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Care for the land, Care for the people, Go forward.

AVON ŌTĀKARO NETWORK

Restoration opportunities assessment for the Avon Ōtākaro Red Zone using a local knowledge approach

Avon Ōtākaro Network

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ERO Report 1
Floodplain restoration principles for the Avon-Ōtākaro Red Zone. Case studies and recommendations.

ERO Report 2
Restoration opportunities assessment for the Avon-Ōtākaro Red Zone using a local knowledge approach.

ERO Report 3
Integrated assessment frameworks for evaluating large scale river corridor restoration.

Copies of the reports are publicly available on the Avon Ōtākaro Network website.

Front cover: Participants at the Ecological Regeneration Options workshop held at Travis Wetland, April 2017.

Photo credit: Shane Orchard

Restoration opportunities assessment for the Avon Ōtākaro Red Zone using a local knowledge approach

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Avon Ōtākaro Forest Park and Greening the Red Zone

LIST OF ABBREVIATIONS

AOFP	Avon Ōtākaro Forest Park
AORZ	Avon-Ōtākaro Red Zone
AvON	Avon Ōtākaro Network
ERO	Ecological Regeneration Options
GIS	Geographic Information System
GtRZ	Greening the Red Zone
NZVD	New Zealand Vertical Datum 2016
PPGIS	Public Participatory Geographic Information System

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Following the Canterbury earthquake sequence of 2010-11, a large and contiguous tract of vacated 'red zoned' land lies alongside the lower Ōtākaro / Avon River and is known as the Avon-Ōtākaro Red Zone (AORZ). This is the second report in the Ecological Regeneration Options (ERO) project that addresses future land uses in the AORZ.

The purpose of this report is to present results from an assessment of restoration opportunities conducted in April 2017. The objectives of the assessment were to identify potential benefits of ecological restoration activities across both land and water systems in the AORZ and characterise the key options for their implementation. The focus of this report is not to provide specific advice on the methods for achieving specific restoration endpoints *per se*. This will vary at different sites and scales with a large number of combinations possible. Rather, the emphasis is on providing an overview of the many restoration and regeneration options in their totality across the AORZ. An additional objective is to support their adequate assessment in the identification of optimum land uses and adaptive management practices for the AORZ.

Participatory processes may play a useful role in assessment and stakeholder engagement by providing opportunities for social learning and the co-creation of new knowledge. We used a facilitated local knowledge based approach that generated a large quantity of reliable and site specific data in a short period of time. By inviting participation from a wide knowledge-holder network inclusivity is improved in comparison to small-group expert panel approaches. Similar approaches could be applied to other information gathering and assessment needs in the regeneration planning process.

Findings from this study represent the most comprehensive set of concepts available to date to address the potential benefits of ecological regeneration in the AORZ. This is a core topic for planning to avoid missed opportunities and opportunity costs. The results identify a wide range of activities that may be applied to generate benefits for Christchurch and beyond, all involving aspects of a potential new ecology in the AORZ. These may be combined at a range of scales to create scenarios, quantify benefits, and explore the potential for synergies between different land use options.

A particular challenge is acquiring the information needed within relatively short time frames. Early attention to gathering baseline data, addressing technical knowledge gaps, and developing conceptual frameworks to account for the many spatio-temporal aspects are all key activities that will assist in delivering the best outcomes. Methodologies by which these many facets can be pulled together in quantitative and comparative assessments are the focus of the final report in the ERO series.

1. Introduction

Regenerations options project

The sequence of strong earthquakes experienced in Canterbury during 2010-2011 caused widespread damage and included four earthquakes exceeding magnitude M_W 6.0, all on previously unrecognised faults (Beavan et al., 2012). Surface deformation effects included liquefaction, lateral spread, subsidence, cliff and bank collapse, rockfall and alterations to hydrological regimes (Allen et al., 2014; Quigley et al., 2016). Responses to earthquake damage included government acquisition of many thousands of residential properties in the city of Christchurch in areas with severe earthquake effects. A large and contiguous tract of this 'red zoned' land lies in close proximity to the Ōtākaro / Avon River and is known as the Avon-Ōtākaro Red Zone (AORZ) (Figure 1-1).

The Ecological Regeneration Options (ERO) project has been developed by Avon Ōtākaro Network (AvON) in collaboration with Avon-Ōtākaro Forest Park (A-OFP) and Greening the Red Zone (GtRZ) to support planning for the future uses of the AORZ. Since the earthquakes, many community-based groups have developed projects or proposals for land uses in the AORZ and collectively these initiatives have mobilised a high level of interest in planning for the future of the area. A key objective of the ERO project is to encourage and facilitate comparisons between ecological restoration opportunities and other land-use proposals. There is also an unprecedented opportunity to develop alternatives to the historical land use pattern in keeping with the changed circumstances, and to explore synergies between potential land-use options. A particular focus is on supporting the Integrated Assessment and 'Better Business Case' evaluations proposed as part of the regeneration planning process being led by Regenerate Christchurch (Regenerate Christchurch, 2017). Better knowledge of restoration opportunities will also inform many of the emerging proposals for future uses of the AORZ.

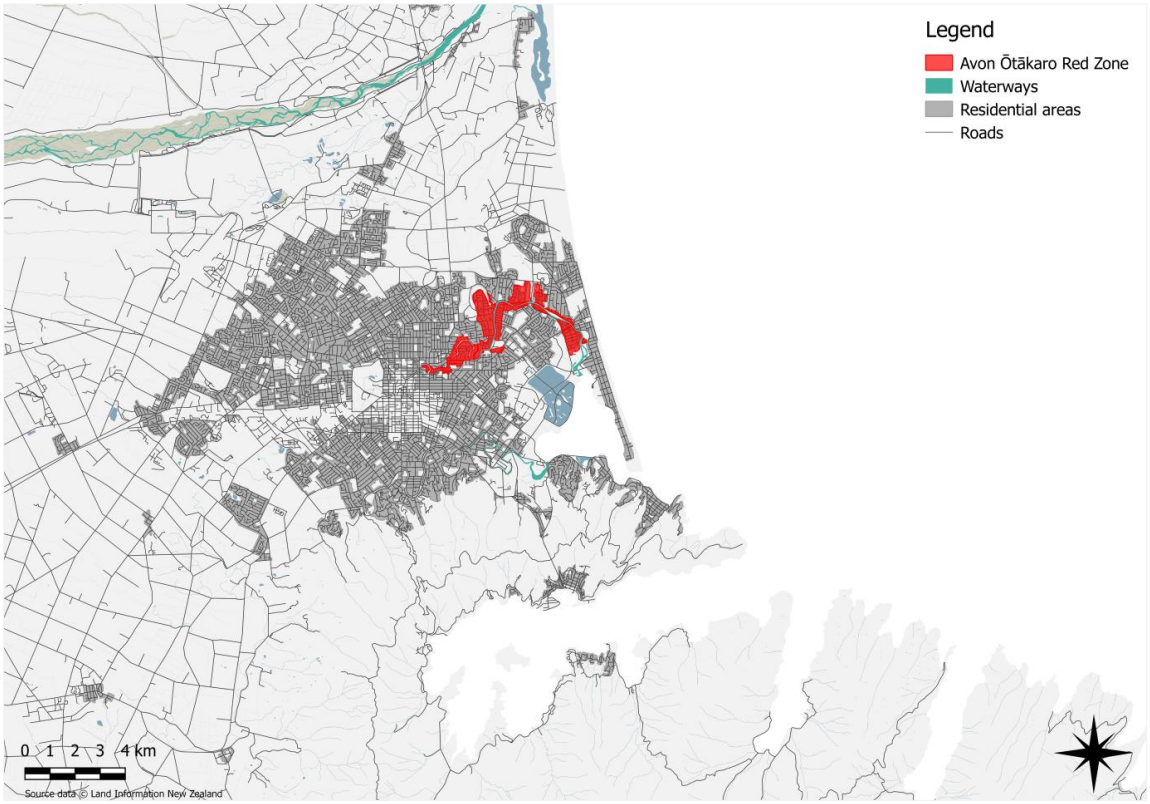

Figure 1-1. Location of the Avon-Ōtākaro Red Zone in Christchurch, New Zealand.

The three components of the ERO project are:
(i) a review of the floodplain characteristics of the AORZ, including consideration of potential inundation effects under sea level rise and synthesis of key principles for the identification of floodplain restoration opportunities, (ii) an assessment of restoration endpoints that are desirable and practical, together with strategies by which they may be achieved (this report), and (iii) a review of methods for assessing the benefits of restored ecosystems across multiple values in the context of the current regeneration planning process.

Floodplain characteristics

The focus of the first ERO project report was to provide an overview of the floodplain characteristics of the AORZ and review of international experience in ecological restoration of similar river margin and floodplain ecosystems to extract restoration principles and associated learnings (Orchard, 2017). Compared to pre-earthquake ground levels, the dominant trend in the AORZ is subsidence, together with lateral movement especially in the vicinity of waterway channels (Allen et al., 2014; Hughes et al., 2015; Quigley et al., 2016). A consequence of land subsidence in the lower Ōtākaro / Avon River is greater exposure to flooding including coastal inundation and the effects of sea level rise (Orchard, 2017).

Compared to pre-earthquake ground levels, the dominant trend in the AORZ is subsidence, together with lateral movement especially in the vicinity of waterway. An important consequence of land subsidence in the lower Ōtākaro / Avon River is greater exposure to flooding and the effects of sea level rise. Scenario modelling for sea level rise indicates that much of the AORZ is exposed to inundation within a 100 year planning horizon based on a 1 m sea level rise. As with decisions on built infrastructure, investments in nature-based 'green infrastructure' also require a sound business case including attention to risks posed by climate change. Future-proofing of the expected benefits of ecological restoration must therefore be secured by design.

Key conclusions from the first ERO report (Orchard, 2017) included:

- There are internationally proven strategies available for hydrological and ecological restoration in the AORZ. These approaches are consistent with a city-to-sea philosophy for river corridor regeneration that accommodates ongoing dynamics including ecological succession, climate change, and resilience to sea level rise.

- Due to the difficulty of producing accurate *a priori* predictions of complex eco-hydrological relationships and expectations for restoration and successional change, an adaptive management approach is recommended.

- A feature of prominent and successful river corridor restoration projects has been the assembly of a core science and information management team able to support and guide the development and implementation of an adaptive management approach. Local and traditional knowledge, practitioner know-how, and technical expertise in ecosystem-based management and the restoration ecology of key taxa are some of the recommended knowledge and skill sets for inclusion. Attention to governance, outreach, science communication, and citizen science activities are additional dimensions that can support the successful implementation of adaptive management in practice.

- Comparative evaluation of restoration options can occur at many different points within an adaptive management cycle to facilitate decision-making. These assessments may help refine or select a short list of options at strategic decision points before committing resources to greater levels of detail. These aspects may be readily included in the proposed Integrated

Assessment activities and Better Business Case evaluations being developed to support the regeneration planning process for the AORZ.

- An adaptive approach can accommodate experimental trials, pilots and innovative demonstrations at small scales to inform the design and planning of larger scale initiatives.

- Close proximity to the central city provides many opportunities for community engagement, education, and experiential activities to feature prominently in the development, design, and implementation of restoration strategies. These have been shown to be the source of beneficial outcomes in other successful projects, including through the socialisation of restoration objectives, and by encouraging participation, buy-in, and ownership of the new management paradigms that may be implemented.

- The process of developing and implementing an adaptive management strategy may itself be a significance source of benefits in relation to overall achievement of project objectives. Attention to, and development of this process is an important component of identifying specifications for ecological restoration in the AORZ, consistent with a socio-ecological systems approach to managing common-pool natural resources. The objective of developing and implementing optimum restoration and regeneration activities lies at the centre of this process and is dependent on it.

- Ecological restoration activities in the AORZ offer an unprecedented opportunity to address national priorities including the remediation of legacy effects on lowland biodiversity and associated cultural values. Through attention to design and integration between compatible activities and co-uses, ecological restoration can be achieved alongside, or incorporated within other beneficial land use options.

Restoration opportunities

The purpose of the current study comes from the need to identify specific restoration opportunities and benefits to facilitate their consideration in comparative assessments of potential land uses. This requires the recognition and characterisation of restoration endpoints that are desirable and practical, together with specification of strategies by which they may be achieved. In addition to a focus on floodplain restoration, there are also areas in AORZ for which inundation is less of an issue due to higher ground surface elevations (Figure 1-2). These areas include the foot-slopes and terraces of older plains ecosystems and several locations where old dune systems are the underlying landform. Restoration opportunities in all of these areas were considered within this study.

Results from the previous study were used to inform the methodology for this restoration opportunities assessment. These results suggested that a multi-disciplinary team including practical know-how and local and traditional knowledge would offer advantages for achieving the key objectives. As identified in other restoration projects, the benefits of a participatory approach inclusive of local knowledge may include interpreting and understanding legacy degradation issues, making use of practical experience, and supporting linkages with local stakeholders with interests in the site and its management (Orchard, 2017). Building upon this approach through time may offer further benefits in terms of supporting iterative assessments that inform adaptive management cycles (Habersack et al., 2015; Koebel & Bousquin, 2014; Moss, 2007). For these reasons the assessment reported here can be considered an initial step of many in the development of restoration strategies that address the opportunities.

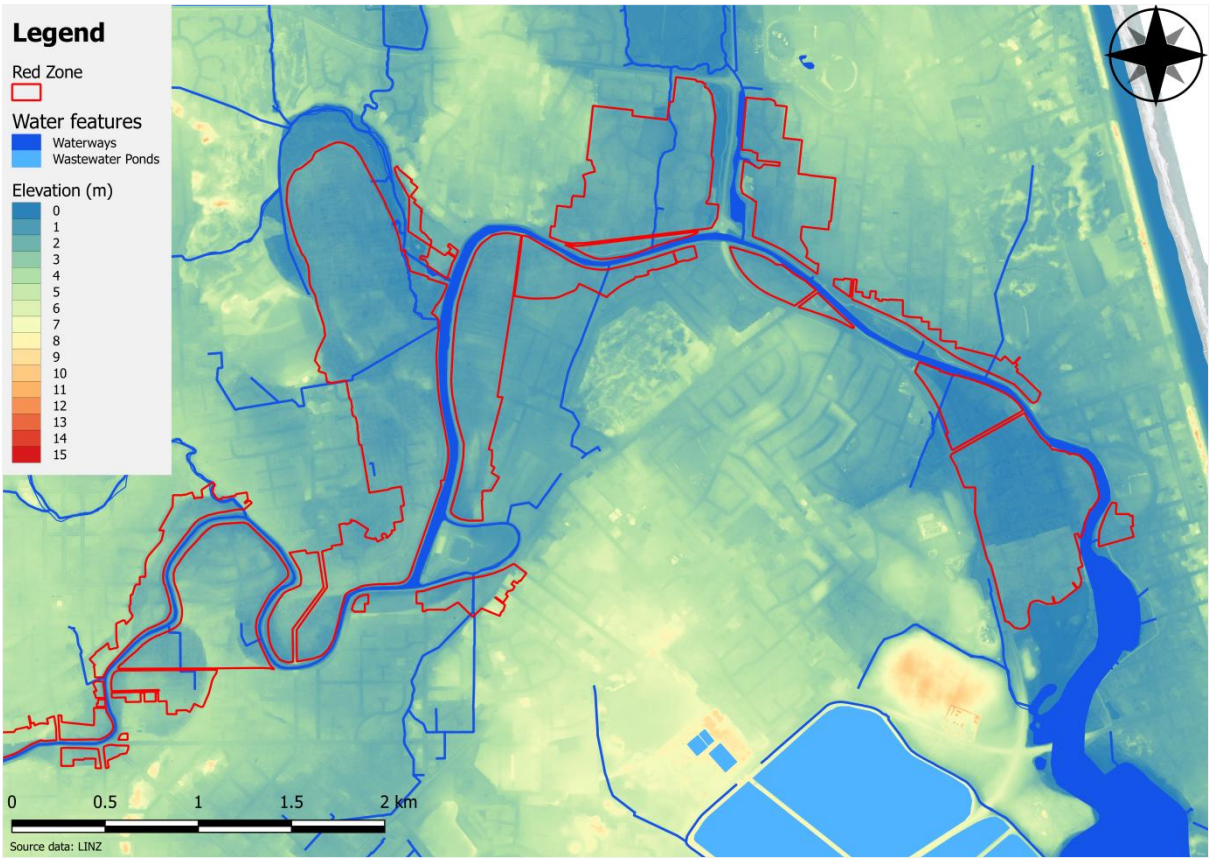

Figure 1-2. Ground surface elevations in the vicinity of the AORZ relative to NZVD derived from 2015 LiDAR data.

Objectives

The key objectives of this study are to contribute to the ERO project by: (a) identifying potential benefits of ecological restoration activities within the AORZ across both land and water systems, (b) characterisation of the key options for their implementation, (c) perspectives on information gaps, risks, and assumptions, and (d) recommendations for addressing these and developing robust methodologies for comparing different land use options in the AORZ.

2. Methodology

Spatial framework

Identifying effective restoration strategies ultimately relies on applying human preferences and appropriate ecological restoration techniques to different objectives and specific sites. Place-based methods can offer a useful framework to facilitate and orient the collection of information to address these needs (Norton & Hannon, 1997). Similarly, place-based frameworks may be used in hierarchical ecosystem and habitat classification schemes and applied to develop sampling strategies for monitoring programmes to support adaptive management. This helps to create a structured approach to information collection by encouraging attention to the specific place of interest whilst also supporting cross-boundary thinking at different scales (Olson et al., 2011). Determining the appropriate level of resolution requires consideration of the spatial and temporal characteristics of the values of interest and is partly dependant on the range of scales at which value intensity is important (Nielsen-Pincus, 2011).

For our purposes, we sought information on a range of perceptions that would collectively identify and define opportunities and implementation strategies in sufficient detail to facilitate comparative assessment of their benefits. Constraints in our process included the availability and time limitations of participants and the need to characterise opportunities across the whole study site. To address this we developed a site-wide spatial framework derived from a two-tiered consideration of the major physical drivers of ecosystem structure and pattern. This simple classification identifies hydrology and substrate type as the major influences on structure and function of ecological communities in the AORZ (Table 2-1). We refer to the resultant Tier 1 classes as hydrosystems in the sense of linked hydrologic-land systems, as used by Johnson & Gerbeaux (2004) within their scheme for wetland classification, and Hume et al. (2016) in a recent classification of New Zealand estuaries. These drivers are of course able to be modified by human intervention.

Table 1 describes four hydrosystem classes found in the AORZ using this approach. The spatial distribution of these (Figure 2-1) shows that they collectively cover all of the AORZ. Other hydrology-substrate combinations may be recognised through further subdivision and may be useful for the development of a more detailed habitat classification scheme. Other classification systems are also available (e.g. Johnson & Gerbeaux, 2004; Lucas et al., 1997; Lucas Associates, 2011). However, strengths of developing an inductive place-based approach to classification include the emphasis on site interpretation, that may be overlooked in deductive approaches (Kruger & Jakes, 2003), and a focus on land-water boundaries and other ecotones that may not readily fit with more generic class descriptions.

Table 2-1. Classification of areas within the AORZ based on a hydrosystems approach.

Tier 1 Hydrologic characteristics	Permanent and regular inundation – aquatic & intertidal	Periodic (non-tidal) inundation - floodplain & freshwater margins	Mesic soils	Dry soils
Tier 2 AORZ Substrates	wet & salty Motukarara soils wet Waimairi & Aranui soils underlying waterway channels	wet Waimairi, Aranui & Taitapu soils	moist Kaiapoi soils	Waikuku & Kairaki deep sands Waimakariri fine sandy loam dry gravels
AORZ areas meeting classification	Waterway channels, saltmarsh & brackish margins	Floodplain swamp & forest	Floodplain terraces & footslopes	Dune remnants, dry forest, gravel fill & stopbanks

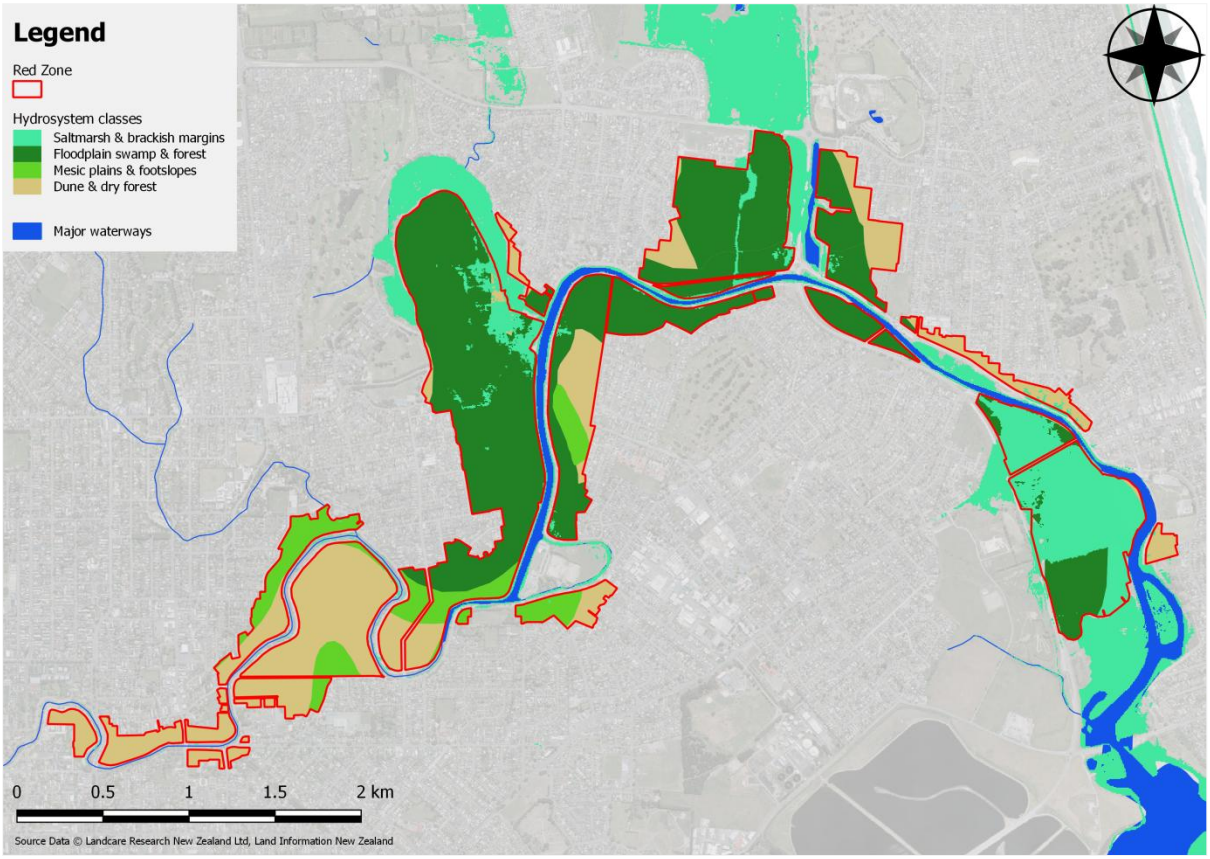

Figure 2-1. Spatial extents of the classification described in Table 2-1 in relation to the AORZ.

To support the participatory process and address time constraints a decision was made to combine the mesic and dry hydrosystem classes since these occup a relatively small percentage of the site. The resultant three classes formed the framework used to develop supporting material for the group activities and facilitation techniques in the workshop programme. To promote a common understanding of the three areas to be addressed we assigned them everyday names to avoid technical jargon (Table 2-2). Maps showing the location and extent of these areas within the AORZ were produced in various formats (Appendix A-1) for the workshop and survey question forms.

Table 2-2. Final spatial framework applied to design of the focus group workshop process and survey forms.

Class name	Wet & salty	Floodplain swamp & forest	Higher & drier
Hydrologic characteristics	Regular inundation – aquatic & intertidal	Periodic (non-tidal) inundation	Mesic & dry
AORZ Substrates	wet & salty Motukarara soils wet Waimairi, Aranui & Kaiapoi soils underlying waterway channels	wet Waimairi, Aranui & Kaiapoi soils	moist Kaiapoi soils Waikuku & Kairaki deep sands Waimakariri fine sandy loams Gravel fill & stopbanks
Example ecosystem types	Aquatic & emergent plant communities Saltmarsh Brackish margins	Floodplain swamp Floodplain forest Freshwater riparian margins	Mesic forests on floodplain terraces & foot-slopes Old coastal dune forest Dry forest Dryland shrub communities

Participatory process

Focus group workshop

The sample includes four target groups which we refer to as researchers (current or retired), government/local government technical staff, local restoration practitioners including local government operational staff (e.g. park rangers), and local community or traditional knowledge holders. The distinction between groups was made on the basis of current workplaces. Restoration practitioners were defined as people who were often involved in hands-on restoration projects, typically as contractors. Researchers and technical staff were separated from practitioners on the basis of their major activity being research or advisory activities, despite that they might also perform some on-the-ground work at times. Local community or traditional knowledge holders were defined as people involved or knowledgeable in aspects of ecological restoration and natural resource management that were not currently employed in those fields, and were not retired academics.

The invitation process followed a purposive sampling strategy designed to ensure inclusion of these key knowledge-holders (Brown & Kytta, 2014) and was successful in achieving participation from all of these groups. An invitee list was compiled over a period of three weeks using a snowballing strategy (Goodman, 1961) beginning with contacting key knowledge holders in the local community in person to inform them of the study and workshop event. In addition to prior personal contact, a formal invitation to participate was sent by email on 1 April 2017 to a list of 87 potential participants representing 33 local organisations and additional individuals. Invitations to organisations included an invitation for any interested staff or colleagues to attend. RSVPs were encouraged and resulted in several positive responses from people interested in the event though unable to attend on the day. Input from these people was invited through a separate survey-based method (see below).

Information gathering methods used at the workshop included semi-structured survey questions presented on information collection forms, and non-structured group exercises making use of a range of interactive documentation methods including preparation of diagrams, flow charts and summary notes. Additional data was collected through photographic documentation of written sheets and by a note-taker. The semi-structured questionnaire consisted of six questions on potential benefits, and four questions on potential strategies for implementation (Table 2-2). Development of the final set of questions was assisted by the preparation of draft versions of the survey questions and information collection form circulated to a reference group for consideration and feedback.

Table 2-2. Content of survey questions and order of presentation in the focus group workshop**.**

Content of questions
Questions on potential benefits of ecological restoration – Environmental benefits – Social benefits – Cultural benefits – Economic benefits – Resilience benefits – What produces them? (specific restoration opportunities)
Questions on how the opportunities can be created – optimum strategies and their components – timelines – information gaps – risks & assumptions
Order of presentation
1. Wet & salty areas (waterway channels, saltmarsh & brackish margins) 2. Higher & drier areas (mesic plains, foot-slopes, dunes & dry forest) 3. Floodplain areas (swamp & forest)

The workshop attendees were divided into two groups that independently addressed the tasks presented and reported back to plenary sessions. Each group was composed of a mixture of attendees of different backgrounds. Attendees also moved around between sessions and some new people arrived part way whilst others left early. Data was captured from each of the two group processes separately to investigate the commonality of ideas or repeat themes. The survey questions were introduced following a semi-structured group interview format (Yin, 2003) with the assistance of a PowerPoint presentation, preceded by background information on the study and research objectives. The same set of questions was addressed for each of the three broad spatial areas of interest as defined by the hydrosystems classification following a brief introduction to the post-quake characteristics of each based on recent field studies. Repeat cycles of the enquiry process, used to address each topic in turn following a consistent format (Table 2-2). However, a greater time period was allocated to addressing the questions for the floodplain class (70 minutes in total) in recognition of the complexity of major habitats and ecotones typical of this environment.

Group facilitation techniques included world-cafe style brainstorming and group report-back to gather and synergise a range of perspectives. This was complemented by a three round Delphi process (Linstone & Turoff, 1975) to address questions on how the benefits could be created. This iteratively refined potential implementation strategies for promising restoration opportunities. A separate focus group exercise was conducted to capture perspectives on the integration of opportunities and strategies across the entire AORZ, ecological succession issues, and other risks, assumptions and knowledge gaps that could produce barriers to successful implementation. The two separate groups used in the workshop format working mostly independently with the exception of the Delphi process.

Survey

To complement the workshop we provided an electronic survey option to encourage and enable additional participation from people who could not attend. The survey period ran for 14 days from April 15 to April 29. Respondents who had indicated interest in the survey in their original RSVP were contacted in person. In addition, survey materials were sent to the full invitee list two days after the workshop together with a cover letter. This provided an opportunity for workshop participants to also use the survey form to submit additional information if desired and a second opportunity to make contact with others who had not previously responded. The survey questions were the same as those presented at the workshop on the information collection forms. Supporting information included the same maps and descriptions of the spatial framework used to define the three (hydrosystem) areas of interest, together with background information on the study and its objectives.

Data analysis

Textual information captured from all sources was compiled into spreadsheets to facilitate coding and content analysis and diagrams captured by digital photography. Text data were initially coded by assigning category labels to related subjects following Kitchin & Tate (1999). In a second stage, categories were combined or subdivided to reflect the recurrence of similar topics in different data sources, and to identify the major themes that organize or connect groups of ideas. Descriptive and summary statistics were used to characterise the resultant categorical data and pattern in relation to the survey questions.

3. Results

Participation

The participant group (n=30) included 21 workshop attendees and 9 survey respondents. The overall response rate as a percentage of individual invitations was 34.9% (Table 3-1). The response rate from organisations was 63.6% including five local businesses with experience in ecological restoration work and an additional 13 other organisations with one or more representatives participating. The generally high response rate indicated a high level of interest in the study and greatly strengthened the knowledge pool available to the study. The number of participants was higher than expected given that the workshop date and time commitment proposed was a compromise of short time frames and the availability of people.

Each of the four target groups was well represented in the study meeting the objectives of the purposive sampling strategy (Table 3-1). Although the response rates varied between groups as expected, the resulting sample was well balanced. Local practitioners were the best represented group (12 people), followed by local community & traditional knowledge holders (8), researchers (5), and government / local government technical staff (5). Although the assignment of people to target groups was made on the basis of their current employment, many of the practitioners, researchers, and local government participants are also members of community-based restoration projects on the ground. As a result, the sample reflects an extensive pool of knowledge and experience specific to local conditions that goes beyond their current workplace.

Further information on the stakeholder groups represented is provided in Appendix A-2.

Table 3-1. Response rates and participation.

(a) Response rates

Participants	Invitations	Participation	Response rate (%)
Local organisations	33	21	63.6
Local businesses	7	5	71.4
Individual invitations	**86**	**30**	**34.9**

(b) Participation from target groups

Target group	Invitations	Workshop attendees	Survey responses	Total responses	Contribution to response rate	Percentage of total reponse
Researchers (current or retired)	8	4	1	5	5.8%	16.7%
Government / local government technical staff	18	4	1	5	5.8%	16.7%
Local practitioners	23	9	3	12	14.0%	40.0%
Local community & traditional knowledge holders	37	4	4	8	9.3%	26.7%
Totals	**86**	**21**	**9**	**30**	**34.9%**	**100.0%**

Ecological regeneration scope and benefits

The first stage of the benefits analysis asked participants to identify major benefits that could be achieved by ecological restoration activities permitting a wide interpretation of the many forms of restoration (that may include aspects of ecological engineering provided the outcomes improved natural values). There was a moderate degree of repetition across the three data streams but each stream also produced additional new information that was not found elsewhere. The resulting dataset (n = 165) demonstrates that there is considerable potential for ecological restoration in the AORZ across a wide range of activities. In the first round of content analysis 73 categories were identified in the combined dataset, each of which relates to the potential benefits of ecological restoration in the AORZ (Table 3-3). The benefits categories with the highest frequency was *connection with nature* (n = 9) followed by *habitat for flagship species* (n = 6), and *cultural values*, *ecotourism*, *recreational fisheries*, and *seed sources* (n = 5) (Table 3-2). These data may also be grouped by hydrosystem to identify the categories that were represented in the data generated for each area, and to identify the recurring categories that have wider applicability (see Appendix A-3).

In thematic analysis, the benefits categories were combined in various ways to identify clusters of related ideas. An example benefits classification is shown in Table 3-3. This identifies 27 themes in relation to the 73 categories of benefit coded to the full dataset (n = 165) of individual responses from study participants.

Consistent with the underlying data, there are different numbers of categories within each of the identified themes (Table 3-4). The biodiversity theme has the largest number of component categories (n=10). This likely reflects the purposive sampling strategy which targeted local ecological knowledge-holders, and the major topic for the study being the ecological aspects of regeneration in the AORZ. However, there are many other aspects of ecological regeneration activities, as shown by the diversity of the themes identified. Collectively these cover all of the four well-beings and resilience, as was expected in response to the survey question prompts on these topics. Considerable additional detail can also be identified in relation to each of these topics. Notable recurring themes included educational and experiential benefits, cultural values, and visitation, and in addition to the benefits related to biodiversity and the restoration natural values in the AORZ (Table 3-4).

Figure 3-1. Local knowledge in action at the Ecological Regeneration Options workshop.

Table 3-2. Potential benefits that could be achieved by ecological restoration as perceived by participants and frequency of each category in the dataset. Combined data for all areas in the AORZ (n = 165).

Potential benefits	Frequency
adjacent land values	4
aquaculture	1
attract business	1
awareness of history	2
awareness of natural processes	3
awareness of natural values	2
branding of Christchurch	3
carbon credits	1
carbon sequestration	3
commercial fisheries	2
community engagement & volunteerism	1
connection with nature	9
connections with history	4
cultural tourism	1
cultural values	5
drinking water supply protection	2
ecological connectivity	1
ecotourism	5
education	3
employment	1
event spaces	1
exemplar value	4
experience of nature	3
fibre	2
fisheries	2
fishing tourism	1
flood mitigation	2
food resilience	1
forest bathing	1
habitat connectivity	2
habitat for flagship species	6
habitat increased	5
halo effect	1
improved access via land & water	1
improved aesthetics	1
improved safety of wild foods	1
improved water quality	2
land & water access modes	1
low site maintenance	1
mahinga kai	1
mental health benefits	4
mental resilience	2
natural hazards buffering	2
novel design opportunities	2
pa harakeke	1
physical health benefits	3
pollution removal	1
protection of natural springs	1
rare taxa	1
recreational opportunities	2
recreational fisheries	5
reduce habitat for geese	2
reduced edge effects	1
reduced urban heat effect	1
research value	1
restored hydrology	4
restored natural processes	7
sediment capture	3
seed sources	5
sense of place	4
sensitive taxa	1
service business opportunities	1
social learning	2
stormwater management	1
sustainable forestry	1
swimmability	1
tangata whenua values	1
tau koura	2
visitor attractions	1
water quality	1
watersports	1
wild harvest	3
wildlife	4
Total responses	**165**

Table 3-3. Example typology derived from thematic analysis of the potential benefits of ecological restoration in the AORZ (n = 165).

Environmental	biodiversity	habitat increased - habitat connectivity - wildlife - habitat for flagship species - rare taxa - sensitive taxa - halo effects - reduced edge effects - seed sources - reduced habitat for geese
	restored natural values	restored natural processes - restored hydrology - protection of springs - reduced urban heat effect - ecological connectivity
	water quality	improved water quality - pollution removal - sediment capture
Social	access	improved access via land & water
	aesthetics	improved aesthetics – novel design opportunities
	educational - experiential	educational opportunities - experience of nature - connection with nature - awareness of natural values - awareness of natural processes - social learning
	health benefits	physical health benefits - mental health benefits
	recreation	recreation opportunities - watersports - swimmability
	stormwater management	stormwater management - flood mitigation
	water supply	drinking water supply protection
Cultural	community identity - sense of place	sense of place - community engagement & volunteerism
	cultural values	cultural values - tangata whenua values - mahinga kai - pa harakeke & mara rongoa - tau koura
	heritage & history	awareness of history - connections with history
	wild harvest	wild harvest opportunities - fibre - safety of wild foods
Economic	adjacent land values	adjacent land values
	avoided costs	low site maintenance - forest bathing value
	branding & marketing	branding of Christchurch
	business opportunity	service business opportunities - attract business
	carbon	carbon sequestration - carbon credits
	employment	employment
	fisheries & aquaculture	fisheries - commercial fisheries – aquaculture - recreational fisheries
	forestry	sustainable forestry
	visitation	ecotourism - cultural tourism - fishing tourism - visitor attractions - event spaces
Resilience	food resilience	food resilience
	mental resilience	mental resilience
	natural hazards buffering	natural hazards buffering
	research & exemplar value	research value - exemplar value

Table 3-4. Recurrence frequency and component categories for the themes identified in Table 3-3.

Themes	Recurrence frequency of theme	Number of component categories
biodiversity	31	10
educational - experiential	18	6
restored natural values	15	5
cultural values	14	5
visitation	13	5
fisheries & aquaculture	9	4
research & exemplar value	7	2
water quality	7	4
wild harvest	7	3
heritage & history	6	2
adjacent land values	4	1
carbon	4	2
recreation	4	3
avoided costs	3	2
branding & marketing	3	1
health benefits	3	2
aesthetics	2	2
business opportunity	2	2
community identity - sense of place	2	2
mental resilience	2	1
natural hazards buffering	2	1
stormwater management	2	2
access	1	1
employment	1	1
food resilience	1	1
forestry	1	1
water supply	1	2
Total	**165**	**73**

Implementation strategies and components

The first stage of the implementation analysis asked participants for perspectives on the range of strategies that could be applied to achieve the key opportunities identified in the benefits assessment. The resulting dataset (n = 298) describes many aspects of successful implementation of regeneration strategies within the AORZ based on knowledge and practical experience of the site and conditions.

A total of 180 categories of ideas were coded to this dataset. Results for the combined dataset are shown in Table 3-5. Collectively, this set of ideas specifies the activities that are required to define and achieve the ecological regeneration potential of the AORZ. In particular, these components may be used to develop quantitative specifications for various parts of the AORZ by identifying the combinations of these activities required to achieve the desired objectives.

Table 3-5. Components of implementation identified in the combined datasets for all areas in the AORZ (n = 298).

Potential benefits	Frequency
Acknowledge previous history	2
Acknowledge previous residents	1
Adaptive approach	1
Adaptive management framework	1
Address knowledge gaps	1
Allow buildings that complement ecological restoration	1
Allow compatible mixed uses	2
Allow for bank erosion	1
Allow for climate change and sea level rise	2
Alter stopbanks	4
Assess upper catchment effects	1
Assess water quality needs and constraints	1
Attract offshore interest	1
Baseline investigation	9
Baseline mapping	2
Baseline modelling	1
Begin sourcing of slow growing species soon	2
Bio-remediation of contaminated land	1
Birds	3
Celebrate models of good practice and success stories	1
Change community attitudes to waterways	1
Change public attitudes on natural transitions	4
Combined nurseries growing seed/plants for other sites	1
Competing values assessment	4
Conceptual models	1
Consider use of sediment traps	1
Contaminated land remediation technologies	1
Control invasive species	4
Create linkages with corporates	2
Create linkages with non-profit groups	1
Create roosting spaces for birds	3
Create space for natural river processes	2
Daylighting of piped stormwater infrastructure	2
Design for resilience	1
Design for succession	1
Desirable and indicator species	1
Develop aesthetic gains	2
Develop community nursery model	1
Develop cultural tourism opportunities	1
Develop early wins	1
Develop educational aspects	3
Develop exemplars and showcases	2
Develop incentives for the community to be involved in monitoring	1
Develop opportunities for volunteerism	2
Develop outreach programme	1
Develop research opportunities	1
Develop strategies for participation	3
Develop transitional uses	1
Early wins	1
Educate contractors on site values	2
Encourage and support community restoration efforts	1
Encourage awareness of land use impacts on waterways	2
Encourage built infrastructure design to reduce stormwater impacts	2
Encourage compatible mixed uses	1
Encourage local ownership	2
Encourage options for mixed land uses	1
Encourage river care groups	1
Encourage use of constructed wetlands and swales for stormwater treatment	2
Enhance hydrologic connectivity	1
Enhance hydrologic variation	6
Enhance in-stream habitat variation	1
Enhance variation in waterway morphologies	4
Ensure building setbacks from waterways	1
Establish virtual reference material for engagement	1
Explore economic aspects of restoration opportunities	1
Explore IP opportunities	1
Extract learning from previous experience	1
Facilitate opportunities for citizen science	1
Facilitate seed collection	1
Fence sensitive areas	1
Fish	1
Focused maintenance around remnants and planted nodes	1
Funding models	3
Governance models	3
Habitat for key fauna	4
Hydrodynamic modelling	1
Hydrology	1
Identify commercial opportunities	1
Identify learning from global examples	1
Identify learning from local examples	2
Impact assessment	2
Improve filtration of run-off	4
Improve microhabitats using shelter	1
Improve shading of waterway margins	2
Improve stormwater treatment	3
Include interim uses	2
Include understory in small species	1
Include value to future generations in assessment of benefits	1
Incorporate community gardens	1

Incorporate community orchards	1
Incorporate event infrastructure	1
Incorporate forestry co-uses	1
Incorporate nursery activities	2
Incorporate recreational uses	1
Incorporate tourism co-uses	1
Incremental changes	1
Insects	2
Integrate access & recreation	1
Invasive species distribution and risks	2
Investigate aquaculture opportunities	1
Investigate camping/glamping co-uses	1
Investigate carbon business opportunities	2
Investigate carbon gains potential	2
Investigate cemeteries as a co-use	1
Investigate dark sky and light show co-uses	1
Investigate health benefits	1
Investigate land ownership and management structures	1
Investigate previous history	1
Iwi engagement	3
Keystone species	1
Landscape alteration	1
Landscape manipulation options	1
Large scale planting designs	1
Local examples	3
Lookout towers to enhance experience	2
Maintenance plan	1
Make linkages to potential labour sources	1
Map earthquake change	1
Map locations of existing infrastructure	1
Mapping	1
Modelling	1
Modify hydrology	2
Monitoring	5
Monitoring of hydrology	1
Naturalisation of boxed drains	1
Nodal planting to assist species dispersal	2
Passive restoration	2
Pests	1
Planning	2
Plant a range of sites	1
Plant riparian vegetation	3
Planting	3
Planting designs and motifs to tell a story	1
Pollutants	2
Prioritise low cost high impact activities	1
Promote a diversity of recreational access modes	1
Protect īnanga spawning habitat	1
Provide habitat for flagship species	1
Provide interpretation for visitors	2
Provide interpretation information for visitors	1
Provide multiple forms of access to natural environments including waterways	1
Raise awareness of NZ species conservation	2
Rare species sanctuaries as a draw card	1
Reconnect the river to the flood plain	1
Recreation	1
Reduce land drainage efforts	1
Reduce pollution at source	2
Remediate contaminated land	1
Remote sensing of wildlife	1
Remove any barriers to fish migration	1
Restore local scale up to catchment scale	1
Retain deadwood and litter	1
Retain existing vegetation	2
Sand wanding	2
Scenario modelling and impact assessment	4
Secure stable funding streams	1
Sediments	1
Soften edges	1
Soil	1
Stable funding streams	1
Staged approach to implementation	2
Stakeholder analysis	1
Stakeholder engagement	7
Stakeholder identification	3
Stop mowing	2
Strategic use of intensive treatments alongside passive elsewhere	2
Support cultural values	1
Target investment at flagship species	1
Use eco-sourced plants	1
Use modern IT technology to connect with youth	2
Use permeable paving options for hard surfaces	1
Utilise local knowledge	2
Utilise participatory approaches	2
Values mapping	1
Wastewater system technologies	1
Water quality & waterway monitoring	1
Water resource info gaps	1
Weeds	2
Wide community engagement	5
Wildlife	1
Total responses	**298**

In developing a thematic classification, 31 of the originally coded categories were adopted as themes, and an additional 32 topics were identified to describe related and linking ideas. This resulted in a final set of 63 major themes that collectively describe the dataset and account for all of the data points (Table 3-6). These themes form the basis of a short list of restoration strategies for implementation. A full list of the themes identified for each AORZ area is provided in Appendix A-4.

Table 3-6. A classification of 63 major themes for implementing ecological regeneration in the AORZ (n = 298).

Themes	Frequency
Stakeholder engagement	22
Allow natural hydrology and associated morpho-dynamics	19
Baseline assessments	19
Invest in key fauna	18
Develop educational aspects	11
Techniques to intercept surface water run-off	11
Develop strategies for participation	10
Integrate with compatible co-uses to minimise opportunity costs	10
Specific habitat enhancements	10
Establish educational partnerships	9
Planting	9
Control invasive species	9
Development of a monitoring programme	7
Integrate access & recreation	7
Low impact designs for intensive & built land uses	7
Scenario modelling and impact assessment	7
Extract learning from relevant examples	7
Develop nursery models	6
Funding models	5
Remove hydrological barriers	5
Values mapping & assessment	5
Investigate carbon potential	4
Investigate ecological engineering technologies	4
Landscape manipulation options	4
Resilience planning	4
Stakeholder identification	4
Adaptive management framework	3
Develop aesthetic gains	3
Develop 'work with nature' strategies	3
Development of conceptual models to inform regeneration	3
Include interim uses	3
Planning	3
Acknowledge previous history	2
Address knowledge gaps	2
Assessment of wider catchment	2
Exemplar value	2
Governance models	2
Make linkages to potential labour sources	2
Mapping	2
Nodal planting to assist species dispersal	2
Prioritise low cost high impact activities	2
Raise awareness of NZ species conservation	2
Research value	2
Retain existing vegetation	2
Staged approach to implementation	2
Targeted investment in key species	2
Utilise local knowledge	2
Water quality & waterway monitoring	2
Aquaculture	1
Cultural tourism	1
Fence sensitive areas	1
Improve microhabitats using shelter	1
Include value to future generations in assessment of benefits	1
Incorporate event co-uses	1
Invest in key flora	1
Investigate health benefits of forests and greenspace	1
Modelling	1
Spatial planning	1
Specify maintenance plan	1
Strategic use of intensive treatments alongside passive elsewhere	1
Tangata whenua values	1
Technical investigations	1
Tourism	1
Total	**298**

Table 3-7 shows a classification relating these themes to 13 strategic components for implementation.

Table 3-7. A classification of major themes for the implementation of ecological regeneration in the AORZ.

Stakeholder participation	Develop strategies for participation Stakeholder identification Stakeholder engagement Acknowledge previous history
Baseline assessment	Baseline assessments Mapping Values mapping & assessment Assessment of wider catchment
Knowledge gaps and technical investigations	Address knowledge gaps Extract learning from relevant examples Technical investigations Investigate carbon potential Investigate ecological engineering technologies Investigate health benefits of forests and greenspace Techniques to intercept surface water run-off Research value
Modelling & options assessments	Development of conceptual models to inform regeneration Modelling Scenario modelling and impact assessment Investigate low impact designs for intensive & built land uses Identify low cost high impact activities Address value to future generations in assessment of benefits Utilise local knowledge
Working with nature' strategies	Develop 'work with nature' strategies Allow natural hydrology and associated morpho-dynamics Remove hydrological barriers Retain existing vegetation Control invasive species Fence sensitive areas
Targeted investment (species and habitats)	Targeted investment in key species Invest in key fauna Invest in key flora Specific habitat enhancements Landscape manipulation options Improve microhabitats using shelter
Planting	Planting Develop nursery models Make linkages to potential labour sources Nodal planting to assist species dispersal
Educational opportunities	Develop educational aspects Establish educational partnerships Raise awareness of NZ species conservation Exemplar value
Integration & synergies with co-uses	Integrate with compatible co-uses to minimise opportunity costs Integrate access & recreation Incorporate event co-uses Develop aesthetic gains Tourism Cultural tourism Aquaculture Tangata whenua values
Monitoring programme	Development of a monitoring programme Water quality & waterway monitoring
Adaptive management	Adaptive management framework Staged approach to implementation Include interim uses
Planning	Planning frameworks Spatial planning Resilience planning Strategic use of intensive treatments alongside passive elsewhere Plan for maintenance requirements
Funding & governance	Funding models Governance models

Priority species and habitats

One of the recurring themes points to the potential benefits of targeting restoration investment towards key flora and fauna (see Table 3-6). The data collected contains many references to examples of species and habitats of particular importance and also occasional notes on potential reference ecosystem types or locations that could be used to guide restoration planning. Priority species identified for attention include īnanga (whitebait), tuna (eels), geckos, mudfish, koura (freshwater crayfish), kuaka (godwits), and butterflies (Table 3-8). In interpreting these data, it is important to note that the subject of priority species was not directly addressed in the research questions. Other species may also be important and these will certainly include habitat-forming plant species which in general are not reflected here.

Table 3-8. Keystone, 'flagship' species, and habitat opportunities identified for particular attention in relation to benefits.

Beneficial species	Recurrence frequency
Wildlife	
Īnanga	5
Tuna / Eels	3
Geckos	2
Mudfish	2
Koura / Freshwater crayfish	2
Kuaka / Godwits	2
Butterflies	2
Kōtuku / White heron	1
Matuku / Bittern	1
Koitareke / Marsh Crake	1
Tuturiwhatu / Banded dotterel	1
Korora / Little Blue penguin	1
Pīwauwau / Rock wren	1
Plants	
Harakeke	4
Kahikatea	3
Totara	1
general references to rare taxa	4
Beneficial habitats / habitat enhancements	
General principles	
Stepping stones for habitat connectivity & plant dispersal	5
Restored corridors for habitat connectivity, wildlife movement	3
Riparian planting for bird and insect habitat	2
Specific proposals	
Enhance īnanga habitat and spawning sites	3
Maintain bird roosting sites at high tide	3
Rockeries for gecko	2
Butterfly gardens	2
Design for a transition to godwit habitat in the AORZ under sea level rise	1
Create mounds in floodplain swamp & pond areas for bird roosting	1
Create Blue penguin habitat on dune landforms	1
Create Banded Dotterel nesting habitat	1
Green roofs designed for rock wren habitat	1
Create habitat for sensitive taxa	1
Designs to host specific insects	1

Target and reference ecosystem types

To expand on the data collected on important species and habitats we considered locally-relevant literature on ecosystem types to identify additional information on habitat and ecosystem types that could be targeted for restoration. Findings are presented for major ecosystem types that are either currently present or suitable for future restoration in the AORZ (Table 3-9). These are specific to current conditions in the AORZ. Although other subdivisions are possible, these provide a starting point for developing a set of specifications to support assessment of the major ecosystem types that may be restored. Finer scale habitat objectives, such as those identified above in relation to keystone and 'flagship' species, are additional to these considerations.

Table 3-9. Major ecosystem types either currently present or suitable for future restoration in the AORZ.

AORZ Ecosystem types	Dominant AORZ hydrosystem†	Equivalent or similar ecosystem types	Reference sites
Estuarine mudflats	Wet & salty	Oioi	Lower Ihutai, Brooklands
Lower saltmarsh	Wet & salty	Oioi	Ferrymead, Bridge Street, Brooklands, Te Waihora, Wairewa, Teddington
Upper saltmarsh	Wet & salty	Oioi	Ferrymead, Charlesworth, Brooklands, Te Waihora, Wairewa, Teddington
Estuarine margins	Wet & salty	Oioi	Charlesworth, Brooklands-Styx, Te Waihora, Wairewa, Teddington
Riparian (riverine) margins	Floodplain swamp & forest	elements of Pukio	Smacks Creek, Lower/Mid Styx, King George V Reserve - Mid Heathcote
Lake & swamp margins	Floodplain swamp & forest	elements of Pukio	Travis Wetland, Otukaikino, Canterbury Park – Wigram Retention Basin
Floodplain swamp & small trees	Floodplain swamp & forest	Pukio & Kahikatea	Travis Wetland, Otukaikino, Wigram, King George V Reserve, Mahinga Kai Exemplar
Floodplain tall forest	Floodplain swamp & forest	Kahikatea	Pūtaringamotu, King George V Reserve, Groynes, Wigram, Ernle Reserve
Low terrace & landfill forest	Higher & drier	Totara	King George V Reserve, Woodbury, Hook Bush, Arowhenua, Wigram, Ernle Reserve
Dry forest	Higher & drier	Hohere & Ti Kouka	Wigram, King George V Reserve, Woodbury, Eyrewell Reserve, Medbury Reserve, Maronan, Rakaia Island
Inland dune forest	Higher & drier	AkeAke	Spencer Park, Travis Wetland (Mairehau Rd), Taylors Mistake, Nape Nape
Gravel (e.g. stopbank) communities	Higher & drier	Tussock	Lower Styx stopbanks, Wairau Diversion

† as used in workshop materials
* following the Christchurch Ōtautahi Indigenous Ecosystems descriptions (Lucas et al., 1997; Lucas Associates, 2011).

Further details of each of these ecosystem types are provide in Appendix A-5 including a general description of the characteristic and beneficial flora and fauna, examples of where they could be restored in the AORZ, the location of reference sites that may be useful to identify more specific information on ecological structure and function, and cross-reference to other similar ecosystem types found in other classifications. The key next steps for specification involve refining the set of ecosystem types to reflect the level of detail needed for various assessments, and mapping them on the ground in the AORZ both in its current configuration and in different scenarios over time.

Information gaps, risks and assumptions

Further information was collected on these topics to support the identification of preferred strategies that will lead to integration of activities in time and space. The results confirmed and highlighted several of the themes identified from the content analysis (Table 3-10). Notable findings include the key role of stakeholder engagement and social learning activities to promote a better understanding of potential benefits and the conditions or processes required to generate them.

Table 3-10. Information gaps, risk and assumptions identified by participants in relation to implementation options.

Risks and assumptions to address in selection of restoration strategies	Current information gaps
Public perception of flooding areas which were previously residential - at present, previous communities are still connected to the 'land'. A sensitive approach to communications and explaining these changes and their necessity to the environment (river, land, estuary) is required.	Can't consider the opportunities/benefits/methods of this zone in isolation from the other zones. Who will have the role of determining the relative boundary of these systems for the medium term.
Make sure people are aware of the process of succession, why it is important for regeneration and that it might look messy to start with.	Constantly changing model. Also, models will be limited in their capability.
Security/perceptions of insecurity - solutions other than scorched earth which is ineffective.	Not sure how released land will behave, smaller scale trials could be useful,
Depends on decisions on stopbanks.	Good channel modelling for hydrology, sediment and pollutants.
Ensuring community understand importance of wet and salty.	Birds moved from earthquake might not have settled down fully.
Competing values e.g. commercial vs community.	Patterns of vegetation types retreat unknown - requires research and predictive models.
Need more than just a walking track - more economic benefit, options for people not interested in ecology.	Sea level rise causes habitat change e.g. birds move upstream for suitable habitat, need to plan for this.
Some people will be resistant to change e.g. taking out the willow, altering the Christchurch English heritage.	How regeneration needs to be managed - lack of knowledge of importance of leaving areas to regenerate on their own - and have pest species removed.
Risk of alienating communities that prefer exotic 'garden city' look to native bush.	Need to recognise where existing infrastructure is and who will pay for them when planning area uses.
Who will do it and how - agencies, groups - long term management.	Insurance aspects of red zone land.

Major objectives and draw-cards

The final workshop session began with the development of concepts that might help coalesce the major opportunities around a clear vision for a future state, or around major draw-cards that might be adopted as a major direction for regeneration (Table 3-11).

Table 3-11. Major objectives and draw-cards for regeneration of the AORZ.

Aspirational targets
Wet & Salty areas
Clean estuarine ecosystems providing recreation for humans and habitat for wildlife linking mountains to sea.
A wide panorama of woven tidal water, silt, reeds and wading birds regenerating along a slowly advancing shoreline.
'Christchurch international bird airport' (with appropriate Māori name) celebrating international importance of migratory bird species, Ramsar status.
Floodplain swamp & forest
Links people and ecosystems from city to sea.
A place for water to spread out and provide a glimpse into Ōtautahi Christchurch's past
A floodplain forest and flaxland formed and managed in an integrated way.
Example of pre-European vegetation, Ōtākaro / Avon River lifeblood. Horsehoe lake reserve - heart of a red zone forest park, Travis – kidneys, Waitākiri eco-sanctuary – an eco-anchor for an eco-city.
Higher & drier areas
Gateway concept.
Gateway to wild Christchurch
Oruapaeroa.
Awa kakariki Ōtākaro.

In an effort to generate some more 'outrageous' ideas on what could be done in an ideal situation with sufficient funding, a feature of the workshop process was the compilation of a wish-list of aspirational components of regeneration. A range of ideas were forthcoming (Table 3-12). Some of these may be related to the draw-cards and objectives identified above, whilst others are complementary concepts that could add value to the overall picture.

Table 3-12. Aspirational components of regeneration in the AORZ.

Aspirational components
Clear governance.
Rewrite the book on wastewater treatment and utilisation of nutrients.
Totally remove any remnants of Bexley landfill dump.
Move Christchurch and all infrastructure inland over time (planned retreat) including sanctuaries, rowing lakes.
Reconfigure Avon from single channel to delta-array.
Aerial roadways to allow environmental processes e.g. fish/bird passage water flows.
Flattened management structure - fewer management between implementers and decision makers/funders
Piloting buildings that are resilient in forested flood zones - not necessarily for housing but backpackers, research centres, visitor experiences.
Investigate lower cost restoration techniques.
Long-term funding streams.
Cat free zones.
Eliminate serious ecological weeds in zone, control seed sources in wider city.
Scientific experimentation.
Follow Wellington's lead to get native birds thriving in the city - needs forests and low predators.
Art in the landscape.
Ecological design guidelines.
Help people recognize native plants (most in Christchurch can't) and invertebrates; develop citizen science capabilities.
Historic park with walkable areas drawing people through pre-human and human histories - including previous neighbourhoods.
Pest control around entire perimeter and/or predator fences in some sites. Predator exclusion and threatened species re-introductions.
Trial and monitor different restoration methods.
Complementary landscape and urban design.
Shelter via terra forming.
Information and monitoring infrastructure innovations to detect changes and trends.

Lastly, participants were asked for a shortlist of integrative concepts that might define the overall direction for regeneration of the AORZ (Table 3-13).

Table 3-13. Integrative concepts.

Aspirational targets
A globally recognised urban ecology urban study centre.
A forest wetland park - healthy zone for people and animals, nature-zone, wild-zone, heritage-zone, educational space, restoring waterway links city to sea.
Reflect rebirth of what was here before - name from iwi.
Places of change between people and nature, land and water, past and future.
Turning challenge and tragedy into leadership and a joined up city.
Bathe in the rarest forest type in the world. Easy access for all, space for enjoyment and relaxation.
Exploring the gateway concept.
Automated online monitoring - a wired ecosystem.

4. Discussion

Results from this study indicate that there are a wide variety of potential benefits from ecological restoration activities (ecological, social, cultural and economic). Bringing these together in a format encompassing multiple perspectives from the local knowledge network was an objective of this assessment. The workshop process was designed to provoke thought and generate a range of perspectives on future uses of the AORZ. This was successful in generating new ideas at every step of the process following a staged approach assisted by a simple place-based spatial framework as an organising theme and provision of background information on each of the areas of interest. The latter focussed on characteristics of particular relevance to high level considerations for regeneration planning (i.e. the four well-beings plus resilience).

This process resulted in an overall decrease in the number of ideas generated and captured towards the end of the workshop, as new ideas became progressively exhausted (for example, see the breakdown of results by hydrosystem in Appendix A-3). Therefore, it is important to note that the data grouped under the floodplain category reflects the research process (as it was the last spatial zone to be addressed in the workshop) and is not an exhaustive set of considerations for floodplain areas. Much of the information gathered may be applicable at many different places throughout AORZ. The floodplain hydro-system was deliberately positioned last in the workshop sequence to encourage a focus on integration across ecotones and between activities in space and time. Some of the data collected in consideration of the 'wet and salty', and 'higher and drier' areas may also be applicable to the floodplain. All of the results can be interpreted as a common pool of knowledge that may apply somewhere in the AORZ with the 3-zone spatial framework for the restoration opportunities assessment having been developed primarily as a facilitation tool to draw out these ideas.

Results from the data analysis showed that the three different data streams (two workshop groups and survey respondents) often produced new information that had not previously been recorded. In addition, there were several recurring concepts. These may reflect ideas that are better known in the local context. Many of these ideas have been identified and in some cases documented in various project proposals for the AORZ[1] including the proposals of AOFP and GtRZ. These information sources are a useful complement to the findings reported here.

The following sections highlight some of the major opportunities that have been identified in this study.

Indigenous biodiversity

The data generated indicates that there are many potential benefits in relation to biodiversity. This is not solely an artefact, of the ecological theme of the study and target participant sample, since it also reflects the presence of degraded conditions. Notable findings include the degree of attention ascribed to key species and habitats. From a local and traditional knowledge perspective these species have been identified as disproportionately important. In the benefits dataset (Table 3-2) references to key species were subsumed within the wildlife category unless there was a specific indication of the need to create habitat for them. The latter forms the basis for defining the 'habitat for flagship species' benefits category. Although detailed methodologies were not the focus of this assessment, the need for strategies that target the regeneration potential of these species is highlighted.

Specifications for implementation may include opportunities to address legacy issues (e.g. contamination, fragmentation) or to introduce new innovations that address the future potential of

[1] see www.avonotakaronetwork.co.nz/projects/ecological-regeneration.html

these species and environmental recovery in AORZ. In relation to this, some of these proposed objectives for regenerated habitats are markedly aspirational with examples including urban green roof habitat for rock wren, and creating habitat for dotterel and little blue penguin on suitable landforms within the AORZ. These are largely untested concepts within an urban context and would require further work to establish more specific details and impact.

In contrast, several of the targeted investment proposals could build upon a relatively well developed knowledge base and in some cases existing projects. An example is the focus on īnanga as a species of high cultural and recreational value (Jolly et al., 2013; Orchard & Hickford, 2016) for which the AORZ provides considerable opportunities (Table 3-8). In 2015, post-quake work established that the spatial extent and productivity of īnanga spawning habitat had increased dramatically as a result of earthquake changes in local waterways (Orchard & Hickford, 2016) and surveys were repeated in 2016 with similar results (Orchard, 2016). These findings have informed additional research and community engagement around the potential to further improve īnanga populations and spawning production in the Ōtautahi Christchurch waterways (Orchard et al., 2016; McMurtrie et al., 2016). Elsewhere in the world characteristic species have been used extensively as a component of the branding and marketing of tourism destinations in addition to directly supporting local businesses involved in nature-based tourism activities (Fillion et al., 1994). There are several locations where characteristic native fauna are a notable feature of urbanised environments with examples including Sika deer in the city of Nara in Japan, and Red-tailed hawks in New York City. New Zealand urban examples include the Oamaru little blue penguin colony and wildlife sanctuaries such as Zealandia in Wellington, both of which have demonstrable impacts as visitor attractions. Other examples include glow-worms and various forms of fishing tourism. There are also several examples of marine species as draw-cards that underpin tourism in New Zealand towns with examples including Kaikoura, Akaroa, and Paihia.

Although there are relatively few examples of the economic impacts of wildlife having been quantified, studies in Australia have identified that opportunities to view wildlife are a major factor driving visitation (Fredline & Faulkner, 2001; Tisdell & Wilson, 2003). Elsewhere in the world bird watching is known to generate considerable tourism especially around viewing characteristic species with some studies reporting high levels of participation per capita on a national basis (e.g. Adams et al., 1997). Examples of tourism involving coastal bird species include many colonial sea birds such as puffins in countries close to the Arctic Circle. New Zealand examples include gannets in Hawkes Bay, albatross in Dunedin and Kaikoura, and marine mammals and sea birds at Kaikoura in addition to penguins at several locations. The identification of bird and fish related targets as potential flagship species for the AORZ is consistent with these examples. Flagship species have also been used successfully to directly promote river restoration projects that challenge the status quo. Notable examples include the role of Atlantic Salmon (*Salmo salar*) and other migratory species including eels (*Anguilla anguilla*) in promoting early restoration efforts in the Rhine River basin (Plum & Schulte-Wülwer-Leidig, 2014; Schulte-Wülwer-Leidig, 1994). These were followed by use of the Black Stork (*Ciconia nigra*) as a flagship species for expanding restoration efforts to encompass natural floodplain processes (Buijse, et al., 2002).

A key finding from this study identifies godwits as a potential ‘flagship species’ with considerable marketing potential for the city. The AORZ is identified as having a role in supporting this opportunity by providing a resilience benefit for long term sustainability of wading bird habitat. This is of critical importance for the migratory species with regards to the management of climate risks. Other findings of the study are complementary to this opportunity and include the need for strategies to maintain high tide roosting habitat for a variety of birds in the design of new land uses and flood management arrangements. These considerations illustrate the importance of the temporal aspects of planning. These may be addressed by ensuring that land use options and assessment methodologies accommodate expected levels of change in shoreline responses to sea level rise, along with other

environmental dynamics. One of the challenges will be the likely competition over the highest driest land with the restoration of forest types with important biodiversity value on the one hand and built environment land uses on the other. This claim on the same class of land will be exacerbated as sea level rises.

Additional value-adding opportunities were identified in relation to the focus on keystone species. An example using citizen science to support a focus on godwits involves facilitating a competition to confirm the most upstream location of the birds over time using the NatureWatch NZ national platform and mobile apps. Simple yet marketable campaigns such as this have been shown to attract high participation rates and are gaining in popularity worldwide (Dickinson & Bonney, 2012) and similar possibilities also exist for many of the species listed in Table 3-8. In summary, there are several aspects worthy of further consideration around the regeneration of habitat for key species in the AORZ. Weaving these together is essential for full recognition of their potential and will help inform specification of the most appropriate implementation strategies.

Economic aspects

Across the dataset, economic benefits of restoration opportunities are prominent. They are consistent with findings from comparable studies that have shown significant economic gains resulting from the restoration of degraded environments (e.g. Peh et al., 2014). The top ten benefits of ecological regeneration in the AORZ on the basis of frequency in the dataset (Table 3-4) are as follows:

- biodiversity
- educational - experiential
- restored natural values
- cultural values
- visitation
- fisheries & aquaculture
- research & exemplar value
- water quality
- wild harvest
- heritage & history

Several of these topics have obvious economic potential. Others including biodiversity, restored natural environments, and water quality are at first glance environmental benefits. However, as discussed above in relation to the economic aspects of key species' regeneration, targeted biodiversity and natural environment regeneration may also drive considerable economic activity. Improved water quality is complementary to these objectives and is particularly relevant to cultural values. In addition, it supports a wide range of aquatic recreation opportunities and has human health implications important to both visitation and wild harvest activities. Other notable benefits with direct economic implication include the promotion of human health. This has physical health aspects associated with recreational opportunities in the AORZ. Additionally, there are mental health benefits that include the avoidance of heath care and associated costs (Hartig et al., 2014). Several studies around the world have sought to quantify these benefits though this remains a difficult subject (Shanahan et al., 2015). Considerations include establishing the degree to which new proposals would change the visitation rates that result in greenspace exposure. To address the additionality requirement it is also necessary to quantify the extent to which different land use options may produce similar benefits due to having a degree of greenspace space included. Addressing these topics requires research that is specific to the site and its wider socio-ecological system. Alongside the physical health benefits of recreation in the AORZ these aspects are potentially a substantial source of value due to the urban location. The corridor configuration results in a long perimeter with many entry points and may lend itself to the development of commuter routes and associated uses that increase these benefits by influencing the frequency of visitation.

The benefits classification example (Table 3-3) provides an indication of the sub-components of major potential benefits. This may be useful in developing more detailed specifications for potential regeneration activities. Although they may cluster within different activity sectors the specific nuances of each as an opportunity in the AORZ are very different. For example, visitation activities provide an obvious point of focus around the concept of an attractive naturally restored environment with a powerful story of its history and significance. The various propositions that may support visitation deserve to be unpacked fully in the design of business cases and comparative assessment exercises. These potential benefits require specific attention as they could present strong business cases for Christchurch and beyond.

Fisheries and aquaculture is another area of focus and includes a potential overlap with fishing tourism. Elsewhere in the world local and traditional coastal fisheries have been shown to be highly dependent on estuarine nursery habitat (Barbier et al., 2011; Peterson, 2003; Sheaves et al., 2015). This could be provided within the AORZ and potentially enhanced as an aspect of regeneration. Examples of opportunities include increasing the availability of rearing and adult habitat for īnanga, koura, and tuna to support local stocks, and potentially also other species. There are few examples of large scale floodplain regeneration activities in New Zealand that have explored these opportunities although there are many examples overseas. A notable exception is a restoration project on Cobden Island at the mouth of the Grey River which has re-engineered the disconnected floodplain by constructing a network of waterway channels that may mimic more natural conditions and provide increased waterway area and habitat diversity (Figure 4-1).

Figure 4-1. An example of large scale ecological engineering in a peri-urban situation on Cobden Island in Greymouth. Data source: LINZ.

There are additional opportunities to support local fishing activities including those that could occur within the AORZ. Examples include recreational fisheries for whitebait, tuna, koura, trout, salmon, and other wild harvest practice that include cultural and customary fishing activities. In support of these, there are further opportunities to address the maintenance of these benefits over time through innovative governance arrangements, such as co-management models that give effect to key cultural values such as mahinga kai and kaitiakitanga.

Participation and community engagement

These aspects were recurring themes that related to many of the regeneration strategies and also the design of such strategies through engagement and collaborative activities. Participation was seen as critical to many aspects of implementing ecological regeneration. These include on-the-ground works such as planting and the potential for community based monitoring. However, participation is also required at the planning stage in various forms to improve the understanding and buy-in for various options some of which may be contentious (Pahl-Wostl, 2006; Smith et al., 2009). In relation to social learning, participation and engagement with AORZ planning, it is likely to be crucial to improve local ownership and acceptance levels for strategies at the 'working with nature' end of the spectrum, especially in drier areas as these will typically involve lengthy restoration trajectories to achieve the desirable end-points such as closed canopy forest. Intermediary seral stages may appear 'untidy' requiring a degree of understanding for the benefits of the strategy. Participation is also a valuable aspect of design or assessment process, as demonstrated here, and these also provide opportunities for social learning and co-creation.

Aside from playing a key role for implementing ecological restoration work, encouraging public interaction with the site is a mainstay of many potential benefits associated with future land uses. A high degree of public use of the AORZ is envisaged. Accompanying this is a focus on ensuring a high level of access for a variety of modes of travel on both land and water. Strategies that deliver or are compatible with enhanced recreational opportunities were also highly supported. This suggests that access and recreational aspects should be considered at all stages of design and assessment processes and recreational enhancements woven into ecological restoration work wherever possible. Exceptions include where sensitive areas may require exclusion (e.g. by fencing) to prevent damage, such as where vulnerable species or life stages may be present or in the early establishment phase for some habitat types.

In another sense, the development of research, restoration and outreach activities has the potential to attract considerable interest and may have ecotourism potential. This presents opportunities for engagement that support visitation and tourism. Several promotional ideas were identified including the citizen science example discussed above, use of interpretive materials, and development of storylines reflecting features such as the place of key species and their management by the local community. The earthquakes have created new storylines around resilience, recovery, and regeneration. Resilience to future change is a further storyline that will unfold over time. The AORZ creates a wealth of opportunities for building Christchurch's reputation through the use of storylines and best practice or innovative approaches taken to regeneration.

Co-uses and integration

The need to achieve integration between compatible co-uses and ecological regeneration activities was one of the recurring themes identified. For example, outdoor and nature-based recreation can offer solutions to many of the issues associated with urbanisation. Associated with this is the need to ensure access for a variety of recreational activities and user groups. The AORZ provides many opportunities to directly provide and integrate recreational gains, by design, alongside other land and water uses. Due to the scale of the site and the ability to start with a 'clean slate', there is an unprecedented opportunity to avoid piecemeal solutions and processes and explore synergies between key values such as biodiversity conservation, cultural, economic, and recreational activities to deliver the greatest possible benefits.

In practice, the process of identifying and facilitating compatible co-uses presents a key opportunity for regeneration planning. In relation to the development of restoration strategies, a useful approach may involve iterations of design, specification, identification of trade-offs and synergies with co-uses, and assessment of alternative scenarios. These may be adjusted and re-tested to sequentially refine

the specification of optimum land uses. The specification process is guided by the results of each assessment cycle and will ultimately inform more detailed design and planning prior to implementation.

Identification of alternative strategies for ecological regeneration

The ERO project has identified many ecological restoration opportunities that may contribute to regeneration of the AORZ, and a comprehensive set of considerations for developing implementation strategies. However in some instances it is difficult to identify a clearly preferred option. The notable exceptions are mainly in the wet and salty environments where hydrological manipulation offers a powerful strategy to bring about change. Additional aspects such as the use of a staged approached and attention to invasive species control can be evaluated using this core strategy as a potential starting point. For many other parts of the AORZ there may be no one optimum strategy and the best option will likely evolve over time. Providing support for an adaptive management approach will be essential. To inform land-use option assessments, pragmatic decisions will need to be made on the choice of strategies and can be assessed in relation to scenarios. These can be constructed by first delineating the areas to which a restored environment objective will be applied using a standardised spatial framework. This is an essential first step to confirm the site specific aspects as well as the scale envisaged. One or more implementation scenarios can then be constructed as alternatives for achieving the objective using the implementation components and considerations identified in Tables 3-5 to 3-13 to aid selection of the activities that are desired or required.

Typically, the level of capital investment available at the initiation of a project has a bearing on the strategic options available. To address this, assessment of a range of strategies that have been shown to be useful in the past (through local experience) is recommended to provide information on different potential scenarios to address different contexts, scale, and value propositions. For comparative purposes it is also recommended that a minimum of two scenarios are constructed and assessed for their benefits and cost-effectiveness, remembering that the process of achieving the restoration objectives can itself be a source of benefits in addition to costs. Opportunism is a further element that presents itself and may be encouraged through processes such as the ERO project that embraces a variety of knowledge sources and potential inputs in support of natural resource planning (Knight & Cowling, 2007).

Often these alternatives will lie somewhere across a spectrum of intensive up-front restoration strategies (e.g. planting an entire area at high densities) and more passive ‘working with nature’ approaches requiring less capital investment and a longer period of maintenance. In considering alternatives it may be useful to scope and assess an intensive up-front strategy as a counterfactual scenario for comparative purposes. Inputs for this scenario should be sufficient to cover all site preparation and commercial establishment costs for the full area to be treated as well as the maintenance requirements for the period until the restored site is expected to be self-maintaining. The exact specification will depend on the restoration objective chosen and the site (for example drier sites may require a longer period of maintenance to achieve canopy closure). The remaining step for the specification exercise will then be to identify one or more other strategies that may represent better investments as alternative scenarios, which may include the status quo.

5. Conclusions

The findings represent the most comprehensive set of concepts available to date to address the potential benefits of ecological regeneration in the AORZ. This is core topic for planning to identify risks and avoid missed opportunities and opportunity costs. The focus of this report is not to provide specific advice on the methods for achieving specific restoration endpoints *per se*. This will vary at different sites and scales with a large number of combinations possible. Rather, the emphasis is on providing an overview of the many restoration and regeneration options in their totality across the AORZ. An additional objective is to support their adequate assessment in the identification of optimum land uses and adaptive management practices for the AORZ.

Results from this study identify a wide range of activities that may be applied to generate benefits for Christchurch and beyond, all involving aspects of a potential new ecology in the AORZ. These may be combined at a range of scales to create scenarios, quantify benefits, and explore the potential for synergies between different land use options. Methodologies by which these many facets can be pulled together to in quantitative and comparative assessments are the focus of the final report in the ERO series.

A particular challenge is acquiring the information needed within relatively short time frames. Early attention to gathering baseline data, addressing technical knowledge gaps, and developing conceptual frameworks to account for the many spatio-temporal aspects are all key activities that will assist in delivering the best outcomes. Participatory processes, as used here, may play a useful role in assessment and stakeholder engagement and provide opportunities for social learning and the co-creation of new knowledge. By inviting participation from a wide knowledge-holder network inclusivity is improved in comparison to small-group expert panel approaches. Similar approaches could be applied to other information gathering and assessment needs in the regeneration planning process.

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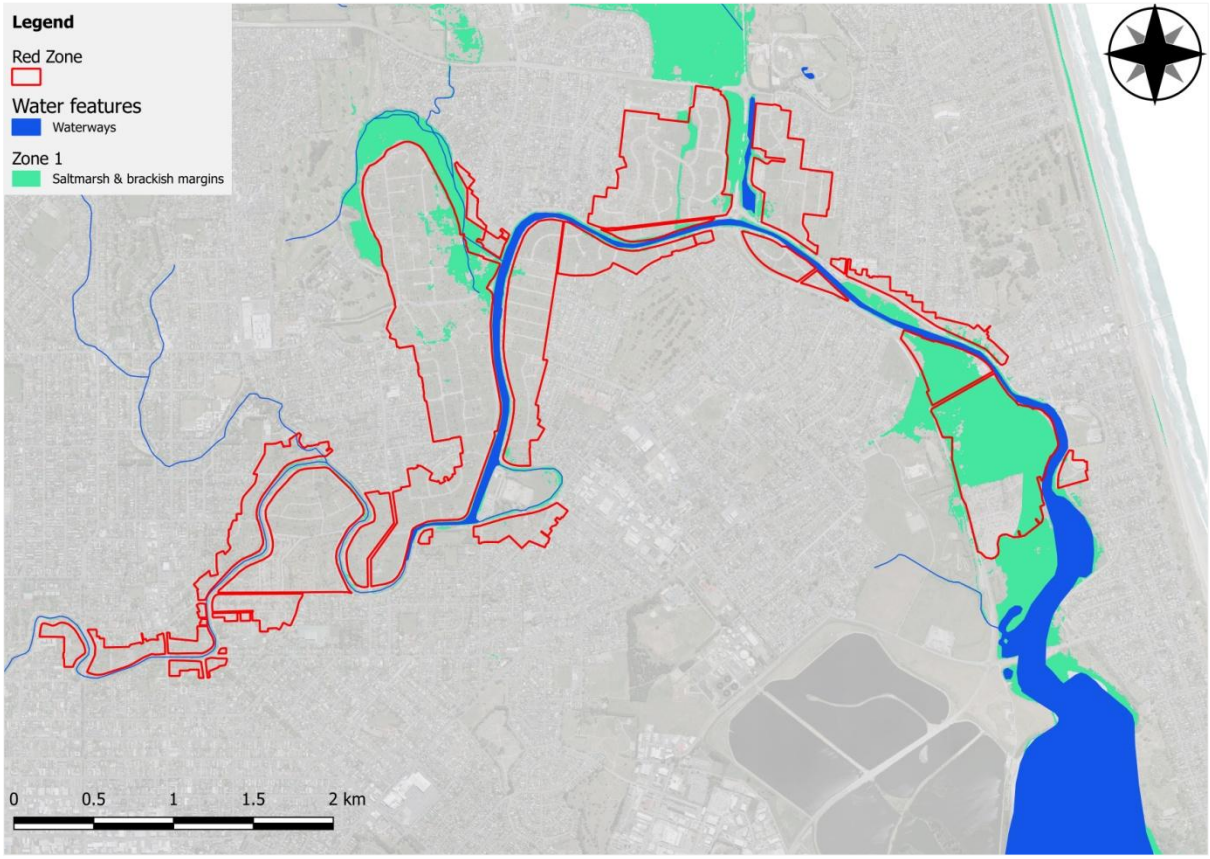
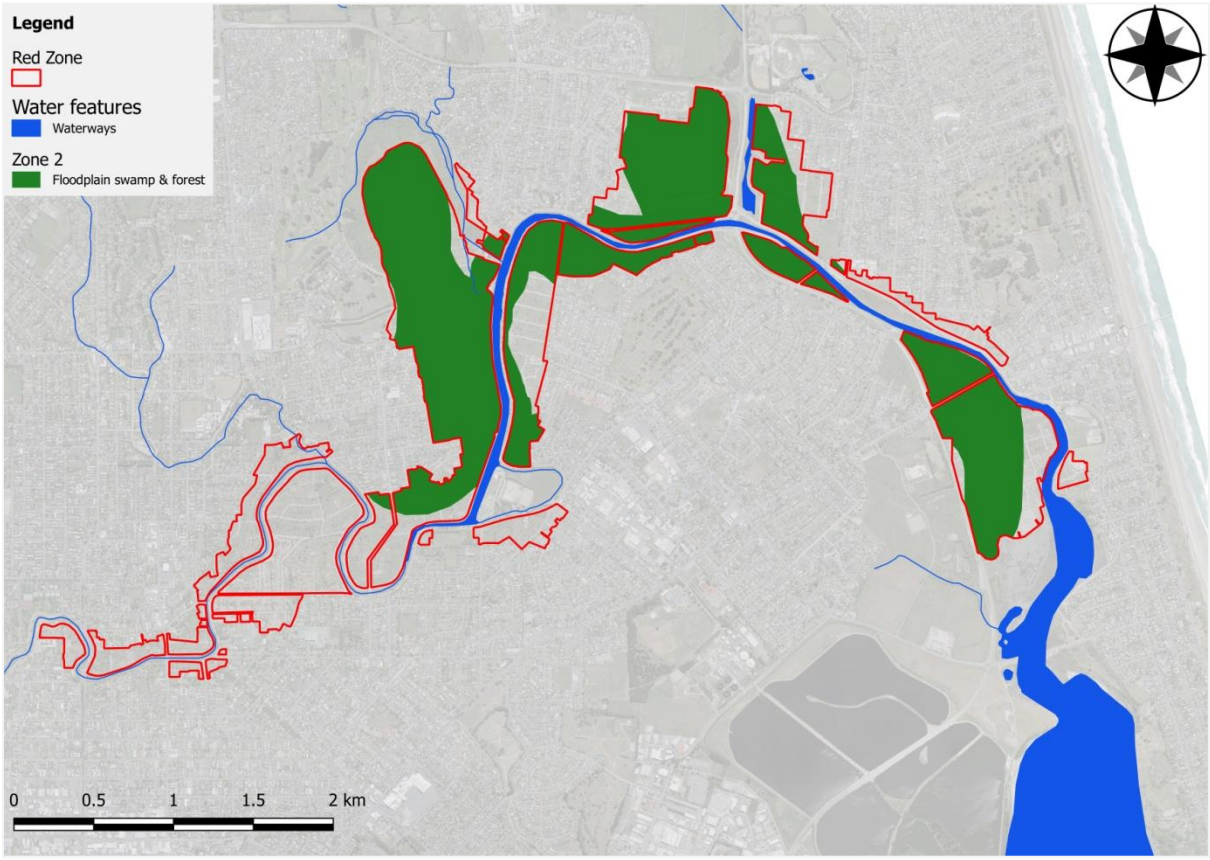
Appendix A-1. AORZ hydrosystems maps used to support the workshop process.

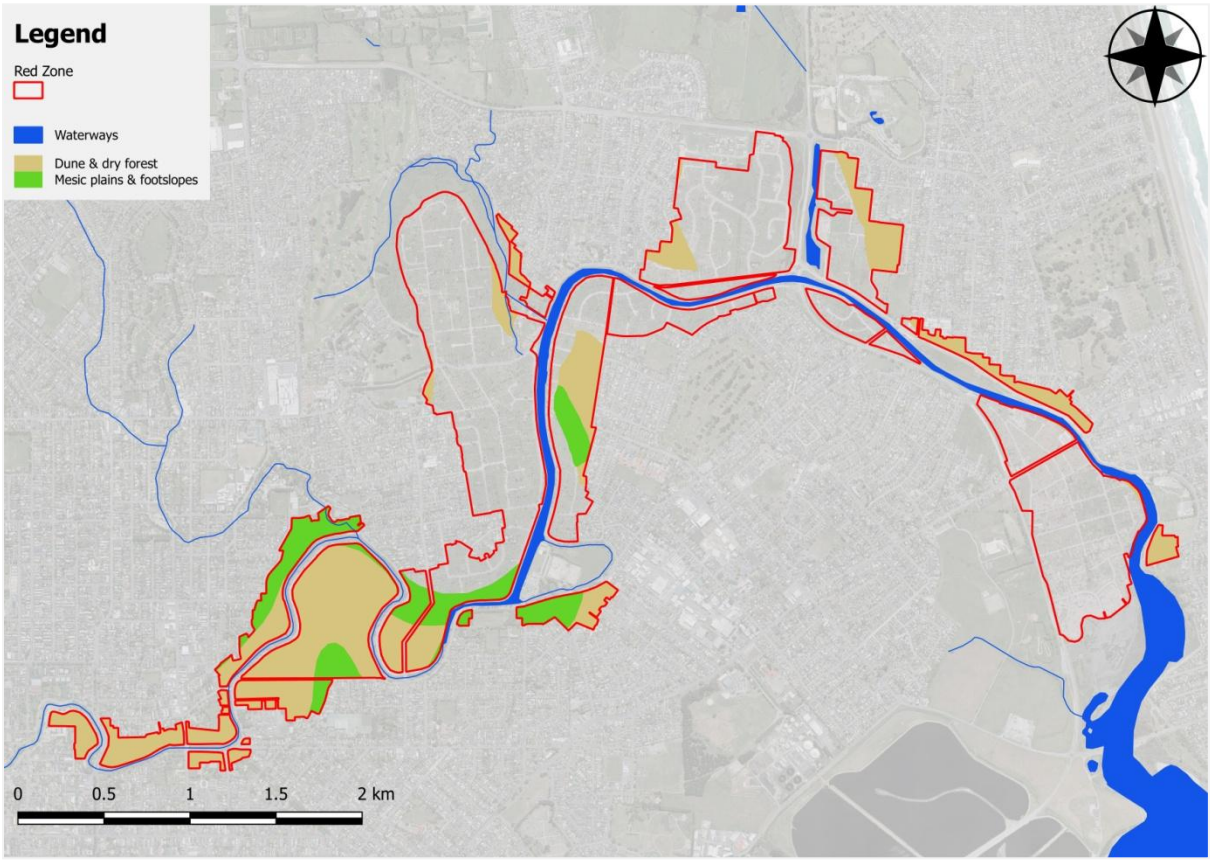
(a) Wet & salty areas



(b) Floodplain swamp & forest areas



(c) Higher & drier areas



Appendix A-2. Participant affiliations.

Organisations and community groups represented
Aquatic Ecology Ltd
Avon-Ōtākaro Forest Park
Avon-Ōtākaro Network
Christchurch City Council
Christchurch West Melton Zone Committee
CityCare Ltd
Coastal Restoration Trust of Nz
Conservation Volunteers NZ
Department of Conservation
Environment Canterbury
EOS Ecology Ltd
Greening the Red Zone
Keystone Ecology
Landcare Research
Lincoln University
Ngāi Tahu
Regenerate Christchurch
Sumner Environment Group
Trees for Canterbury
University of Canterbury
Waiora Landscapes
Working Waters Trust

Appendix A-3. Potential benefits of ecological regeneration for each of three hydrologically defined areas. (n=165).

Potential benefits	Frequency
Wet & salty areas	
restored natural processes	7
connection with nature	4
connections with history	4
ecotourism	3
habitat increased	3
sense of place	3
awareness of history	2
awareness of natural processes	2
connection with nature	2
drinking water supply protection	2
exemplar value	2
fisheries	2
habitat for flagship species	2
improved water quality	2
recreational opportunities	2
recreational fisheries	2
restored hydrology	2
aquaculture	1
attract business	1
branding of Christchurch	1
carbon credits	1
commercial fisheries	1
educational opportunities	1
employment	1
experience of nature	1
fishing tourism	1
food resilience	1
improved aesthetics	1
improved safety of wild foods	1
land & water access modes	1
low site maintenance	1
mahinga kai	1
mental resilience	1
natural hazards buffering	1
novel design opportunities	1
rare taxa	1
sediment capture	1
sensitive taxa	1
service business opportunities	1
tangata whenua values	1
cultural tourism	1
watersports	1
wild harvest	1
wildlife	1
Floodplain areas	
adjacent land values	2
carbon sequestration	2
flood mitigation	2
habitat connectivity	2
habitat for flagship species	2
mahinga kai	2
reduce habitat for geese	2
restored hydrology	2
sediment capture	2
tau koura	2
tourism	2
commercial fisheries	1

forest bathing	1
mental health benefits	1
mental resilience	1
natural hazards buffering	1
pa harakeke	1
pollution removal	1
protection of natural springs	1
recreational opportunities	1
reduced urban heat effect	1
stormwater management	1
swimmability	1
visitor attractions	1
water quality	1

Higher & drier areas

cultural values	5
seed sources	5
connection with nature	3
adjacent land values	2
awareness of natural values	2
branding of Christchurch	2
ecotourism	2
education	2
exemplar value	2
experience of nature	2
fibre	2
habitat increased	2
habitat for flagship species	2
recreational opportunities	2
social learning	2
wild harvest	2
wildlife	2
awareness of natural processes	1
carbon sequestration	1
community engagement & volunteerism	1
ecological connectivity	1
event spaces	1
halo effect	1
improved access via land & water	1
mahinga kai	1
mental health benefits	1
physical health benefits	1
reduced edge effects	1
research value	1
sense of place	1
sustainable forestry	1

Appendix A-4. Major components of implementation for each of three hydrologically defined areas. (n= 298).

AORZ Hydrosystem	Frequency
Wet & salty	
Baseline investigation	9
Enhance hydrologic variation	6
Alter stopbanks	4
Enhance variation in waterway morphologies	4
Improve filtration of run-off	4
Monitoring	4
Birds	3
Competing values assessment	3
Create roosting spaces for birds	3
Improve stormwater treatment	3
Stakeholder engagement	3
Allow for climate change and sea level rise	2
Baseline mapping	2
Create space for natural river processes	2
Daylighting of piped stormwater infrastructure	2
Encourage awareness of land use impacts on waterways	2
Encourage built infrastructure design to reduce stormwater impacts	2
Encourage use of constructed wetlands and swales for stormwater treatment	2
Extract learning from global examples	2
Impact assessment	2
Improve shading of waterway margins	2
Insects	2
Invasive species distribution and risks	2
Modify hydrology	2
Passive restoration	2
Plant riparian vegetation	2
Planting	2
Pollutants	2
Reduce pollution at source	2
Sand wanding	2
Weeds	2
Wide community engagement	2
Floodplain	
Begin sourcing of slow growing species soon	2
Create linkages with corporates	2
Develop aesthetic gains	2
Develop exemplars and showcases	2
Investigate carbon business opportunities	2
Investigate carbon gains potential	2
Iwi engagement	2
Local examples	2
Lookout towers to enhance experience	2
Provide interpretation for visitors	2
Stop mowing	2
Use modern IT technology to connect with youth	2
Utilise participatory approaches	2
Acknowledge previous history	1
Address knowledge gaps	1
Assess water quality needs and constraints	1
Attract offshore interest	1
Bio-remediation of contaminated land	1
Change public attitudes on natural transitions	1
Combined nurseries growing seed/plants for other sites	1

Create linkages with non-profit groups	1
Design for resilience	1
Design for succession	1
Develop cultural tourism opportunities	1
Develop early wins	1
Develop outreach programme	1
Develop research opportunities	1
Develop transitional uses	1
Early wins	1
Encourage compatible mixed uses	1
Encourage local ownership	1
Encourage local ownership	1
Establish virtual reference material for engagement	1
Explore economic aspects of restoration opportunities	1
Explore IP opportunities	1

Higher & drier

Habitat for key fauna	4
Control invasive species	3
Develop educational aspects	3
Develop strategies for participation	3
Scenario modelling and impact assessment	3
Stakeholder engagement	3
Allow compatible mixed uses	2
Change public attitudes on natural transitions	2
Develop opportunities for volunteerism	2
Educate contractors on site values	2
Funding models	2
Governance models	2
Include interim uses	2
Incorporate nursery activities	2
Nodal planting to assist species dispersal	2
Raise awareness of NZ species conservation	2
Retain existing vegetation	2
Stakeholder identification	2
Utilise local knowledge	2
Wide community engagement	2
Acknowledge previous history	1
Adaptive management framework	1
Competing values assessment	1
Control invasive species	1
Develop community nursery model	1
Fence sensitive areas	1
Identify commercial opportunities	1
Improve microhabitats using shelter	1
Include value to future generations in assessment of benefits	1
Incorporate community gardens	1

Appendix A-5. AORZ ecosystems types and reference sites.

Reference sites for **Estuarine Mudflats**		
Locations	Lower Ihutai, Brooklands	Reference Photos
Physical description	Tidal and sub-tidal mudflats; saline raw soils, fine textured substrate.	
History	Shifting coastal hydrosystems (e.g. at Ihutai currently associated with a sandspit barrier forming a lagoon type estuary). Historic trend towards estuarine infilling and hardened edges, recently modified by earthquake ground level changes and liquefaction. Encroachment from seawalls and landfill constructions. History of sedimentation from adjacent/upstream land uses and pollution (e.g. heavy metal accumulation, wastewater discharges). Ecosystems are less modified from historical/indigenous types at the lowest extent of tidal range.	
Characteristic flora	Eel grass, sea lettuce	
Characteristic fauna	mudsnails, shellfish, wading birds including godwit, spoonbills, pied stilt, oystercatcher, banded dotterel, kotuku & kotare	
Potential restoration strategies in the AORZ	Natural occurrence and regeneration in situ below the AORZ; expected to migrate upslope with SL rise	

Ferrymead – algal beds in background & mudsnails with perching kotare

Ihutai – algal & eel grass beds at low tide with Royal spoonbill grazing

Ihutai – mudsnails & godwit on mudflats

Reference sites for **Lower Saltmarsh Reeds and Rushes**		Reference Photos
Locations	Ferrymead, Bridge Street, Brooklands, Te Waihora, Wairewa, Teddington.	
Physical description	Mid Tidal flats; Saline Raw Soils, regular tidal inundation, fine to sandy textured substrate with patchy vegetation, more pronounced in low energy areas.	
History	Shifting coastal hydrosystems (e.g. at Ihutai currently associated with a sandspit barrier forming a lagoon type estuary). History of sedimentation from adjacent/upstream land uses and pollution (e.g. heavy metal accumulation, wastewater discharges). Encroachment from seawalls and landfill constructions. Relatively unmodified at the upper extent of average tidal range where flooding is permitted.	
Characteristic flora	Three square, oioi, sea rush, sea sedge, Bolboschoenus, glasswort and saltmarsh herbs. Grades into upper marsh herbfields.	
Characteristic fauna	shellfish, crabs, wading birds including godwit, spoonbills, pied stilt, oystercatcher, banded dotterel, kotuku, bittern & kotare.	
Potential restoration strategies in the AORZ	Natural occurrence and regeneration in situ below the AORZ; expected to migrate upslope with SL rise providing there is space available to expand.	

All above – Ferrymead with sea rush, algae in channels and oioi

Bridge Street lower marsh showing sea rush stands interspersed with herbs

Reference sites for **Upper saltmarsh**	
Locations	Ferrymead, Charlesworth, Brooklands, Te Waihora, Wairewa, Teddington.
Physical description	Upper tidal flats and supratidal area; Saline Raw Soils, fine textured substrate.
History	Shifting coastal hydrosystems (e.g. at Ihutai currently associated with a sandspit barrier forming a lagoon type estuary). History of sedimentation from adjacent/upstream land uses and pollution (e.g. heavy metal accumulation, wastewater discharges). Encroachment from seawalls and landfill constructions has truncated upper levels.
Characteristic flora	Glasswort, remuremu, sea primrose, bachelor's button, bucksthorn plantain with oioi, grading into saltmarsh ribbonwood, and other shrubs & grasses characteristic of estuarine margins.
Characteristic fauna	crabs, roosting wading birds including godwit, spoonbills, pied stilt, oystercatcher, banded dotterel, pukeko, putakitaki, kotare
Potential restoration strategies in the AORZ	Natural occurrence and unassisted regeneration in situ and restoration of meadow where reflooding is permitted (e.g. where embayments previously truncated by causeways), below the AORZ; expected to migrate upslope with SL rise providing there is space available to expand.

Reference Photos

Ferrymead – foreground saltmarsh herbs in mosaic with sea rush grading to oioi & saltmarsh ribbonwood above

Reference sites for **Estuarine Margins**		
Locations	Charlesworth, Ferrymead, Lake Kate Sheppard, Te Waihora.	Reference Photos
Physical description	Spring Tidal levees and banks including unprotected low landfill at the uppermost extent of extreme tidal range; *Motukarara* Recent Soils, periodically dry with divaricating and scrambling shrubs up to 2 m tall.	
History	Variously modified through filling, and hardening edges.	
Characteristic flora	Marsh ribbonwood, scrambling pohuehue, mikimiki, toetoe, manuka, harakeke, ti kouka.	All above – Charlesworth showing foreground saltmarsh herbs with oioi (orange reeds) transition to estuary edge shrubland & coastal bush
Characteristic fauna	Passerines, roosting shags. kotare	
Potential restoration strategies in the AORZ	Natural occurrence and unassisted regeneration in situ at lower edge of AORZ; but with occasional weed incursions; expected to migrate upslope with SL rise providing there is space available to expand; some weed control (tall fescue grass) will assist with regeneration together with some planting.	Ferrymead – coastal bush edge of ngaio, akeake, harakeke, manatu, tarata, kohuhu & karamu  Lake Kate Sheppard at high tide showing partially restored estuarine margin on the eastern shoreline

Reference sites for **Riparian Margins**	
Locations	Smacks Creek, Lower/Mid Styx, King George V Reserve - Mid Heathcote.
Physical description	Riverine banks and margins, alluvial recent soils, always wet, fluvial dynamics promote disturbance, sedimentation, and channel reworking to various degrees. Grades downstream into brackish, tidal riparian margins, may grade into pond and swamp margins (e.g. in drains and tributaries).
History	Modified by past engineering works on rivers for flood relief, capable of regenerating and successfully planted, but often weedy (e.g. tall exotic grass and yellow flag iris).
Characteristic flora	kapungawha, oioi, toetoe, umbrella sedge, kuawa, harakeke, marsh ribbonwood, mikimiki.
Characteristic fauna	Ducks, black swans, putakitaki, pukeko, kotuku, īnanga.
Potential restoration strategies in the AORZ	Partly self-regenerating along mid AORZ river reaches but often requires weed control. Planting strategies affected by approach taken to fluvial dynamics e.g. river bank stabilisation or flood engineering. Planting generally easiest at very top of range where disturbance is less frequent.

Reference Photos

Smacks Creek – pukio, harakeke & kiokio

Restored margins in the mid Styx River / Puharakekenui

Partially restored section of Anzac Creek in the Mahinga Kai Exemplar

Reference sites for **Lake and Swamp Margins**	
Locations	Travis Wetland, Otukaikino, Canterbury Park – Wigram Retention Basin.
Physical description	Lentic ponds & swamps; Permanent open water with free floating, rooted floating, and emergent vegetation with Raw fine textured hydric soils.
History	Aquatic systems are generally short-lived and quick to regenerate or they develop towards dryland succession.
Characteristic flora	Raupo, kapungawha, pukio, harakeke, toetoe, kiokio, sedges, rushes, milfoil, pond weed.
Characteristic fauna	Grey ducks, pūtakitaki/paradise shelduck, grey teal, scaup, tuna, inanga, koura, waikākahi/ freshwater mussels.
Potential restoration strategies in the AORZ	Natural regeneration and planting are quick to establish after disturbance into new available aquatic habitats; planting should occur at driest period as low down the profile as possible so plants can become established before water levels rise.

Reference Photos

Wigram Retention Basin – lined with pukio, harakeke & ti kouka with kapungawha & raupo emergent from water

Otukaikino – spring/pond lined with pukio, raupo & ti kouka

Raupo and duckweed in a spring-fed water body in Anzac Drive Reserve near Travis Wetland

Reference sites for **Floodplain Swamp and small trees**		
Locations	Travis Wetland, Otukaikino, Wigram, King George V Reserve, Mahinga Kai Exemplar	Reference Photos
Physical description	Permanently flooded wetlands and seepages with fine textured, gleyed Recent soils	
History	Once extensive through eastern Christchurch and being re-established in many places; grades into Fen peatland, but this substrate is not in AORZ	
Characteristic flora	Raupo, pukio, sedges, rushes, harakeke, toetoe, kiokio, mikimiki, ti kouka, manuka	
Characteristic fauna	Bittern, pukeko, crake, tuna	
Potential restoration strategies in the AORZ	Natural regeneration and planting are quick to establish provided exotic grasses are initially & willow continually controlled.	

Travis Wetland – umbrella sedge, pukio, toetoe, harakeke & ti kouka

Kaputone Stream swamp dominated by pukio & ti kouka

King George V Reserve swamp dominated by harakeke, pukio & manuka in foreground

Reference sites for **Floodplain Tall Forest**		
Locations	Pūtaringamotu, King George V Reserve, Groynes, Wigram, Ernle Reserve	Reference Photos
Physical description	Periodically flooded tall structured forests with fine textured, permanently moist, gleyed *Taitapu* soils	
History	The original forest is represented at Riccarton, although the timber trees were removed early on for building; also reflected in The Chalice which features silhouettes of foliage from the ancient flood-buried forests. Some quite good examples of 20-30 year old restoration, some de novo and other examples established under exotic canopies – willow and other deciduous trees	
Characteristic flora	Kahikatea, pokaka, matai, manatu, houhere, rohutu, horoeka, turepo, kaikomako	
Characteristic fauna	Kereru, korimako, tui, kaka, riroriro, pīwakawaka/fantail, and other bush birds some extinct	
Potential restoration strategies in the AORZ	Intermediate terraces will be suitable for this forest type, bordering wetlands, ponds and riparian zones – provided they are sufficiently elevated or protected from medium term SL rise. Ongoing weed control will be necessary until canopy closure has been achieved.	

Peel Forest dominated by kahikatea

King George V Reserve dominated by kahikatea, pokaka & ti kouka

Nottingham Stream – interior of restored floodplain forest

Reference sites for **Low Terrace and Upper Landfill Forest**	
Locations	King George V Reserve, Woodbury, Hook Bush, Arowhenua, Wigram, Ernle Reserve
Physical description	Infrequently winter-flooded middle terraces and foot slopes of old dunes and on upper landfill equivalent to *Kaiapoi* mottled soil supporting tall structured forest
History	Very few natural examples survive on the Canterbury Plains because of the historically high value of the dominant timber trees and of the land for agriculture; landfill has created facsimiles of the original soil type, but has poor structure and is often compacted so site preparation by ripping is likely prerequisite to restoration. It is a common restoration situation due to it being the rarest forest type in Canterbury.
Characteristic flora	Matai, totara, hinau, houhere, manatu, kapuka, tarata, mahoe, horoeka, putaputaweta, kaikomako
Characteristic fauna	Kereru, korimako, tui, kaka, riroriro, pīwakawaka/fantail, and other bush birds some extinct
Potential restoration strategies in the AORZ	An important and crucial forest type to be established widely in the city and across the Plains for its important fruit supply especially to kereru. It will occupy the more elevated parts of the AORZ and as such will be contested for other purposes; landfill will need to be prepared for planting by ripping. And ongoing weed control will be necessary until canopy closure has been achieved.

Reference Photos

Canterbury Park, Wigram – 1990s restored totara-matai forest on low terrace

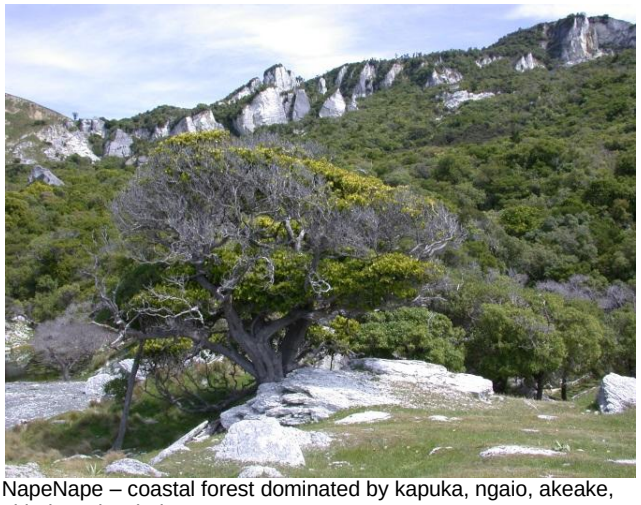
Woodbury – totara, kowhai & kanuka

Woodbury – totara-matai forest

Woodbury interior of totara-matai forest

Reference sites for **Dry Forest**		
Locations	Wigram, King George V Reserve, Woodbury, Eyrewell Reserve, Medbury Reserve, Maronan, Rakaia Island	Reference Photos
Physical description	On the most elevated terraces, upper landfill and shaded old dune side-slopes; experiencing regular drought on the equivalent of *Waimakariri* soils. Similar environments may also exist on current or future stop banks.	 Maronan, mid-Canterbury – dry kanuka-ti kouka woodland
History	Very few natural examples survive on the Canterbury Plains because of the historically high value of the dominant timber trees and of the land for agriculture; landfill has created facsimiles of the original soil type, but has poor structure and is often compacted so site preparation by ripping is likely prerequisite to restoration. It is a common restoration situation due to it being the rarest forest type in Canterbury.	 Medbury Reserve, Culverden Basin – dry kanuka-matagouri-mikimiki woodland
Characteristic flora	Totara, houhere, kowhai, kanuka, ti kouka, kapuka, kohuhu, tarata, horoeka, whauwhaupaku	 Rakaia Island – kanuka-kowhai-kohuhu-ti kouka woodland
Characteristic fauna	Kereru, korimako, tui, kaka, riroriro, fantail, and other bush birds some extinct	
Potential restoration strategies in the AORZ	An important and crucial forest type to be established widely in the city and across the Plains for its important fruit supply. It will occupy the more elevated parts of the AORZ and as such will be contested for other purposes. Site preparation may include ripping of compacted landfill.	 Rakaia Island – interior kanuka woodland

Reference sites for **Inland Dune Forest**		
Locations	Spencer Park, Travis Wetland (Mairehau Rd), Taylors Mistake, Nape Nape	Reference Photos
Physical description	Old dunes form crescentic ridges representing former coast lines; mostly these have been favoured building sites in eastern Christchurch; the soils are mapped as *Waikuku* sandy loams. Equivalent environments exist on existing or future stop banks	
History	Again most of this bush and scrub was eliminated in the early days of European settlement, and then stabilised by exotic marram grass, lupins and pines. There is now an active dune restoration programme around the country and in coastal Christchurch.	
Characteristic flora	Ngaio, akeake, akiraho, shrub pohuehue, tauhinu, matagouri, small-leaved coprosmas, ti kouka, prostrate kowhai, kanuka, kapuka, kohuhu, porcupine shrub	
Characteristic fauna	passerines forest birds	
Potential restoration strategies in the AORZ	The driest environments will be found on natural dunes and some artificial surfaces. This will complete the gradient of this AORZ hydro-sequence	



NapeNape – coastal forest dominated by kapuka, ngaio, akeake, akiraho & kowhai

Brooklands sand dune – recently planted coastal bush edge of ngaio & akeake

Reference sites for **Gravel and stopbank communities**		
Locations	Lower Styx stopbanks, Wairau Diversion	Reference Photos
Physical description	Artificial banks and levees subject to tidally fluctuating water levels but above the salt wedge; fine to coarse textured alluvial substrate prone to scouring and bank collapse	 Lower Styx stopbank with mosses & otherwise largely exotic species on upper slopes and crest & salt marsh species on lower slopes
History	Generally heavily modified by river engineering to alleviate flooding by dredging and stop-banking; in the past riparian vegetation was continually trimmed but with softer management tussocks re-establish and are relatively easy to plant above the high water levels from which plants can self-establish when favourable conditions are prolonged.	 Wairau Diversion – 1960s stopbank with wide range of native mat plants (pohuehue), creepers (sand convolvulus), grasses (Zoysia twitch) & shrubs (matagouri & scrambling pohuehue)
Characteristic flora	pukio, sedges, rushes, harakeke and toetoe on mid slopes with cyclical inundation, and mikimiki, koromiko, pohuehue, tauhinu, toetoe, matagouri, porcupine shrub and silver tussock on crests	
Characteristic fauna	inanga, tuna in tidal edges, putakitaki, spur-winged plover, pipit on dry banks	 Wellington waterfront – Waitangi Park with planted gravel beds of silver tussock, knobby clubrush, rice-bush & NZ linen flax
Potential restoration strategies in the AORZ	Natural regeneration and planting are quick to establish on lower slopes, but generally need to plant tussocks and reeds at top of tidal range and let plants spread vegetatively downslope; will migrate upstream with SL rise; dry crests need to be planted in Autumn and provided with water in first summers to ensure optimum moisture for establishment	