities need to be supported by trusting, two-way conversations; by funding, science and networks.

One of three Pilot Projects proposed under the H.Local to Landscape, the **Spring Plains Watershed Repair Project** targets a local hotspot for Threatened Woodland Birds (esp. Swift Parrot) and aims to repair landscape health and build resilience to Climate Change by scaling–up measures like ecological thinning and soil amelioration that help make watersheds more absorbent and productive again. Recent trials conducted nearby by PV has demonstrated the efficacy of ecological thinning (felling 50% of the canopy basal area, retained *in situ* as 'coarse woody debris' CWD) for promoting tree and understorey growth, as well as boosting fauna habitat. Landscape Ecology research elsewhere has shown how ecological thinning can also greatly improve landscape hydrological function when rolled out at sufficient scale along with other measures. These other measures include: targeted contour ripping and revegetation with native grasses and other understorey plants (esp. via direct seeding) to allow greater soil water infiltration and to begin the process of rebuilding soil health; and in–stream 'leaky weirs' to promote cascades of semi–permanent ponds to help build drought resilience.


72 Local community members attended a Heathcote Local to Landscape Walkshop in 2018, visiting the Spring Plains Nature conservation reserve as part of the Heathcote Local to Landscape planning process.

Historic research and practice

The project draws on three lines of historic research and practice that has varying degrees of connection to central Victoria and the Goldfields. These are (1) forest silviculture, (2) habitat manipulation trials (PV), and (3) Landscape Functional Analysis (LFA, see Tongway and Ludwig 2011).

Forestry has a long history in Victoria and the central Victorian Goldfields (see ECC 2001), where silvicultural practices such as thinning (reducing tree density) have long been used to increase the growth and form of residual trees, especially to boost the yield of sawlogs (NRE 1997; 1998). Whereas historically all unmerchantable trees (now including what are now considered Large Old Trees LOTs or habitat trees) were removed in the context of very different economic times, thinning today in this system typically involves the selective removal of trees 'from below' (i.e. small diameter trees – leaving the larger better–formed trees as potentially future sawlogs (NRE 1996) or 'from above' (i.e. typically larger diameter trees for posts/poles and railway sleepers – leaving some better formed trees as potentially future sawlogs). However, since the seminal "Box–Ironbark Forests and Woodlands Investigation" (ECC 2001 which resulted in the conversion of many former State Forests into conservation reserves (including many National Parks), and also due to past overcutting in State Forests across the region, timber resources have been so diminished that today the sawlog industry is defunct. The only timber industry operating in the region today is domestic firewood collection and some 'minor produce' which has been relegated to small residual areas of State Forest. Thus, thinning – to manipulate forest structure to accelerate residual tree growth rates – is no longer practiced in the region on any meaningful scale. Firewood and miscellaneous 'minor produce' harvesting is however allowed on private land throughout the region, but these practices (and industries) are not or poorly regulated and managed, and (with some exceptions) do not result in widespread improvements in forest structure. Also see Brown *et al.* (2019) for increased tree growth–rates under ecological thinning trials.

No timber cutting is currently practiced within any public conservation reserves across the region, with the exception of a few isolated trials investigating the potential for ecological thinning to improve habitat values (Palmer *et al.* 2010; Pigott *et al.* 2010; Brown *et al.* 2019) and [to a limited degree] landscape hydration and function (Baker–Gabb *et al.* 2012). The PV trial was established (at four locations – Spring Plains, Pilchers Bridge, Chewton and Paddys Ranges) in the early 2000's with a sophisticated experimental design and significant funding to investigate the promise of forest canopy manipulation with various thinning treatments to improve wildlife habitat.

Following many years of careful monitoring the researchers concluded that the trial manipulation did on balance serve to improve wildlife habitat value. Apart from the obvious increase in CWD (i.e. thinned stems left on the ground rather than removed) and mean stem diameter, ecological thinning (1) increased herb and tussock–grass cover; (2) lead to more profuse flowering of herbs and shrubs; (3) increased species richness among bird assemblages (esp. understorey birds); and (4) resulted in stable or positive responses in invertebrate, reptile, bat and terrestrial and arboreal mammals activity (Palmer *et al.* 2010). However, despite these positive and promising results, the trial has been effectively discontinued, the results poorly publicised and there has been no commitment (form PV or the DELWP) either for further research or for trialling any operational roll–out within local reserves.

The Shelbourne NCR trial – which also looked at ecological thinning as a restoration tool – was initiated by the Mid–Loddon Conservation Management Network or CMN and Mid–Loddon Landcare Network, but supported by the land manager PV and funded by DSE (now DELWP). A further contrast with the PV thinning trial, was that at Shelbourne part of the objective was to try and demonstrate how this practice could improve "landscape leakiness." Long championed by Ludwig and Tongway (2011) – mostly in drier rangeland conditions – this research looked at addressing excessive loss of rainfall from landscapes caused by various land use induced impacts (i.e. lack of topsoil, CWD and understorey vegetation, soil compaction and gully erosion etc.). Ludwig and Tongway (2011) argue that such degradation results in a profound loss of landscape productivity, diversity and resilience; that many landscapes have been pushed into a permanent state of dysfunction that can only be improved with specific restoration interventions. Alarmingly, the work of Ludwig and Tongway (2011) has become increasingly relevant to the temperate landscapes of south eastern Australia, as these areas have become increasingly 'desertified' with intensive post European land uses, exacerbated by Climate Change.

Soil Water Balance and Desertification, and conservation strategy

A key insight from LFA research (Tongway and Ludwig 2011) is that landscapes and soils can be severely compromised by land degradation legacies and processes that have often been driven by land use practices such as over grazing (by stock and feral animals), clearing and other (human) disturbances exacerbated by drought, fire and other natural disturbances. These impacts can be so severe that even if the (human) disturbance is removed, the system will not bounce back to its former 'natural' state with (relatively) high levels of resilience, diversity and productivity. This permanent degradation process is often referred to as 'desertification' as explained by Arnalds and Archer (2000) in the context of rangelands:

"The self–generating nature of degradation processes often means that restoration cannot be achieved by removing the stress that started the degradation [desertification] process… Consequently, degraded landscapes are often abandoned because the cost of restoration is likely greater than the boost to on–site production."

'Desertification' is an apt descriptor of this process even in temperate regions like south eastern Australia as the functional cause of the drying–out of landscapes is the dramatically lowered soil moisture availability driven by soil loss and compaction, vegetation loss or homogenisation and broader hydrological dysfunction (see Figure 1). And given water is often central to (human) land degradation, according to Arnalds and Archer (2000), " *the watershed is a logical, natural management unit for restoration activities*."

In Box Ironbark Forests such as those typical of the Bendigo and Heathcote regions and at Spring Plains NCR, the (local) production imperative is perhaps now far less important than the conservation and moral imperatives to affect restoration caused in relatively recent times (in evolutionary terms) by the Goldrush and the overharvesting of timber (amongst other things).

Many of these former timber production areas (and initially goldfields) have been today converted to conservation areas as a reflection of changing public expectations to look after central Victoria's environment and unique biota. However, few in the public appreciate just how damaged the environment is and thus it is increasingly critical to intervene to reverse 'desertification' to simultaneously address multiple sustainability challenges to secure the public benefits expected (and indeed demanded), while at the same time urgently educating the public as to why and how this restoration is needed.

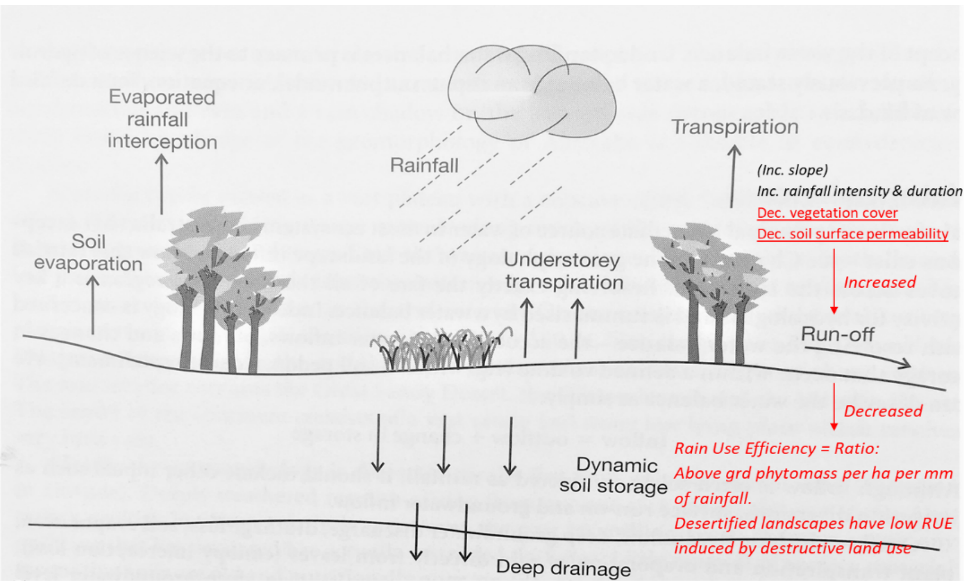


Figure 1: Conceptual model of a local soil water balance (source: Eamus et al. 2006). Schematic shows the critical role of local terrain and conditions in influencing

understorey (and tree) transpiration, run–off and soil storage and drainage. In general, along with increased slope and rainfall intensity and duration, understorey vegetation condition and soil surface permeability (driven by disturbance and soil health) will greatly increase run–off (the loss of moisture to the local system). The ratio of the above ground phytomass per ha per mm of rainfall (Rain Use Efficiency or RUE) is often used by ecologists to assess patterns in ecosystem function and condition. Typically 'desertified' landscapes have low RUE induced by land degradation. In Wet forests this 'drying out' of landscapes can be the result of intensive logging (Lindenmayer et al. 2020) exacerbating the desiccating impacts of Climate Change by increasing risk (frequency and severity) of wildfire. In dryer forests similar effects due to gold mining, logging, fragmentation and overgrazing ('desertification' = Leaky landscapes often increase fire risk in these landscapes due to loss of productivity in formerly wet valleys and the increasing of the extent and duration of seasonally drought stressed vegetation). In farmland 'desertification' is widespread due to vegetation clearance, soil loss and compaction, replacement of perennial pastures (often diverse native systems) with exotic annuals driving low productivity, weed invasion, poor drought resilience and instability.

In a recent review of nature conservation in Victoria (Bennett *et al.* 2009; also see McGregor 2008), based on the emerging science of landscape function and ecosystem processes, it is clear the old asset–based approach to conservation (e.g. CAR – Comprehensiveness, Adequacy and Representativeness; see Sharafia *et al.* 2012) has failed to adequately progress us towards our sustainability aspirations. The narrow compositional or 'postage stamp collection' strategy (as it is often seen) conceives of nature in more–or–less fixed physiognomic, structural and compositional terms, rather than as underpinned by a range of (fundamental) dynamic, functional processes. Under compositional thinking, the 'fixed' natural environment has been diminished only in terms of extent and condition, and the conservation/sustainability project is therefore understood to be one of preventing further decline through a comprehensive network of 'fixed' reserves (primarily achieved through the reclassification of public land). According to the review (Bennett *et al.* 2009) however, there are numerous "*complexities in the ways in which threats affect ecological processes and their outcomes for biodiversity conservation*" that are not adequately addressed by traditional conservation and sustainability strategies. This means that threats and their consequences for biodiversity conservation, are complex and pose difficult challenges as they drive on–going and long–standing trends towards species extinctions, 'desertification' and lack of resilience (Arnalds and Archer 2000). Thus, many of Victoria's ecosystems and currently productive landscapes are careering towards dysfunction under the combination of past and current land use impacts – irrespective of the number of public conservation reserves.

The restoration strategy embodied in the **Spring Plains Watershed Repair Pilot Project** challenges this 'traditional' passive recovery view of natural conservation – that all you need to do is remove threats via the declaration of parks and reserves on public land and eventually nature will recover. Unfortunately, as our functional understanding of landscapes is revealing, this is a false hope, especially in the face of Climate Change. This pilot project not only has the potential to help show the local and regional community why a different approach to nature conservation (and Parks management) is urgently needed, but also to address the widespread view in the community that under the CAR regime alone (see Sharafia *et al.* 2012), parks and reserves simply aren't being managed. A further advantage (in the eyes of the broader public), is that restoration to improve ecological health also has the potential to address fire hazard reduction with means other than clearing vegetation and intensive planned burning (a strategy that warrants further investigation and research).

Pilot Project Area

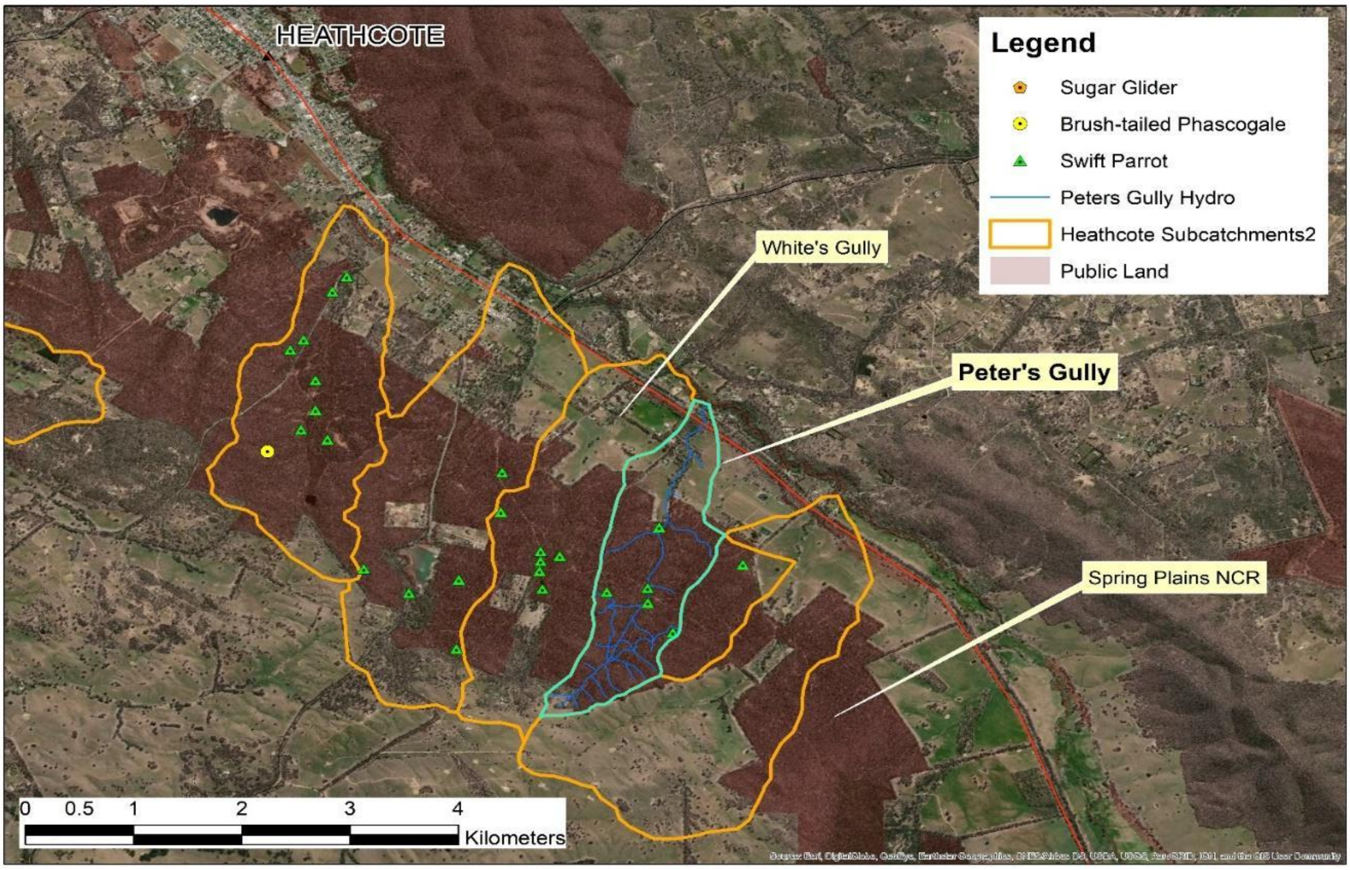
The Pilot Project has been designed to compare treated and untreated micro–watersheds, a framework consistent with adaptive management, to show indicative relative improvement/change in key ecological metrics, but not like a traditional academic research project (see later discussion). The objective is first and foremost a demonstration of the (presumed) effectiveness of an integrated set of ecological restoration interventions to hopefully catalyse the broader take up of similar landscape repair projects throughout the region. While collaborative research may be possible, this is not the main purpose.

A series of suitable candidate micro–watersheds have been identified within Spring Plains NCR, a few kms south of Heathcote within the McIvor Creek (Campaspe River) catchment (Figure 2). The micro–watersheds range between ~200 and 400 ha and occur exclusively on older sedimentary rocks draining into valleys with narrow strands of recent (Holocene) colluvium and alluvium, which in turn flow into McIvor Creek and later, Lake Eppalock. All micro–watersheds predominantly comprise forested public land (Spring Plains NCR), although in places the upper and lower elevation extremes are mostly subdivided freehold land.

The area has a history of pastoralism (from the late 1830's), gold mining dating from the 1850's, and later timber harvesting (amongst other things) which, collectively, has profoundly impacted its natural values – with widespread loss of Large Old Trees (LOTs), tree densification, loss of topsoil, gullying, fragmentation, weed invasion and a loss of structural and species diversity.

This area was chosen for several reasons – firstly, it's part of a habitat hotspot in the local region for winter–migrating Swift Parrots (and other significant species); secondly, the area still supports an extensive area of remnant bushland with some LOTs; third, it is very close to PVs ecological thinning 'Spring Plains' trial site (also within the NCR). Peter's Gully is one of the smaller of the four micro–watersheds examined with the highest proportion of its catchment within the NCR, no inlying freehold titles and marginally less (soil) degradation (Figure 2).

Figure 2. Map showing Peter's Gully and adjacent micro-watersheds in the Spring Plains Nature



Conservation Reserve.

The adjoining White's Gully is broadly similar and will be used as the untreated (control) watershed to compare the relative ecological impact of the restoration interventions. The pilot will be restricted to the intersecting 138 ha section of Spring Plains NCR within Peter's Gully plus the similarly–sized adjoining portion within White's Gully. The area to be treated has been further subdivided into three terrain strata, namely: Valley Bottom, Lower Slopes and Upper Slopes, respectively 12.25, 72.22 and 53.55 ha that broadly correspond to the three Ecological Vegetation Classes or EVCs: Creekline Grassy Woodland (EVC 068), Box Ironbark Forest (EVC 061) and Grassy Dry Forest (EVC 020) (see Figure 2, Appendix 1).

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Integrated landscape functional repair – drawing from a range of conceptual frameworks, thinking, research and trials aims to establish a kind of ecologically 'modular' approach to the restoration of degraded bushland in central Victoria based on functional (hydrological) thinking. Modular is used here in the sense that it can be potentially scaled–up or transferred and adapted to different locations across the region, and also because it represents the " *logical, natural management unit for restoration activities*" (Arnalds and Archer 2000, also see the 'smallest hydrological units' (SHUs) or sub–watersheds in some water catchment classification systems; i.e. Edwards *et al.* 2015; Özalp *et al.* 2017).

“The drainage patterns of a watershed form the framework of important energy flow and nutrient cycles that determine the structure and function of the ecosystem” (Arnalds and Archer 2000). In Australia sub–catchment classification at continental scale has been attempted for conservation reasons (see Stein 2006 cited in Mackey et al. 2010). This process stratified south east Australia into thousands of sub–catchments with huge variation in size (which within the Goldfield sub–bioregion ranged from 6 ha to >63,000 ha, with a mean of nearly 4,500 ha). The manually defined local watersheds south west of Heathcote within the >19,000 ha McIvor Creek catchment averaged only 288 ha and thus are on the lower end of size ranges and are perhaps a level below sub–catchments and thus called here ‘micro–catchments’ or ‘micro–watersheds’. The reason why this scale has been selected is because they are considered operationally manageable [as well as a significant step–up from current relevant trials and projects], and a level that still has meaning to local communities. These micro–watersheds were viewed as ‘gullies’ during the Goldrush and this framework still permeates local understanding of geography and history (e.g. Newlyns, Peters, Whites, Long and Caledonia Gullies; see Wohlt et al. 1998; Wohlt and Edwards 1999).

Very few large old trees remain in the regrowth forests of the Spring Plains Nature Conservation Reserve. Somehow this grey box survived the historical gold mining and timber cutting undertaken in the region. It serves as a salutary reminder of just how changed the forests are.

Project Objectives

The **Spring Plains Watershed Repair Pilot Project** aims to draw on and integrate the three historic traditions of research and practice (discussed earlier) into a more holistic and ecologically ‘modular’ approach (based on landscape science) to demonstrate:

- the great potential of landscape–scale restoration to quickly and significantly reverse trends of decline (locally); and
- that the approach can be cost–effectively adapted and scaled–up across the region to help tackle the great crises of the modern era – declining ecological resilience (contributing simultaneously to the extinction crisis, Climate Change, declining soil health and productivity, and social/economic decline).

This crisis of declining ecological resilience used to be described in the narrow (and somewhat benign sounding) terms as ‘land degradation’ or ‘soil erosion’, but we have long known that the 175+ years of post–European land use has wrought a much wider, deeper and pervasive impact on our environment, economy and society.

It was explained earlier that while the project interventions are expected to immediately drive improvements in soil moisture availability within Peters Gully (absorbent and productive vs. leaky and 'desertified' watersheds/ecosystems), the full impacts of the restoration could take up to a decade to manifest.

The Ecological Outcome Monitoring regime proposed under this pilot has been designed as a kind of integrated summary of the key landscape/trophic elements typical of Box Ironbark ecosystems and associated watersheds (see Table 1). Another way to think about these metrics is to see them as a measure of ecosystem state relative to an undisturbed system with high diversity in species and processes within and across various scales. Collectively, improvements in all these elements should indicate a boost in ecological resilience – an emergent quality of complex systems that is defined as "*the magnitude of a disturbance that triggers a shift between alternate states*" (Gunderson *et al.* 2010).

Under this framework, Box Ironbark Forest systems have been pushed into a degraded (discontinuous) state by massive past disturbances that exceeded the system's capacity to absorb them. In other words, they have been forced into a different (poorer) state with a different set of species and ecological processes (Gunderson *et al.* 2010) – exhibiting a different set of characteristics (e.g. [relatively] leaky, biologically inactive soil, unproductive (low biomass across trophic level), trophic imbalance (too many kangaroos), and species poor) which in turn make them more vulnerable to disturbances such as drought, fire and disease/dieback (more frequent or severe), species extinctions, and lower utility (for humans – i.e. less timber/biomass).

The aim of the project in the short to medium term (say within 10 years) is to (significantly) elevate the state of the system within Peters Gully c.f. before intervention and with Whites Gully as measured by the collective metrics (cascading over that time from the bottom up).

It should also be pointed out that restricting the restoration to within the micro–watershed should result in greater efficiency in terms of (local) ecological outcomes per hectare or dollars spent). In the longer term (perhaps with the requirement of further targeted interventions) it may be possible to aim to push the system in Peters Gully to a higher stable state, and with replication of the ('modular') approach in multiple adjoining watersheds, improve the system over an even broader scale.

As per the degraded regrowth dry forest ecosystem referenced earlier, this shot during the peak of the 2016 Indian Ocean Dipole floods, suggests all is right with the world: namely water flowing and green vegetation on the ground. However, in reality, this is clear evidence of a "green drought" or "desertification" due to past damaging land uses. Most of the green vegetation is in fact an annual exotic grass (Briza minor) that is a symptom of severe soil disturbance and loss of soil health and ecosystem resilience. The flash flow is in fact a tangible measure of the moisture lost to a local landscape that is no longer capable of absorbing it so that it is available for local food webs. Only weeks later this same site (which used to be the upper end of a Grassy Woodland dominated by Yellow Box and Kangaroo Grass Themeda triandra) was total devoid of surface water and most of the understorey vegetation had cured–off revealing the same tell tale sign of dysfunction: regrowth over a dense layer of unrecycled leaf litter. The Spring Plains watershed repair project aims to show how this severely damaged bushland can be quickly and cost effectively "reset" to begin rebuilding resilience and once again providing refugial habitat for threatened wildlife.

Project Restoration Elements

In line with this integrated approach (of the three historic traditions of research and practice discussed earlier), it is considered that canopy thinning alone will not be sufficient to generate improvement in landscape function, at least not within a pragmatic time frame. The important insight provided by Ludwig and Tongway's LFA (2011), is that restoration interventions must address the functional processes of: (1) land surface stability, (2) water infiltration, and (3) nutrient cycling. At its core, these are the fundamental processes that drive soil activity, productivity and ecosystem health and unless these can be manipulated in a meaningful way (and at a meaningful spatio–temporal scale – in both conservation and agricultural systems), then it is unlikely to drive the level of rehabilitation we need to create truly healthy, sustainable landscapes. In this sense the pilot project also draws to an extent on the holistic (ecological literacy) thinking behind the parallel movements of Regenerative Agriculture (see Massey 2017) and Holistic Management (Savory 2016). A closer examination of these links is, however, beyond the scope of this plan.

Fundamental to the application of these principles in specific settings is learning to adapt the mix of proposed interventions based on a thorough understanding of regional ecology as well as local assessment and analysis/interpretation of local conditions. Again, it is beyond the scope of this document to elaborate on the fundamental principles, but this plan does represent an example of how the broad concepts already introduced are applied in this particular case. Suffice to say, that each context will be different and that no two operational plans (for two different sites) will be the same. As per Regeneration Agriculture, adaptation of the principles and concepts based on ecological literacy is at the heart of landscape restoration. So for instance, the LFA approach of Ludwig and Tongway (2011) can be adapted beyond the arid and semi–arid rangelands into very different landscapes, but that have never–the–less become 'desertified'.

The following restoration elements are proposed for Peter's Gully in Spring Plains NCR:

- Ecological Outcomes Monitoring;
- Contour (keyline) ripping;
- Direct seeding;
- Kangaroo Grazing pressure reduction;
- Ecological thinning;
- Gully hydration and ponding with targeted (pond) planting;

Ecological Outcomes Monitoring

A key aspect of the project monitoring strategy is that ultimately it is 'outcomes' or 'impacts' and not just 'outputs' that we are looking to measure in order to demonstrate ecological improvements. The distinction between these two concepts is important and a central component of what is often called 'adaptive management' (see Margoluis et al. 2009). In a nutshell, adaptive management is learning–by–doing, but with a very clear designation of what you are trying to achieve. It is based on how humans develop and learn, and as such is normally quite easy for people to grasp. Under 'adaptive management' typically 'outputs' are the immediate results of project activities (i.e. number of plants established, area of forest thinned), while 'outcomes' are the interim results (objectives) achieved by the outputs and the 'impacts' are the desired end goals of the project (Margoluis *et al.* 2009). Examples of 'outcomes' in this case might be an increase in soil water infiltration and productivity of the understorey, while the ultimate 'impact' might be an increase in the population of Brush–tailed Phascogales or boosted nectar flows that attract more Swift Parrots while migrating from Tasmania and improved ecological resilience.

The monitoring elements listed have been incorporated into the Volunteer Innovation Fund which was awarded to Biolinks in 2021. The proposal is to use these funds to create citizen science tools which will be available to members of the local community to assist in monitoring, particularly for arboreal mammals, bird assemblage (specifically swift parrots) and kangaroo populations. The goal is to elevate the ecological comprehension of interested people while also gathering useful data. The program will have to be designed with simplicity and longevity in mind.

It is important to see interconnected hierarchical links between these concepts in the context of landscape restoration (see Figure 2). This diagram shows a trophic cascade built from foundational biotic and abiotic drivers right through to the apex consumers/predators and illustrates the functional interdependence of biodiversity (in the narrow sense; species composition) and the ecological processes that sustains ecosystems (see Lindenmayer *et al.* 2008; Bennett *et al.* 2010). This functional framework helps structure a broader regime of 'outcomes' and 'impacts' that is much closer to the goal of improved landscape health (ecosystem resilience).

The second key aspect is that the project is not an academic research project but more like a 'proof of concept' trial that must necessarily be focused on 'outcomes'/'impacts' as well as practical considerations of cost–effectiveness. The undertaking must be efficacious and it must also have a reasonable price tag – otherwise it is unlikely to be politically supported or funded as a reasonable approach to natural resource management. At least this is the *status quo* and to date it has only been possible to persuade governments to allocate relatively modest budgets that are expected to 'chip away' at the problem progressively over time. The same equally applies for the actions as it does to the monitoring and evaluation, which is critical given the adaptive framework proposed and the fact that much of our effort to date has had little or no cumulative impact (see Campbell *et al.* 2017).

In this case, six key aspects of the Food Pyramid have been targeted for the monitoring regime: Bird assemblage; Arboreal mammals; Kangaroo surveys; Vegetation cover/biomass/abundance; Canopy and understorey productivity; Soil condition assessment. These have been carefully selected as they are groups/methods considered easiest, cost–effective and (collectively) highly informative (of ecological improvement) (Table 1).

The monitoring has been designed around a treatment/control and before/after structure (stratified by terrain type) with adjoining (similar) micro–watersheds to be used as the control site (White's Gully; Figure 2). Pre–treatment assessments will occur before the works in both micro–watersheds.

According to LFA work in rangelands (Ludwig and Tongway 2011), degraded landscapes can return to functional condition – in terms of stability, infiltration and nutrient cycling – with the types of interventions proposed (using least modified reference sites as the 'living benchmark') within six years; and within ten years for the reestablishment of groundcover perennial grasses and shrubs. Given no *bona fide* reference micro–catchments likely exist in the Goldfields (see ECC 2001), reference site comparison isn't deemed possible in this case. Although it is likely (given the climate differences between rangeland and temperate woodlands environments – the latter with higher and more seasonably reliable rainfall) that understorey vegetation recovery could be much quicker; decade–long recovery period seems a reasonable (conservative) expectation.

Although there were some positive trends under the PV ecological thinning trial (see later discussion), results were often ambiguous and inconclusive because post–treatment assessment was only undertaken once for most parameters and sometimes within a very short time frame following treatment. For example, at Spring Plains NCR assessment occurred within six months of the treatment, and given here perennial tussock grass was initially very high (and >twice that of any of the other trial sites), it isn't surprising that cover hadn't yet had the chance to respond. The key exception was a second post–treatment assessment of understorey and ground cover undertaken in 2012 (Tolsma 2012), and although there was no formal analyses of these data, the descriptive results showed further promise with an increase in perennial grass and shrub cover (with the largest increases in perennial grasses at Spring Plains NCR) that was slightly higher c.f. control sites (Tolsma 2012 cited in Brown 2016) and mean understorey species richness was also (substantially) higher than at thinned sites.

The PV thinning trial is now 13 to 15 years old (the Spring Plains NCR plots were established between November 2005 and April 2007; Palmer *et al.* 2010) and should be urgently reassessed with the same methodology to properly gauge the medium to longer term impacts of thinning. In line with the LFA work in rangelands (Ludwig and Tongway 2011), it is only now – more than decade later – that we are likely to see the expected 'permanent' improvements in wildlife habitat and other landscape functional attributes.

Table 1: Ecological outcome monitoring of key landscape/trophic elements; Also see Food Pyramid

Category	Description
Monitoring management	Coordination, collation, storage, analysis and interpretation
Bird assemblage	Species and abundance in each of three landscape zones (with multiple replicates – ideally on different days and times of day in spring); Before and after treatment in both micro–watersheds; Site coordinates with GPS, and standard 20 minute Diurnal Bird Survey (see Palmer *et al.* 2010); Swift parrot survey will be created in cooperation with Birdlife Australia as part of the volunteer innovation fund
Arboreal mammals	(Tuans, Sugar Gliders and Yellow–footed antechinus) in each of three landscape zones using comparable nest box and remote camera methods; Nest boxes to be built and installed in Year 2; Assessment before and after treatment in both micro–watersheds to be led by ecologists and completed by volunteers as part of the volunteer innovation fund; Latest research suggests interventions to maintain or improve hollows and foraging resources could help secure or increase populations (e.g. thinning, CWD and improved ground vegetation and invertebrate abundance); Owl–call Playback, Spotlight surveys, Hair–tube Surveys, and Bat Echolocation (see Palmer et al. 2010) replaced here by nest boxes and cameras (see Scida and Gration 2017);
Kangaroo surveys	Stratified exclosures (3 replicates of 3x3 m fences per strata) and pellet counts will be used to develop an index of kangaroo abundance as well as an indication of the impact of removing grazing pressure plus the species being targeted. In addition kangaroo highway and wildlife path mapping combined with motion camera assessment will help calibrate abundance estimates; Volunteers will assist in the establishment and monitoring of the exclosures
Vegetation cover/biomass/abundance	Transect/point quadrat method based on vegetation assessment used in PV thinning trial (see Palmer et al. 2010); Includes CWD and tree density/sizes, vegetation structure and composition; Stratified by landscape zone and three replicates; Assessment before and after treatment in both micro–watersheds (i.e. 9 transects per micro–catchment);
Canopy and understorey productivity	Remote sensing for NDVI of understorey and canopy to look at overall patterns; Before and after treatment in both micro–watersheds; annually; Work with BHA, La Trobe University and CDM Smith obtain high resolution baseline imagery (using drones stratified by canopy and ground layer) that can be processed into NDVI and related metrics to measure and map variation in productivity (biomass);
Soil condition assessment	Structured into three elements: (1) soil transects (biological [soil organic carbon (SOC), as a measure of soil organic matter, and carbon dioxide respiration as a measure of microbial activity] and physical measurements such as pH, EC and bulk–density); and (2) soil infiltration tests (water retention and soil permeability) as a baseline description repeated every 2 or 3 years (data stratified by watershed and terrain), and (3) on–going seasonal monitoring of carbon dioxide respiration as a measure of microbial activity, and photography along transect (note that remotely sensed biomass dynamics assessed under 'canopy and understorey productivity' will complement the soil assessment);

Contour (keyline) ripping

Ludwig and Tongway (2011) have demonstrated the efficacy of deep–ripping along contours and creating troughs and banks in soils compacted by heavy machinery in the context of mine site rehabilitation. Such measures enhance water retention in landscapes by reducing run–off and sediment/resource loss, increasing water infiltration and soil water storage, thus boosting soil biological activity and nutrient recycling, and (when present) the vegetation productivity. Such intervention can be equally applicable to mining rehabilitation as to soils degraded by agricultural processes (such as compaction by stock and top soil loss exposing a less permeable subsoil). In fact, the concept has been long established in holistic, biodynamic, organic and regenerative farming settings to directly improve landscape and soil hydration. Yeomans (2008) describes a sophisticated system of keyline ploughing (equipment and techniques) designed to manipulate the movement of water through paddocks to boost soil health and productivity.

Deep–ripping has long been used in targeted ways to facilitate local revegetation projects on public lands (i.e. decommissioning eroding or obsolete tracks and other damaged sites within the bushland matrix), but there are few examples of landscape scale–use of such methods in central Victorian Box–Ironbark forests.

Two related minor projects include the use of a bulldozer to intensively rip a ~37 ha network of degraded (old gravel–stripped) areas in Lockwood State Forest (a collaboration between the Mid–Loddon CMN and Landcare Network, and DELWP) and to rehabilitate an area of Mallee shrubland near Wedderburn degraded by 100+ years of intensive eucalyptus oil harvesting. In both cases, the natural vegetation was dominated by drought–adapted sclerophyll lifeforms, effectively 'desertified' by disturbance. Although neither project was well monitored, the anecdotal evidence is encouraging with an apparent stimulation of perennial plant regeneration in the 'conserving' contour troughs and the virtual absence of weed invasion (often associated with soil disturbance in these landscapes). The Wedderburn ripping was augmented by the felling of regrowth mallee branches and the direct seeding of native perennial grasses (Wallaby Grasses *Rytidosperma* spp.) and other common understorey perennial forbs and small shrubs. While the Lockwood project was much more intense (rip–lines ~1 m apart c.f. 20 m at Wedderburn), regeneration was effectively passive – driven by existing soil seed banks and local dispersal from adjoining complex mosaics of healthier remnant understorey vegetation. Recent observations of the 2017 Lockwood work shows considerable post–disturbance understorey regeneration apparently linked to improved surface hydration along the rip–lines. Further anecdotal evidence from private land suggest such measures are likely to be cost–effective even in degraded regrowth bushland with only minimal risks in terms of weed invasion, damage to residual vegetation, soil erosion and failure to passively regenerate (see Appendix 3, Image 6).

It is proposed to undertake widespread and intensive contour ripping between regrowth trees using a tractor (fitted with a 'yeomans' type tyne) wherever terrain permits throughout Peter's Gully. This excludes steep and rocky slopes – which are mostly restricted to the more elevated sections of the Upper Slopes strata and thus will be mostly targeted within the Valley Bottom and Lower Slopes strata covering ~ 90 ha. The procedure will involve using a smaller tractor (instead of a bulldozer) to ensure ready access, weaving in between regrowth trees and minimal soil surface compaction.

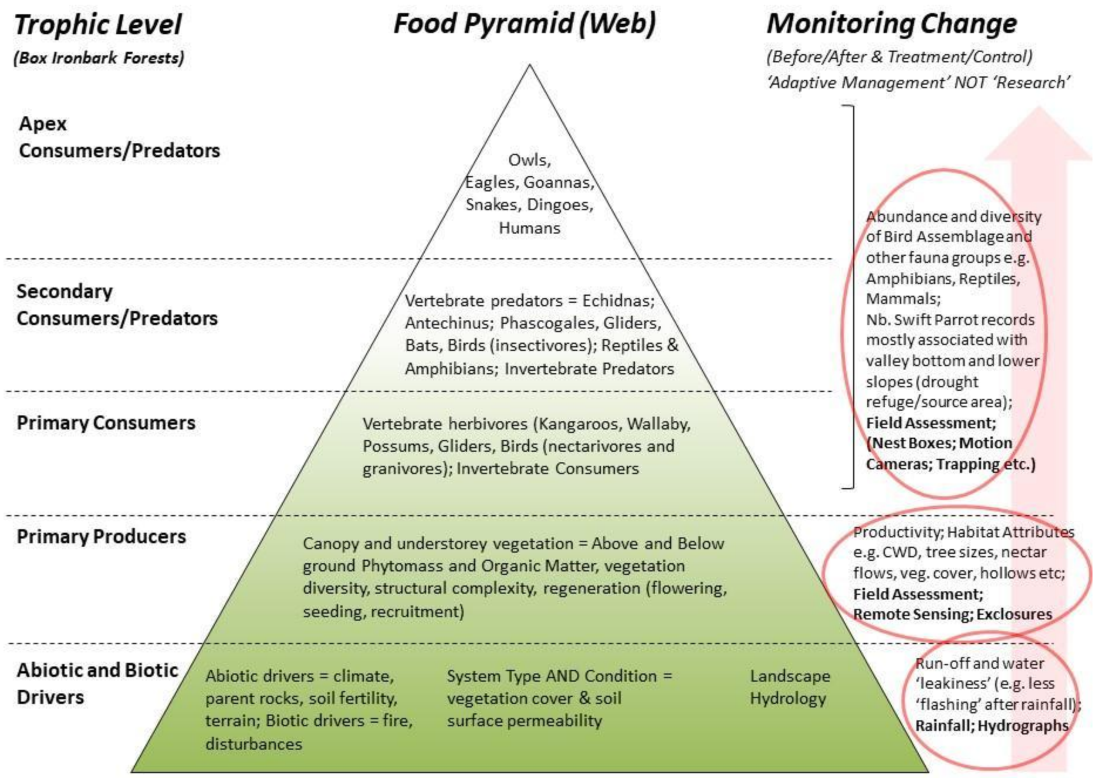
The ripping will also target minor unused 'bush' tracks (not required for management purposes – possibly as much as ~4 kms; See Appendix 3) and degraded areas adjoining some tracks. Maintained tracks could also be improved in terms of run–off with the installation of strategically placed humps to appropriately divert run–off away from tracksides and into adjoining vegetation. These measures will help increase soil water infiltration by fracturing subsoil and providing micro–barriers to overland flow and soil loss.

Direct seeding (indigenous perennial grasses)

Critical to the effectiveness of the contour ripping (aiming to increase water infiltration and soil water storage) is to ensure this immediate stimulation in soil biological activity drives an increase in plant growth, soil organic matter accumulation and overall understorey productivity (as a key foundational process in the Food Pyramid; see Figure 3). Herbaceous perennials – especially grasses – are potentially excellent colonising life forms capable of quickly regenerating and growing rapidly in the newly created micro–habitats of the contour troughs. While native grasses are ubiquitous in the landscape their distribution is patchy and in many areas recolonization can be hindered by grazing pressure, weed competition and long dispersal distances (as soil seed banks are generally not long–lived). In Peter's Gully (and indeed Spring Plains NCR more broadly), the understorey is often sparse and patchy, while some areas in better condition on the upper slopes and ridgetops are dominated by a kind of 'grassy dry' sclerophyll woodland or forest typically characterised by Red–anther Wallaby Grass (*Rytidosperma pallidum*) – which can often form thick stands of large, wiry tussocks along with a range of sub–dominant grasses, forbs and shrubs.

Although Red–anther Wallaby Grass is common in Peter's Gully, it is very patchy and passive recruitment throughout cannot be guaranteed. Consequently, targeted direct seeding of locally sourced seed (florets) will help to ensure rapid plant colonisation along the ripped contour troughs, especially in the context of a reduced canopy cover and managed grazing pressure (amongst other things; see Appendix 3 Image 5). A range of other understorey species (shrubs and robust forbs) could also be used for this process – but perennial tussock grasses are considered the most cost–effective colonisers. Depending on what happens in the first few years, there may be scope to supplement this initial broadcast with other species and life–forms. Ideally, most of these other understorey species will be passively boosted by the improved landscape function resulting from the restoration interventions.

Figure 3: Hypothetical food pyramid (web) schema typical of Box–Ironbark ecosystems



Kangaroo grazing pressure management

It has already been noted that numbers of Eastern Grey Kangaroos in and around Peter's Gully are significant based on incidental observations of animal numbers, pellet counts and impacts on understorey vegetation – especially on the ridgetops. Although there is limited literature on the impact if high kangaroo grazing pressure on Box Ironbark Forest ecosystems of central Victoria, it can be reasonably assumed that significant reductions in understorey biomass negatively alters fauna habitat, moisture retention, nutrient recycling and vegetation composition (Manning *et al.* 2011). Restoration projects in this region are unlikely to be successful without simultaneously managing kangaroo grazing pressure. However, this issue is complex in terms of both landscape ecology as well as regulation and requires a considered and well–designed strategy to strike the right balance between landscape health and kangaroo abundance. Note that kangaroos and their impacts are spread across the NCR as well as on neighbouring farmland, and so management must necessarily involve this broader landscape context, and thus Peters Gully cannot be realistically treated in isolation.

Four elements are proposed: (1) grazing exclosures; (2) movement detection cameras; (3) kangaroo abundance measures (pellet counts); and (4) controlling kangaroo numbers (in two steps).

A network of small (3x3 m) **exclosures** are proposed in each of Peters and Whites Gully micro–watersheds stratified to the three terrain types with limited replication mostly for operational redundancy (due to fallen limbs, vandalism or animal damage etc.). Small exclosures are less attractive to kangaroos and easier to maintain. Those in the valley bottoms will need to be carefully placed to avoid getting washed away or damaged by debris mobilised by local run–off. Exclosures should also be paired with unfenced plots and photopoints will help record the visual and ecological impacts of total grazing exclosure compared with the surrounding (managed) landscape.

Motion **cameras** can be a useful tool set–up on boundary (fenceline) kangaroo highways, on wildlife paths within the NCR, and also near specific plants (such as Red–anther Wallaby Grass and other common understory shrubs) that are being targeted for grazing. This will not only help estimate numbers, but also confirm if any other animals are present and contributing to the grazing impacts (e.g. Swamp Wallaby and deer). A survey of fence holes (i.e. number per 100 m) including height and width, and some measure of activity (e.g. major, moderate, minor) would also help quantify the local population and guide with the placement of cameras. Boundaries with any adjoining or nearby cleared land are especially important, including the 'pinch–point' at Newlyns Gully between the northern and southern halves of the NCR.

Given the nature of the area, **pellet counts** on fixed transects are likely to give the most reliable data on kangaroo density. The diagram below (Figure 4) shows the basics of this method, which can be modified to suit specific sites. Pellet counts give a robust density estimate using the Faecal Accumulation Rate – old pellets are cleared off plots and new ones counted after 3–4 weeks, and an average output rate of just under 500 pellets/kangaroo/day is applied. While this method is 'low–tech', just two visits (at least) to the plots will get good results. If enough plots are established, reduction of kangaroo numbers by shooting as part of the project should be reflected in the plot data (see below). This method would be ideal for local participation (i.e. a citizen science project).

A two–step approach to **controlling kangaroo numbers** in Peter's Gully is proposed once baseline monitoring has been established (i.e. exclosures, cameras and pellet counts) and the case for a reduction in numbers is compelling – and as a progression towards a sustained local landscape–scale approach. The first step would be indirectly lowering numbers (in line with landscape–scale targets within Peter's Gully – see 'target density' discussion below) by facilitating targeted culling on adjoining private land, and the second phase would be a more whole–of–landscape program controlling numbers across tenure including in Spring Plains NCR under a Kangaroo Management Plan (KMP) developed in collaboration with PV and DELWP (similar to programs used in National Parks elsewhere in Victoria).

In terms of 'target density', compared with the latest statewide survey (Maloney *et al.* 2018), Peters Gully sits just above the southern boundary of the CoGB, with Mitchell Shire immediately to the south, with the overall densities (of kangaroos reported in the statewide survey) is respectively 11 and 23 km^{-2} – so it would be reasonable to apply the average density of ~17 km^{-2} for Peters Gully. It is highly likely kangaroo numbers would be higher than this across the NCR and that if numbers were hypothetically reduced to this level, there would be a local effect with little or no impact (on the population) at the broader, municipal scale. This mean density figure provides a target of 231 kangaroos for the whole reserve (13.6 km^2), or ~136 for the northern section of the NCR (i.e. north of Newlyns Gully). Given the aim (for kangaroo management) is to get the population down to a density that allows recovery of the ecosystem, and keep it there for as long as needed, this figure of 17 kangaroos km^{-2} is a good place to start. Under adaptive management, this level would be routinely reviewed and adjusted up or down iteratively as information accumulates.

The best way to achieve a reduction in kangaroo numbers within Peter's Gully in the short term would be to have cooperating owners of neighbouring private properties apply for an Authority to Control Wildlife or ATCW (issued by DELWP to enable culling of kangaroos on private property by the landowner or someone on their behalf) to undertake culling on their properties. (Note that use of commercial harvesters can be problematic as they tend to target large male kangaroos which can, perversely, increase in the capacity for the population to grow, since there will be a greater proportion of females after culling). This initial measure will allow some reduction in kangaroo numbers locally while Biolinks works with PV to develop a longer–term KMP that would take longer to produce and could see limited additional culling within the reserve itself in line with landscape targets.

In light of this longer–term objective (to develop a KMP for at least the Peters Gully section of the NCR) it is recommended to begin discussions with both PV and DELWP (about the kangaroo management aspect of the project) as soon as possible, as both agencies are likely to support the local landscape–scale approach as part of the pilot project.

(Note that this strategy has been developed in consultation with Ian Temby (Wildlife Management Consulting based at Ashbourne, west of Woodend) and Graeme Coulson (Honorary Principal Fellow, School of BioSciences, Science Faculty, The University of Melbourne). Both Ian and Graeme are skilled and experienced experts in kangaroo management in central Victoria and more broadly.)

Ecological thinning

Peter's Gully is more–or–less entirely dominated by dense regrowth Box Ironbark Forest with Grey Box mostly occupying the Valley Bottom, Grey Box and some Yellow Gum on the lower slopes, and Red Stringybark, Long leaf Box, Red Box and Red Ironbark on the Upper Slopes.

In providing a detailed background and rationale for the PV thinning trials, Brown (2015) describes in some detail the short and long ecological (mainly habitat) benefits expected with significant (thinning from below) canopy reduction, along with the various monitoring elements (i.e. forest structure, fauna habitat features, survey of floristics, and selected vertebrates and invertebrates). A number of studies describe preliminary results and projected ecological benefits of this sort of restoration (Grant *et al.* 2010; Piggott *et al.* 2010; Brown 2015; Jones *et al.* 2015). Typical of regrowth in Box Ironbark forest of central Victoria, Peter's Gully is dominated by small diameter coppice regrowth mostly <30 cm DBHOB (NRE 1998; ECC 2001; Brown 2015; Holland *et al.* 2015; Jones *et al.* 2015).

It is proposed to base the ecological thinning in this pilot project on that used in the PV trial, but to extend the treatment throughout Peter's Gully (along with other measures) in an attempt to demonstrate additional, landscape–scale functional benefits. The treatment will be to reduce the basal area (from below – i.e. no medium to large diameter stems would be felled) equivalent to 50% pre–thinning status with an informal patchy application depending on the current nature of the site. All felled stems would be left onsite and aligned along the contour as far as possible. In other words, some areas would be more–or–less heavily cut and some patches left unthinned altogether – representing a thinning regime in line with the 'isolated' treatment in Palmer *et al.* (2010) and Piggott *et al.* (2010).

Gully hydration and ponding (and targeted planting);

Despite the long post–European history of disturbance in Peter's Gully, remarkably, it still retains in places functional aspects of what is thought to have been the original valley hydrology. These include 'natural' shallow depressions mostly located further down slope that capture some run–off following significant rainfall at least on some occasions in typical seasons. Additional ponding has also been created by old mine shafts in one section of the upper part of the drainage line that happen to be seasonally filled with run–off rather like the 'natural' ponds observed further down slope. Today the drainage line is mostly dominated by Grey Box, but it is thought the improved hydration in and around this cluster of ~30 old mine shafts has allowed for the persistence of a small patch of Red Gum and Yellow Box – the original dominants that were effectively 'knocked out' of the local landscape by goldrush related disturbance. The water ponding serendipitously created in this section of the drainage line represents the kind of effect it is hoped hydrological repair will replicate throughout the valley bottom (see Appendix 2, Image 4). Thus, in the longer term – it is possible Red Gum and Yellow Box could progressively recolonise the rehydrated valley bottom.

It is proposed to use a combination of ecological thinning and minor excavation to create a series of ephemeral ponds throughout the valley that will seasonally hold run–off following significant rainfall events. The ponds will act as a cascade of 100's of minor 'leaky weirs' capable of holding sufficient moisture for weeks or months after rainfall to support local zones of productivity (vegetation and wildlife) that are currently rare or absent.

These ponds will be created using carefully–sighted combinations of the following techniques: (1) Gully repair; (2) Scour augmentation; (3) Artificial scours, and (4) Impeding CWD (see Appendix 2, Images 1 to 3). These ponds will be consolidated and vegetation recovery enhanced by targeted planting with robust perennial wetland tussocks such as Tall Sedge (*Carex appressa*), Poong'ort (*C. tereticaulis*), Common Tussock (*Poa labillardierei*), Spiny–headed Mat–rush (*Lomandra longifolia*), Rushes (*Juncus* spp.; e.g. *J. pallidus*) and Umbrella Sedges (e.g. *Cyperus gunnii*).

2. Project Stages and Milestones

Although the outcomes are long term, the immediate operational aspects (Phase 2) are planned over a three year period. Beyond this, there is an expectation of on–going monitoring and further adaptive interventions (with potentially a longer–term Phase 3). However, this will be subject to securing the necessary resources and approvals to develop beyond Phase 2.

Table 2: Overview of Project Stages and Milestones

Stage		Milestones		
Stage	Stage Desc.	Milestones Year 1	Milestones Year 2	Milestones Year 3
1	Project and Monitoring management	-	-	-
2	Site selection finalisation	Watersheds chosen - Peter and Whites Gully	-	-
3	Detailed operational plan development, approvals and funding	Phase 2 plan complete	-	-
3.1	DELWP approval	Recieve approval for veg removal exemption. Awaiting DELWP response	-	-
3.2	Parks Vic Approvals	Finalise partnership arrangement with PV. Awaiting Exchange Letter/Notice of Intent. Presenting to science and research directorate	-	-
3.3	TLaWC Approvals	PV managing approvals	-	-
3.4	CoGB Planning Permits	Permit not required	-	-
3.5	NCCMA Planning Permits	Permit not required	-	-
4	Cultural heritage assessment	Complete CHA for spring plains. Pending PV advice on appropriate consultant	-	-
5	Pre–implementation and follow up monitoring	-	-	-
5.1	Bird assemblage	Baseline complete (2020)	Post treatment monitoring	Follow up monitoring
5.2	Arboreal mammals (Nest boxes)	-	Nest box installation complete	Follow up monitoring
5.3	Kangaroo surveys (exclosures)	-	Exclosures, cameras and pellet count transects established	Follow up monitoring
5.4	Vegetation cover/biomass/abundance	Baseline complete (2020)	Post treatment monitoring	Follow up monitoring
5.5	Canopy and understorey productivity	Baseline imagery captured and processed	Post treatment monitoring	Follow up monitoring
5.6	Soil condition assessment	Baseline complete	Post treatment monitoring	Follow up monitoring
6	Contour ripping	-	Ripping complete	-
7	Direct seeding (collection in Nov/Dec 2020 and 2021)	Seed collection	Seed collection	-
8	Kangaroo Grazing Pressure Reduction	Baseline surveys	Post treatment monitoring	Population reduction
9	Ecological thinning	-	Thinning	-
10A	Gully hydration and ponding	-	Ponding	-
10B	Targeted (pond) planting	-	Planting, initial	Planting, supplementary
11A	Citizen science tool development	-	Tools developed	-
11 B	Survey method documentation and monitoring guides/manual	-	Survey and monitoring manual	-
11 C	Advertising and promotions	-	Create and distribute materail	-
11 D	Volunteer engagement event in forest	-	Hold field event	-

The first year (Stages 1 to 4 and 5) will be predominantly a planning and set–up period to spell out the details of all the interventions proposed, secure the necessary approvals and funding to fully implement over the three years, and establish the baseline monitoring (prior to works). The second year (Stages 5 and 6 to 10) will focus on implementation of the proposed restoration works plus the first post–treatment monitoring. And the third year (mostly Stage 5) for the second round of follow–up monitoring (plus any follow–up works that were not completed in Year 2). Oversight of the project by Biolinks, including all the monitoring activities is considered an on–going role more–or–less throughout the three year period (See Table 2). Extra stages (11 A, B, C & D) have been added and referred to in appendix

Detailed operational plan development and approvals

A detailed operational plan for the project will be developed, requiring wide consultation and assembly of detailed information and some innovation, in Year 1 of the project. It will allow for the formal approvals process to begin. The key formal approvals involved include: (1) CoGB planning scheme regulations; (2) Cultural Heritage and Land Use Activity Agreement compliance; (3) Works on a waterway permit; (4) Occupational Health and Safety regulations and protocols; (5) DELWP Native vegetation Removal exemption and (6) Wildlife management regulations (kangaroos). The details behind each of these elements is provided in the Approvals Section of this plan. In addition, the restoration plans proposed in Peter's Gully will need to be considered and approved by PV in terms of operational impacts viz–a–viz the routine management of Spring Plains NCR.

Traditional Owners

The Spring Plains project area is located within the traditional lands of the Taungurung Nation. The Taungurung Land and Waters Council (TLaWC) is the corporate representative of the Taungurung People. The Council is the Registered Aboriginal Party for the management and protection of Taungurung cultural heritage. It also manages and administers the rights and interests set out in the Recognition and Settlement Agreement signed off with the Victorian Government in 2018, formally recognising the Taungurung people as Traditional Owners of their land. TLaWC serves to uphold the interests of the Taungurung people with respect to culture and Country, ensuring they have a significant role in the management and care of traditional land and waters.

As required, Biolink Alliance will engage with Parks Victoria and TLaWC to complete all cultural heritage investigations and to negotiate under the Land Use Activity Agreement. Biolinks is strongly committed to working with Traditional Owners across central Victoria.

Ecological outcomes monitoring

The first phase of monitoring (pre–intervention) will commence in Year 1 of the project with the establishment of as many of the seven of the key assessment programs implemented variously by Biolinks staff, expert private contractors and local community volunteers (see Table 1).*Citizen science monitoring has been expanded through the volunteer innovation fund with greater scope for continued monitoring.

- **Bird assemblage** monitoring using the methods described earlier will be established as a pre–intervention baseline (data will be stratified by watershed and terrain type) in the Spring of Year 1 by local ornithologist Gary Cheers. Follow–up assessments (post–intervention in Yrs 2 and 3) could be either repeated by Gary and/or in conjunction with BirdLife Australia and other local and amateur ornithologists;
- **Arboreal mammal** monitoring using nest boxes – Given the cost of constructing the nest boxes, this program will likely be carried out in Year 2 when the newly constructed boxes would be installed in large trees along the valley bottoms of both gullies by skilled community volunteers associated with the Whroo Goldfields CMN nest box program. Follow–up assessment in Yr 3 (using remote camera technology) would be similarly undertaken by the same community volunteers;
- **Kangaroo grazing pressure** surveys (involving exclosures, cameras and pellet counts) will be established by Graeme Coulson (The University of Melbourne) in conjunction with interested community volunteers In . The volunteers will be important for on–going routine pellet counts (within a network of plots) plus the processing of camera images, located to track daily movements and to document which species graze on specific plants;
- **Vegetation** cover/biomass/abundance – Paul Foreman (Biolinks) will establish a network of vegetation structure and composition transects in Spring 2020 (again data stratified by

watershed and terrain type) similar to the approach used in the PV ecological thinning trial. Follow–up assessment will also be undertaken by Paul Foreman possibly supported by skilled community volunteers;

- **Canopy and understorey productivity** – Glen Norris (Bush Heritage) will assist with baseline collection of imagery across both Peters and Whites gullies using a drone fitted with suitable sensors. Data processing (NDVI) likely through La Trobe University (data stratified by watershed, terrain type and canopy/understorey or CSIRO's 'Veg machine' could be used to provide trend analyses of remotely sensed biomass over time – supported by CDM Smith) with at least annual follow–up reassessment to detect changes in biomass/productivity;
- **Soil condition** assessment – The monitoring regime will be developed and overseen by Jon Fawcett of CDM Smith with either Biomass staff, contractors or skilled community volunteers. There will also be a (2/3 yearly) cost for laboratory processing of soil transect samples;

Contour (keyline) ripping

It is proposed to implement this work using a tractor (private contractor) over about a week in Year 2 (Spring ideally) to ensure ripping is most effective and surface impacts are minimised. The ripping will necessary be less intense (c.f. an open paddock) and the tractor will need to carefully pick a practical line in between trees so as to achieve a balance between maximising the ripping and avoiding impacting trees. Experience elsewhere in the region has shown that careful navigation is possible and that there are little or no negative impacts on trees due to stem or root damage. Provided the machine is cleaned prior to works, it is expected the disturbance will result in minimal weed growth (mostly ubiquitous annual grasses if any). This work will need to occur prior to the thinning and will include the decommissioning of redundant bush tracks as approved (see Appendix 3; intersecting red tracks). In addition, at least some of the retained tracks could be modified with diversion bunds ('whoa–boys') as appropriate to ensure track water flow is minimised and diverted into adjoining bushland (see Appendix 3; intersecting green tracks).

Direct seeding

Large stands of suitable native grasses are known locally from both public and private land that will be targeted for harvesting in late spring (especially following years of good rainfall using a local/private contractor). The private land sites are likely to be the best candidates because grazing pressure can be more easily managed. Seed will be collected from a suitable nearby location (likely private land) in Year 1 (November) and locally stored (i.e. a dark, dry shed free from insect pests and rodents) over summer until proposed broadcast in spring of Year 2 following the completion of works. The direct seeding will take the form of manually broadcasting florets along rip lines.

(According to online sources, Red Anther Wallaby Grass is usually collected in November to December and seed retains viability for 2–3 years when stored (4 months after–ripening period) at room temperature. Sowing is best in late Spring to Summer with germinates in 4–8 weeks – so wetter seasonal conditions and/or adequate site preparation to ensure soil moisture availability will be essential to maximise results. Also, smoke treatment improves germination rate for fresh seeds (see www.treeproject.org.au)).

Kangaroo Grazing pressure management

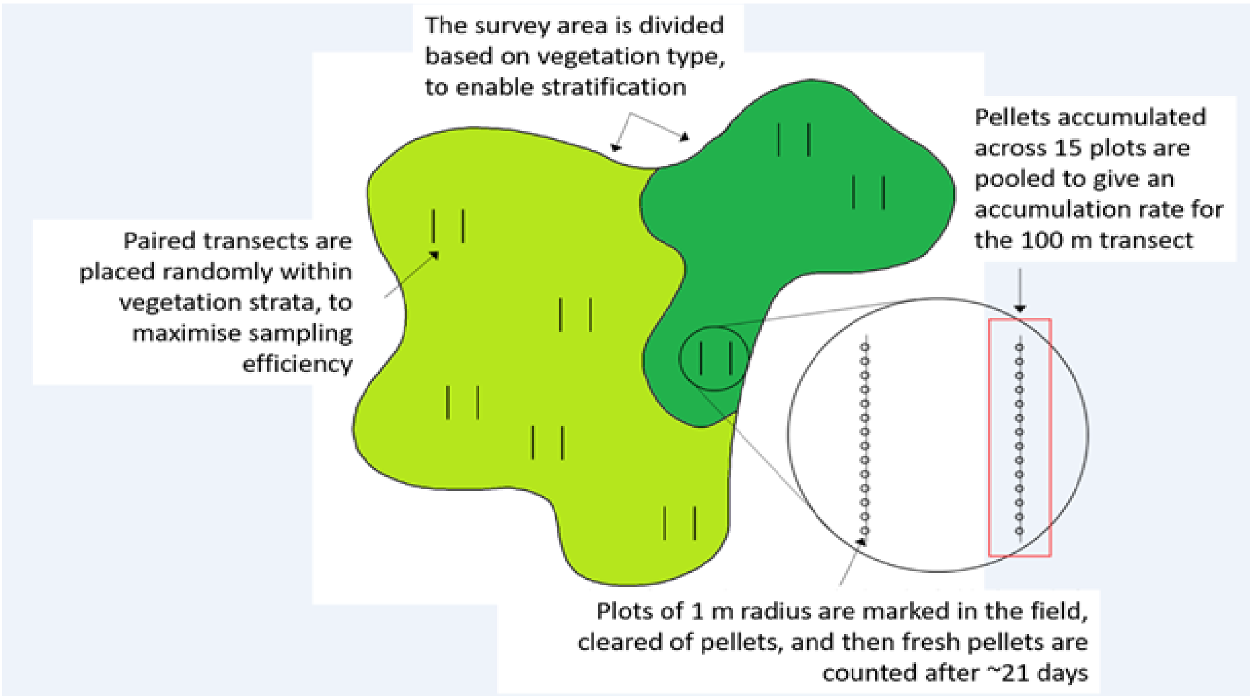
All of the elements of this stage (with the exception of target density control) could be carried out by a Project Manager with assistance of local community members and/or contractors – with occasional strategic input from kangaroo control experts (Graeme Coulson or Ian Temby).

Installation of the 18 exclosures (3 x 3 m; 2 watersheds, 3 strata and 3 replicates) as well as surveys of kangaroo highways and wildlife paths (including for the placement of cameras) would be undertaken in Years 1/2. The pellet assessment plots could be established near the exclosures and regularly revisited (say monthly or quarterly – along with retrieval and processing camera imagery) throughout the project's life.

It is recommended the exclosures are constructed using galvanised netting such as Rabbit Netting Heavy Galvanised (e.g. 120/4/1.4mm, 50m or 100 m rolls from Southern Wire). The 1,200 mm height will be sufficient to exclude kangaroos from a small enclosure. As there are few rabbits and hares in the area, it may not be necessary to include an 'apron' of rabbit netting laid on the ground around the exclosure, but they should be checked periodically for signs of digging. The netting should be clipped to a bottom wire and strained tightly at ground level so that gaps are not present between the bottom of the fence and the ground. Given the terrain and the soil, treated pine posts are not considered practical, so tall steel posts (1800 mm plus) would be advisable, probably with supporting stays – a fencing contractor would be able to advise on this. If fencing contractor is used, plain fencing wire (and clips to attach the netting) would likely be supplied and included in their costs;

Reconyx Hyperfire HF2X **cameras** are recommended as they are reliable (but still reasonably priced). It is the brand that the DELWP Arthur Rylah Institute uses for many projects, and Ian Temby has three of them (after trying Bushnell cameras that all failed after a year or two). At least four for cameras is recommended for monitoring boundary kangaroo trails and possibly another four for monitoring plants. Ian Temby has shopped around and purchased his cameras from Outdoor Cameras Australia, and found them really good to deal with. Note that the exclosures and their paired plots can be monitored by establishing photo-points (and other measures), rather than having dedicated cameras set up. Ian Temby obtained a price for the Reconyx cameras at $710.00

Figure 4: Schematic showing the structure of the stratified pellet count transects recommended for estimating kangaroo abundance.



from the Outdoor Cameras website, but they will drop the price to $580 each for an order of 6–10 cameras;

Setting up say three pairs of 100–200 m **pellet count** transects in each of the three terrain types is strongly recommended (Figure 4), and each transect would have say 5–10, 1 m radius (3.14 m^2) plots. A peg is placed permanently to mark each plot (coordinates also recorded with a GPS), and a 1 m cord is attached with a loop to define the perimeter as each plot is checked initially and cleared of all pellets. It can help to mark a nearby tree at the ends of each transect, so that the plot pegs can be relocated easily. If the three pairs of transects are insufficient to gather pellet data, then the radius of each plot could be doubled to 2 m (12.57 m2) to see if that provides adequate counts (the aim is to ensure each plot has some pellets). Alternatively, more transects may need to be established. It is better to start small and expand if necessary to collect sufficient data. It may be useful to have a simple set of instructions on a laminated sheet for transect monitoring, so that any interested person will be able to undertake the task in the same way. Graeme Coulson is happy to demonstrate the method, evaluate a trial set of plots and provide the simple formula for calculating density based on pellet accumulation rates.

Controlling kangaroo numbers will involve two steps: (1) facilitating culling on collaborating adjoining properties under the ATCW process; (2) initiation of discussions with PV and DELWP towards a long–term whole–of–landscape Kangaroo control program in and around Peter's Gully under a KMP. The first step will involve finding collaborative landholders and as appropriate facilitating the ATCW application process and then maintaining liaison with these landholders and monitoring all culling activities undertaken by the landholders or their agents. It is expected control should start to show up in the pellet count monitoring undertaken at Peter's Gully – reflecting a decline in numbers towards the initial target of 17 km^{-2} (see earlier discussion). Over this same time frame, discussion would commence with the agencies towards developing a whole–of–landscape KMP for the Peters Gully section of Spring Plains NCR and surrounds (as has been developed and now routinely implemented in National Parks elsewhere in Victoria).

Ecological thinning

It is proposed to undertake the work with a small crew of skilled and experienced chainsaw operators (private contractors – e.g. Gary Hendy of Treeheadquarters) which would be expected to take up to ~2 months (likely Winter Year 2 depending on conditions) to complete the project area.

Gully hydration and ponding (and targeted planting)

This work will be closely supervised by Biolinks staff and in close association with the ecological thinning crew as well as a small earth moving machine (i.e. Bobcat controlled by an experienced operator with restoration skills). The machine operator and supervisor will work systematically along the drainage line to determine the exact location and nature of works as detailed earlier. Careful placement of cut regrowth stems (in a kind of 'herring–bone' pattern) throughout this section of the valley will augment the flow of surface run–off into the cascade of seasonal ponds. This work will be undertaken at the same time as the ecological thinning (with due safety protocols to avoid dangerous felling; see Approvals section); and immediately followed up with targeted planting with robust wetland tussocks (tube stock) as described earlier. The planting will be carefully placed to both help consolidate loose soil and litter, and to allow rapid establishment (of the plants) in close proximity to the ponded water. In the medium term, it is intended that these plants will establish and maintain a cascade of new high quality wildlife habitat throughout the valley floor.

Threatened Brush-tailed Phascogales (Tuans) will be monitored using comparable nest box and remote camera in each of the three landscape zones methods;

3. Project Budget

The total estimated budget for the project (over three years, including Phase 1 planning) is $325,071. The first year is largely a set up phase with planning, approvals, funding and some limited baseline assessment ($80,350). The bulk of the cost will occur in the second year ($209,471) when most of the intervention works will be undertaken (mostly in the middle of the year). The third year is largely a follow up assessment phase ($35,250). It is hoped that monitoring (amongst other things) will be maintained beyond Year 3, but this will be funding dependent – linked of course to short term outcomes (Table 2).

Table 2: Budget summary

Stage	Stage Desc.	Expenditure Yrs 1-3
1	Project and Monitoring management	$ 60,000
2	Site selection finalisation	$ –
3	Detailed operational plan development, approvals and funding	$ 25,000
4	Cultural heritage assessment	$ 22,000
5	Ecological Outcomes Monitoring (Total)	$ 109,178
6	Contour ripping	$ 10,000
7	Direct seeding (collection in Nov/Dec 2020)	$ 3,300
8	Kangaroo Grazing pressure reduction	$ 13,021
9	Ecological thinning	$ 82,000
10	Gully hydration and ponding (and targeted planting)	$ 26,500
11	Citizen science program development	$ 9,000
		$ 359,999

The pilot project will be overseen by part–time Biolinks staff – community engagement and administration (Project Manager), plus ecological expertise (Paul Foreman). The key assumptions have been listed in the comments column and in most cases the figures have been derived from quotes provided by specialist local and regional contractors (see Appendix 5).

On the income side of the equation, much of the planning elements (i.e. Site selection finalisation, Detailed operational plan development, approvals and funding) have been largely funded by a $25,000 philanthropy fund contributed to by five donors affiliated with the Australia Environment Grantmakers Network (AEGN). The development of a Cultural Heritage Management Plan has also been funded by a separate philanthropic donation. A Ross Trust Grant has funded Project and Monitoring Management and some funding towards Ecological Thinning.

4. Approvals

A series of permits and approvals and other requirements will need to be satisfied in order for the project to proceed. Although the project isn't unprecedented (see Baker–Gabb *et al.* 2010; Pigott *et al.* 2010), given the relatively 'novel' nature of at least some aspects of the proposal, it will be necessary to negotiate numerous formal processes addressing both government policy and existing regulatory requirements.

Five key processes are considered relevant and will require active management negotiating with the relevant authorities and agencies. These include: (1) Planning Scheme regulations (CoGB); (2) Cultural Heritage and Land Use Activity Agreement compliance, (3) Works on Waterways permit, (4) Occupational Health and Safety (OHS) standards; and (5) Authority to Control Wildlife (ATCW).

The proposed project area is public land managed by PV for its conservation and protection. However, under the Recognition and Settlement Agreement (RSA) – which formally recognises the Taungurung People as the Traditional Owners of this part of Victoria. Biolinks will need to work closely with both PV and TLaWC to negotiate and meet all requirements and approvals relevant to the works proposed under this project. While there is a formal requirement for a Cultural Heritage Management Plan (CHMP), Biolinks is especially keen to work more actively with the TLaWC as an integral and on–going collaborator.

The land is zoned Public Conservation and Resource Zone (PCRZ) and is subject to the Environmental Significance Overlay – Schedule 3 (ESO3) and Bushfire Management Overlay (BMO). The regulatory approvals required are based on scenarios where the works are conducted by or on behalf of PV and where PV consents to Biolinks or another third party carrying out the proposed works.

CoGB Planning Scheme Regulations

A planning permit may be required under ESO3 only and further advice is required from the CoGB. Specifically:

- PCRZ – Clause 36.03–2 states that a permit is not required if the works are carried out by or on behalf of a public land manager or PV under various Acts of Parliament. PV does not require a planning permit for the proposed works under PCRZ;
- ESO (Schedule 3) – Clause 42.01–2 states that a permit is required to carry out works including to remove, destroy or lop any vegetation, including dead vegetation. This does not apply: – if a schedule to this overlay specifically states that a permit is not required. The schedule states that a permit is not required unless the removal or lopping is greater than 1 ha; or within 30 m of a waterway. **A planning permit may be required** under ESO3 and **further advice is required** to determine the amount and location of the proposed vegetation removal. Note: Council should be contacted to determine how they will apply the 1 ha exemption;
- BMO – Clause 52.17–1 states that a permit is required to remove, destroy or lop native vegetation, including dead native vegetation. However, the table of exemptions states that a permit is not required if the native vegetation that is to be removed, destroyed or lopped to the minimum extent necessary to enable the carrying out of conservation work or to manage Crown land with the written agreement of the Secretary to DELWP. A permit is not required under this overlay for the proposed works (although these exemptions may require the written consent of the Secretary to DELWP);
- Biolinks will need to demonstrate the ecological benefits (of the proposed restoration works) to avoid native vegetation removal offsets. Due diligence would especially need to be applied to endangered flora and fauna. This may include consideration of Environment Protection

and Biodiversity Conservation (EPBC) Act 1999; Flora and Fauna Guarantee (FFG) Act 1988; Environmental Effects Act 1978.

- MNES – list for site and any other species/communities listed under the FFG Act. A standard Protected Matters Search Tool (PMST) search report was produced for the project area. This report provides a 'general guide only' (not all species and ecological communities listed under the EPBC Act have been mapped) of all MNES known to or likely to occur within the specified search area and its immediate surrounds.
- A total of ten state and nationally significant species of vertebrate fauna and vascular flora have been recorded within the two watersheds targeted for the pilot project. These are mostly birds and all but one species are listed as only significant in Victoria (Table 3). Only Swift Parrot, the nationally endangered migratory species, is listed under the EPBC Act. This species briefly stops over during Winter and Spring, sheltering in bushland and utilising nectar resources mostly associated with larger old trees scattered in the valley bottoms of these micro watersheds. In this case (as with all the other state listed species – and indeed all native species in these landscapes), the restoration works proposed will serve to improve their plight over the medium to long term by boosting primary productivity manifesting through the food chain as higher understorey phytomass, increased invertebrate abundance, greater nectar flows and accelerated tree growth rates (which leads to improved arboreal habitat such as hollows).

Table 3: List of significant flora and fauna recorded in the Peters and White Gullies study areas

Species	*Recs*	*Year*	*FFG*	*EPBC*	*AROTS*	*VROTS*	*Group*	*Comments*
Chestnut–rumped Heathwren *Calamanthus pyrrhopygius*	1	2006	L			VU	Birds	Relatively recent Gary Cheers record at the end of the Peters Gully valley bottom (margin of farmland)
Crested Bellbird *Oreoica gutturalis*	1	1998	L			NT	Birds	Old declining woodland bird record from Whites Gully
Diamond Firetail *Stagonopleura guttata*	1	1998	L			VU	Birds	Old declining woodland bird record from Whites Gully
Musk Duck *Biziura lobata*	1	1999				VU	Birds	Old record near Caledonia reservoir
Pied Cormorant *Phalacrocorax varius*	1	1999				NT	Birds	Old record near Caledonia reservoir
Black–chinned Honeyeater *Melithreptus gularis*	4	1998 to 2006				NT	Birds	Relatively recent records in both Whites and Peters Gullies
Brown Treecreeper (south–eastern ssp.) *Climacteris picumnus victoriae*	5	2004 to 2006				NT	Birds	Relatively recent records in both Whites and Peters Gullies
Swift Parrot *Lathamus discolor*	16	1998 to 2006	L	EN	EN	EN	Birds	Numerous records in recent decades as local 'hotspot' for Swift parrots; Restoration of habitat condition to benefit swift parrots (and other declining woodland birds) a key project objective
Ausfeld's Wattle *Acacia ausfeldii*	1	1972 to 2020				v	Plants	Old record but commonly observed scattered in the sections of the valley bottoms of both watersheds
Annual Buttercup *Ranunculus sessiliflorus var. pilulifer*	1	2020				k	Plants	Recent observation during baseline vegetation establishment in Peters Gully valley bottom near watered historic mine shafts

- Two listed ecological communities may occur in the valley bottoms of Peters and Whites Gullies, namely: Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South–eastern Australia, and White Box–Yellow Box–Blakely's Red Gum Grassy Woodland and Derived Native Grassland ('Box Gum Woodland'). However, according to the listing advice for the (TSSC 2010) this community is not associated with Creekline Grassy Woodland (EVC 068). As discussed earlier it is thought the Grey Box dominated minor valley bottoms in both micro watersheds are degraded forms of Red Gum and Yellow Box Grassy Woodland that today are closer to Grey Box dominated lower slope forms of Box Ironbark Forest (EVC 061). A similar story applies for 'Box Gum Woodland' in that it is mostly associated with more extensive valleys and plains, particularly granitic and metamorphic landforms and low sedimentary rises on the margins of the northern plains. In summary the valley bottoms of both Peters and Whites Gullies do not support ecological communities listed under the EPBC Act;

Cultural Heritage and Land Use Activity Agreement compliance

Taungurung Land and Waters Council Aboriginal Corporation (TLaWC) and the State of Victoria have entered into a Recognition and Settlement Agreement (RSA) which formally recognises the Taungurung People as the traditional owners of this part of Victoria. The TLaWC Land Use Activity Agreement (LUAA) is a sub–agreement to the RSA.

Taungurung Land and Water Council approvals

We are seeking to obtain approvals from the traditional owners of the land where the project is proposed. The form that this will take is currently unclear and could be a LUAA or fall under a different legislation within the RSA. Regardless, the project is designed to work with Taungurung to achieve a result that is desirable for everyone involved.

Cultural Heritage Assessment

Taungurung Land and Waters Council is also the Registered Aboriginal Party (RAP) for Taungurung Country under the Aboriginal Heritage Act. RAPs are the primary source of advice and knowledge on matters relating to Aboriginal Cultural Heritage for their area and play a key role in the identification, management and compliance of Aboriginal Cultural Heritage protection in Victoria. A Cultural Heritage Management Plan (CHMP) will be required specifically for works that disturb the soil, namely "ripping" and possibly the proposed creation of semi-permanent ponds.

Works on a Waterway Permit

A works on a waterway permit may be required from the North Central Catchment Management Authority (CMA) if works are proposed on designated waterways – named or unnamed, permanent or seasonal, river to a natural depression (declared under the Water Act 1989). The North Central CMA will be contacted to confirm the locations of designated waterways in this instance.

DELWP Native Vegetation Removal exemption

A Native Vegetation Removal Exemption may be necessary to facilitate ecological thinning. This would sidestep local government approvals but will also require detailed project information to be evaluated by the native vegetation support team at DELWP.

Occupational Health and Safety considerations

Risk assessment will be conducted to evaluate the comparative OHS and ecological impacts of each practice. This will be used to guide management principles and decisions on which methodology to use. Particularly of concern is the choice between mechanical felling with excavator vs manual felling with small plant. In order to understand these different applications a rigorous evaluation of the site conditions, safety protocols and each methodology are required as well as a set of matrices to quantify the risks. Appropriate Occupational Health and Safety protocols will be in place for all mechanical works undertaken by contractors on site as a standard work requirement (machine operation [earth works and ripping], ecological thinning [chainsaws]). This includes the following:

- Qualified workplace first aider/s on site at all times (i.e. Cardiopulmonary Resuscitation HLTAID001; Basic Emergency Life Support HLTAID002; and First Aid HLTAID003);
- Timber fallers will all have the following training/qualifications: Environmental Care FWPCOR2203; WHS Policy & Procedure FWPCOR2205; Maintain chainsaws FWPCOT2237; Manual fallers FWPCOT2236; Trim and Cut Felled Trees FWPCOT2239; Agricultural Chemical Users Permit individual (ACUP); Prepare and Apply Chemicals AHCCHM307; Transport and Store Chemicals AHCCHM304; Commercial Chemical Operators License (Business);
- All timber falling will be undertaken according to a Falling Operations Plan covering: appropriate native vegetation removal permits; Falling operations Safe Work Method Statement (SWMS); Falling operations site hazard notification signage; Operations designated exclusion areas; Operations designated safe areas; Job Safety Analysis (JSA) to be conducted daily with all operations personnel; Site management diary/ visitor site induction/ sign in; Forest Operators License as required;
- All personnel and visitors to site to wear Personal Protective Equipment (PPE), including: Hi–visibility clothing vest as a minimum; Hard hat; Eye protection; Steel cap over ankle lace up boots;
- All operators to wear as a minimum: Hearing protection; Cut protection trousers or chaps; Gloves; Hi–visibility clothing vest as a minimum; Hard hat; Eye protection; Steel cap over ankle lace up boots
- Safe Operating Procedures include: All personnel to participate in daily Job Safety Analysis (JSA); Develop daily work plan; All appropriate PPE is available in good order, worn and used; Hazard falling operations signage is in place; Pre–operation equipment inspection service, all equipment is safe to operate and safety devices are working; Fallers to work identified individual site areas at least 2 tree height lengths away from each other; Falling operations within tree length of forest tracks require traffic spotter to be in place; Trees to be fallen along slope contour; Fallen trees to be trimmed to lay on ground; No fallen trees to be left hanging in other trees, all hangers to be put to ground.

Wildlife Management considerations

Biolinks will work with landholders on adjoining/nearby farms to facilitate the uptake of ATCWs (under the Wildlife Act 1975) to undertake culling on their properties (that reduces grazing pressure in the landscape) that benefits both the landholders and the adjoining bushland (Peters Gully). Permits can be applied for via the DELWP website and culling of specified numbers can be approved subject to assessment which considers if all non–lethal methods have been investigated and proven to be ineffective or impractical in managing the wildlife problem (i.e. damaging buildings, pasture, crops or other property; posing a risk to human health and safety, or damaging the environment).

Biolinks also aims to negotiate a longer term KMP for the Peters Gully section of Spring Plains NCR in conjunction with PV, DELWP and TLaWC.

Seed Collection Permits

There are no plans for native vegetation seed collection from Crown Land as per a DELWP permit that would be required to take flora under the Flora and Fauna Guarantee Act 1988 – including for non–commercial purposes. On private land a permit is only required for the commercial collection of grasstrees, tree–ferns and sphagnum moss. In this case, for a number of reasons outlined earlier, it has been determined to collect limited Red Anther Wallaby Grass and other native grass seed from private land nearby and thus no permit will be needed.

Approvals summary

In order to carry out the works proposed under this restoration project, Biolinks Alliance would need to:

- Apply for Landowner and Land Manager Consent from PV, this will include a permit to enter the land (i.e. **works agreement**);
- apply for planning permission through the City of Greater Bendigo; **A planning permit may be required** under ESO3 and further advice is required;
- **DELWP native vegetation removal exemption** may be required and may also usurp planning permits under ESO3
- Engage with TLaWC to meet Cultural Heritage protection compliance through the development and implementation of a **Cultural Heritage Management Plan** as well as compliance with the **Land Use Activity Agreement**.
- A works on a **waterway permit may be required** from the Catchment Management Authority if works are proposed on designated waterways;
- Appropriate **Occupational Health and Safety protocols** will be undertaken for all works undertaken by contractors on site as a standard work requirement;
- In order for adjoining landholders/farmers to undertake culling on their properties (that would also benefit nearby bushland), collaborating **landholders/farmers will need to apply to DELWP for a ATCW permit**;

5. Project Implementation

Funding has been secured for the Phase 1 Planning. First version of the plan was completed in October 2020 and was followed by further consultations and discussions to (1) negotiate the relevant approvals with various authorities and organisations; (2) secure the funds for project implementation (Phase 2). These discussions are ongoing. Much of the funding for Phase 2 has been acquired through philanthropic, public and grant funds. As of the beginning of 2022 the project is currently awaiting final approvals from the relevant partner groups. A hypothetical Phase 3 is envisaged beyond Phase 2. Although it is expected the proposed interventions will drive immediate improvements (e.g. soil water infiltration), it is anticipated the full ecological benefits will take up to a decade to be manifest, and thus Biolinks is committed to managing the project over at least this time frame – both in terms of follow–up interventions using an adaptive management framework as well as longer term ecological monitoring (again subject to funding and relevant approvals).

Critically, once necessary funding and approvals have been secured for Phase 2, all proposed works/actions will be facilitated and overseen by two Biolinks Staff: (1) Project Manager – an on–going part–time position over 2 to 2.5 years filled by local people with suitable community, project management and ecological skills/experience; and (2) Ecologist – Paul Foreman (Biolinks Conservation Strategy and former Chair of the Board) who will play an on–going strategic oversight roll such as the detailed planning, overseeing on–ground works with contractors, and implementing/coordinating key aspects of the Ecological Outcomes Monitoring program – which will be critical for quantifying change and (hopefully) demonstrating significant ecological improvements. Biolinks Executive Director since 2013, Sophie Bickford (and former research Ecologist) will also play a critical strategic role for general promotion and fundraising.

A key role of the project Manager will be to engage with the community and other collaborating organisations (esp. NGOs) throughout the life of the project (Phase 2) both to promote and educate viz a viz Biolinks and Landscape restoration science, as well as to actively involve interested and skill community members in various activities – esp. under the Ecological Outcomes Monitoring program. Those aspects of the program particularly dependent on community participation include Bird assemblage survey (i.e. Birdlife Australia with Swift Parrot surveys), Kangaroo grazing pressure surveys (camera image analysis and pellet counts), Arboreal mammal surveys (i.e. nest box assessment), Canopy and understorey productivity (Bush Heritage and La Trobe University) and Soil condition assessment (i.e. carbon dioxide respiration, water infiltration and transect photography). There may well be real scope to nuance and expand this community participation (citizen science) aspect of the project as it matures.

A wide range of mostly local contractors and carefully selected specialist/experts as well as local community organisations have been directly consulted to contribute specific aspects of project implement as per this plan. In some cases this has involved commissioning expert advice (during the planning phase) or the provision of a quote in response to a detailed (often field based) briefing on the activities envisaged. In most cases these are not straightforward (routine) services, but require a level of careful adaptation and even a level of innovation that requires a specialised set of skills and experience. In one instance those experts commissioned for specialist advice during the planning stage have offered to assist with aspects of implementation on an in-kind basis (driven at least in part by Biolinks community status and the funding to date deriving almost exclusively from philanthropic sources). It is expected that (subject to full funding and approvals), these contractors and experts asked to quote will be given first offer to deliver the works under Biolinks oversight. As far as practicable, Biolinks will endeavour to involve TLaWC in the project, including in its direct delivery.

Experts/Contractors consulted, include:

- Bill Featherstone, Local Nursery – Seed collection, direct seeding and plant propagation
- David Griffiths, Geometree – Contour ripping
- Gary Cheers, Contract Ornithologist – Bird surveys
- Gary Hendy, Treeheadquarters – Ecological Thinning
- Geoff Brown, Arthur Rylah Institute (DELWP) – Ecological Thinning Trials
- Glen Norris, Bush Heritage – Drones and imagery capture
- Graeme Coulson, University of Melbourne – Kangaroo grazing pressure management
- Ian Temby, Wildlife Management – Kangaroo grazing pressure management
- Iestyn Hosking, Natimuk – Native grass seed harvesting
- Jerry Grayson – Drones and imagery capture
- Jon Fawcett, Hydrogeologist CDM Smith – Soil condition assessment
- Miles Geldard, Wildlife Nestboxes – Nest box construction
- Orlando Desma Talamo, Whroo CMN – Nest box monitoring
- Patrick Piggott, PV – Ecological Thinning Trials
- Phil Pegler, PV – Kangaroo grazing pressure management
- Shane Monk - Taungurung Land and Waters Council - Cultural Heritage and LUAA
- Sherryn Antonopoulos - Taungurung Land and Waters Council - Cultural Heritage and LUAA
- Francisco Almeida - Taungurung Land and Waters Council - Cultural Heritage and LUAA

6. Project Evaluation and Review

As introduced earlier, the pilot project has been planned on the principles of adaptive management – whereby actions are continually reviewed and adjusted in accord with the project/task aim (a kind of 'learning by doing' process that mimics the way humans naturally learn). The essential goal of the evaluation process is to test whether the results of the interventions implemented have produced the results desired – firstly in terms of operational effectiveness and secondly in terms of the ecological outcomes and impacts. The process explicitly analyses the link between inputs and outcomes and provides the conceptual framework for determining if the actions have been effective or if (and how) they need to be adjusted or replaced (Hockings et al. 2006; Margoluis et al. 2009).

Although this natural learning by doing process applies across all aspects of the project at various scales, ultimately it's the longer term ecological outcomes and impacts that is we are interested in – in particular significant improvements in ecological health (state) or resilience. Landscape science shows how this can be quantified (and stratified by the three terrain/vegetation strata) using a collection of metrics representative of the local food pyramid (from the bottom up) and comparing before and after treatment, with a control micro–watershed (Whites Gully).

- Bird assemblage and target species (i.e. Swift Parrot and Declining woodland birds) – composition, diversity and abundance;
- Arboreal mammal abundance (i.e. Tuans, Sugar Gliders and Yellow–footed antechinus);
- Vegetation composition, diversity and abundance (cover);
- Canopy and understorey productivity – spatio–temporal patterns of biomass (phytomass/ha); and
- Soil condition assessment – spatio – temporal patterns in soil organic carbon (as a measure of soil organic matter), carbon dioxide respiration (as a measure of microbial activity), physical properties (such as pH, EC and bulk–density); and soil infiltration (water retention and soil permeability).

While in general we aim to see an overall increase in all or most of the metrics, the detailed patterns of change will be critical for better understanding local landscape function. Perhaps the only metric we might wish to see go down would be kangaroo numbers, however this is more an output of active control, with expected outcomes manifest in improved understorey vegetation metrics. A variety of other variables could add value to this evaluation (e.g. invertebrates, reptiles, fungi etc.), but the combination proposed have been judged the most cost effective in terms of telling us about the state of the system as a whole for minimal effort and cost.

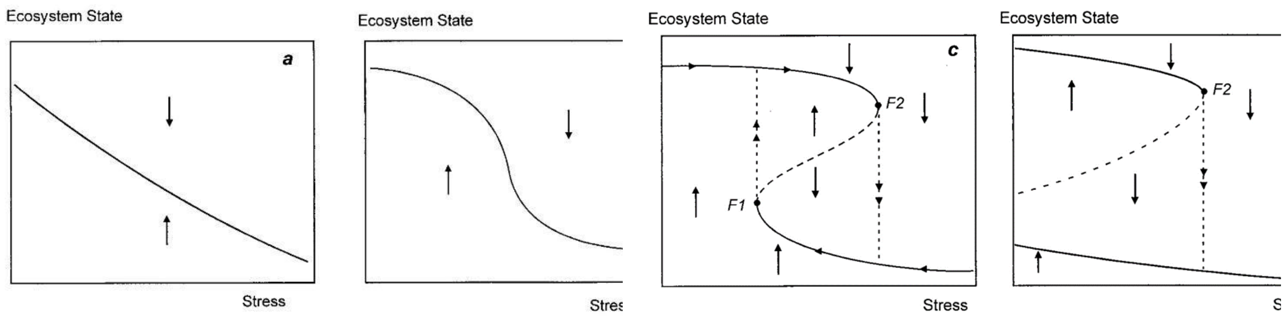


Figure 4: Schematic representation of four possible responses (a to d) of ecosystems to stress imposed by human use (adapted from Gunderson and Holling 2002). It is assumed Box Ironbark Forest ecosystems conform to 'response c or d' with at least two alternate stable states – one healthy and another degraded.

It is assumed the Box Ironbark Forest ecosystem (such as that at Peters Gully) has likely been forced into a stable degraded state due to the extreme pressures of past human disturbances including the gold rush, timber harvesting and weed invasion etc. and that the system will not just return to its former condition with the removal of these stressors (Figure 4; Response d). However, it may be possible to eventually drive an improvement in ecosystem state (and resilience) big enough to see the system flip back into an alternate stable healthy state, at least in areas.

In addition to this primary ecological objective, there is scope for additional evaluation of other social, operation/technical and economic aspects of the project. Some of the key principles of the

Biolinks Local to Landscape process is to build community (conservation) capacity, collaborate widely, innovation and cost–efficiency in terms of striving for the biggest bang for dollars invested – and it would be appropriate to quantify (where possible) and assess improvements with respect to these issues as part of the evaluation and review process in Year 3 and again in Year 10.

In contrast to the typical state of dry forests across much of central and northern Victoria (dense regrowth and little but leaf litter on the ground – and often an eerie sense of "an absence"), this shot shows one of the few areas that has somehow or another escaped the worst impacts of the goldrush and the over harvesting of timber. Although Large Old Trees are still lacking, the ground layer supports a dense cover of a diverse indigenous flora comprising shrubs, grasses, herbs, orchids and mosses/lichens (a rich structure that is also good wildlife habitat). Such benchmarks help us understand just how much these landscapes have been altered, and just as importantly, how we might be able to turn the tables and begin to restore some of the health and vitality that once characterised the ecosystem.

7. References

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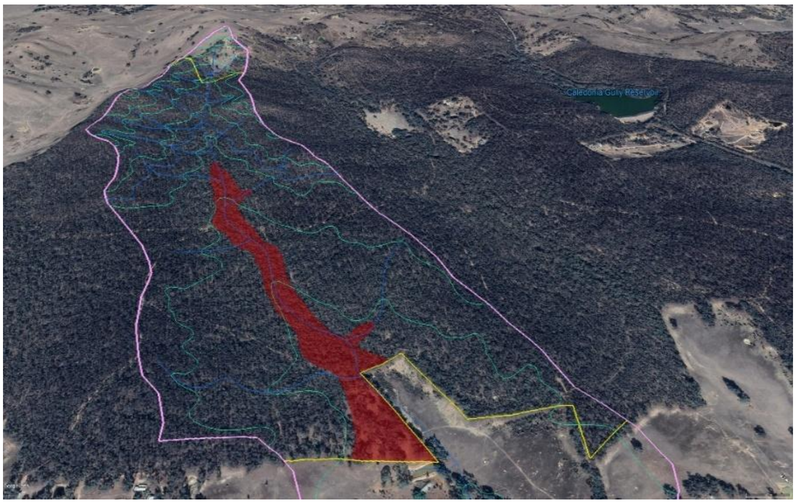
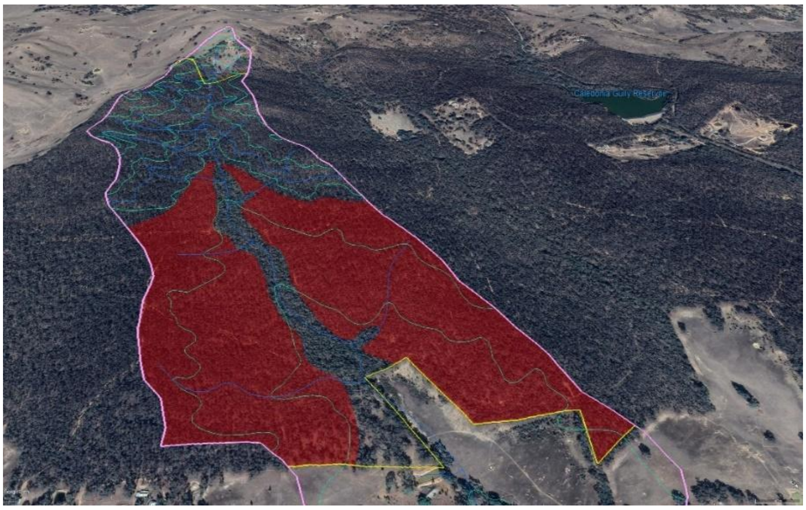
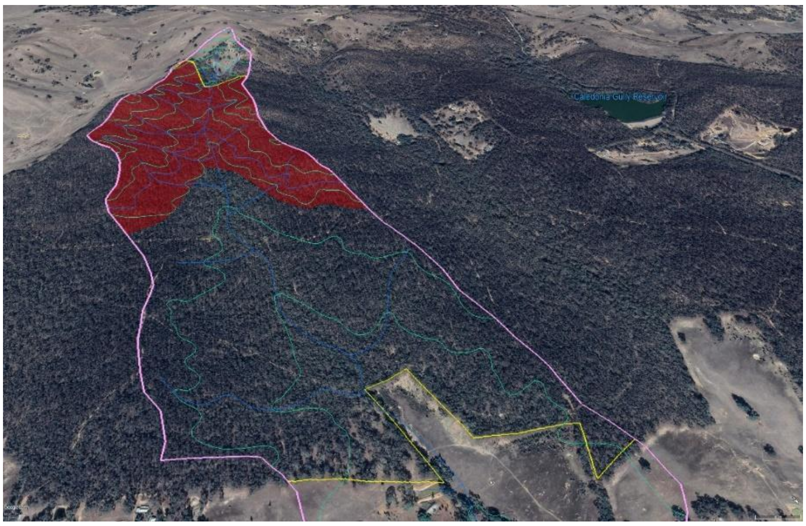
Appendices

Appendix 1: Peter's Gully stratification (3 zones – valley, lower slopes and upper slopes)

	12.25 ha Valley Bottom that broadly corresponds to Creekline Grassy Woodland (EVC 068). However, there is evidence to suggest only one small portion of the middle section of this valley retains vegetation close to its original form – dominated by Red Gum and Yellow Box. The rest of the valley has been largely 'desertified' and is today dominated by Grey Box and eucalypts from the adjoining dry slopes. (see Images 1–4 in Appendix 2)
	72.22 ha Lower Slopes broadly correspond to Box Ironbark Forest (EVC 061) (see Image 5 in Appendix 2).
	53.55 ha Upper Slopes that broadly correspond to Grassy Dry Forest (EVC 020). However, there is evidence to suggest at least some of this vegetation may be closer to the related EVC Grassy Dry Forest (EVC 022) often with a ground layer dominated by Red Anther Wallaby Grass. These upper slopes also have some pockets of Red Ironbark that could be classified as Box Ironbark Forest (EVC 061) (see Image 8 in Appendix 2).

Appendix 2: Selected images (interventions)

Image 1: Gully repair in a more incised section of watercourse below the old Soil Conservation Authority (concrete) structure. Annotations represent construction of numerous minor 'leaky weirs' from regrowth stems and local regolith, consolidated with robust perennial wetland tussocks (Carex spp. etc.)

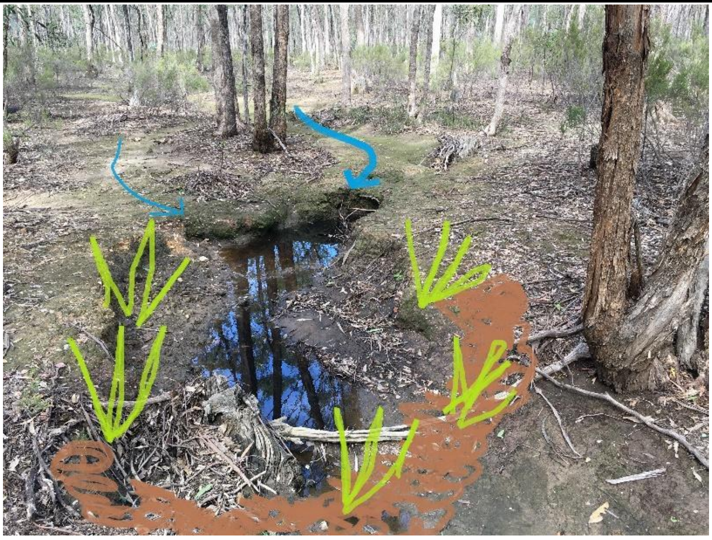


Image 2: Where appropriate augment the numerous existing minor scours along drainage line with regrowth stems and consolidation with robust perennial wetland tussocks (Carex spp. etc.)

Image 3: Where appropriate creation of numerous 'artificial' scours along drainage line with minor excavation, regrowth stems and consolidation with robust perennial wetland tussocks (Carex spp. etc.)

Image 4: Ponding created by old mine shafts in the upper section of valley floor that is thought (ironically) responsible for the persistence of Red Gum and Yellow Box effectively knocked out of the system by gold rush related disturbance. Today the drainage line is dominated by Grey Box. The water ponding serendipitously created by runoff flowing into a cluster of old mine shafts at this location represents the effect the broader hydrological repair intervention aims to replicate throughout the valley bottom.

	
Image 5: Typical lower slopes in Peter's Gully with very small (but often very dense) coppice regrowth stems and variable, often degraded ground layer. The annotations indicate that keyline ripping, ecological thinning and direct seeding robust perennial tussock grasses (Red Anther Wallaby Grass)	**Image 6:** Use of tractor to establish keyline (contour) ripping in regrowth forest with degraded ground layer (i.e. striped top soil, exposed compacted subsoil, sparse understorey) typical of Box Ironbark bushland throughout central Victoria.
	
Image 7: Ecological thinning in degraded regrowth showing the removal of ~50% of the stems (from below – i.e. retaining all the larger stems) dropped manually on the contour over area subject to Keyline ripping. Slope running down to RHS.	**Image 8:** Rocky upper slopes showing similar (often dense) degraded regrowth forest with minimal ground layer vegetation due to both soil loss and persistently high grazing pressure from kangaroos (and to a lesser degree rabbits and deer). Annotations show proposed ecological thinning and likely improvements in sparse understorey with kangaroo population control measures (permitted culling or fencing). Exclosures and scat counts will be used to quantify the impact of grazing pressure.

Image 9: Private land near Hardings Lane with extensive stands of Red Anther Wallaby Grass and one option for seed collection in late spring.

Image 10: A 'natural' seasonal shallow pond in the drainage line in Peter's Gully. These minor depressions capture some run off along or close to the valley bottom that are thought to mimic the original 'chain of ponds' like structure of the pre gold rush valleys. Note the robust sedge (Tall Sedge Carex appressa) growing around the margins.

Appendix 3: Peter's Gully Tracks (Red tracks to be decommissioned?)