# ENCOURAGING REVEGETATION IN AUSTRALIA WITH A GROUNDWATER RECHARGE CREDIT SCHEME

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# Encouraging Revegetation in Australia with a Groundwater Recharge Credit Scheme

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ABSTRACT

*This paper describes a comprehensive method to design, test and then implement a Payments for Ecosystem Services (PES) framework to combat the environmental consequences of extensive native vegetation clearance in Australia. Clearing of vegetation, primarily due to the expansion of farming areas, has often resulted in regional dryland and irrigation salinity. The market based approach adopted – a groundwater recharge credit trading scheme – was designed using empirical data from a social survey and experimental economics. The objective of the trial is to test the cost effectiveness of an incentive based recharge credit trade scheme designed to engage landholders in establishing and managing deep rooted pasture and woody perennials to reduce these adverse salinity impacts. The scheme, based on a voluntary 'cap and trade' approach, allows farmers to meet recharge obligations by land management actions or by trading credits. Assessment of the scheme so far suggests that an incentive for aggregate group outcome achievement included in the design may have motivated higher enrollment rates than would have otherwise resulted. A schedule has been developed relating land management practices and recharge credits. The audited performance based payment system, has provided increased motivation to manage for environmental outcomes compared to the previous policy.*

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## INTRODUCTION

Widespread clearing of deep rooted perennial native vegetation on individual landholdings in Australia, primarily for agriculture, has occurred over the last 200 years. Environmental consequences have manifested as increased dryland and irrigation related salinity, reduced habitat for native species, rising water tables, and declining water quality in rivers and streams. Past policy approaches to address the adverse environmental consequences of native vegetation clearance have often not motivated land management changes at a scale sufficient to meet mitigation targets. Using a case study approach, this paper describes a developed methodology to assist in the implementation of a Payments for Environmental Services (PES) framework to combat the effects of native land clearing. This  PES approach – a groundwater recharge credit trading scheme – was implemented in the Bet Bet Catchment dryland farming community of north central Victoria, Australia (Figure 1).

*FIGURE 1 ABOUT HERE*

In Australia, the approaches falling under the PES framework are referred to as Market Based Instruments (MBIs). Market Based Instruments involve regulations or laws that encourage behavioral change through the price signals of markets, as opposed to the explicit directives for environmental management associated with regulatory and centralized planning measures (Stavins, 2003). The primary motivation for MBI approaches is that if environmentally appropriate behavior can be made more rewarding to land managers, then private choice will better correspond to the best social, economic and environmental outcomes. To encourage development of market based approaches to water quality and salinity from diffuse sources, the Australian Commonwealth Government allocated funds to eleven MBI pilot projects in 2003 (NAP, 2003; Grafton, 2005).

The Bet Bet Catchment is a relatively small catchment of approximately 9600 ha. in the Murray Darling Basin, identified as the major source of more than 40,000 tonnes of salt annually entering the Boort irrigation area from the Loddon dryland catchment areas (Connor et al., 2004). The Bet Bet Catchment (which lies in the south west corner of the Loddon River Catchment) was chosen as an area to field test a recharge cap and trade policy because recharge in the area contributes more salt per volume of drainage to local rivers than any other sub-catchment in the region (Clifton, 2004).

Figure 2 is a schematic representation of rising groundwater recharge levels resulting from land management effects in catchments similar to the Bet Bet. Groundwater recharge increases as an inverse function of the level of deep rooted perennial vegetation (illustrated in panel B). Increased hydraulic pressure in the mound above the saline aquifer causes a subsequent rise in both the water table and the level of salt intrusion in the river system. In the Bet Bet region, the majority of salinity impacts are exported to downstream river districts, where the costs of salinization are incurred primarily by downstream irrigators. Increased volumes of recharge resulting from native vegetation clearance, lead to episodes of increasingly mobilized salt loads in the landscape. The additional salt is exported into connected river systems presenting a risk for the long-term viability of downstream irrigated horticultural and agricultural crops through soil salinization that leads to yield loss. In addition, increased river water salinity levels lead to accelerated infrastructure degradation (Clifton 2004), and threaten the functional organization of downstream riparian ecosystems (Overton and Jolly, 2004).

*FIGURE 2 ABOUT HERE*

Recharge rates and associated rates of salt mobilization in the area depend on the regional geomorphology with localized fractured rock conducive to high groundwater recharge rates. In addition, the rate of recharge and thus external salinity impacts, depend on the type of vegetation ground cover and farm specific cropping, grazing and management decisions. Extensive replacement of deep rooted woody perennials and perennial pasture with shallow rooted annual pastures has been identified as a key factor in increased rainwater soil percolation and subsequent groundwater recharge.

The dryland salinity problems explained above are becoming increasingly common across agricultural regions in Australia. This pilot project was designed to test an MBI approach to motivate re-vegetation efforts and thus reduce consequent groundwater recharge. The objective of the trial was to develop and test the feasibility of a recharge credit scheme to provide flexible incentives to motivate more cost effective re-vegetation efforts, to reduce consequent groundwater recharge, mobilized salt loads and eventual levels of river salinity.

Tradeable permit schemes for managing environmental problems are becoming more widely accepted by policy makers in Australia, North America and elsewhere (Randall, 2003; Sterner, 2003; Harrington et al., 2004). Subject to controversy and debate ten years ago (Keohane et al., 1998), MBIs have evolved to the point of becoming received wisdom in many environmental policy circles (Stavins, 2003). The National Action Plan for Salinity and Water Quality and the National Heritage Trust exemplify a Commonwealth impetus for the increasing application of market based solutions in Australia. Despite this increasing acceptance, Tietenberg (1998, 1999) concludes that many tradeable permit schemes have failed because of inadequate attention to ex ante instruments and institutional design. To date, a priori prescriptions of alternate market institutions and auction systems, calibrated to catchment specifications, enabling the reliable translation of market theory to an operational reality, have not yet emerged. The outcome for managing authorities may be the hasty adoption and implementation of potentially inappropriate market structures and procedures, often to expedite and satisfy policy imperatives. Any adverse consequences of a poorly designed scheme may remain undetected for long time periods, possibly eroding the potential economic benefits and exacerbating the problem that the change was originally intended to resolve. Inappropriate design may also negate the opportunity for further innovation.

This paper describes a novel methodology used in the design and evaluation of the Bet Bet recharge trading scheme. The approach involved ex ante identification and evaluation of a complete range of potential impediments to the effective functioning of a market for the exchange of tradeable recharge credits. Experimental economics settings were framed by a synthesis of salient biophysical, economic, and attitudinal characteristics and prevailing social norms of the catchment (Ward et al. 2006). Experimental treatments measured and evaluated behavioral responses to alternative cap and trade solutions and voluntary, community crafted compacts for recharge management. The ex ante design and testing methodology used in this trial represents an emerging systematic process for policy-makers to gain confidence, experience and expertise in the design and testing of a cap and trade policy prior to its implementation. Until recently, in-depth appraisals of the potential inclusion and capacity of cap and trade instruments in Australian policy portfolios have been limited. This paper shows how the design and testing methodology empirically informed on-ground policy implementation, including detailed specification of landholder obligations to manage recharge, credit accounting and trading rules, monitoring protocols and non-compliance enforcement.

## ACTORS AND ECOSYSTEM SERVICES INVOLVED

The trial is designed to demonstrate that a market based approach to achieving land use change is a viable alternative to the current government system of regulatory approaches, and input based payment incentives. In the past, government sponsored efforts to motivate changes in management regimes on privately tenured land have relied on traditional farm extension processes, legal and statutory remedies and a scheme providing scheduled payments for the re-establishment and management of deep rooted perennials. Despite regional promotion, the level of established re-vegetation and consequent groundwater recharge and river salinity, have not been at a scale sufficient to comply with prescribed salinity targets (Connor et al., 2004).

The status quo property rights arrangement in Victoria where the trial is being implemented involves no explicit requirements for dryland farmers to meet water quality requirements or to manage levels of recharge resulting from their practices. Nor are there currently any well defined and enforceable arrangements that would allow those who may suffer adverse consequences of increased salinity to compensate farmers causing salinity to reduce impacts. In essence what has existed is an implicit but poorly defined right of dryland farmers to manage recharge as they like. The trial scheme described was therefore implemented in an attempt to achieve better outcomes than previously administered instruments, constrained by extant property right regimes. The trial is expected to run for two years.

The Bet Bet trial relies on voluntary participation in a process designed to demonstrate how altered individual land use decisions can contribute to collective outcomes that reduce the aggregate impact of salinity. The Bet Bet community is comprised of approximately 130 landholders, 17 of whom have agreed to enter into individual contracts to change land management actions on their properties and comply with individually specified and contractually obligated recharge targets. Collectively these individuals contribute to a catchment-wide (community) goal for aggregate recharge reduction. Overall, the market elements of this trial, chosen through the trial design process, include:

- community agreement to achieve a specified level of recharge control,
- individual landholder contracts to achieve a specified level of recharge control in return for payment,
- trading of excess recharge credits between landholders in order for all landholders to meet their contract obligations,
- bonus payments to landholders who exceed their recharge control targets, and
- a community bonus if the catchment target is met or exceeded.

A tradeable recharge right involves establishing an enforceable, prescribed threshold of aggregate recharge attributable to the Bet Bet Catchment, distributing entitlements amongst recharge sources as a specified number of units and allowing trade of those units among scheme participants. To satisfy compliance obligations, each participant in the scheme must be able to surrender units equal to their entitlement at the end of an accounting period of two years. Therefore, participants can choose to alter land actions in response to individual management capacity, landscape attributes and production costs. Alternatively those in deficit can secure additional recharge units from those in surplus through market exchange. Compliance is therefore defined in terms of a resource use cap rather than direct requirements for delivery of a service. The link between the two however is explicitly calculated and recorded when performance assessments are carried out.

Performance is assessed by monitoring vegetative groundcover at the end of each cropping year in December. The functional relationship between vegetation type, management, landscape position and groundwater recharge in the Bet Bet Catchment has been previously established as part of the instrument design process (Connor et al., 2004; Clifton 2004). Audits, measuring the percentage of groundcover that landholders actually achieved, are conducted and the results used to compute an empirically based estimate of the recharge volume for each landholder. A credit surplus or deficit position is assigned based on the audited cover that each landholder has achieved relative to the level of credits that they committed to provide.

An independent 'auditor' is involved in the trial to audit pasture groundcover and tree establishment performance. For pastures, the auditor takes multiple measurements to provide a representative sample for each paddock. Measurements are taken using a 500x500 mm square with four evenly spaced, horizontal and vertical strings or wires. The quadrant wires intersect at 16 points within the square (Figure 3). Cover is assessed by placing the square on the pasture, grass or crop and then counting the number of intersections that lie directly above the green vegetation. The percentage of those 16 intersections that sit above green vegetation is the cover at that point.

*FIGURE 3 ABOUT HERE*

An additional actor involved in the trial is an independent ‘broker’ who is engaged to maintain the recharge accounts for each landholder. These accounts show:

- the obligation agreed to,
- the audited estimated recharge,
- the reference level of recharge, and
- the number of credits in excess or in deficit of the reference level.

The broker is also able to facilitate the creation and trading of credits. Credits can be created by undertaking additional perennial plantings within the target catchment. Trading of credits facilitated by the broker can also take place for landholders holding salinity recharge credit surpluses or deficits. Salinity recharge credits can be traded at any price negotiated by the landholders.

While capping recharge imposes a cost on individuals, the opportunity to trade has the potential to compensate that loss or reduce the cost burden. Some individuals will choose to use more than their quantum (and incur a debit), and others will choose to use less (being rewarded with credits). The brokerage feature is an approach to overcome the policy challenge to create the opportunity for a “frictionless” market setting where participants can quickly learn to understand the advantages of trade with low learning and exchange costs relative to trade benefits. To the extent that brokerage reduces market friction, savings to landholders through market exchange between individuals with surplus credits and those in deficit may be considerable. Brokerage can increase the level of information from market exchange and thus reveal any differences in returns to management options that reduce environmental consequences and thus enhance the probability that opportunities for gains from trade are quickly discovered and exploited.

The ecosystem services improved by the scheme are directly related to reduced levels of groundwater recharge and the lowering of salt levels in soils and waterways. With planting of deep rooted tree species, other ecosystem services, such as biodiversity and provision of shade for livestock, may also be improved. Spatially, the services affected and improved are located in the Bet Bet Catchment but also include down-stream water users and those who enjoy the amenity values of low lying floodplain areas affected by recharge from the Bet Bet region. Participants in the scheme however are only those that reside in the Bet Bet Catchment and volunteer to take part under the conditions of the contract. The eventual beneficiaries therefore may be downstream and not necessarily reside in the catchment.

## THE IMPLEMENTATION PROCESS

Implementing the scheme takes place based on the contract agreed to by the landholder to establish and maintain perennial plantings in ways capable of reducing recharge in the landscape. In essence, landholders will receive payment in exchange for their actions to change land-use. The actual agreements related to land-use change are restricted to the types of plantings involved. Five possibilities exist including:

- low density farm forestry,
- high density farm forestry,
- native tree establishment,
- phalaris perennial pasture, or

- lucerne perennial pasture.

Payment is based on performance and includes an establishment (initial) payment, and a management (subsequent) payment(s) based on monitored performance in the following years. Payment is on recharge credits calculated on a per hectare basis. Table 1 describes the levels of credits per hectare that can be achieved given monitored performance levels for each specific practice. The actual level of assigned credits depends on the level of cover of the pastures and/or the number of stems on tree plantings measured each year as described in the previous section.

*TABLE 1 ABOUT HERE*

Based on the ex ante analysis, approximately 3000 credits are sought from tree based (forestry, native tree establishment) practices. Provided 90 per cent (2700 credits) of the tree based target is met, up to 1000 credits will be available for perennial pasture (phalaris/lucerne) establishment. In total, $38.50 is offered to landholders for each unit of recharge they control over the life of the project. If a total of 3750 recharge units are produced then there will be a communal ‘bonus’ payment of $7500.

Table 2 gives an example of what outcomes of participation in such a tradable credit recharge scheme could look like for four different landholders in the Bet Bet region.

*TABLE 2 ABOUT HERE*

At the outset there were concerns that low returns to some farmers that had resulted in near zero enrollment in the existing scheduled payment scheme prior to the cap and trade trial would also lead to limited enrollment in the cap and trade scheme. In fact, enrollment increased from only 5 ha in 2004 using a standard input based payment to over 100 ha in the 2005 cap and trade scheme. The relatively small scale of the program, viz. 17 participants, is a result of an intentionally limited number of targeted potential participants and limited budget for this trial program.

## ADDITIONAL INCENTIVES INVOLVED

The voluntary nature of the credit trading scheme, contingent on the lack of articulated property right obligations for recharge management, means that non-compliance within the Bet Bet Catchment does not attract any sanctions if people do not wish to participate. Vatn and Bromley (1995), Ostrom (1998) and Gintis (2000) argue that non-monetary rewards and motivations such as prestige, public recognition, group belonging, avoidance of group sanction, and desire to contribute to the public good can all represent powerful motivators in some contexts. There has been considerable theoretical work suggesting that policies involving collective outcome based payments or penalties can motivate high rates of environmental action and cost effectiveness in certain settings (Segerson, 1990; Isik and Sohngen, 2003; Ipe et al., 2001). In particular, previous research (e.g. Ostrom, 1998; Gintis, 2000; Tisdell and Ward, 2004) reports willingness to diverge from individualistic profit maximizing behavior for the public good in small, cohesive communities. Poe et al., 2005 posit that a free riding problem can arise with collective incentive policy where there is too little individual incentive and individual behavior is not easily observed.

Given the small cohesive nature of the Bet Bet community revealed in social survey results (Connor et al. 2004), a policy designed to harness the potential power of pro-social motivations in the trial area may have potential to increase trial enrollment. Experimental economics results (Ward et al., 2006) suggest that a collective payment could have potential to address the risks of low enrolment given relatively flat payoffs to recharge reducing practices and informational challenges associated with understanding payoffs. Thus a feature of the scheme is a community level payment in addition to individual payments compensating establishment and opportunity costs. The community incentive is paid in the form of a community bonus if an aggregate recharge reduction target is met or exceeded. This type of scheme attempts to harness peer group pressure to ensure that each individual meets the contracted target so that the entire community benefits. There is also additional community based motivation for highly targeted, non-bidding members of the Bet Bet farming community to take part in the scheme.

## PERMANENCE, MONITORING AND ACCOUNTING

Mechanisms have been put in place to ensure that the effects and benefits of the trial will extend into the future. One mechanism to favor more permanent action assigns credit levels and therefore payments based on two factors:

- Expected permanence – practices expected to be more permanent are given more credit (native vegetation protection is assumed to be more permanent than farm forestry which is assumed to be more permanent than perennial pasture).
- Expected annual recharge reduction – the expected recharge reduction for each practice has been estimated using a crop water balance model and are calculated relative to a defined baseline level of recharge equal to the estimated recharge under perennial pasture with 70 per cent December cover.

With regards to permanence however, a lack of well defined property rights represents a significant impediment. Without a more explicit definition of either farmer obligations to manage groundwater recharge or rights to contract water quality improvement for those adversely impacted by dryland recharge induced salinity, no formal and permanent market for recharge credit can be established.

A feature of the scheme to encourage more persistent action is a contract including not only commitments to establish perennial vegetation but also commitments to maintain plantings in a manner that will provide permanent recharge outcomes. While the former program in the area was based on input payments with no incentive for ongoing management to achieve environmental goals, the cap and trade policy rewards landholders who persist with management with performance based incentive payments.

Shortle and Horan (2001) and Schary (2003) argue that developing policies capable of realizing savings by focusing on performance coupled with compliance flexibility is challenging for diffuse source pollution because monitoring actual outcomes is often technically infeasible or very costly. This represents a substantial challenge to effective cap and trade schemes to address diffuse source environmental issues such as salinity. To effectively participate in the exchange of tradable recharge credits, land managers need accounting and auditing that allows an evaluation of their management decisions prior to implementation and monitoring of progress against their targets or commitments. Similarly, administrators of the scheme must also have the capacity to monitor and audit the outcomes of changes in land use or management practice and to attribute change in recharge to either landholder action or climate. Since groundwater recharge and salinity are not readily measured directly, a prerequisite to implementing a cap and trade is the development of a reliable and transparent surrogate indicator to assist all participants in evaluating recharge and salinity impacts of land management actions.

Thus a first step in this project was development of robust and community validated biophysical and hydrological modeling to provide information about groundwater recharge rates as a function of variable vegetation cover and land management at the farm scale, differentiated according to landscape position (Clifton, 2004; Connor et al., 2004).

The resulting crop water model accounts for:

- differences in rates of annual and perennial crop and native tree evapo-transpiration,
- temporal differences between tree and crop types for maximum transpiration rates to be realized; and
- differences in recharge reduction resulting from landscape position (differential recharge reduction is a function of rainfall, slope, soil permeability, levels of fractured granite and soil transmissivity).

In the model (illustrated in Figure 1) Ri represents the recharge rate for farm i, managing crop j, where:

$R_i = (C_{ij}, A_{ij}, R_{Ai}, G_{i,} L_k)$: and (1)

$C_{ij}$ is crop type and management

$A_{ij}$ is area of crop type

$R_{Ai}$ is annual rainfall

$G_i$ is soil type and geomorphology

$L_k$ is landscape position, k=1, 2 or 3 where:

k=1 represents lower slope;

k=2 represents break of slope;

k=3 represents ridge and upper slope.

j = 1-5, where:

j=1 represents annual grazing;

j=2 represents perennial pasture (phalaris set grazing);

j=3 represents perennial pasture (phalaris rotational grazing);

j=4 represents native tree vegetation;

j=5 represents farm forestry (less than 10 years old).

$C_{ij}$, $A_{ij}$ represent endogenous variables in a farm decision set; and

$R_{Ai}$, $G_i$, $L_k$ represent exogenous variables in a farm decision set.

The model developed accounts for three key biophysical determinants of recharge differences across locations and actions shown in Figure 1:

1. Ceteris paribus, for crop j, recharge from lower slope (L1) is less than the recharge from break of slope ($L_2$) which is less than recharge from upper slopes ($L_3$). *Viz*. $RL_1<RL_2<RL_3$.
2. Increased deep rooted perennial vegetation reduces groundwater recharge: *viz.* for landscape position $L_k$, subject to land management regime $M_P$ (Panel A) or $M_G$ (Panel B), recharge $R_i$ is such that $R_i\ L_k\ M_P < R_i\ L_k.\ M_G$

3. The estimated costs of groundwater recharge for land management activity at farm *i*, at landscape position $L_k$ is such that;

   $R_{MG} > R_{MP}$; recharge from annual grazing is greater than recharge from perennial grazing or forestry;

   $WT_{MG} > WT_{MP}$; the water table level is higher for annual grazing than perennials;

   $SL_{MG} > SL_{MP}$; salt load is greater for annual grazing than perennials;

   $C_{MG} > C_{MP}$: incurred irrigation costs are greater for annual grazing than perennials.

Another impediment to establishing a robust, permanent, recharge exchange scheme is the potential for thin markets. One of the conditions necessary for efficient, functioning, competitive markets is a sufficient number of traders to ensure that no one participant can influence the terms on which transactions occur. Thin markets are characterized by small numbers of buyers and sellers. A limited number of buyers and sellers introduces the potential for credit trade market failure in a number of ways including price volatility and restricted supply (Stavins, 1995; Kampas and White, 2003), spatial concentration of permits, permit hoarding and a potential impedance of new market entrants (Tietenburg, 1998), a lower probability of satisfying market needs associated with increased transaction costs (Stavins, 1995) and unreliable recharge outcomes (Dinar and Howitt, 1997). Goodstein (2002, p. 330) argues that the United States EPA's emissions trading program, introduced in 1976, floundered because of thin markets and concerns about permit hoarding and spatial concentration of effluent. Stavins (1995) argues that a thin market reduces market efficiency by raising the relative costs of transactions: fewer participants implies a lower probability, both real and perceived, of finding trading partners to resolve market demands, while transaction costs remain constant or increase. To date, the trial focus has been on a relatively small area with relatively few participants. Smith (1982) argues a countervailing view, noting experimental economics findings that suggest that the numbers in the trial are sufficient to avoid thin market problems.

In the design phase it was recognized that the problem of thin markets could be exacerbated by the impact of random variation in weather conditions on the success of actions to reduce recharge. For example, many years of drought, would tend to lead to higher rates of establishment failure. Given that effects of weather on credit surpluses or deficits would tend to be correlated across years for participants within the geographically small trial area, potential for excess credit supply or demand within seasons was seen as a factor that could lead to people deciding not to participate in future market schemes. To overcome this impediment, banking and borrowing of credits is allowed. Goodstein (2002) found that in the U.S. unleaded gasoline refinement quota cap and trade system, temporal flexibility implemented through credit banking was a key reason for the program’s cost effectiveness. Thus in the Bet Bet trial, a participant who has credits in excess of obligations after annual performance monitoring and salinity account reconciliation, can bank or set aside credits to offset debits in future years. Any participant with credits banked in previous years can use them against debits to balance a current salinity account.

## POTENTIAL PROBLEMS

In ideal markets where there are no transactions costs, trade takes place whenever there is potential for marginal gains and profit. Real markets for tradeable emissions credits, including recharge, require substantial investment of time by participants to understand potential gains, seek out trading partners, and negotiate trades (Randall, 2003). A potential impediment to credit trade results if potential gains from trade are low compared to transaction costs. Newell and Stavins (2003) and Sterner (2003) have identified small potential gains from trade arising from relatively small differences in marginal abatement costs across sources as an impediment to credit trade policy in point source contexts. Vanclay (2004) and Barr (1999) argue that financial returns are only one factor in the utility function determining farm management choices. When there is relatively little difference in payoffs across management practice, non-financial considerations such as family lifestyle are often key determinants of management practice choice.

The potential gains from trade in the salinity credit trade trial and returns arising from recharge reduction options across land management practices and landscapes within the Bet Bet were modeled. Results indicated that whilst there is sufficient differentiation in marginal abatement costs across practices and location, potential gains from trade are less than 10% of total revenues (Connor et al., 2004). Field interviews (ibid) suggest that some practices which farm economics modeling indicate can reduce recharge and improve returns, may be less attractive than purely economic considerations would indicate. More careful rotational grazing and other perennial pasture management in particular are effective at reducing recharge and have potential for slightly greater per hectare returns, but require much more management effort.

Ultimately, potential for gains to credit trade are limited by differences in physical productivity and opportunity costs among potential trade participants. The amount that is actually realized can be influenced by policy design. Ensuring that participants realize potential gains from trade involves designing an administratively efficient method of monitoring and recharge accounting. Policy initiatives to ensure the introduction of cost effective monitoring and accounting schemes that are transparent, consistent and credible to all participants predicate successful cap and trade schemes. Accounting conventions establish a clear link between land management actions at appropriate scales and the consequent environmental outcome. As the functional relationship between river salinity, groundwater recharge and land actions are not readily visible, a proxy indicator inclusive of revegetation type, success of establishment and maintenance was imputed in this case study.

When the differential in marginal abatement costs is small, expressed as a flat payoff function, Pannel (2004) proposes that the manner of presentation and treatment of information to potential adopters can be a key determinant of the level of practice adoption. Strong social networks generally and membership in catchment groups (Cary et al. 2002), as well as extension and promotion programs (Marsh et al. 2000) have been shown to be important determinants of conservation practice uptake in flat payoff function settings. This suggests that in trial implementation information and credit trade policies are likely to be complementary. A design solution to the impediment of a flat payoff function with little information is information provision.

In all such schemes, there are also issues related to concerns of equity and fairness for all members of the catchment community being targeted. For example, there can be considerable equity concerns related to the method of entitlement distribution in cap and trade schemes. Perman et al. (1999, pp. 316-317) note that the initial distribution of property rights determines the division of the net gains which accrue to the negotiating parties. Thus, a major challenge in designing a credit trade system is the mechanism used to allocate the initial permits to individuals (Baumol and Oates, 1988). Auctions and free distribution (grandfathering) are the two main procedures employed by governing agencies in the allocation of transferable resource permits. Revenues from auctioning of permits go to the state, whereas the benefits gained from the grandfathering accrue to those granted the entitlement (Tietenberg, 1999).

The status quo ante in the catchment is an upfront payment for implementation of a practice (e.g. a payment per hectare of trees planted). A primary focus of the trial is to test a performance based system with payments based on the outcomes of practices (e.g. payment on success rate of establishment of tree planting). The shift from the status quo ante to the trial approach will change expected costs, income and income variability. With the status quo ante, the risk of less than intended recharge reduction (e.g. through planting establishment failure) is assigned to the Government. Changing to a performance based system shifts that risk to farmers. There are two risks relating to returns that participants could face in a performance based system: a) risk associated with random, exogenous events such as rainfall variability, and b) the risk of management related failures of options in achieving recharge reduction.

Given that the trial involves voluntary participation and that the status quo ante program continues to run simultaneously, there is potential for low enrollment rates to impede functioning if the trial involves greater risks to participants than the status quo ante without commensurate improvements in potential returns.

If a fundamental change in property rights that created limits on dryland farm recharge could be implemented, distribution of recharge rights by auction would be possible. As mentioned above this is the mechanism that economic theory suggests is most economically efficient. Within the current property rights framework without any explicit limits on recharge, the only possibility is to begin by grandfathering the right to the current level of recharge and offering payment for improved practice or performance. A tension arises because the approach that would create the superior performance incentive, payment on outcome, involves significant risk in comparison to the status quo ante incentive, payment on implementation of practice. Low participation rates are a likely outcome. The compromise solution implemented in the trial, involved a partial payment on establishment and a partial payment based on audited performance outcome.

## CONCLUSIONS AND NEXT STEPS

Rigorous comparison of trial results with the status quo ante scenario to ascertain if significant salinity reduction has occurred is still too early to be carried out. The trial commenced in the first quarter of 2005 and the first performance appraisals of farms occurred around December with audits being completed around the first quarter of 2006 (one year after the first contracts were signed).

Upon completion of the trial in mid-2006, the success of this scheme relative to previous instruments and recharge management policies will be modeled and compared. Additionally, the beneficial effects of tree planting may not start to be realized until several years after the start of the trial. Although it is still too early to gauge the success or otherwise of the current trial, some policy related issues can be highlighted as a result of the review of the scheme provided in this paper, guiding and informing future decisions.

One problem is the geographically constrained trial area which can potentially lead to the adverse effects of thin markets. Conceptually, the most obvious approach to overcoming thin market problems would be expansion of the scale of the trial to include more participants. If this involved an expanded geographic area, it is also possible that potential for weather related excess credit supply or demand leading to thin markets would be reduced. Credit banking and borrowing across years as exists in the current trial is one approach to reducing thin market problems arising from weather related excess credit supply or demand. As the trial is only over two years it will be difficult to assess the effectiveness of credit banking but this ability should be subject to greater scrutiny if the trial is allowed to continue longer.

Theoretically, tradable recharge entitlements can be assigned to either one of the negotiating parties: farmers (as the source of recharge) or the downstream beneficiaries of recharge reduction. At present, the trial only involves participants from the Bet Bet Catchment – the initiators of the salinity problems. The current property rights framework allows farmers to manage recharge without regard to external effects. Participants are induced to cap recharge through an incentive payment. This is in contrast to the more common cap and trade approach, reliant on statutory obligations. A future option may seek to develop specified property rights for clean water for those harmed by salinity or recharge management obligations for those who create salinity. This would involve establishing legally defined and enforced limits on recharge rights or some proxy for recharge such as inputs, outputs, or practices correlated with groundwater emissions as a property rights basis for the tradable recharge policy trial.

As mentioned previously, some of the benefits and costs of the land-use change induced here may be impacting outside of the trial area and so some of the more important participants who should take part in the scheme are actually excluded. Redefining property rights could overcome the impediments of thin markets by engendering wider participation from agents characterized by a greater differential in costs of salinity abatement. Finally, a thorough comparison of this scheme with the previous incentive scheme, where farmers were rewarded with cash payments for beneficial land-use change, is required. Careful measurement of the biophysical benefits, revenue implications for farmers and the cost effectiveness from the perspective of the implementing agency is required, including evaluation of the transaction, administration (including brokerage) and monitoring costs.

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*Figure 1. Map of Bet Bet Catchment*

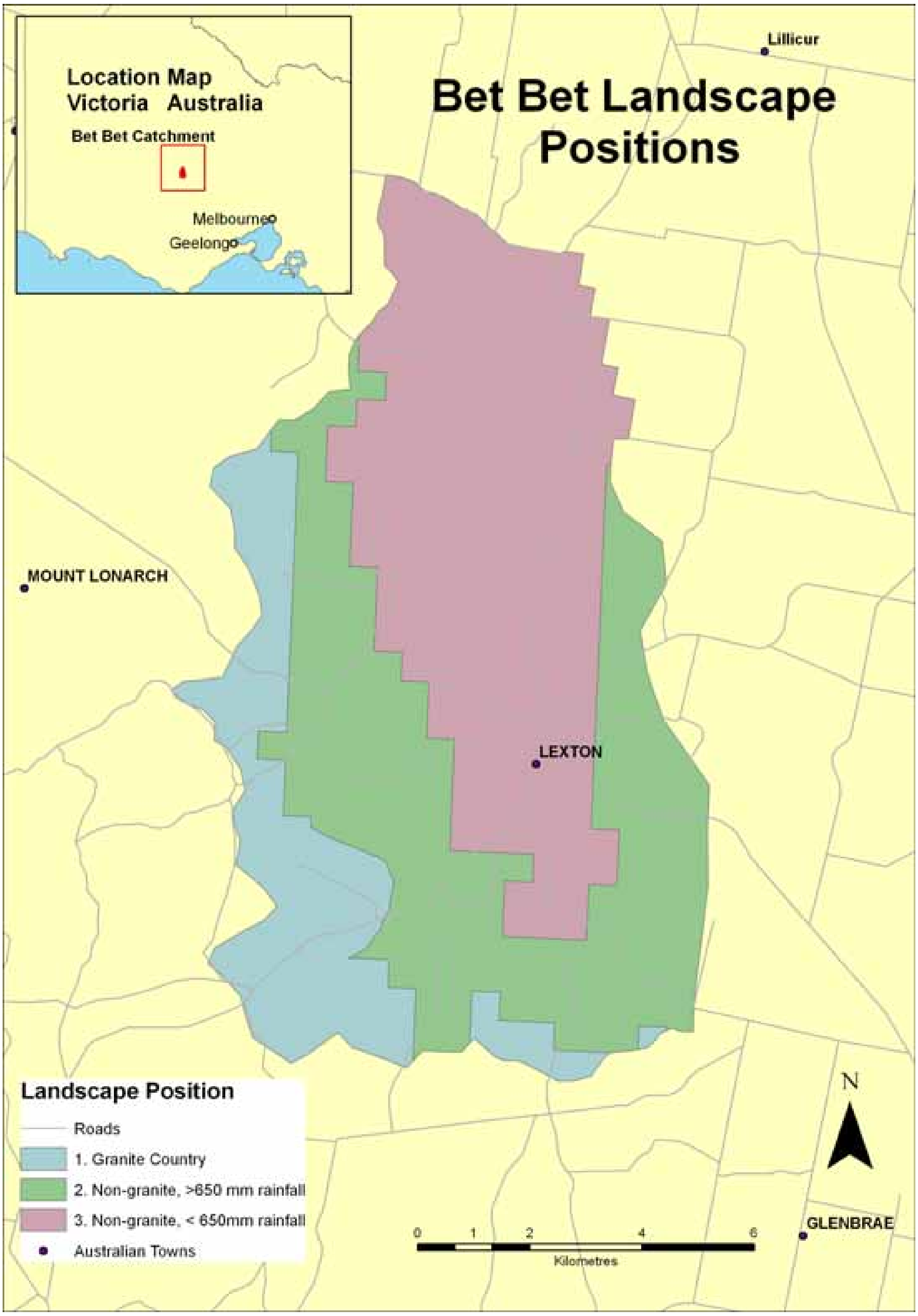

*Figure 2. The Salinity Problem - schematic of the hydro-geology of irrigation water quality affected by variable upper catchment salt loads*

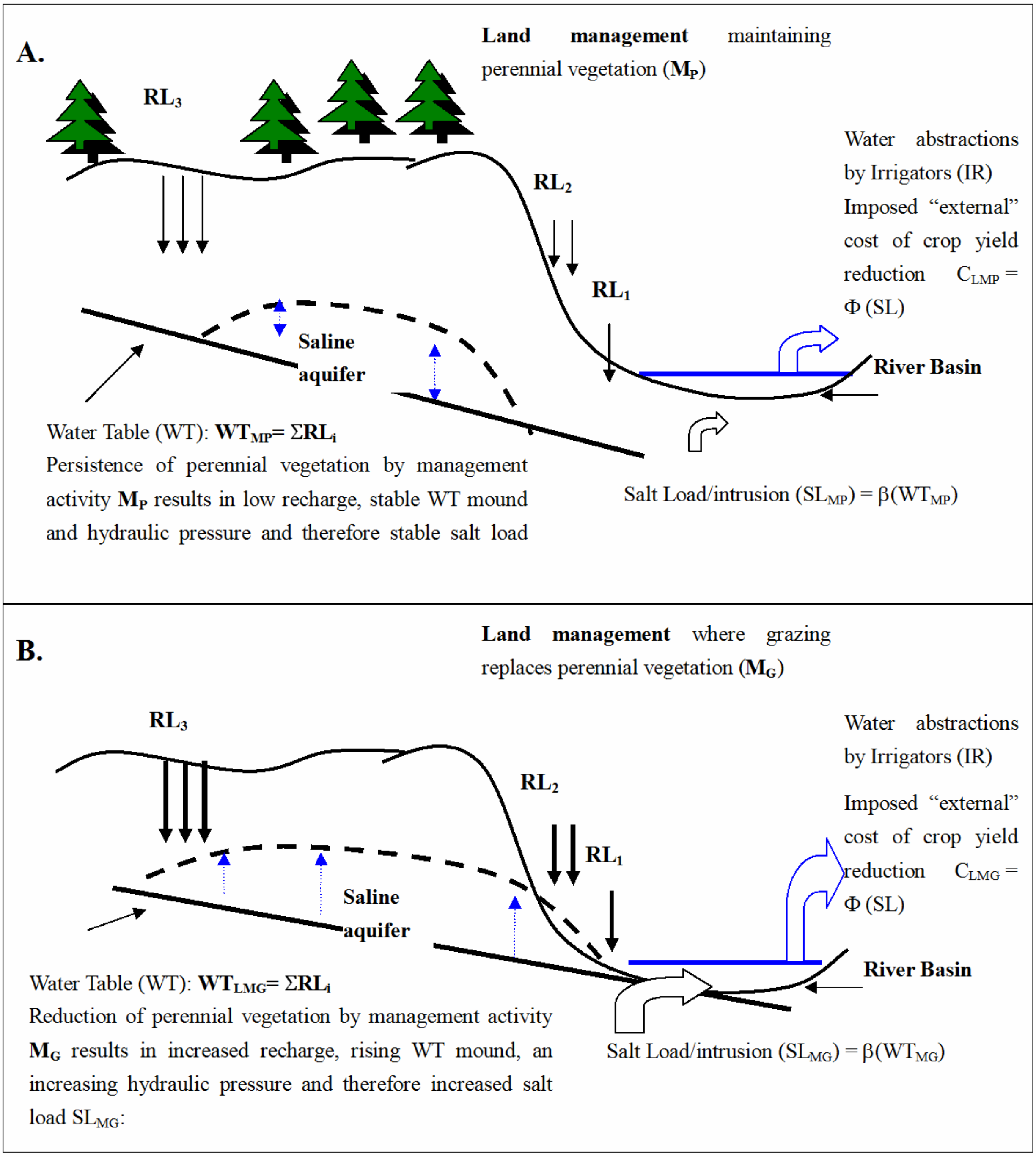

*Figure 3. Measurement of Cover for Pastures, Crops and Understoreys*

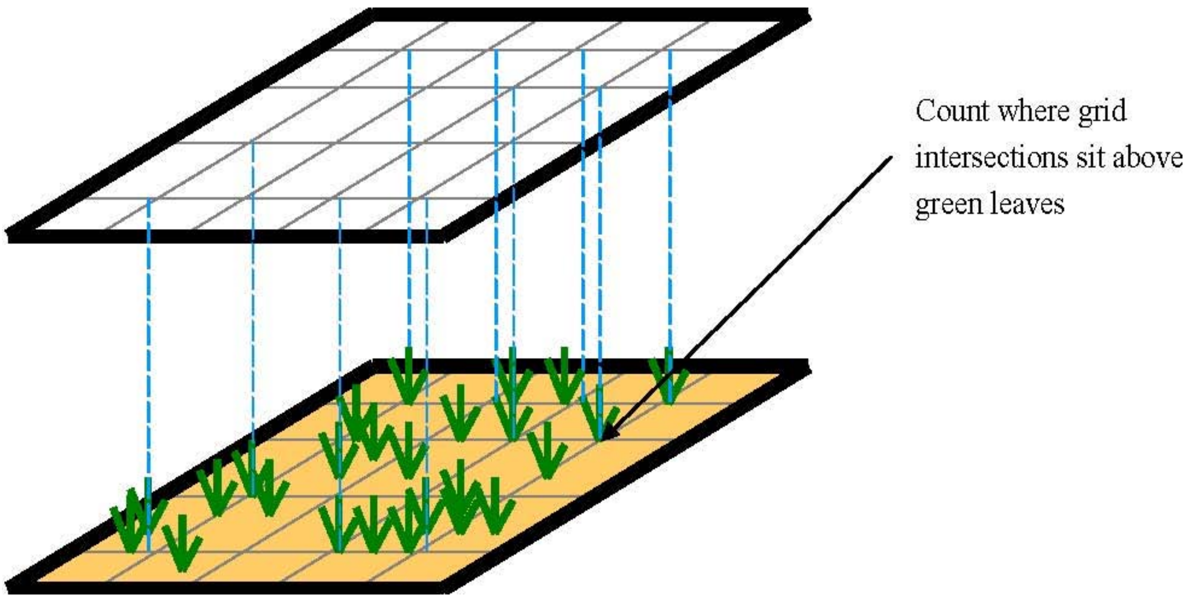

*Table 1. Recharge Credits According to Audited Ground Cover Landscape Position and Annual Rainfall*

| Practice (audited performance /ha) | Zone 1 (700mm+)[a] | Zone 2 (650mm+) | Zone 3 (600mm+) |
|---|---|---|---|
| Low density Farm Forestry (200 stems) | 6.1 | 4.9 | 3.7 |
| High density Farm Forestry (600 stems) | 9.6 | 7.6 | 5.7 |
| Low density Farm Forestry (180 stems) | 5.4 | 4.3 | 3.2 |
| High density Farm Forestry (540 stems) | 8.4 | 6.8 | 5 |
| Low density Farm Forestry (160 stems) | 4.5 | 3.5 | 2.6 |
| High density Farm Forestry (480 stems) | 7 | 5.5 | 4.1 |
| Low density Farm Forestry (140 stems) | 3.5 | 2.7 | 2 |
| High density Farm Forestry (420 stems) | 5.5 | 4.3 | 3.2 |
| Native Tree Establishment (600 stems) | 21 | 16.9 | 12.7 |
| Native Tree Establishment (540 stems) | 19 | 15.1 | 11.3 |
| Native Tree Establishment (480 stems) | 15 | 12.1 | 9.1 |
| Native Tree Establishment (420 stems) | 12 | 9.4 | 7.1 |
| Phalaris Pasture (100% cover) | 2.4 | 2.4 | 2.4 |
| Lucerne Pasture (100% cover) | 4.4 | 4.2 | 3.5 |
| Phalaris Pasture (90% cover) | 2 | 2 | 2 |
| Lucerne Pasture (90% cover) | 3.5 | 3.5 | 3.5 |
| Phalaris Pasture (80% cover) | 1.6 | 1.6 | 1.6 |
| Lucerne Pasture (80% cover) | 3 | 3 | 3 |
| Phalaris Pasture (70% cover) | 1.2 | 1.2 | 1.2 |
| Lucerne Pasture (70% cover) | 2.5 | 2.5 | 2.5 |

[a] Annual Rainfall (from Clifton 2004)

*Table 2. Schematic Representation of Salinity Recharge Credit Trial Functioning for an Illustrative Example*

| | | **Landholder 1** | **Landholder 2** | **Landholder 3** | **Landholder 4** |
|---|---|---|---|---|---|
| | | contracts to convert pasture to farm forestry | contracts to convert degraded annual pasture to perenial lucerne | contracts to convert pasture to native vegetation | contracts to convert degraded annual pasture to perenial lucerne |
| contract negotiation | Baseline recharge under current landuse, $Qi^b$ = | 120 ML | 200 ML | 150 ML | 300 ML |
| | Expected recharge for successfully established farm forestry = | 15 ML | 70 ML | 10 ML | 100 ML |
| | Obligation under contract, $Qi^0$ = | 105 ML | 130 ML | 140 ML | 200 ML |
| | Start-up incentive = \$50/ML * $Qi^0$ = | $5,250 | $6,500 | $7,000 | $10,000 |
| Year of implementation: the season turns out to be low rainfall | | | | | |
| Audit and Credit/Debit Accounting | Landholder 1's audit = 75% of stems required to fulfil obligation | audited reduction = 78.5ML | | | |
| | Landholder 2's audit = 80% of cover required to fulfil obligation | | audited reduction = 104ML | | |
| | Landholder 3's audit = 60% of stems required to fulfil obligation | | | audited reduction = 84ML | |
| | Landholder 4's audit = 65% of cover required to fulfil obligation | | | | audited reduction = 130ML |
| | All obligation seasonally adjusted by weighted avg performance of 69% of obligation | | | | |
| | debit/credit = audited seasonally adjusted recharge - obligation | +6 ML | +14ML | -12ML | -8ML |
| Trading | Landholder 1 sells 6 credits to Landholder 4 | 0 ML balance | + 14 ML balance | -12 ML balance | - 2 ML balance |
| | Landholder 2 sells 12 credits to Landholder 3 | 0 ML balance | + 2 ML balance | 0 ML balance | - 2 ML balance |
| | Landholder 2 sells 2 credits to Landholder 4 | 0 ML balance | 0 ML balance | 0 ML balance | 0 ML balance |
| | Bonus paid equal to 20% of start-up in proportion to contribution to total recharge | $1,140 | $1,510 | $1,220 | $1,885 |