Development of a GIS-based decision support model for riparian zone ecological restoration at two special scales: a case study for the Waihi River, Canterbury – New Zealand

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Proposal

A dissertation to be
submitted in partial fulfilment
of the requirements for the Degree of
Master of Natural Resources Management and
Ecological Engineering

At Lincoln University

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1 Introduction

Restoration is used as a means to re-establish functions and related physical, chemical and biological characteristics of a degraded and disturbed system (Cairns, 1988). The National Research Council (1992) defined restoration as the return of an ecosystem to a close approximation of its condition prior to disturbance. In general, human activities related to land use and land development activities (e.g. intensification of dairy farming and irrigation) are the key factors in altering, threatening and destroying aquatic and related ecosystems in rural regions by disturbing and changing the geomorphic, hydrologic, and biological states and structures of those ecosystems (United States Department of Agriculture, 1992).

Restoration of riparian zones can be an appropriate approach to improve and support the functions of riparian areas, such as streambank stability, denitrification of groundwater and (runoff) inflows, shading of the channels for temperature, in-stream plant control, and downstream flood control. Riparian zones, as three-dimensional zones of direct interaction between terrestrial and aquatic ecosystems (Gregory et al., 1991), can have a significant role in controlling the effects of human activities on streams and downstream aquatic systems (Ministry for the Environment, 2000). As a result, efforts to restore these zones can result in the enhancement of stream habitat and water quality and the mitigation of negative impacts of human land use and land development activities ; (Fry et al., 1994; Petersen, 1992; Harris et al., 1997; Boon et al., 1998; Quinn, 1999; Quinn et al., 2001a; Quinn, 2003).

Many efforts have been undertaken to develop classifications and approaches for assessing, evaluating, and managing riparian areas (Table 2). A range of criteria and approaches to define, assess and evaluate riverine areas have been developed worldwide. This study focuses specifically on the classification and assessment approaches for riparian areas.

In general riparian classification and assessment systems can be divided into 2 main groups: geomorphic and the biotic (plants and wildlife); some also use criteria from both approaches. Riparian restoration approaches proposed by Petersen (1992), Fry et al. (1994), Boon et al. (1998) SERCON (System for Evaluating Rivers for Conservation), the USDA Forest Service (1992), and Harris & Olson (1997) are all representatives of the biotic classification approach. These systems all assess, evaluate and classify riparian zones according to criteria, values, benefits and physical or biological functions such as width, completeness and type of vegetation, aquatic invertebrates and naturalness of the channel and its riparian zone. However, Harris & Olson (1997) acknowledge the association between vegetation and geomorphology by defining geomorphic reference conditions for specific plant communities. Rosgen's Classification (1994) is included among the geomorphic classification and assessment approaches because it assesses geomorphic and in-channel characteristics such as channel gradient, sinuosity, width-to-depth ratio and soil erodibilty and stability. Rosgen's Classification (1994) is not indisputable in the literature. However it is an important contribution to the field of river classification and it is also basis for various riparian classification and assessment approaches. (Naiman et al., 2005) approach is a mixture of both main classification groups because it uses, on the one hand watershed-level information on basin topography and, on the other hand, land cover to rank the potential suitability of all sites within the watershed for either preservation or restoration of riparian areas and wetlands.

In New Zealand Quinn et al. (1999, 2001a, 2003) have developed the Riparian Management Classification (RMC) for assessing and classifying riparian areas regarding their functions and physical attributes from a catchment scale down to a stream reach scale (10^2 m). The RMC was created by surveying relevant site characteristics at reaches and then by using statistical analysis tools to group sites with similar function and physical attributes. There are two main issues with integrating the RMC with a GIS-based decision support system. Firstly, the RMC is limited by scale for using it as a GIS decision support system for on site restoration efforts. The scale of operation and applying is limited to the stream reach scale (10^2 m). And secondly, its character is basically more statistical than a GIS tool although visualisation and GIS analysis is possible on principle if the data from the surveys are linked to the sections in the REC (River Environment Classification for New Zealand) accordingly to the NZREACH-NUMBER both exhibit as attribute.

Although Harris & Olson’s (1997) approach would fulfil two criteria it fails to fulfil the third criteria. Their approach to determine the upstream and down stream reach boundaries on their susceptibility to erosion or deposition during peak flows and cross valley reach boundaries determined by the geomorphically defined valley floor is impossible to implement into a model because it requires human editing work and site mapping. Also Russell et al.’s (1997) approach would fulfil two criteria to be a two-staged GIS-based decision support model, at least partly. But to facilitate on-site restoration efforts it lacks the ability to fulfil the important criterion of “also applicable at a site scale. This approach is limited to the catchments scale.

Although there are significant differences among approaches, the advantage of such a variety is the ability to choose the appropriate tool for a specific environment, such as for low land areas or the headwater areas of a river. None of the systems, however, were developed as a GIS-based decision support model. Further they all share a lack either in one or more of the following criteria to be a GIS based decision support model facilitating riparian restoration efforts (Table 1). Although none of them fulfil all the criteria, shown in Table 1, to be a useful two-staged and GIS-based decision support model they offer the possibility to use the suitable criteria or parts of them for the proposed GIS decision support system (Table 1). The aim of the proposed GIS decision system is to fulfil all three criteria to provide a two-scaled GIS decision support model. It is going to be based on criteria and parts developed and applied in one or more of already existing approaches but it will integrate it within a multi-scaled GIS-based decision support system.

Systems	**Criteria can be derived from GIS-data**	**applicable also at a site scale (10^1 – 10^2 m)**	**Potential for integration into a GIS decision support model**
RCE (Petersen, 1992)	**No**	**No**	**Low**
RESA (Fry et al., 1994)	**No**	**very limited**	**Low**
Harris & Olson (1997)	**Limited**	**Yes**	**Low**
USDA (1992)	**No**	**Yes**	**Low**
Russell et al. (1997)	**Yes**	**No**	**Limited**
RMC (Quinn et al., 1999, 2001a, 2003)	**limited**	**No**	**Medium**
SERCON (Boon et al., 1998)	**very limited**	**No**	**Low**
Rosgen (1994)	**No**	**No**	**Low**

Table 1: Various riparian classification systems and their ability being a GIS-based decision support model to facilitate on-site restoration efforts

Biotic or geomorphic classification	Country	Name	Author	Objectives	What was measured (Criteria)	Scale/GIS use
Biotic	Sweden	RCE (Riparian, Channel and Environmental Inventory)	Petersen (1992)	Assessment of the physical and biological conditions of small (< 3 m wide) stream channels in low gradient, agricultural landscapes	16 characteristics (Adjacent land-use pattern, width of riparian zone, completeness of riparian zone, vegetation of riparian zone, retention devices, channel structure, channel sediments, stream-bank structure, Bank undercutting, stony substrate/feel and appearance, stream bottom, riffles/pools or meanders, aquatic vegetation, fish, detritus, macrobenthos)	Assessment for 100 m sections Recommendation for using a 1: 10000 topographical map No GIS use
Biotic	United States	USDA Forest's Service Integrated Riparian Evaluation Guide	USDA (1992)	Evaluation of the integrity of riparian areas to categorize and prioritise riparian areas for restoration and monitoring	Criteria (Stream type after Rosgen, Cover types, Soil, aspect and elevation, wildlife and fish species presence, land use activities and influence, bank stability, vegetation community type composition, area extent or riparian area, aquatic habitats, valley bottom type, stream type/channel morphology, woody species regeneration, foliage height/volume)	Level 3 is operating on a site specific level (10^1 to 10^0 m) similar to level two of the proposed two-staged GIS decision support system to find the most suitable riparian sites for restoration GIS application unknown
Biotic	United States	RESA (Riparian Evaluation and Site Assessment)	Fry et al. (1994)	Assessment and evaluation to rank river segments to facilitate appropriate land-use decisions Determine appropriate buffer widths for stream corridor protection	Natural functions, values and benefits 3 criteria (perennial riparian, intermittent riparian and ephemeral riparian) and 10 site-specific attributes (vegetative cover density and diversity, channel morphology, state of erosion, habitat diversity, local land use, surface water quality enhancement factors, groundwater recharge enhancement factors, recreation potential, upland condition)	Only on site assessment applied by cross sections (transect) Application for GIS not mentioned
Biotic	United States		Harris & Olson (1997)	Prioritizing stream reaches and riparian communities for restoration by acknowledging the association between geomorphology and riparian vegetation	Criteria are land cover (vegetation), land use and geomorphology (valley floor, width and slope, substrate and gradient) Ranking based on previous defined reference conditions varies from protection (reference sites) to restoration (lowest ranking) Criteria for the reference conditions are: Percent canopy cover of tree, shrub and herb communities, percent of urban and other irreversible land use, percentage of floodplain-upland boundary – connectivity to upland, number of patches of native riparian communities, mean size of those patches	Two-staged system; operates on a stream reach scale (10^2 to 10^3 m) and on a on site scale (10^2 to 10^0 m) Use of aerial photos (stage one) and grids or transects (stage two)

Biotic and geomorphic	United States		Russell et al. (1997)	Ranking sites regarding their potential for preservation or restoration of riparian areas and wetlands within a watershed	Land cover – land use, Topography of the watershed and a calculation of a relative wetness (consideration of the hydrological factor), size of the sites and the proximity to existing riparian vegetation	Operates on a watershed (catchments) level Use of GIS
Biotic	United Kingdom	SERCON (System for Evaluating Rivers for Conservation)	Boon et al. (1998)	Assessment of the conservation value of a river corridor Tool for strategic river corridor management	Criteria: Naturalness, physical diversity, representativeness and species richness	Using 'Evaluated Catchment Sections' (ECS) as units (between 10 and 30 km length) SERCON includes an own computer software to calculate the results
Geomorphic	United States	Rosgen's Classification	Rosgen (1994)	Stream type classification	Geomorphic and in-channel characteristics (Landform, valley morphology, soil, river profile, width to depth ratio, channel material, sinuosity, bank erodibility, riparian vegetation)	Ends at the stream or channel reach scale (10^2 to 10^3 m) GIS application unknown
Biotic and geomorphic	New Zealand	RMC (Riparian Management Classification)	Quinn et al. (1999, 2001a, 2003)	Assessment and classification or riparian areas according to their functional roles in improving stream habitat, controlling contaminant input and enhancing aesthetics, biodiversity and recreation RMC as tool for planning and prioritising riparian management actions	Criteria (bank stabilisation, filtering contaminants from overland flow, nutrient uptake by riparian plants, denitrification, shading for instream temperature and plant control, input of large wood and debris, enhancing instream fish habitat and fish spawning areas, controlling downstream flooding, human recreation)	Assessment for 100 m sections Use of GIS for analysis and presentation of the results possible

Table 2: Summary of various riparian classification systems developed throughout the world

This Masters Dissertation aim is to build a GIS-based decision support system that facilitates both, stream reach (10^3 – 10^4 m) and on site (10^2 m – 10^1 m) restoration efforts at riparian areas by restoration groups, farmers or interested people. Although the RMC itself does not fulfil all three criteria of Table 1 to be a two-scaled GIS-based decision support system for facilitating ecological restoration efforts it provides appropriate and very useful information. The following paragraph points out the advantages of using the RMC as both, a framework and a criterion for stage one of the GIS-based decision support system.

The GIS-based decision support system will be a two-staged model and will use at its first stage the RMC because it is a New Zealand based system and provides useful information for facilitating ecological restoration efforts in New Zealand. The GIS-based decision support system will use the RMC in two ways. Firstly, it will use the RMC as a framework, because the RMC is based on the REC (River Environment Classification for New Zealand) and this means that the RMC results derived from surveys and statistical analysis can be linked to the REC shapefiles via the attribute NZREACH-NUMBER that both systems comprise. Hence, using the RMC as framework provides the possibility to use accurate GIS-based catchment and river data in form of shapefiles. And secondly, it will use the results of the RMC as one criterion to classify riparian areas regarding their suitability for ecological restoration on a stream reach scale. The result of the RMC is an analysis of the current and the potential (under best riparian management practices such as planting and fencing) state of riparian areas, subdivided into 100 m sections, regarding their biophysical functions.

Stage two of the GIS decision support model will refine the results of the first stage analysis by using the additional data collected on site as criteria for classifying riparian areas at a finer operational scale. To prove if the model is going to deliver reasonable and helpful results fieldwork will be done after developing this GIS support system to get on site data for running the model. The model is meant to be complementary to the RMC to support and enhance restoration efforts at the on site scale (10^2 m – 10^1 m), the scale at which the restoration ultimately occurs (Russell et al., 1997). Whereas the RMC stops at a stream reach scale (10^2 m) and is more a general tool for managing riparian areas than specialised on restoration.

Based on the findings in Table 1 the GIS-based decision support system will use those parts of the analysed systems that meet the criteria of being a useful two-staged GIS-based decision support system (Table 1). Furthermore it will use those criteria, pointed out in Table 2 that provide an appropriate and efficient support to determine the most suitable riparian areas for ecological restoration.

The GIS-based decision support system is going to be developed in cooperation with NZERN (New Zealand Ecological Restoration Network), Lincoln University and the University of Natural Resources and Applied Life Sciences in Vienna, Austria.

2 Objectives and approach

The aim of the thesis is develop and build a two-staged GIS support system to facilitate and enhance on site restoration efforts at riparian sites done by restoration groups, farmers and interested people. Thus it has to be easy in use, easy to understand, but still incorporates all relevant data and criteria to be scientifically accurate and offer the possibility to find the most potential (prioritised) riparian areas where to start with restoration work. The objectives underlying the aim are pointed out in this and the next two chapters.

The methodology of the dissertation consists of three main parts and follows the structure of the three objectives and is pointed out in this and the next two chapters too. The first two parts (two objectives) are using ArcGIS software (ESRI) to build a two-staged support system to facilitate on site restoration efforts by mapping the most potential sites for the restoration efforts. This shall not be constricted to one certain area so the aim is to build a model that is applicable for every river and stream in Canterbury. Hence the two-staged model is going to be a suitability model. The third part is verifying the model by populating it with collected data from the Waihi River (South Canterbury).

The resulting maps from both stages will have the same suitability classification:

- Very suitable for ecological restoration efforts
- Suitable for ecological restoration
- Low Suitability for ecological restoration
- Not suitable for ecological restoration

2.1 Objective one: Stage one of the GIS model

Developing the first stage of the GIS supporting tool based on the RMC, the Land Cover Database 2, data on landownership, geology, soil, flood zones and former riparian areas for a classification of riparian areas regarding their suitability for ecological restoration on a catchments down to a stream reach scale (10^5 m- 10^2 m).

2.1.1 The objective

To find the riparian areas with the highest potential of improvement regarding to their biophysical and ecological functions (as support for proposed riparian restoration efforts) on a stream reach scale.

2.1.2 Methodology

Stage one of the GIS model uses the RMC as a framework. Stage one is going to be the basis for the second stage of the model because its resulting suitability map is going to be used for the on site surveys. The on site surveys are essential to collect the data for stage two of the model. Doing the stage one analysis is a bottom down approach because it just uses already existing data and there are no restoration groups, farmers or interested people involved who could incorporate work or data.

The result of running the first stage of the model is going to be a map that displays the riparian areas classified in different categories (in 100 meter sections) from very suitable to not suitable for restoration efforts based on the RMC and further relevant data (criteria/parameter). Therefore see Table 3. Besides this first and raw classification of the riparian areas regarding their suitability for restoration the map also includes

- additional data (topographical elements like bridges, streets and ownership boundaries) and orthophotos are laid underneath to ease the orientation for the data collection by restoration groups, farmers or interested people for stage two of the model.

- a grid (20 by 20 meters) and a finer grid (10 by 10 meters) to subdivide the 100-meter section into 5 (20 by 20 meters) and if the proposed sections show a very heterogeneous composition of the riparian area an additional 10 by 10 meters grid.

Every grid gets a number and the map is going to be printed out and is the basis for the on site data collection for stage two of the model.

Criteria/Parameter	Data source
RMC rating of the potential of the functions the riparian areas deliver in this section (under best management practices: fencing and planting)	RMC
Landownership	NRFA (New Zealand Rural Fire Authority)
Land Cover	Land Cover data base 2
Land Cover of adjacent land	Land Cover data base 2
Land use	LINZ, NRFA
Land use of adjacent land	LINZ, NRFA
Proximity to already restored areas	NZERN data base
Proximity to natural habitats	DOC data
Soil type	LENZ
Soil moisture	LENZ
Geology	GNS (Institute of geological and nuclear sciences) -in progress)
Flood zones	In progress
Former areas of riparian areas	Historical data (Floodplains) – in progress

Table 3: Criteria of stage one of the GIS model

Following data is going to be used for stage one of the model:

- RMC (after Quinn) – Excel spreadsheets and vector data
- Historical data (pictures, maps to figure out the pre-disturbance state of the area) and what would be the native vegetation in the specific areas (divided into different lateral zones within the riparian zone)
- REC (NIWA) – Vector data
- LIDAR (Light detection and ranging). These aerial photos might be an alternative to orthophotos because of their higher resolution.)
- LINZ (Topology data) – Vector data
- LENZ (Land Environment New Zealand) data – raster data
- NZERN data (restoration sites and areas) – vector data
- Orthophotos – Raster data

2.2 Objective two: Stage two of the GIS model

Developing the second stage of the GIS supporting tool that is based on the results of the first stage by adding data collected regarding to the onsite criteria during fieldwork This stage is going to refine the results of the first stage analysis by using the additional collected on site data as criteria for classifying riparian areas on a finer on site scale (10^2 m – 10^1 m).

2.2.1 The objective

Find the riparian areas with the highest potential of improvement regarding to their biophysical and ecological functions (as support for proposed riparian restoration efforts) on an on site scale (10^2 m – 10^1 m).

2.2.2 Methodology

The second stage of the model is based on the results of the first stage and is going to fill the gap mentioned earlier by calculating a refined map of the 100 meter sections (from the RMC) which classifies those 100 meter sections into five 20 meter sections and two 50 meter sections when significant changes in one section make it necessary to refine this section. This second map is based on input data (criteria/parameter for the model) collected by on site surveys. Hence the second stage supports a bottom up approach by integrating people in the data collection process.

Following criteria/parameter are going to be assessed for every gird that is in the riparian zone. They will be assessed for both sides of the river (true left and true right). The criteria and parameter can be divided into hydrological and geomorphic, a biotic and zonal (lateral profile of the survey site) criteria and parameter. These criteria/parameter (Table 4) are based on literature and already existing systems to manage, evaluate, prioritize riparian areas regarding their biophysical functions, conditions, values and benefits. The criteria/parameter are adopted from Petersen's RCE (1992), Federal Interagency Stream Restoration Working Group's Stream Corridor Restoration Report (1998), Fry et al.'s (1994) RESA (Riparian Evaluation and Site Assessment), Rosgen's Classification (1994), the USDA Forest's Service Integrated Riparian Evaluation Guide (1992) and Quinn et al.'s (1999, 2001a, 2003) RMC (Riparian Management Classification). They are slightly modified for the use at an on site scale. The ranking system of the classes is based on Petersen's RCE (1992).

This will be backed up by professional knowledge and local knowledge of people who have been involved in riparian restoration and have long-lasting experience in this type of work that includes planning and realisation. The criteria/parameter itself were chosen out of a wide range of systems and approaches that are not only focused on ecological restoration of riparian areas only. Hence the selection of those criteria/parameter is based on their relevance for successful ecological restoration at riparian areas. Every criterion/parameter contains various options to choose at an on site assessment regarding their ability or potential for a successful restoration of riparian areas.

Criteria/Parameter	Rating for classes	Description
Soil type, USDA Forest's Service Integrated Riparian Evaluation Guide (1992); adapted for riparian New Zealand native plants and their needs for growing	30	In progress! According to the NZERN soil type guide – In progress
	20	Wide selection of plants may be successfully planted or seeded
	5	Fewer plants are adapted and can be successful planted or seeded
	1	Not suited for planting or seeding
Channel or stream form, Rosgen's Classification (1994); Interagency Stream Restoration Working Group, 1998)	25	Thread: single (steep: > 10 %, no sinuosity)
	15	Thread: single (less steep: 4 – 10 %, small sinuosity, sometimes little meandering)
	5	Thread multiple – braided (gentle: < 4 %, meandering)
	1	Thread multiple – anastomosed (gentle: < 4 %, meandering low to high)
Channel structure (channel width to depth ratio), Rosgen's Classification (1994)	25	< 12 W/D ratio
	15	12 to 25 W/D ratio
	5	26 to 40 W/D ratio
	1	> 40 W/D ratio
Local land use of the adjacent upland, Petersen (RCE, 1992); Fry et al. (RESA, 1994)	30	Undisturbed, consisting of forest, natural wetlands, bogs and/or mires
	20	Permanent pasture mixed with woodlots and swamps, few row of crops
	10	Mixed row of crops and pasture
	1	Mainly row crops
Width of the riparian zone from stream edge to field, Petersen (RCE, 1992)	30	Marshy or woody riparian zone > 30 m wide
	20	Marshy or woody riparian zone varying from 5 to 30 m
	5	Marshy or woody riparian zone 1 to 5 m
	1	Marshy or woody riparian zone absent (what if woody riparian zone is not the optimal reference site for that area in NZ?)
Completeness of riparian zone, Petersen (RCE, 1992)	30	Riparian zone intact without breaks in vegetation (Lateral and longitudinal)
	20	Breaks occurring at intervals of > half the length of the grid used for assessment
	5	Breaks frequent with some gullies and scars every half of the length of the grid used for assessment
	1	Deeply scarred with gullies along its length

Vegetation of riparian zone within 10 m of channel, Petersen (RCE, 1992); Fry et al. (RESA, 1994)	25	> 90 % plant density on non-pioneer trees or shrubs, or native marsh plants
	15	Mixed pioneer species along channel and mature trees behind
	5	Vegetation of mixed grasses and sparse pioneer tree or shrub species
	1	Vegetation consisting of grasses, few trees and shrubs
Slope of the riverbank, Quinn et al.'s RMC (1999, 2001a, 2003); USDA Forest's Service Integrated Riparian Evaluation Guide (1992);	20	< 1°
	10	1° – 2°
	5	2° – 4°
	1	> 4°
Land cover of adjacent upland	30	Regarding the Landcover database 2
	20	Refinement of the Land cover database 2 and group them together into 4 categories
	5	In progress!
	1	
Bank undercutting (Grade of erosion, Petersen (RCE, 1992; US Federal Interagency Stream Restoration Working Group, 1998); Fry et al. (RESA, 1994)	20	Little or none evident or restricted to areas with tree root support
	15	Cutting only on curves and at constrictions
	5	Cutting frequent, undercutting of banks and roots
	1	Severe cutting along channel, banks falling in
Stream bank structure, Petersen (RCE, 1992)	25	Banks stable, of rock and soil held firmly by grasses, shrubs and tree roots
	15	Banks firm but loosely held by grass and shrubs
	5	Banks loose soil held by a sparse layer of grass and shrubs
	1	Bank unstable, of loose soil or sand easily disturbed
Riffles and pools or meanders (sinuosity), Petersen (RCE, 1992, US Federal Interagency Stream Restoration Working Group, 1998)	25	Distinct, occurring at intervals of 5-7x stream width
	20	Irregularly spaced
	10	Long pools separating short riffles, meanders absent
	1	Meanders and riffles/pools absent or stream channelised
Fencing existent to prevent stock access to riparian area, Quinn et al. (1999, 2001a, 2003, RMC)	25	Fencing along the whole grid unit
	1	No fencing along the grid unit

Table 4: On site assessed criteria of stage two of the model

The on site criteria are going to be assessed and collected on the map from the stage one analysis accordingly to the appropriate grid fields. After collecting the data they are going to be plugged back into the GIS model to run it and get the resulting fine-scaled map (The transfer of the data optionally could be done via ArcIMS on the NZERN server). The resulting map of stage two model shows the riparian areas classified by their suitability for ecological restoration efforts.

Both stages of the GIS support system are going to be built with the model builder included in the ArcGIS 9.0 software.

2.3 Objective three: Data collection (test survey) and verifying the model

After considering objective one and two, objective three is to verify if the GIS decision support systems provides reasonable and helpful results.

2.3.1 The objective

To collect on site data to prove and test by running the model with the collected data, if the model is going to deliver reasonable and helpful results to support and improve such on site restoration efforts.

2.3.2 Methodology

A test survey (collecting data from 3 randomly chosen sites at the Waihi River (South Canterbury) is planned to prove and verify if the model delivers sensible and useful information. A restoration group have been working there for more than 5 years and some restoration work is done at the Waihi River. This is an important point to verify if the model brings reasonable results because it allows proving the relevance of the criteria proximity to already restored areas.

The way of doing the data collection has to be set up before starting the survey accordingly to the criteria/parameter that are going to be assessed. The step of collecting the data in the field has to include a consideration of trade off between feasibility/accessibility and complexity.

3 Work plan including time table

Date	Steps
27.02. – 05.03.2006	Writing of proposal Literature review Meeting with Mike Peters (NZERN) Formulating a hypothesis (questions)
06.03. – 12.03.2006	Writing of proposal

	Literature review Meeting with Prof. Ian Spellerberg Start to work out a conceptual model for the GIS model
13.03. – 19.03.2006	Meeting with Brad Case to discuss the GIS model and criteria Start working at NZERN (GIS model) Literature review Data collection for the GIS model (aerial photographs, LIDAR)
20.03. – 26.03.2006	Data collection for the GIS model (aerial photographs, LIDAR) Work on the GIS model Working on the theoretical part (basis for the model) about riparian restoration
27.03. – 02.04.2006	Working on the theoretical part (basis for the model) about riparian restoration Data collection for the GIS model (aerial photographs, LIDAR) Work on the GIS model
03.04. – 09.04.2006	Working on the theoretical part (basis for the model) about riparian restoration Data collection for the GIS model (aerial photographs, LIDAR) Work on the GIS model Preparation for the field work
10.04. – 16.04.2006	Working on the theoretical part (basis for the model) about riparian restoration Work on the GIS model Data collection for the GIS model (aerial photographs, LIDAR) Preparation for the field work
17.04. – 23.04.2006	Midtermbreak (Samoa - cancelled)
24.04. – 30.04.2006	Midtermbreak; Working on the GIS model Preparation for the field work
01.05. – 07.05.2006	Field work at Waihi River (mapping, collect data, observations)
08.05. – 14.05.2006	Field work at Waihi River (mapping, collect data, observations) Discussion of the collected data Populate the model with my collected data

15.05. – 21.05.2006	Discussion of the results (does the model work) Writing Time for working on the GIS model (improvement, correction of mistakes)
22.05. – 28.05.2006	Writing Time for working on the GIS model (improvement, correction of mistakes)
29.05. – 04.06.2006	Writing Time for working on the GIS model (improvement, correction of mistakes)
05.06. – 11.06.2006	Discussion and meeting with Ian Spellerberg, Brad Case, Mike Peters Writing Revision
12.06. – 18.06.2006	Writing Revision Layout and Editing of dissertation
19.06. – 25.06.2006	Revision Presentation of the results at NZERN
26.06. – 02.07.2006	Completion of draft version (dissertation) Layout and Editing of dissertation References revision
03.07. – 09.07. 2006	Revision
10.07.2006	**Final draft version of my dissertation**

4 Budget plan

Expenditure	Cost (in NZD) 2006
Travel expenses & accommodation in Geraldine (140 km one way Christchurch – Geraldine, 3 trips planned for field work)	**250**
Printing	**100**

Copying	**100**
ESRI virtual campus tutorials for GIS software	**250**
Field work (data collection according to criteria/parameter, measurement devices, batteries)	**200**
Stationary	**50**
Total	**950**

5 Implications of Research

5.1 General implications

This GIS decision support model aims to refine an already existing larger scaled riparian classification system (RMC) in New Zealand by adding on-site collected data. Hence this dissertation can have five major implications

- Verify the feasibility and necessity of creating such a fined scaled model as tool for restoration efforts
- After testing the model with data collected by surveys and examination of the results (Are the resulting maps reasonable and helpful) this model can be used by many other restoration groups throughout Canterbury.
- This GIS decision support system can be seen as a new tool for supporting a bottom up approach in riparian restoration efforts, because it combines already existing data (REC, RMC, LENZ) with data collected by local participants (i.e. restoration groups and farmers). The result is an empirical robust and easy understandable tool for on site restoration efforts.
- Because of its bottom up approach this model can offer an incentive for many other restoration groups or interested people to go out and collect data at their river and riparian zone and combine through the model with larger scaled data from REC and RMC to get the information needed for a sound restoration of riparian zones.

5.2 Implications of applying the model as basis for a ArcIMS service

As a result of successfully building the model it could be the basis for an ArcIMS service offered by NZERN on their homepage were users can interact with NZERN via ArcIMS, which is a GIS application besides Arc GIS desktop software, which supports the internet use of GIS in general. The restoration group, farmer or NZERN member can download and print out the map which is the result of the first stage analysis plus additional topographic features for a better orientation) and includes the grids. The user can see a broad classification of the proposed section and can so focus on the sections with a higher potential for restoration efforts. With this map the fieldwork can be done via collecting the data (on site criteria/parameter) regarding to the specific grid fields. This data can be plugged back into the NZERN GIS environment via ArcIMS to calculate the finer second stage map of the proposed area. So the user gets a fine-scaled map that displays the sites with the most potential for restoration efforts. The entering of the data for each grid field optionally could also be done via entering the data in electronically forms (i.e. number of the grid). This could be supported by pictures of various riparian sites out of the RMC to ease the fill out of the forms (i.e. the question what type of profile is it, is easier to classify with some pictures as visualisation support).

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