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Characterising land ownership patterns in a salt-affected catchment: key implications for revegetation

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ABSTRACT

Land ownership is an important factor in the implementation of revegetation programmes to manage dryland salinity. Because revegetation tasks involve costs that are usually supported (partially or fully) by the land owners, it is necessary to characterise the land ownership patterns of the targeted area to aid revegetation planning and impact analysis. To gain insights to the land ownership characteristics of an area earmarked for revegetation of salt-affected areas, and to develop appropriate analytical techniques, a case study of the Spring Creek sub-catchment (10,522 ha) in Queensland, Australia, was conducted. Using a geographic information systems (GIS) based approach, thematic maps of revegetation priority areas, salinity areas, land parcel, and land ownership data were processed and analysed using raster overlay operation, attribute query, and descriptive statistics. Results show that 83% of the area needing revegetation is owned by only 28 of the total 110 owners in the catchment. There are 11 salt-affected owners of the 301 hectare area affected by salinity. However, those with salinity problems on their property own only 14% of the total revegetation area. This could pose some serious problems in convincing land owners to revegetate on their properties to combat salinity problems occurring on land owned by others. The methodology presented in this paper provides a structured and systematic approach to characterising land ownership and its possible implications for revegetation planning. It could generate information indicating the number of land owners (along with the proportion of land areas involved) that will most likely participate, or otherwise, in revegetation efforts.

KEYWORDS: land ownership, revegetation, dryland salinity, GIS

Introduction

It is estimated that about 2.5 million hectares of land is affected by dryland salinity in Australia (National Dryland Salinity Program, 1999). Salt-affected lands are causing significant socio-economic and environmental problems, with costs estimated in excess of $270 million per year (Bennet *et al.*, 1997). Realising this threat, the federal and state governments have recently launched action programs that will address dryland salinity and water quality issues.

The socio-economic attributes of the land, such as land tenure, rights and ownership, affect its use. For instance, although crown leasehold land in Australia has a large percentage of lands vulnerable to degradation, they are less degraded than the freehold lands (Malafant *et al.*, 1999). In Eastern Cape, South Africa, differences in land tenure systems were found to be the dominant factor controlling variations in vegetation degradation (Kakembo, 2001). In a more localised study in the Lockyer Catchment, Queensland, Australia, the tenure status of the land was found to be significantly associated with the riparian vegetation clearing (Apan *et al.*, 2002).

The ownership of the land is one of the factors that affects peoples' participation in environmental programmes. For example, in a research involving behavioural analysis of wetland owner's decision to participate in a Wetland Reserve Program (WRP) program in the US, the ownership of farmed wetlands was found to be a significant and positive influence on the decision to offer to participate in the WRP (Luzar and Diagne, 1999).

The main cause of dryland salinity is inappropriate clearing of deep-rooted perennial vegetation and its replacement with shallow-rooted crops and pastures or with urban development (RIRDC, 2000; Stirzaker *et al.*, 2000). Revegetation can help restore the water balance in a catchment (Martin and Metcalfe, 1998). Trees and high water use crops can reduce deep drainage by using more water to a greater depth and by intercepting more rain in the canopy than most pastures or crops (DNR, 1997). Thus, revegetation has been identified as a high priority activity to mitigate dryland salinisation in heavily cleared areas (Stirzaker *et al.*, 2002). In some cases, however, a combination of revegetation and engineering strategies is needed (DNR, 1998).

The implementation of revegetation programmes depends on local community support. More importantly, it also depends on the actions of individual land owners. Even if land owners in downstream and salt-affected areas are willing to participate, the refusal of property owners in the critical upper catchment areas to take appropriate action could hinder salinity mitigation efforts. While salinity occurs irrespective of who owns the land, mitigation strategies, such as revegetation, are largely affected by land ownership. Thus, the pattern of land ownership and its relationship to the catchment hydrology must be understood prior to the development of revegetation policies and plans.

The objectives of this study were to a) characterise the land ownership patterns of a catchment that requires revegetation to mitigate dryland salinity, and b) to gain insights on the possible implications of land ownership characteristics to revegetation strategies. This work is part of a larger study investigating the design of an analytical framework for the spatial prioritisation of revegetation sites for dryland salinity management.

Research Methods

Study Area

The study area covers the Spring Creek sub-catchment (151° 40′ E and 27° 45′ S), a part of the Hodgson Creek catchment in south-east Queensland, Australia (Figure 1). It is located south west of the city of Toowoomba, approximately 150 km from Queensland's capital city of Brisbane. Spring Creek catchment has a total area of 10,522 hectares and it is located within the shire of Pittsworth.

The climate in the catchment is predominantly sub-tropical, with summer dominant rainfall (about 70% of the annual rainfall occurs in the October to March period) (DPI, 1988). The average annual rainfall in Pittsworth is about 659 mm, while the temperature ranges from a mean minimum of 5.2°C in July to a mean maximum of 30.2°C in January (DPI, 1988).

Approximately 52% of the catchment is under intensive cultivation. Grasslands cover about 35%, while native vegetation patches comprise 12%. Settlement areas cover 1% of the catchment. Soil erosion has been identified as a severe land degradation problem in cultivated areas of the catchment. The catchment is also affected by a number of forms of salinity, including seepage, and scalding (Carberry and Walker, 1993). The dominant form of salinity in the catchment is saline seepage, associated with the clearing of native vegetation, overgrazing, and increasing areas of crop production.

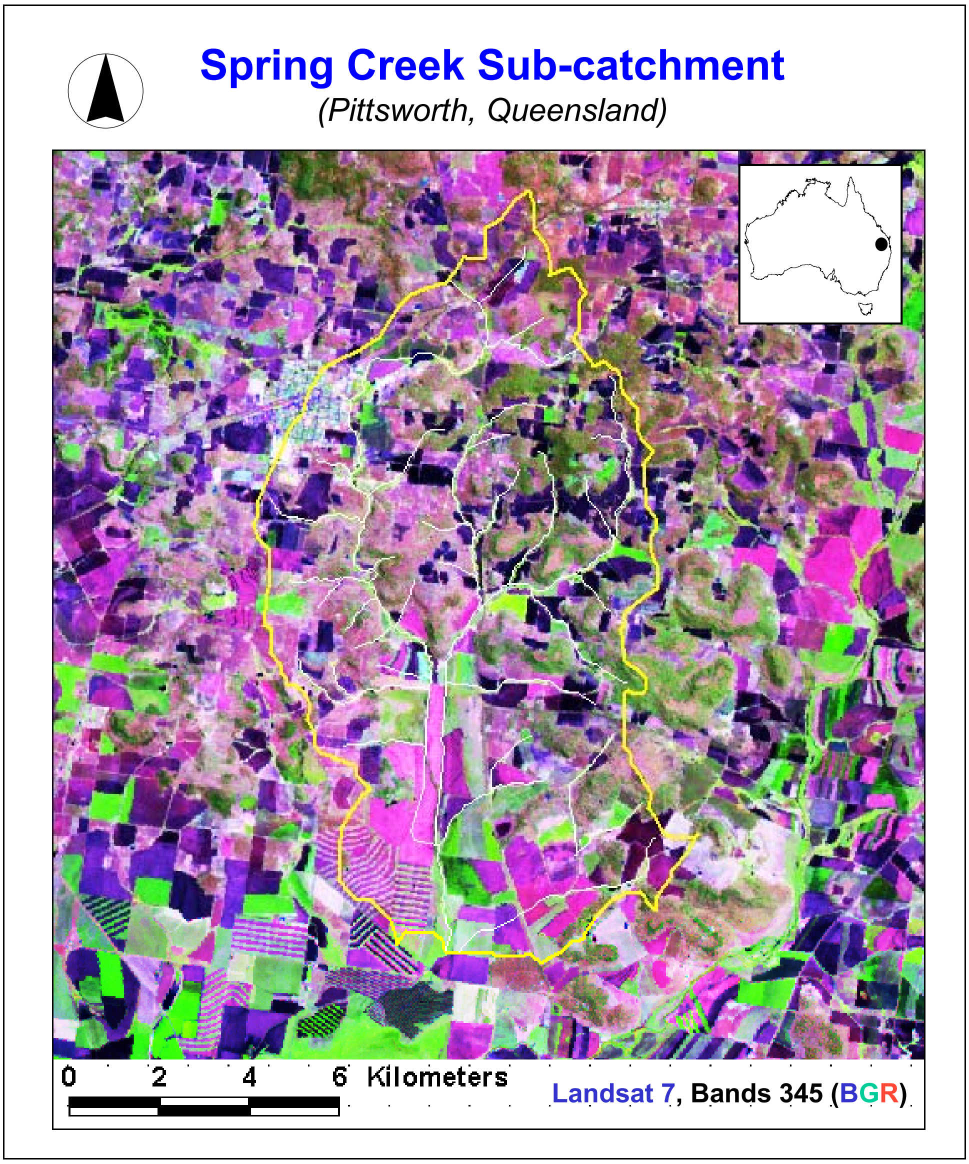

Figure 1. Study area

Data Acquisition and Processing

The *Digital Cadastral Data Base* (DCDB) produced by the Queensland Department of Natural Resources and Mines (NR&M) provided the information on land parcel boundary. Current as of 2000, this data has expected accuracy of at least 10m or better. This dataset was "joined" (i.e. relational joining of attribute tables) with the *Queensland Valuations and Sales* (QVAS) textual data that carried the land ownership information (Figure 2). QVAS includes information on the name of owner, lot on plan or locality, sales date and pricing, area, land use and zoning. The salinity map was sourced from the study made by Carberry and Walker (1993). This was based from field data collection and interview with individuals in the community.

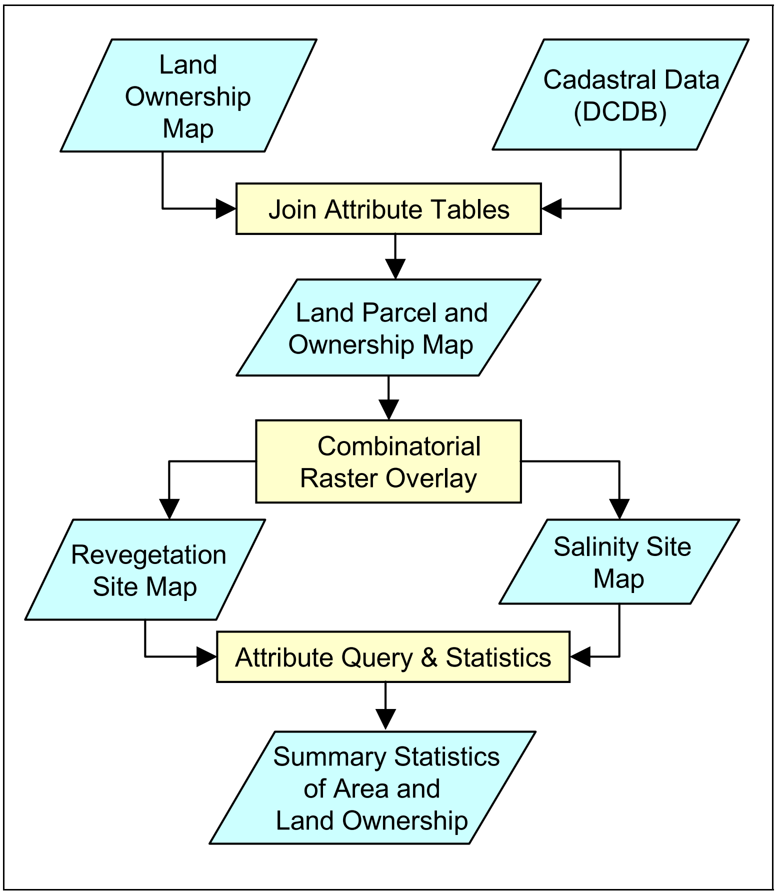

Figure 2. Key processing steps in the processing of land ownership data, revegetation priority sites and salinity areas.

Priority revegetation sites were mapped according to Apan *et al*. (submitted). In this technique, the spatial prioritisation of revegetation sites for dryland salinity management is undertaken using an analytical framework that incorporates the use of a Landsat 7 satellite image, digital elevation model, soil map, and salinity map. These map layers were processed using image processing techniques and a raster-based geographic information system (GIS). Revegetation sites were mapped and their priority determined based on recharge area, land use/cover and sub-catchment salinity. The priority areas include recharge zones associated with pasture/grassland, cultivation or settlement.

For the current study, the "*land ownership map*" and "*revegetation site map*" were combined using the ArcView GIS Spatial Analyst software. This generated a raster layer of unique values for every exclusive combination of two grid layer values (Figure 3). The same procedure was applied to the "*land ownership map*" and "*salinity map*" (Figure 4). Furthermore, a combined raster map of "*land ownership map*", "*revegetation site map*" and "*salinity map*" was produced. The attribute tables produced from these tasks were exported to Microsoft Excel for further processing to generate the basic descriptive statistics on area of properties and the number of land owners involved.

Attributes Of Spingownrev1b

Value	Count	Revegetation	Land Owner
1	216	2	74
2	53	1	74
3	258	1	6
4	500	2	6
5	9	1	47
6	164	1	40
7	40	1	2
8	104	2	40
9	4	2	2
10	1481	1	8
11	552	2	8
12	244	1	23
13	1491	1	42
14	14	1	36
15	578	2	42
16	20	1	34

Figure 3. Resulting attribute table of combined "land ownership map" and "revegetation map". "Count" refers to the number of a 25 x 25 cells; the codes "1" and "2" in the "Revegetation" field refer to priority scale; and a unique number in the "Land Owner" field corresponds to a unique land owner.

Attributes Of Springownsalt

Value	Count	Land Owner	Salinity
1	172	120	100
2	1340	42	100
3	687	11	100
4	429	123	100
5	37	94	100
6	141	104	100
7	455	103	100
8	6	106	100
9	350	99	100
10	1017	8	100
11	179	91	100

Figure 4. Resulting attribute table of combined "land ownership map" and "salinity map". The code "100" in the "Salinity" field refers to the presence of salinity.

Results and Discussion

There are 110 land owners in the 10533 ha study area (Table 1 and Figure 5). For a single owner, the largest property area is 318 ha, while the smallest is less than one hectare. The average land parcel size within the catchment is 39.6 hectares.

Applying the methodology developed earlier (Apan *et al.*, submitted), some 2197 hectares were identified as priority revegetation sites. This represents about 21 % of the catchment (Figure 6). Within this 2197 hectare area, there are 68 land owners. However, the majority of the area (83%) is owned by only 28 land owners.

Table 1. Summary descriptive statistics for land ownership, revegetation sites and salinity areas in the Spring Creek sub-catchment, SE Queensland.

A. CATCHMENT

1. Total catchment area – 10522 hectares
2. Total number of land owners in the catchment – 110 owners

B. PRIORITY REVEGETATION AREAS

1. Total area identified for priority revegetation – 2197 ha. About 21% of the total catchment area.
2. Total number of land owners for the 2197 ha area identified for priority revegetation – 68 land owners
3. There are 10 land owners who own 52% of the 2197 ha area identified for priority revegetation.
4. There are 28 land owners who own 83% of the 2197 ha area identified for priority revegetation.

C. SALINITY AFFECTED AREAS

1. Total area currently affected by salinity – 301 hectares (~3% of the total catchment area).
1. The 301 ha area affected by salinity is owned by only 11 land owners.
2. 190 hectares (i.e. 63%) of the salinity affected area is owned by only 3 owners.
3. The largest area affected by salinity owned by a single land owner – 84 ha
4. The smallest area affected by salinity owned by a single owner – 0.4 ha

D. LAND THAT IS BOTH SALINITY AFFECTED AND A PRIORITY REVEGETATION AREA

1. Only 102 ha (4.6%) of the total 2,197 ha identified for priority revegetation is also affected by salinity.
2. Only 10 land owners own both areas which are both salinity affected and priority revegetation areas. This is only 14% of the total 68 land owners with priority revegetation areas.
3. Only 3 owners own the majority (70%) of these common / overlapping areas

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For the 301 hectares affected by salinity, there are 11 land owners, although only three of which owns the majority (190 hectares or 63%) of the total salt-affected sites. When areas prioritised for revegetation were overlaid with salt-affected sites, there were only 102 hectares found to be common. This represents only about 4.6% (*102 ha / 2,197 ha*) of the areas targeted for revegetation. Under this category, only 10 owners are involved, or just 14% of the 68 land owners corresponding to revegetation priority areas. In fact, only 3 owners own the majority (70%) of these common (revegetation and salinity) areas.

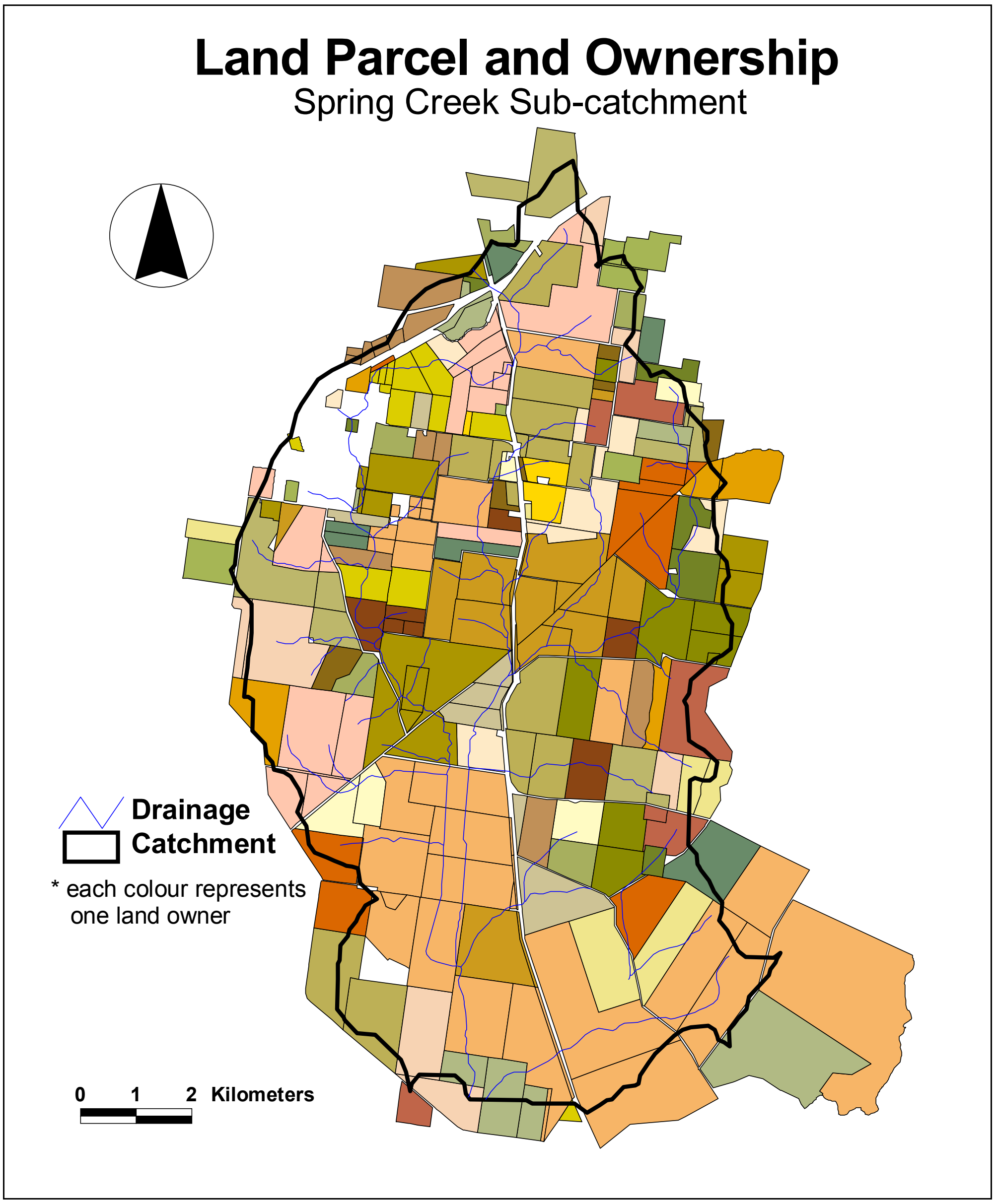

Figure 5. Land parcel and ownership distribution (as of 2000) in the Spring Creek sub-catchment, SE Queensland.

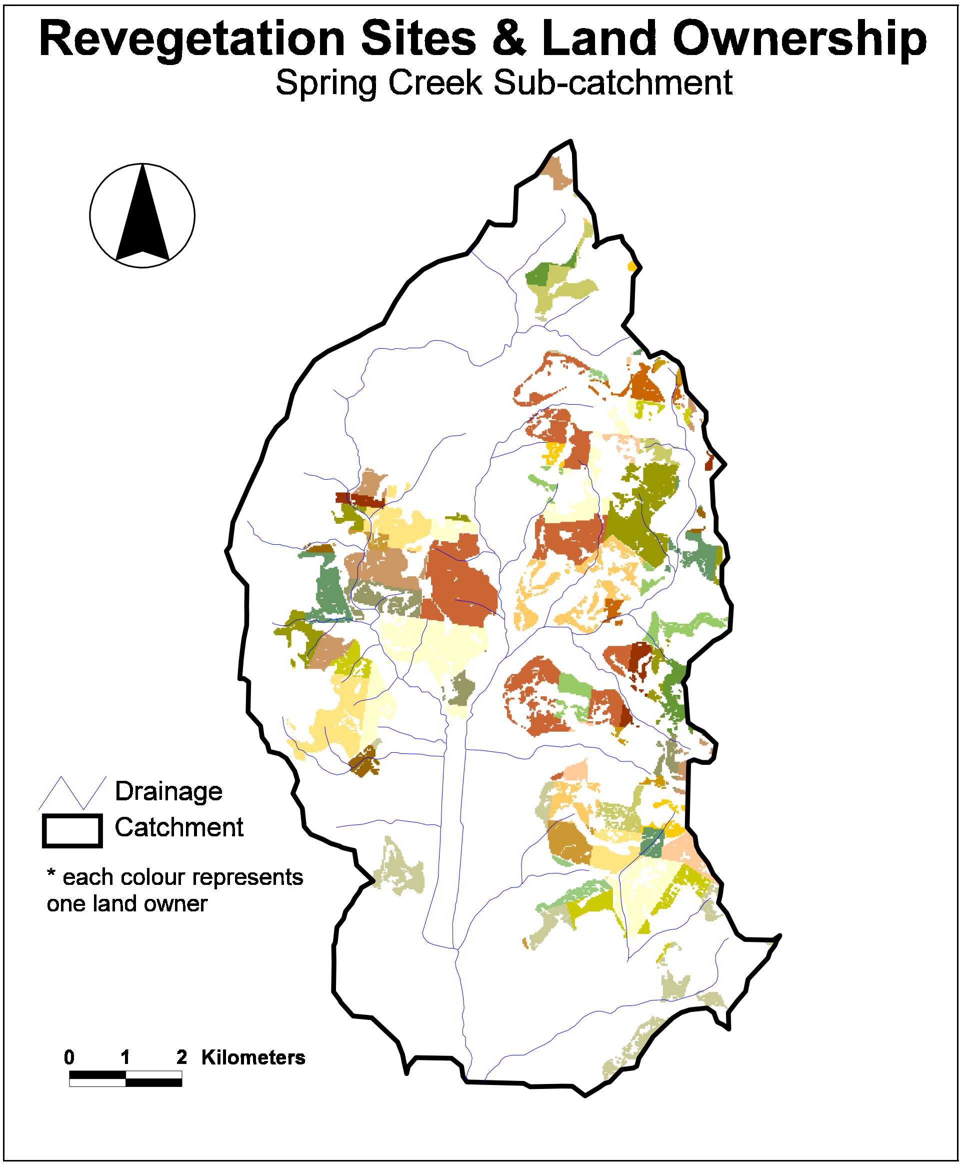

Figure 6. Revegetation sites and land ownership distribution (as of 2000) in the Spring Creek sub-catchment, SE Queensland.

To fully realise the possible implications of land ownership to revegetation for salinity, we developed the following ideas:

The salinity areas are the "*problem areas*" that an affected land owner will most likely wish to rehabilitate from salinity. However, based from our previous analytical framework, not all salinity affected areas could be prioritised for revegetation. For prioritisation, they are only those located in recharge areas. Thus, the most likely supportive land owners are those who own areas both affected by salinity and identified for revegetation.

The revegetation areas are the "*solution areas*". The land owners may or may not participate in any revegetation programmes. There could be myriad of factors involved, but incentives in various forms could provide motivation for them to participate. Thus, land owners who will need convincing are those who own areas identified for revegetation, but not affected by salinity.

From the summary statistics (Table 1), and by using the construct espoused above, the establishment of revegetation programmes in the Spring Creek sub-catchment will need more, rather than less, effort in convincing land owners to participate in revegetation. There are only 10 land owners (i.e. 14% of the priority revegetation area land owners) that will directly benefit from replanting efforts on their own properties. As previously mentioned, this represents only 4.6% of the total 2197 ha targeted for revegetation. Therefore, the majority of land owners will need an additional motivation for them to actively participate in a programme intended to address problems on other properties, which could be tens of kilometres away from their property.

In developing a revegetation program, it may be appropriate to incorporate a process of prioritising the targeting of land owner inducements. In this case, there is 2197 ha identified within the Spring Creek sub-catchment as suitable for priority revegetation and this area is owned by 68 land owners. By ranking the total area covered by each property owner, a sorted list can be produced (*see for example, the top 20 land owners in Table 2*). Enlisting these owners' support will be crucial for the success of revegetation programmes. In the QVAS database, their names and addresses are known, thus they can be identified. This information may prove critical in revegetation planning.

Table 2. Land owners with the highest total land parcel area identified for revegetation.

Land Owner Code	Rank	Property Area (Hectares)	% of Total Revegetation Area
1	1	219.13	9.97
120	2	168.13	7.65
42	3	129.31	5.88
8	4	127.06	5.78
22	5	118.75	5.40
10	6	95.69	4.35
7	7	76.75	3.49
92	8	72.38	3.29
58	9	64.13	2.92
94	10	61.06	2.78
54	11	58.63	2.67
29	12	52.69	2.40
65	13	51.06	2.32
91	14	50.75	2.31
6	15	47.38	2.16
57	16	43.19	1.97
106	18	42.75	1.95
100	19	40.75	1.85
107	20	39.50	1.80

The methodology developed in this study presents a structured and systematic approach in characterising land ownership and its possible significance in revegetation planning. It could generate information indicating the number of land owners (and the proportion of land areas involved) that will most likely participate, or otherwise, in revegetation efforts. This information can be used in designing strategic actions that focus on gathering community or individual support, particularly when participatory approaches are increasingly becoming essential in natural resource management.

A possible improvement to the approach presented here refers to land parcels that may have appeared in the registry as owned by different individuals or groups, but effectively owned by the same. This could happen if owners used different business names, or registered the land to each member or combined members of the family. In these cases, the effective ownership of the land, as well as the decision on its use, rests on one or few people, rather than the several owners reflected in the database. While there are some "clues" that can be gleaned from the QVAS and DCDB data (e.g. a land parcel may be owned by "*J. Smith*" while the adjoining land parcel is owned by "*J. Smith and S. Smith*"), it will be difficult to establish land ownership information accurately. Thus, there is a need to use other sets of information that could distinguish these unique ownership characteristics.

Lastly, this study can be extended to focus on the detailed analysis of costs and benefits, particularly on the implications of the land use type (e.g. grazing or cropping) and the type of farmer (e.g. hobby farmer or traditional farmer) that will be "displaced" by revegetation. The issues of lost production and opportunity costs can be more critical in motivating land owners to participate in revegetation programmes. For this kind of study, cadastral and land ownership datasets will not be sufficient, thus information from social and economic survey at the local level is essential.

Conclusions

The ownership of the land being targeted for revegetation can be a crucial factor in the success of revegetation programmes for salinity mitigation. More specifically, the number of land owners and the proportion of affected land area owned by individuals may have significant implications for the level of participation that can be generated. This study presented a case where only a small proportion of the area needing revegetation is owned by those individuals with salinity problems evident on their land. This implies that a large proportion of the priority revegetation sites, which also accounts for the majority of land owners, may have no direct motivation to participate in vegetation rehabilitation efforts. They could easily argue that there is no immediate threat of dryland salinity on their land. Therefore, revegetation planning and design should include strategies that will maximise the participation of these land owners. The analytical techniques developed in this study should help to identify these land owners, as well as to systematically locate and analyse the size and ownership attributes of the land parcels involved.

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