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Finding a cohesive and effective conservation strategy in the Overberg - An experimental application of the Agglomeration Bonus.

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Abstract

The Overberg region in the Western Cape is an area rich in conservation value. This region has another distinctive feature in that there are three different landowners adjacent to one another, each boasting land rich in biodiversity value. In the event that the land use practices of the landowners are in conflict with biodiversity conservation on their land, there is a trade-off between net social benefit and landowner welfare. Currently, there is no explicit conservation regulation that governs the way these landowners manage the conservation value of their land. This study investigates the viability of the application of an agglomeration bonus as a voluntary incentive mechanism aimed promoting sound conservation practices at three sites managed within the region. The analysis is unique in its application of both the normal form game theory and spatial mapping approaches to the problem in a three-player context. The primary finding of this work is that in a controlled environment the application of an agglomeration bonus does result in the creation of contiguous reserves between adjacent landowners.

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1.0 Introduction:

This study will be evaluating the viability of the application of an agglomeration bonus as a voluntary incentive mechanism geared at promoting sound conservation practices at three sites managed within the Overberg region. Two of these sites are effectively tied to the Ministry of Defence and one a dedicated conservation site managed by Cape Nature.

The three sites are situated in Cape Floristic Region (CFR), which is in the Western Cape, more specifically the Overberg region. This region is unique in that it boasts over 8700 plant species making it the world's richest floral kingdom albeit the smallest (Low, 1996). The fynbos biome, which is largely confined to nutrient poor soils in the winter rainfall areas of the Western Cape, is most commonly associated with the CFR (Turpie et. al., 2002; Cape Nature, 2008). The economic value stemming from the environment in the CFR is approximated to be R 10 billion per annum (in 2000 US$1:R7) accounting for over 10 percent of the region's Gross Geographic Product (Turpie et. al., 2002). Given this contribution, it is of concern to note that the continued existence of the region is threatened by three main factors namely: the misuse of both marine and terrestrial resources, the constant threat of invasive alien organisms and the move towards urban development and agriculture (Rouget et. al., 2001; Pressey et. al., 2003; Turpie et. al., 2002).

The Overberg has another distinctive feature in that there are three different sites adjacent to one another, each boasting land rich in biodiversity value. This creates an interesting problem in that an inherent characteristic of a natural asset, in this case biodiversity, is its contribution to net social benefit; however, the land is managed so as to prioritise its primary land use. In the event that the land use practices on the respective sites are in conflict with biodiversity conservation, there is a trade-off between net social benefit and primary land use benefits. Currently, there is no explicit conservation regulation that governs the way these landowners manage the conservation value of their land. It is essentially left to the good graces of each site's managers to create and manage conservation practices on their respective sites.

It is thus important to understand each of the land managers' primary land uses and conservation practices in order to contextualise the discussion on the creation of a coherent conservation management strategy between them.

The first landowner in question is Denel, a defence related parastatal, which controls the Overberg Testing Range (OTB). OTB has a ground area of 60 000 hectares and is a multipurpose weapons testing range. With respect to conservation, OTB has appointed an environmental manager tasked with the conservation and management of all matters pertaining to the environment on the range (Denel, 2008).

The second of the landowners is Cape Nature which operates the De Hoop nature reserve. The reserve is approximately 34 000 hectares in size and is situated east of Bredasdorp in the Overberg (Cape Nature, 2008). De Hoop is primarily a sanctuary for a collective of birds, animals and vegetation and is part of the Cape Floral Kingdom in which Fynbos is the dominant vegetation group. Given the nature of the site, it is unsurprising that De Hoop has a comprehensive environmental and conservation management strategy (Cape Nature, 2008).

The third and final land manager[1] in question is the South African National Defence Force (SANDF) through Air Force Base (AFB) Overberg. The base is 33 200 hectares in size. It hosts both the Test Flight and Development Centre (TFDC) of the Air Force and the 525 squadron (SANDF, 2008). From an environmental perspective the base is fully compliant with ISO 14001 standards which are aimed at ensuring responsible and sustainable environmental practices (SANDF, 2008).

From the above it is apparent that only one of the three landowners, namely Cape Nature, is primarily tasked with conservation. At face value, one might assume as a matter of course that Cape Nature would be the site that makes available the largest effective budget for conservation with the most comprehensive and well-executed conservation objectives. This is not necessarily the case. As such, the effective budget that each of the three sites make available for conservation coupled with their respective conservation objectives are of interest. The problem however with investigating this is a lack of the relevant data pertaining to the three sites. As a result, a more normative approach to this investigation will be taken.

[1] The site is owned by the Department of Public Works but is managed by the SANDF. For the sake of clarity we will refer to the SANDF as a landowner in the experimental design.

The two Defence related sites have common characteristics not shared with the Cape Nature site; although they have positive environmental programmes, their primary land use has negative consequences for the environment. Weapons' testing in a biodiversity rich area such as the Overberg has necessarily negative consequences for the state of biodiversity in the area. Examples range from the eradication of certain species because of disturbances caused by weapons testing to the biomes that exist in the affected area, to outbreaks of highly destructive fires in the affected areas and their surrounds. Given this reality, how does a regulator ensure the survival of at least some the biodiversity value on this land, while bypassing the often costly exercise of enforcing statutory conservation practices on the sites?

In answering this question, a voluntary incentive mechanism directed at the creation of a contiguous reserve that is subject to a unique and coherent environmental and conservation management strategy will be investigated. More simply put the idea of the creation of a contiguous reserve and its implications on the quantity and quality of conservation over the three sites will be investigated. As no strategy such as the one being investigated in this study has been implemented in the region, physical observation of the process is not possible as such; an experimental framework will be designed and applied to facilitate the investigation of interest.

Section two of this study will present a brief discussion of the literature pertaining to the question at hand. Section three will provide a detailed explanation of the methods used to conduct the investigation. The experimental design of the study will also be presented in this section, which is an interpretation of that provided by Parkhurst et. al. (2002) and Parkhurst and Shogren (2007). In these studies, the authors examined the implementation of the agglomeration bonus between two and four subjects in a game theoretic and spatial mapping application respectively. This study differs from the others in that it investigates both the normal form and spatial mapping applications of the bonus for groups of three subjects. This extension allows for the examination of:

- The viability of the creation of a contiguous reserve in the absence of an agglomeration bonus, which will be investigated in treatment 1.
- The application of the agglomeration bonus in both repeated and one round games while taking into consideration the effects of the target reserve structure, which will be investigated in Treatment 2.

- The effects of communication on the outcomes of treatment 2, which will be investigated in treatment 3.

This examination will be conducted over three treatments as section 3.2 will explain in detail. Section four will be a presentation of the experimental results in which the bio-economic efficiency of the results and their implications for the Overberg case study will be discussed. Finally, section 5 will present the recommendations and conclusions of this work.

It is necessary at this point to address the matter of external validity. Given the controlled environment in which the experiment is conducted, some might argue that the results are in no way extendible to the Overberg case studies. However the idea that although the subjects in the controlled experiments may not share identical value functions with those of the land managers relevant to this study, it is apparent that the subjects are rational agents aiming to maximise their returns from the experiments. This is a characteristic shared by the land managers on the three sites thus allowing scope for this form of investigation.

2.0 Literature Review:

Before any discussion on the creation of policy can commence, it is important that accurate and relevant information be accessible to policy makers. As Doremus et. al. (1998) so eloquently put it, "information is pre-requiste to regulation" (Doremus et. al., 1998 ,p. 23).This can be illustrated by posing a simple question: is it worth the effort? Policy makers, well aware of the costs of policy formulation, need to be certain that the associated costs are outweighed by the benefits stemming from it. The procedure is no different for environmental policy, although many might argue that it is not possible to quantify accurately the costs and benefits stemming from nature as Cardenas (2008) explains. The fact is that nature is a natural asset and like most assets, it can be valued, even in monetary terms.

Numerous approaches have been brought to light with respect to environmental valuation. While knowledge on the valuation of environmental benefits has increased over the last few decades, many have argued that its worth as a tool for creating conservation policy is unclear. This position is often rooted in the fact that the worth of such knowledge is often undermined by its incorrect application in answering particular questions (Pagiola, 2008).

One popular approach to the valuation of nature and, in this case biodiversity, is that of physical valuation which is often conducted in conjunction with experts in the field of natural science. Although relatively accurate, this method has two major disadvantages. Firstly, the process tends to be very time consuming which can prove very expensive. Doremus et. al. (1998) provide the second drawback to this approach by stating that: *"to precisely confirm the value of a parcel of a particular species. Direct examination of the area is usually needed to locate species of interest accurately and to determine their population density. This kind of ground- truthing through field visits does face legal barriers."* (Doremus et. al., 1998, p. 12). More simply, direct examination (particularly on private property) requies landowner buy-in to be successfully executed. In the instance that landowners do not consent to the valuation of their environmental endowment this method of valuation proves very difficult to conduct.

Given the large overlap of conservation demands and private property rights, the challenge has become the creation of incentive mechanisms that garner the cooperation of private property owners. The matter then becomes whether a tool exists that promotes the objectives of conservation, while still functioning in the confines of the sovereignty that private property rights provide landowners. More precisely, what is required is a tool that will "achieve economically efficient habitat conservation while maintaining political feasibility and scientific validity" (Michael, 2003, p. 243).

Many tools have been suggested to achieve this objective such as Pigouvian compensation and taxation to name but a few. The former is designed to align landowners' land-use incentives with societies economic and conservation objectives and in the latter, landowners are taxed if they use land with conservation value. The tax is imposed on landowners as a result of the lost public use value of the land in question (Innes, et. al., 1998). Many of these approaches have been criticised for the distortionary effects they have on both net social benefit and economic efficiency. These issues resulted in the interest in incentive provision, as means to bridging the gap between conservation priorities and private property rights, while limiting the distortionary effects that conservation efforts could have on efficiency.

In the realm of incentive provision, policy makers are then faced with two scenarios with respect to conservation management on privately owned property. The first is to offer landowners conditional compensation.

For example, the landowner(s) in question will only receive compensation in the instance that they retire targeted sections of their properties in order to advance conservation objectives. The second is to offer the landowner(s) unconditional compensation in which landowners find it in their best interest to determine land of their choosing on their respective properties in order to advance voluntarily conservation objectives (Parkhurst et. al., 2002). The immediate problem with the first approach is that landowners, knowing the desire of regulators to attain their land will be incentivised to over report their land value in order to elicit the highest possible compensation rents from authorities which have negative impacts on economic efficiency (Innes et. al., 1998; Doremus et. al., 1998).

This brings our discussion to the provision of voluntary incentive schemes. "An incentive scheme or mechanism is voluntary if the landowner is no worse off when voluntarily choosing a contract than not choosing one" (Smith and Shogren, 2002). To date these incentives include conservation easements; leases; habitat banking; safe harbours; candidate conservation agreements and the list goes on (Parkhurst et. al., 2002). The push towards incentive provision has been spurred on by the shortcomings of regulatory approaches (despite their comparatively low budgetary costs) at overcoming the consequences of the costs that they impose on landowners. These costs, in the absence of compensation have been found to incentivise landowners to harm species and conceal information in attempts to evade incurring them, which is to the detriment of the conservation objectives that regulatory approaches purport to be promoting (Michael, 2003; Innes et. al., 1998). Further, the imposition of highly restrictive regulation has resulted, in some instances, in landowners being forced to alter their primary land use activity, which has been shown to be to the detriment of economic efficiency (Doremus et. al., 1998).

This study is unique in that it investigates the feasibility of the conception of a uniform and effective conservation strategy, through the creation of a contiguous reserve, between landowners with such divergent primary land uses in an area as ecologically valuable as the CFR. The primary tool of investigation will be the agglomeration bonus, which is classified as a voluntary incentive mechanism. The reason for the selection of this approach as a conservation strategy between the three sites, from a practical perspective, is in its ability to avoid the task of needing to alter the land management strategies on the three sites.

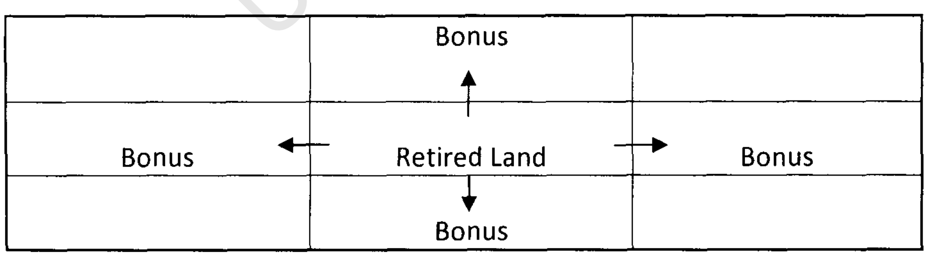
It also allows for a more coherent and effective conservation strategy across the three sites. In addition, this mechanism permits this process to occur at no financial cost to the landowners in question thus, evading one of the most commonly cited barriers to conservation on private landholdings, namely expense.

2.1 Conceptual Framework: The agglomeration bonus

In light of the argument presented thus far, it is apparent that ideally there should exist a tool that encourages private landowners to create biologically desired habitats across their boundaries without overt government orders on which land to retire (Parkhurst et. al., 2002). The agglomeration bonus is that mechanism. It is designed to create contiguous habitats across adjacent sites (Parkhurst et. al., 2002). The basic feature of the bonus is that it offers each landowner a schedule specifying a monetary payment or transfer, for the acres of land that they retire.

The idea is that landowners receive an additional payment for each retired section of land that shares a border with another retired section regardless of who owns the land (Smith and Shogren, 2002). The bonus thus creates a positive externality across privately owned sites (Parkhurst et. al., 2002). In the instance that adjacent landowners retire land at their common border, then they will be able "piggy-back" off one another's retired acres. As long as landholders prefer more money to less, no government pressure is needed to create a contiguous habitat across landholdings (Smith and Shogren, 2002).

Diagram 1: The agglomeration bonus[2]



Information source: Michael (2003)

Each block in the diagram represents a section of land owned by a landowner.

The key point is that the agglomeration bonus offers remuneration for the border, not specific land. This allows landowners the freedom to select the land that they retire because their remuneration is not dependent on the type or quality of the land they retire, yet they still reap benefits from retiring land that shares boundaries with other sections of retired land (Parkhurst et. al., 2002). Also the bonus essentially captures the additional benefit of conservation on the perrifery, or border as it were. The bonus incentivises the reitrement of land at the borders as opposed to other areas on a given plot.

This study is unique in its application of both the normal form game theory and spatial mapping approaches to the problem in a three-player context. Such variation makes the study novel in its approach and makes for a well grounded point of departure for future investigation.

3.0 Methodology:

In conducting the analysis required by this study, two questions must be answered namely:

1. Is there a voluntary incentive mechanism that facilitates more and better conservation in the region albeit over separately owned property? More in the sense that conservation is guaranteed on all three sites.
   Better by ensuring both uniform efficacy of conservation across all three sites while incentivising landowner choices aimed at conservation that are both biologically and economically efficient.
2. How can we use a controlled experimental setting to study whether such a mechanism can result in:
   - A uniform conservation strategy which is guaranteed on all three sites?
   - Landowners being incentivised to make the most biologically and economically efficient land retirement decisions in the creation of the contiguous reserve?

In answering the first question, an experimental economics mechanism known as the agglomeration bonus will be presented using a hypothetical scenario between the three sites. The rationale being that the conservation strategies over the three sites are understandably very different, given the diverging primary land uses over the three sites, and as described earlier, of different efficacy.

From the perspective of an independent party with a conservation motive a unique, coherent and effective conservation strategy that spans all three sites regardless of landowner would be desirable. The second question will be answered by evaluating both the biological and economic efficiency of the experimental results.

3.1 Application of the agglomeration Bonus

The current approach to conservation over the three sites is a fragmented one, with each site managing their endowment of natural assets, in this instance land that is rich in biodiversity. Let us assume for the sake of progress that information on the value of biodiversity as explained earlier has been collected on all three sites and also, by attaining this information, that the most effective conserver of the three has been identified. One would want, given the knowledge of the most effective conserver, all three landowners to follow a conservation strategy that is at least similar to that of the most effective conserver.

This desire would in all likelihood be unattainable without third party intervention because as one might expect, firstly conservation is not the main priority on all the sites and secondly changing existing conservation practices for more effective ones often times means more money. A desire for bigger budgets for non-primary land use is highly unlikely.

Pagiola (2008) correctly states that "land use decisions are generally made by groups who receive mainly direct use benefits, these groups often have strong incentives to manage land so as to maximise direct use benefits and often pay little or no attention to the consequences for other benefits" (Pagiola, 2008, p. 2). If more effective conservation strategies are needed across the three sites, then a different approach to conservation that is not in conflict with the primary land uses on the three sites should be investigated.

It is in this context that the agglomeration bonus presents itself as a desirable mechanism in aligning the conservation strategies across all three sites. What it does is essentially create new reserves in which sections of land from all three sites are grouped together. So although not all the biodiversity value across the three sites will be protected under the new reserve, some of it will. A separate authority, or even one of the three sites, that is able to implement a uniform and effective conservation strategy across sections of land that currently fall under the three different sites will then manage this new reserve.

As a voluntary incentive mechanism in which landowners are completely sovereign in their land use decisions it minimises political conflict, whilst still allowing for the implementation of the desired management strategy across land that spans all three sites. What this means is that managers on the three sites will be incentivised to internalise conservation objectives and make their land retirement decisions based on evident payoffs. This minimises the costs associated with statutory conservation mandates as discussed earlier.

3.2 Experimental design:

As a point of departure it is necessary to create a hypothetical scenario pertaining to the land owners in the Overberg, and the approach towards creating a contiguous conservation area between them. The basic experimental design is an interpretation of the design presented by Parkhurst et al. (2002) and Parkhurst and Shogren (2007) as was explained in the introduction.

Diagram 2: Demarcation of Overberg case study[3]

OTB			DHNR			AFB Overberg
Low	High	Med	Low	High	Med	[redacted]
Low	High	Med	Low	High	Med	
Low	High	Med	Low	High	Med	
Low	High	Med	Low	High	Med	
Low	High	Med	Low	High	Med	

The diagram above represents the three sites included in the case study. The initial design shows each of the landowners namely OTB (left), De Hoop Nature reserve (DHNR) (middle) and AFB Overberg (right) respectively. Each of the three sites is represented by 15 blocks. Each block represents a portion of the land that each of the landowners is able to retire in response to the incentives provided. The black bars represent the boundaries separating the respective sites from one another.

[3] This is a preliminary demarcation of the boundaries and is subject to change over the course of the experiment as is shown in Treatment 2. The values of the land to the respective landowners are shown in each cell and are: low; high; and medium (med). An explanation for these allocations is presented in the text.

Each of the sections of land has been assigned a land value. This value is a reflection of the productive value of that section of land to each landowner, of which each of the landowners is aware. Ideally, these land values would be more accurately calculated incorporating the net value of the natural assets on each of the sites, but again this investigation is limited by the lack of data required to do so. Instead, by conducting telephonic interviews with the conservation managers at two of the three sites, land values on the sites have been proxied.

DHNR land is valued highest in the centre of the site. The reason for this is that the condition of the vegetation on the land closest to the boundaries is of a lower quality than that at the centre. This is a result of the land use on adjacent sites, although all the sites are very similar from an ecological perspective (Hoekstra, 2009). The value of the land on the two boundaries was assigned as low or medium arbitrarily. The low and high value columns were interchanged over the course of play to determine if the land value structure had any influence over the decisions that subjects made.

From an OTB perspective land in the centre of the site is considered to have the highest use value as the primary testing operations are carried out at the centre of the site (Gomez, 2009). The land at the boundary is assumed to be of medium value to the landowner, as although it is not used for the primary operations of the site, the integrity of the boundary of the site is important as a security measure. The assumption of emphasis on security is reasonable given the sensitive nature of operations on the site.

The landowners (subjects) are each given schedules showing the monetary value of the different sections of land (as shown in Table 1) below and these land values remain unchanged over all treatments.

Table 1: Land quality/price schedule[4]

Value of land	Rand value
High	10
Medium	5
Low	2

From the table above each landowner's plot has a total net value of R 85 [5*R10 + 5*R5 +5*R2] in the absence of the conservation transfer.

It is necessary at this point to present the framework in which the experiment was conducted:

- This experiment was conducted on a sample of 30 randomly selected university students.
- Each subject was paid a R10 participation fee and told that they could earn an extra R10 as a result of their patterns of play.[5]
- These subjects were randomly split into groups of two or three for each treatment.
- These groupings remained unchanged for the duration of each treatment.
- The experiments were conducted manually, and subjects did not know who they were grouped with until the experiment began.
- Each participating group was assigned a monitor, to oversee the process and ensure that all subjects understood the instructions and procedure of the experiment.
- The experiment was conducted over three treatments: the first investigates the application of conservation transfer in the absence of an agglomeration bonus; the second investigates the introduction of an agglomeration bonus while restricting subjects from communicating with one another. Finally, the third investigates the application of the agglomeration bonus in the presence of communication between subjects.

[4] The rand values of the land were randomly assigned to ensure that all subjects could have a clear and common understanding of the values of the land.

[5] This was done to incentivise rational, income maximising play over the course of the experiment. The size of the incentive was determined by conducting interviews with undergraduate students to determine how much they are paid in their next best source of income on campus. This information and the budgetary constraints of the study were then incorporated to determine the figure.

Treatment 1: conservation transfer with no agglomeration bonus.

The first treatment of the experiment serves as a baseline case. In this treatment, the creation of a contiguous reserve in the absence of an agglomeration bonus will be investigated. According to Parkhurst et. al. (2002) the theoretical outcome of this treatment should be that all the subjects will retire all five low-valued sections of their land.

Meaning that in the absence of an incentive mechanism outside of the transfer, landowners should not take into consideration their neighbour's land retirement decisions when they make their own. In analysing this prediction, the subjects were divided into groups of two and were prohibited from communicating with one another. They were then instructed to assume the role of a landowner over the course of the treatment. The subjects were randomly assigned a plot of land meaning they were equally likely to be the landowner of any of the sites. Further, the subjects were not informed of the primary land use on their plot and the instructions of the treatment were given outside of any particular context, this was done to ensure that the outcomes of the experiment were not influenced in any way.

In this treatment subjects were alerted to the fact that there would be a transfer awarded to any private landowner who was willing to retire land for conservation purposes.

Further, subjects were told that they would be allowed to retire any five sections of their 15 in return for the R4 per section transfer on offer[6].

[6] The landowner would receive the difference between the transfer and the value of the retired land as net income.

Diagram 3: Illustration of highest conservation value land between adjacent landowners.

A)

2	10	5	5	10	5
2	10	5	5	10	5
2	10	5	5	10	5
2	10	5	5	10	5
2	10	5	5	10	5

B)

L	H	M	M	H	L
L	H	M	M	H	L
L	H	M	M	H	L
L	H	M	M	H	L
L	H	M	M	H	L

Information source: interview[7]

For ease of understanding[8], the sites are subdivided into groupings of two as illustrated in diagram 3 above. The shaded area indicates the areas considered to have the highest conservation value between OTB, DHNR; DHNR, and AFB Overberg respectively. Therefore, both borders of the site in the middle of diagram 2 have high conservation value[9]. This weighting is made in light of the fact that the optimal conservation outcome in this scenario is the successful creation of a contiguous reserve between the site pairings. The two panels in Diagram 3 illustrate the land allocations to each of the players respectively.

The first panel illustrates the values in monetary terms whilst the second panel illustrates the allocation in value alone. It is worth noting that the land with the highest conservation value is of medium value to the landowners. It is apparent from this that there is a distinct difference between the conservation value of the land and the landowner's value of the land.

The weighting is viable because from a conservation perspective, the three sites share ecological characteristics due to their close proximity to one another.

[7] Telephonic interviews with Mr Tierck Hoekstra (Cape Nature) and Mr. Andre Gomez (Denel).

[8] This treatment is conducted using the game theoretic approach suggested by Parkhurst et. al. (2002)

[9] Although both the middle site's borders are of high conservation value, the land value to the landowner is unchanged as is depicted in diagram 3.

This allows the experimental freedom to weight conservation value and desirability between the three sites such that the creation of a contiguous reserve at the adjacent borders is prioritised.

Each landowner (subject) is presented with eight options pertaining to their response to the conservation incentives:

1. No: no participation
2. L: retire all five low value sections
3. M: retire all five middle value sections
4. H: retire all five high value sections
5. 3L/2M: retire three low and two medium value sections
6. 3M/2L: retire three medium and two low value sections
7. 3M/2H: retire three medium and two high value sections
8. 3H/2M: retire three high and two medium value sections

   Adapted from: Parkhurst et. al. (2002)

The strategy space is limited to these eight strategies as all other strategy sets would result in strictly dominated outcomes and as such they have been eliminated. This approach was also adopted by Parkhurst et. al. (2002). The elimination of strictly dominated strategies is the biggest criticism with taking a normal form game theoretic approach to the application of the agglomeration bonus as the results are somewhat altered by the limited strategies (Parkhurst and Shogren, 2007). That said, this approach allows subjects to make their land retirement decisions based on evident payoffs given all the potential strategies that their neighbour could adopt. In other words the subjects have perfect information regarding thier neighbour's strategy space. This is highly unlikeley in reality, but it makes for a more complete benchmark case.

Returning to experimental procedure, the subjects were each presented with the payoff matrix presented in Table 2 below, from which they were able to select their preferred strategy. They were then instructed to select their preferred strategy by highlighting the appropriate box in the leftmost column or in the first row. The subjects made their strategy choices without knowing what choice their neighbour had made on their respective payoff matrix. Once both parties had made their choices, the pair was informed of their final payoff decision given both parties' strategy choices.

For example, if subject 1 (playing the row option) selected to play the No strategy by highlighting it in the top left cell, and subject 2 selected the H strategy (playing the column option), then the pair would earn total payoffs 85 and 55 for the treatment, for a diagrammatic representation, refer to section 1.1 in Appendix A.

From Table 2, we see that the (L, L) strategy results in the socially optimal outcome, because no other strategy will result in higher payoffs for either of the subjects. This strategy also results in the Nash equilibrium as no other strategy can be played by either of the players without making themselves worse off. From what we can see, the creation of a contiguous reserve given only the transfer is not likely given the associated payoffs.

Table 2: Payoff matrix R 4 transfer without agglomeration bonus

	No	L	M	H	3L/2M	3M/2L	3M/2H	3H/2M
No	85 85	85 95	85 80	85 55	85 89	85 86	85 70	85 65
L	95 85	[redacted]	95 80	95 55	95 89	95 86	95 70	95 65
M	80 85	80 95	80 80	80 55	80 89	80 86	80 70	80 65
H	55 85	55 95	55 80	55 55	55 89	55 86	55 70	55 65
3L/2H	89 85	89 95	89 80	89 55	89 89	89 86	89 70	89 65
3H/2L	86 85	86 95	86 80	86 55	86 89	86 86	86 70	86 65
3M/2H	70 85	70 95	70 80	70 55	70 89	70 86	70 70	70 65
3H/2M	65 85	65 95	65 80	65 55	65 55	65 86	65 70	65 65

Adapted from Parkhurst et. al.(2002)

Key:

	Nash equilibrium

Given that each landowner is aware of the value of their land and has an incentive to retire a certain portion of the total land at their disposal, the landowner would choose to retire the land that they find least valuable in exchange for the transfer. One would not expect ex-ante that these subjects in their roles as landowners would retire land that would result in the creation of contiguous reserves.

Treatment 2: Introduction of an agglomeration bonus with no communication between subjects.

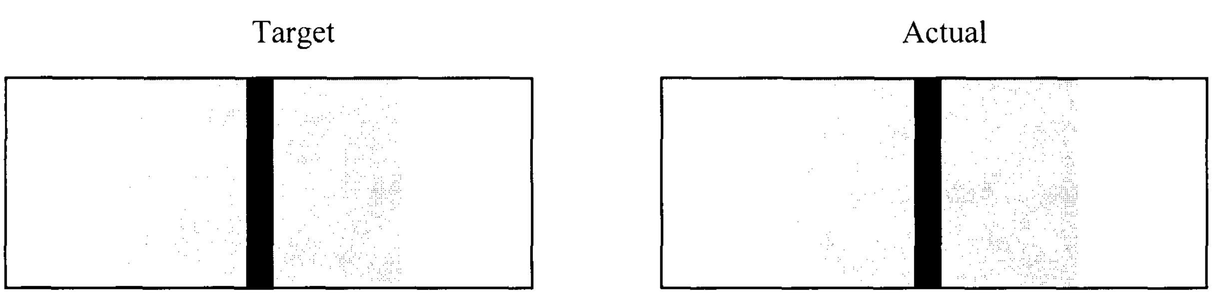
In this treatment, the agglomeration bonus as presented by Parkhurst and Shogren (2007) is introduced. The aim of this treatment is to determine if the provision of an agglomeration bonus is effective at facilitating the creation of contiguous reserves. The key here is that the subjects are informed of the fact that on top of the transfer introduced in the first treatment; they will be paid an additional bonus for every section of land they retire that is bordered by another retired piece of land. Unlike the first treatment, in this treatment the inclusion of the border bonus allows for an active investigation of the two questions presented in the methodology.

- If the retired land shares at least one border with another retired piece of land then the subject earns an agglomeration bonus.
- The amount of income that subjects can achieve because of the bonus is solely dependent on the number of eligible borders and as such can be considered a border bonus.
- The subjects are also presented with two grids showing two potential scenarios regarding their proximity to one another.
- The subjects are then presented with payoff menus showing the incentive composition of the different grid patterns.

The rationale behind this treatment is as follows: the conservationist or regulator has a target reserve in mind that they would like to see created by the bonus. Incentive structures for the bonus are then created to promote the formation of the target reserve. Given the design of the treatment, three outcomes are possible:

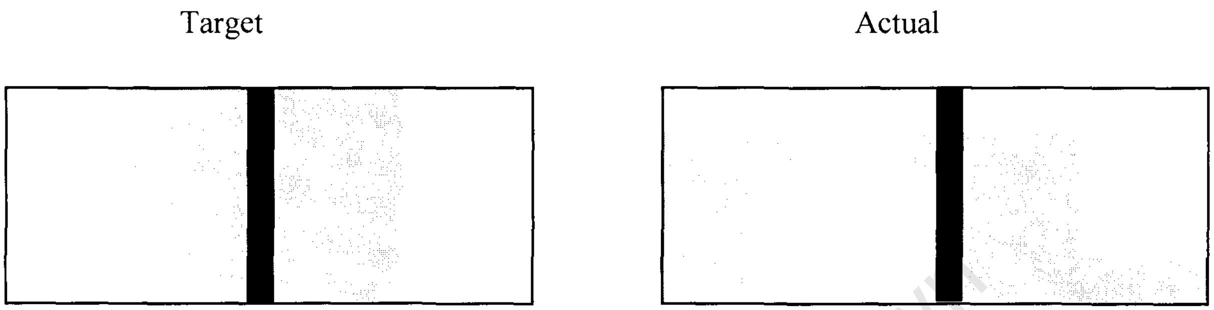
1. Subjects attain the target reserve.

Diagram 4a: illustration of subjects attaining target reserve

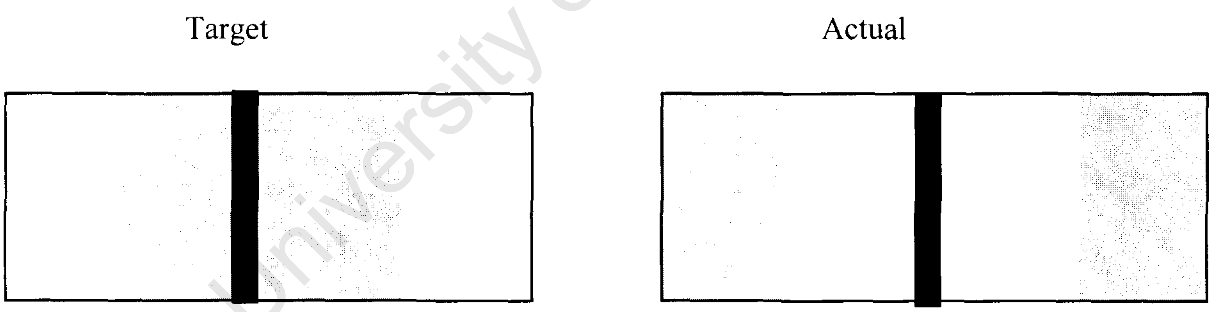


2. Subjects create a contiguous reserve, but not the target reserve. This outcome is identified as a block reserve.

Diagram 4b: illustration of subjects attaining block reserve



3. Subjects fail to create any form of contiguous reserve; this outcome is identified as coordination failure.
4. Diagram 4c: illustration of subjects failing to coordinate



It is apparent that the size of the bonus received by each landowner is determined by the number of borders it shares with other pieces of retired land, (as is illustrated in Diagram 1) and the type of border that the retired piece of land shares with a neighbour's retired piece of land. It is important to note that in theory the net value of the land at the borders should not be the only motivation behind the subjects' land retirement decisions, but rather that the potential income that can be derived from the border bonus should be incorporated into land retirement decisions.

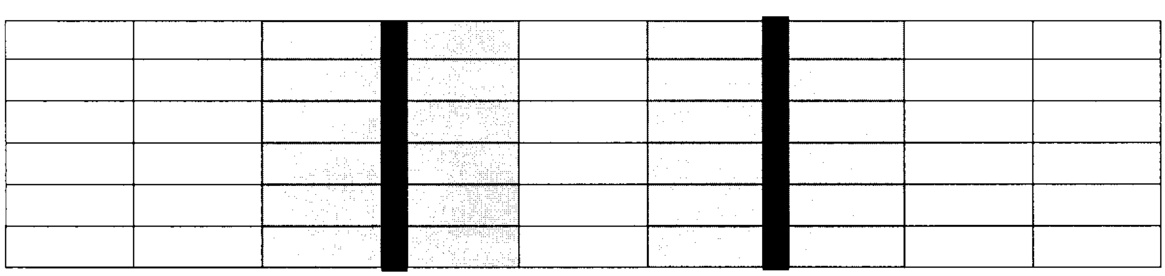
Whether this is truly the case remains to be seen and will be assessed upon analysis of the experimental results.

From the literature presented thus far, the idea of the border bonus is unsurprising. What is new at this stage is the difference in the size of the bonus. In this treatment there is a difference in payoffs based on whether land is retired in adjacent rows or columns with a neighbour's retired land. In this treatment a spatial mapping application of the problem is presented, as proposed by Parkhurst and Shogren (2007) which is different from the normal form game presented in Treatment 1. This approach is considered because unlike the normal form game presented in Treatment 1, no strategies of play are eliminated, and the added complexity of having to read payoff matrices is lifted from subjects who may not have any experience with game theory.

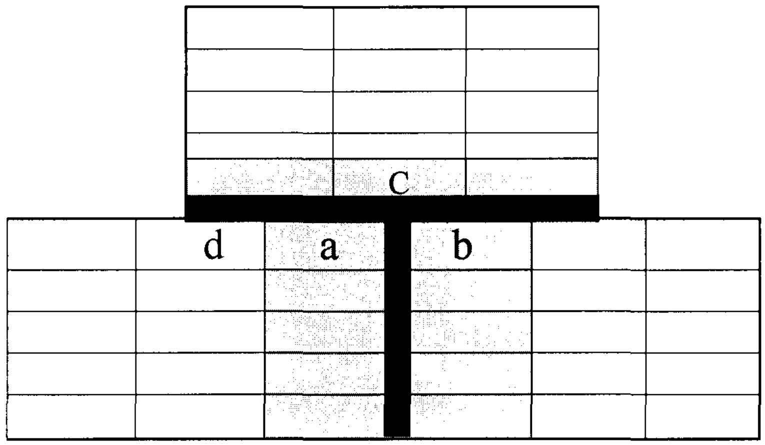
There are two target reserves in the treatment. The first is the corridor reserve as depicted in panel a. of Diagram 4, the second is the windmill target reserve as shown in panel b. the reason for the creation of two reserve types is to observe whether the layout of a grid has an effect on the creation of a contiguous reserve. Secondly, the two grids require a different number of contiguous reserves to obtain the target. The corridor grid requires two, while the windmill grid requires the creation of only one. The subjects' response to this difference may have some interesting implications for the application of the agglomeration bonus in the case study. The creation of the different target reserves is incentivised by offering subjects varying payoffs.

Diagram 5: Target reserves for Treatment 2

a. Corridor:



b. Windmill:



There are four income-generating means in this treatment, namely a transfer, which is the same transfer introduced in treatment 1. The second is an own border bonus which is the bonus that landowners receive if the sections of land they retire both belong to that landowner. The third is the row border bonus and is the bonus that adjacent landowners receive in the event that they both retire land in a row at their common boundary.

The last is the column border bonus and is the bonus that adjacent landowners receive in the event that they both retire land in a column at their common boundary. For example if the landowner in the leftmost plot of Diagram 4b retired sections a and d on their plot, they would two R 4 transfers, one for each section, and one R 7 own border transfer. If two adjacent landowners retired sections a and b from their respective plots, they would each earn the R 4 transfer and the R 14 column border bonus.
If the landowner who owns the top plot retired section c the landowner in the leftmost plot retired plot a then each of the landowners would receive the transfer and a row border bonus. The monetary amounts used in this example are presented in Table 3 below.

<u>Table 3: Payoff Menu for Treatment 2</u>

Land Distribution Pattern	Transfer (per section)	Own Border Bonus	Row Border Bonus	Column Border Bonus
Corridor	R 4	R 7	R 14	R 0
Windmill	R 4	R 7	R 14	R 14

Adapted from: Parkhurst and Shogren (2007)

The 30 subjects are divided into two groups of 15. The first group plays a repeated version of each of the two games, corridor and windmill over five rounds, while the second group plays the two games over one round. This division is made to observe whether repetition has an impact on the subjects' patterns of play or the efficiency of their outcomes. Heinemann (2000) in his study finds evidence of learning effects causing a convergence of subject behaviour to rational expectation, it would be interesting to see if the results from these treatments conform to this prediction.

The groups of 15 are further divided into groups of three and are instructed to play a particular grid over a specified number of rounds with the associated payoff menu (5 groups of three or 15 subjects playing either repeated or one round games). In the five round games, the subjects play the same grid and its associated payoffs structure for five consecutive rounds and then play the next grid in the same way. In the one round game, the subjects play only one round of each grid.

Table 4: Case structure of Treatment 2

Case	Structure
1	Five groups are instructed to play the corridor game over five rounds
2	Five groups are instructed to play the corridor game over one round
3	The five groups from case 1 are instructed to play the windmill game over five rounds
4	Five groups from case 2 are instructed to play the windmill game over one round

The addition of the spatial mapping application of the agglomeration bonus has an additional advantage over the normal form application because the Nash equilibrium and social optimum are the same. The target reserve is both the Nash equilibrium and the social optimum of the game because no player can achieve higher earnings than they would in the event that the target is reached nor could they deviate from the strategy without making themselves worse-off. This is a result of the combination of the high payoffs associated with the row and column border bonuses added to the own border bonuses and the transfer income.

Treatment 3: Introduction of an agglomeration bonus with communication between subjects.

This treatment is designed in exactly the same way as the treatment before, the exception being that in this treatment, subjects are permitted to have non-binding written communication between one another over the course of the treatment as proposed by Parkhurst et. al. (2002). This means the Nash equilibrium and socially optimal outcome are the same in this treatment are the same as they were in Treatment 2.

The aim of this treatment is to determine whether communication between the subjects increases the chance that they will create the target reserve and thus attain both the Nash equilibrium and socially optimal outcome. The ex-ante expectation for this treatment is that the grouped subjects should play more coordinated strategies. This expectation is based on the fact that they are aided in their decision making process by the agglomeration bonus. Furthermore, the ability of the subjects to engage in non-binding communication allows for them to co-ordinate their efforts towards maximising their earnings and creating the contiguous reserve. The rationale for the inclusion of this treatment is as follows: it is of interest to determine if granting landowners the ability to coordinate their land retirement efforts will improve the efficiency of the land retirement process.

In treatment 2 it was shown that both the socially optimal outcome and the Nash equilibrium was for each group to attain the target reserve. This treatment investigates whether allowing subjects to coordinate their strategies through communication increases the number of target reserves created and as such socially optimal outcomes that subjects come to. This treatment is run over four cases as follows:

Table 5: Case structure of Treatment 3

Case	Structure
1	The 5 groups playing the five round cases are instructed to play another five round corridor game in which each subject is allowed to send one message to the other group members in every round.
2	The 5 groups playing the one round cases are instructed to play another one round corridor game in which each subject is allowed to send one message to the other group members in that round.
3	The 5 groups playing the five round cases are instructed to play another five round windmill game in which each subject is allowed to send one message to the other group members in every round.
4	The 5 groups playing the one round cases are instructed to play another one round windmill game in which each subject is allowed to send one message to the other group members in that round.

3.3 Bio-economic efficiency.

Three measures of efficiency will be presented for the purpose of analysis. The first measure is strict biological efficiency (SB) which is a measure of the number of times each group attained the target reserve in each treatment, and is calculated by an absolute count of the number of times the group attains the target reserve (Parkhurst and Shogren, 2007).

The second measure is weak biological efficiency (WB) and is a measure of the number of land sections that each group retires that fall within the target reserve area. It is calculated by determining the number of blocks that each groups retires in the relevant rounds that fall within the area of the target reserve. This figure is then divided by the maximum number of blocks that would fall in the target area if the target were to be attained (the number of blocks that are in the target reserve). This count is then converted into a percentage by multiplying the ratio by 100.

$$WB\ (\%) = \frac{number\ of\ sections\ retired\ in\ target\ reserve\ area}{number\ of\ sections\ retired\ if\ target\ reserve\ is\ created} \times 100$$

Adapted from: Parkhurst and Shogren (2007)

Intuitively the measure is yardstick for the success of the bonus from biological perspective. The higher the WB percentage, the closer the target. For instance a WB measure of 50 percent means that only half of theconservation value of the target reserve has been accomplished.

The third and final measure of efficiency is economic efficiency. This is a measure of the group efficiency in net earnings. More simply put, it is a measure of how much money each group made given how much money they could have made. The measure is calculated by determining the total net earnings that each group attained and dividing this value by the total net earnings that the group can attain in the event that they obtain the target reserve. for a numerical example refer to section 1.3 of Appendix A.

$$EE(\%) = \frac{\textit{money made by the group} - \textit{maximum amount of land value that the group can retire}}{\textit{money made if target reserve is achieved} - \textit{maximum land alue lost to make reserve}}$$

Adapted from: Parkhurst and Shogren (2007)

4.0 Experimental Results:

Treatment 1: conservation transfer with no agglomeration bonus.

In this treatment, the apparent outcome is for subjects to retire all five low value sections of land in exchange for the R 4 transfer. The outcomes of the experiment indicate that 100 percent of the subjects each play the dominant (L, L) strategy from the first round of the first treatment, which is the pure strategy Nash Equilibrium of the treatment. Parkhurst et.al. (2002) come to a similar finding in their study.

This outcome is unsurprising as the ex-ante expectation of the game was that players would only retire land with a lower value when compared with the transfer and the other sections of land respectively. The subjects each play rationally and maximise their net earnings.[10]

Treatment 2: Introduction of an agglomeration bonus without communication between subjects.

[10] Income from transfer less the value of their retired land.

Table 6: Results Summary – 5 round corridor game with no communication.

Round	Co ordination failure (no reserve)	Block Reserve	Target Reserve
1	3	2	0
2	4	1	0
3	3	1	1
4	2	3	0
5	2	2	1

Source: Own observations Treatment 2, case 1, subjects 1-15.

Two of the five groups failed to attain either the block reserve or the target reserve. They chose instead to play the "safe-strategy" and gave up all five sections of their low value land, which incidentally was their optimal strategy in the previous treatment. Regardless of the knowledge of the much higher payoffs they would receive in the instance that they retired sections of land at the borders with their neighbours. This outcome is very interesting in that it suggests that there is some form of conflict between landowner strategies. On the one hand, landowners have the opportunity to play the safe strategy that players found in Treatment 1 that ensures positive net earnings without incurring the costs of retiring land that is more valuable. On the other hand, subjects are provided the opportunity to make substantial gains in earnings by retiring land at their borders if their neighbours do the same.

The primary difference between the two strategies is that unlike the former, the latter involves uncertainty. The question for landowners is whether to avoid the risk associated with agglomeration, or to pursue the potentially more lucrative rewards at the border albeit with exposure to risk. Parkhurst and Shogren (2007) corroborate this observation in finding that the spatial externalities created by the application of the agglomeration bonus can result in a divergence between the individual incentives, and the collective payoffs of the subjects.

Table 7: Treatment 2 - Case 2 One round corridor game

Group	Coordination failure (no reserve)	Block Reserve	Target reserve
6	0	1	0
7	0	1	0
8	0	1	0
9	1	0	0
10	0	1	0

Source: Own observations Treatment 2, case 3, subjects 16-30.

Subjects played a once off game as opposed to the five round game played in the first case of this treatment. Of the five groups, all but one managed to play some form of coordinated strategy (as shown in Table 7), realising even without communication that 'piggy-backing' off their neighbour's retired land was in their best interest.

This result serves to reinforce the assertion made by Smith and Shogren (2002) that the inclusion of an agglomeration bonus creates a positive network externality across landholdings; thus resulting in each subject or landowner having a clear incentive to create a contiguous habitat across their respective properties voluntarily. The bonus reinforces the importance of retiring land at the border, which is the core strength of this technique. The added incentive to retire land at the border promotes the creation of contiguous reserves as opposed to block reserves.

It is also worth mentioning, that although the majority of groups did create the block reserves, none found the social optimum, or most lucrative outcome namely the target reserve. This again may be the result of divergence between landowner incentives and collective payoffs because of the agglomeration bonus.

Table 8: Treatment 2 - Case 3, Five round windmill games

Round	Co ordination failure (no reserve)	Block Reserve	Target Reserve
1	0	3	2
2	0	3	2
3	0	2	3
4	0	0	5
5	0	0	5

Source: Own observations, Treatment 2, case 3, subjects 1-15

In the third case of this treatment all five groups found the first best reserve type (the target reserve) by the fifth round of play as shown in Table 8. In this case, subjects spent the least time of the four cases deliberating on what strategy to play. A practical explanation for this is that the spatial design of the problem (windmill as opposed to corridor) coupled with the incentive structure provided were very effective in articulating the importance of the boundary bonus with a neighbour. As such, subjects tended to cluster their land retirement choices around the borders of their territories in the faith that their neighbours would be like-minded and opt for the high row and column bonuses.

The results reinforce the idea that landowners will unite unilaterally, given the right incentives. The use of an agglomeration bonus to create contiguous reserves over private property as was found by Parkhurst et. al. (2002) seems to have some merit in light of the findings thus far. However, it will be interesting to explore is whether the repeated play results in subjects developing a learning effect[11] as they are exposed to more rounds of the experiment this idea will be further inspected in the section 4.2.

[11] A process in which subjects learn the likely responses of their group members as a result of the increasing number of rounds that they are exposed to over the course of the experiment.

Table 9: Treatment 2 - Case 3 (One round windmill games)

Group	Coordination failure (no reserve)	Block Reserve	Target reserve
6	0	1	0
7	0	0	1
8	0	1	0
9	0	1	0
10	0	1	0

Source: Own observations Treatment 2, case 3, subjects 16-30.

The final case of this treatment shows all groups making at least one contiguous decision between them. This is reflected in the absence of a coordination failure result in the treatment. Four of the five groups created block reserves; while one group made the decision to create the first best reserve type which is the target reserve.

Treatment 3: Introduction of an agglomeration bonus with communication between subjects.

Table 10: Treatment 3 - Case 1, 5 round corridor game with communication

Round	Coordination failure (no reserve)	Block Reserve	Target reserve
1	0	2	3
2	0	0	5
3	1	2	3
4	0	1	4
5	0	0	5

Source: Own observations Treatment 3, case 1, subjects 1-15.

In the repeated version of the game all the groups managed to attain the target reserve by the second round. Surprisingly, after finding this outcome, one of the groups deviated from this income maximising strategy over the next two rounds. Given the peculiarity of this strategy the group was asked why they made these decisions. They responded that one of the players who had deviated from the optimal strategy in the third round created mistrust in the group and the subject sharing a boundary with this player retaliated in the fourth round by reducing the number of sections they retired on the boundary.

This signified that even in the presence of communication, players who did not fulfil their communicated strategies, were open to retaliation from other parties even if it resulted in the other parties receiving lower boundary bonuses themselves. Brunton et. al.(2000) in thier study of the "spite dilemma" had similar findings, they found that subjects were more trusting of risk-seeking behaviour if it resulted in higher payoffs for the group, and mistrusted players who deviated from the strategy once the group has settled on a high-risk high reward outcome. They found that player retaliation because of the deviation was not uncommon and that strategies of spite were often played in retaliation.

Table 11: Treatment 3 - Case 2, 1 round corridor game with communication

Group	Coordination failure (no reserve)	Block Reserve	Target reserve
6	0	1	0
7	0	1	0
8	0	1	0
9	0	0	1
10	0	1	0

Source: Own observations Treatment 3, case 2, subjects 16-30.

In the second case of the third treatment, the presence of communication did result in the creation of the target reserve by Group 9. Four of the five groups, however were able to coordinate their efforts and create the next best reserve type being the block reserve. This is unsurprising given the coordination opportunity that communication provided for them as can be seen in Table 11 above. Further, the case resulted in the absence of coordination failure.

Table 12: Treatment 3 - Case 3, 5 round windmill game with communication

Round	Coordination failure (no reserve)	Block Reserve	Target reserve
1	0	3	2
2	0	3	2
3	0	1	4
4	0	0	5
5	0	0	5

Source: Own observations Treatment 3, case 3, subjects 1-15.

In this case of the third treatment, all five groups came to the first best or social optimum outcome in the fourth round and maintained it in the fifth round. This behaviour is unsurprising given the exposure that the subjects had to the game by the time this treatment was played as posited by Heinemann (2000). It is highly likely that the subjects discovered that the income maximising strategy was to retire sections of land in such a way as to maximise the high income generated from the borders shared with their neighbours. The presence of communication thus allowed the subjects to share this knowledge with their group and corroborate their strategies. Again, it is necessary to give mention to the fact that a learning effect may be influencing these patterns of play thus taking the results at face value may be misleading.

Table 13: Treatment 3 - Case 4 (one round windmill game with communication)

Group	Coordination failure (no reserve)	Block Reserve	Target reserve
1	0	0	1
2	0	0	1
3	0	1	0
4	0	0	1
5	0	0	1

Source: Own observations Treatment 3, case 4, subjects 16 -30.

In the fourth and final case of this treatment, four of the five groups found the first best (target) outcome. This too is unsurprising given that even in the case where subjects were not permitted to communicate "unilateral cooperation"[12] was the rule rather than the exception. What is worth mentioning here is that three more groups found the target outcome in this instance than in that where communication was prohibited. This increase in coordination may well be attributable to communication as it is the only factor that changed between the two cases in question.

4.1 Bio-economic Efficiency.

From the experimental results, it is apparent that in some instances, the groups were able to attain optimal outcomes by creating target reserves.

[12] Parkhurst et. al.(2002)

Thus far, the analysis has not investigated the efficiency of the experimental outcomes observed. As such, the question of efficiency will be analysed in this section.

Table 14 shows that in case 1 of treatment 2, (the five round corridor game in which the subjects are not allowed to communicate) strict biological efficiency is low with only Group 2 attaining the target reserve over their five round game. This group managed to attain the target reserve twice, once in each of their last two rounds of play. Weak biological efficiency is not much higher at an average of 57.8 percent across all five groups. Finally, the economic efficiency measure shows that the subjects were only able to make 52.02 percent of the potential earnings they could have attained in the treatment.

From the second case, where five groups played the single round corridor game, none of the groups was able to achieve the target reserve. What is of interest however is the economic efficiency percentage that the group obtained of 63.92 percent. In comparing the outcomes of the two corridor cases in this treatment, what is interesting is that although both biological measures in the repeated case are higher, economic efficiency is on average, 11.9 percent higher in the single round case. In the repeated case, the bulk of co-ordination failures occurred in the first three rounds for all five groups.

Upon closer analysis it is apparent that all counts of co-ordination failure occurred because at least one of the players in each group played the "safe -strategy" that was discovered in the first treatment. Here, subjects show firstly that the net value of their land endowment is of importance to their retirement decision. Subjects, knowing of potential gains from retiring more valuable land for a potential higher bonus in the event that their neighbour does the same, choose not to, but rather choose to retire all their low value land for the much lower own border bonus and conservation transfer. The second revelation presented by this strategy is that subjects in this treatment are somewhat risk averse, and forgo the higher payoffs associated with the risky practice of retiring their higher valued land in return for the high neighbour border bonus as was discussed in section 4.0.

In explaining the difference in economic efficiency, analysis of the player grids for the two cases revealed that the players playing the repeated games often played inefficient strategies in the understanding that their net income would be cumulative over all five rounds. In the one round game, subjects seemed to take an 'all or nothing' approach with more group members retiring higher valued land at the borders in attempts to maximise their net earnings in their one round of play.

Comparing the one round windmill games to the one round corridor games, it is apparent that on all counts of efficiency the windmill game is superior. The primary distinction between these two cases, (other than the difference in design) is the number of contiguous reserves that subjects can make. The corridor design requires that two sets of adjacent landowners retire land at their relevant borders to create two contiguous reserves, whereas the windmill case requires that all three land owners retire land in the same region and create a single target reserve. From the results thus far it is apparent that subjects creating one contiguous reserve come to more efficient outcomes than they would in the event that were creating more than one.

On the land grid in which Group 7 was able to create the target reserve, all three players were required to retire land of at least medium value, in fact one of the three players chose to retire three sections of high value land in order to attain the target[13]. This outcome suggests that the subjects in Group 7 were willing to give up high valued land in order to attain the high income returns associated with the target reserve. Given this finding, it is then of interest to determine whether the subjects in this case of the treatment were generally more willing to part with higher valued land in exchange for the very high neighbour border returns.

[13] For group 7's actual grid see section 2.1 in the Appendix B.

Table 14: Efficiency measures for Treatment 2

Group	Round	SB	WB(%)	EE(%)
Case 1 : 5 round Corridor				
1	1 – 5	0	50	47.2
2	1 – 5	2	79	78.2
3	1 – 5	0	60	48.6
5	1 – 5	0	50	39
	Average:	**0.4**	**57.8**	**52**
Case 2 : 1 round Corridor				
6	1	0	45	66.6
7	1	0	65	68.4
8	1	0	60	77.7
9	1	0	35	46.9
10	1	0	50	60
	Average:	**0**	**51**	**63.9**
Case 3: 5 round Windmill				
1	6 – 10	2	86	91.4
2	6 – 10	1	91	82.3
3	6 – 10	2	93	94.7
4	6 – 10	1	79	73.9
5	6 – 10	1	85	81.9
	Average:	**1.4**	**86.8**	**84.9**
Case 4: 1 round Windmill				
6	2	0	70	98.2
7	2	1	100	100
8	2	0	80	56.7
9	2	0	73	55.1
10	2	0	75	66
	Average:	**0.2**	**79.6**	**75.2**

Source: Own observation, Treatment 2, 30 subjects.

Table 15: Medium and high net value land retired in 1 round corridor and windmill cases.

Group	**1 Round Corridor**			**1 Round windmill**		
	Medium	High	Total	Medium	High	Total
6	9	3	12	6	3	9
7	10	2	12	11	3	14
8	7	1	8	8	2	10
9	5	6	11	4	4	8
10	5	0	5	8	2	10
Average:	**7.2**	**2.4**	**9.6**	**7.4**	**2.8**	**10.2**

Source: Own observation, Treatment 2

From Table 15 it is apparent that on average, the proportion of high and medium valued land sections retired was on average 0.6 percent higher in the windmill case than in the corridor case. Granted in absolute terms this increase is not substantial, but it is worth acknowledging.
From what the investigation in this section has revealed, there exists the possibility that given the creation of one large contiguous reserve, subjects playing one round games reach more efficient bio-economic outcomes than those playing one round games with more than one contiguous reserve as a target outcome.

Table 16 below shows the efficiency measures of the four cases in Treatment 3. Overall, all three measures of efficiency are higher in this treatment than they were in Treatment 2 for all four cases respectively. The most apparent difference in efficiency, however, is that the five round corridor game is now more efficient on all counts than the one round corridor game. As has been discussed, the presence of a learning effect between fixed matching of subjects playing multi-round games may be the cause of the perceived improvement in efficiency. The idea is simply that players having been matched over numerous rounds are able to predict their group members' most likely strategies based on past experience thus giving a false sense of increased efficiency which attributable only to the learning effect.

Table 16: Efficiency measures for Treatment 3.

Group	Round	SB	WB(%)	EE(%)
Case 1 : 5 round Corridor				
1	1 – 5	3	91	85.09
2	1 – 5	2	88	86.4
3	1 – 5	5	100	100
4	1 – 5	5	100	100
5	1 – 5	5	100	100
Average:		**4**	**95.8**	**94.298**
Case 2 : 1 round Corridor				
6	1	0	80	60.6
7	1	0	65	71.1
8	1	0	85	95.1
9	1	0	50	59.5
10	1	0	68	70.8
Average:		**0**	**69.6**	**71.42**
Case 3 : 5 round Windmill				
1	6 – 10	3	92.6	94.1
2	6 – 10	2	81	86.3
3	6 – 10	5	100	100
4	6 – 10	4	94.3	96.1
5	6 – 10	4	95.9	98.1
Average:		**3.6**	**92.76**	**94.92**
Case 4: 1 round Windmill				
6	2	1	100	100
7	2	1	100	100
8	2	0	93.3	87.8
9	2	1	100	100
10	2	1	100	100
Average:		**0.8**	**98.66**	**97.56**

Source: Own observation Treatment 2

The efficiency results of the corridor game continue the pattern presented in treatment 2, with the one round games proving to be most efficient across all measures. What is worth mentioning at this point is that of all the cases presented over both treatments, the one round windmill games in the presence of communication result in the most efficient outcomes. Incidentally, the one round windmill games in treatment 3 also show that on average landowners retired 12.4 percent more medium and high valued land than they did in the one round corridor games. This suggests that in the event that landowners are incentivised with adequately high bonuses and are allowed to communicate, the efficiency of the land retirement process will be higher than it would be in any other permutation of the experiment presented in this study.

4.2 Applying experimental results to the Overberg Case Study

The results of the experimental process have been presented. What remains is to apply the results obtained from the experiments to the Overberg case study. Although subjects were not given information pertaining to their primary land uses when they assumed the roles of each of three landowners relevant to the case study, the composition of the land values of each of the landowners and the experiment's target reserve structures were based on the case study in the Overberg.

From the discussion of the problem and the results generated by the experimental process, it is apparent that the private land use decisions made by landowners such as the three presented in our case study have an impact on net social benefit. As a result, any intervention regarding conservation management in the region must align the utility maximising land use practices of landowners with the net social benefits that the conservation of natural assets imparts on current and future generations. The challenge is then to ensure that this alignment occurs without undermining the sovereignty that property rights impart on landowners. The need for such alignment is necessary in the Overberg case.

Two of the three landowners namely OTB and AFB Overberg have quite sensitive land use functions in terms of weapons testing and national defence, which contribute to net social benefit in their own way.

Therefore, any regulation needs to be approached with a view towards finding common ground between land use benefits and natural asset conservation. Before any suggestions regarding the implementation of the agglomeration bonus can be discussed, valuation of all three sites needs to occur in order to ensure that the cost associated with the implementation of an agglomeration bonus are at least matched by the benefits that such an intervention would generate.

Once valuation has been conducted and it is found valuable to create the contiguous reserve, then the agglomeration bonus can and should be applied to ensure the creation of a contiguous reserve with a uniform and effective conservation management strategy. The biggest issue with respect to the acceptability of the mechanism in the Overberg will be in the way it is presented to the relevant landowners. As opposed to presenting it as a corrective mechanism structured to rectify the inadequacies of landowners in successfully conserving biodiversity on their sites. The mechanism should rather be presented as a mutually advantageous strategy aimed at reducing the added administration and cost requirements that segmented conservation has imposed on the landowners.

In implementing the agglomeration bonus in the region, our experiments have shown that a once off approach to the application of the bonus is most likely to result in the most efficient outcomes, both from a biological and economic perspective.
Further approaching the application of the bonus between the sites in this manner minimises the costs of the entire process as the costs associated with the negotiation process and retirement decisions will be incurred once off and can be appropriated as sunk costs associated with the creation of the new reserve.

From the experiments, we found both biological and economic efficiency were highest when one contiguous reserve was being targeted as presented by the windmill grid cases. So the intervener needs to identify what section of land they want retired and structure their incentive provision such that it ensures that their targeted conservation area is attained. In addition, our experiments showed that efficiency was higher in the cases where subjects were permitted to communicate with one another, as such any attempt at implementing the mechanism in the region should consider this. A cautionary note is necessary at this time.

It is important to note that although communication between landowners may increase efficiency as it is defined in this study, this concession for communication could result in landowners colluding to engage in rent–seeking behaviour that is often times to the detriment of net social benefit and the more general definition of economic efficiency.

However in what is possibly the most interesting outcome of the study, it has been shown that presented with high incentives, one target reserve and the ability to communicate, landowners are willing to retire land that they perceive to be of relatively high value in attempts to attain a single target reserve. As such, it is not impossible to target a contiguous reserve that falls across even high valued land on the sites, on condition that the incentives and environment are correctly controlled.

5.0 Conclusion

This study has found that in a controlled environment the application of an agglomeration bonus does result in the creation of contiguous reserves between adjacent landowners. Furthermore, the results have shown that in the absence of the agglomeration bonus, the provision of a conservation transfer does not result in the creation contiguous reserves between landowners. It was also revealed that despite the divergence that the bonus created between landowners' individual incentives and bargaining groups' collective payoffs, the bonus did result in group's achieving more coordinated outcomes than they did in its absence. Moreover, the results showed that given high neighbour border bonuses, subjects were willing to retire even high valued land to create the target reserves and maximise their net earnings.

On the subject of efficiency, it was found that the number of reserves targeted had implications on the efficiency of landowners' land retirement decisions. The study found that subjects made more efficient decisions, both biologically and economically when they were required to create one contiguous reserve as opposed to two.

Even faced with numerous constraints, the findings of this paper are valuable and warrant further investigation. What remains to be seen is whether these results are extendible to larger sample sizes and different sample groups. Also, further investigation into the effects that the true net values of landowners' initial endowments have on the efficiency of their land retirement decisions would be very valuable. However, as initially stated a study determining these net values has to be conducted as precursor to the investigation of the impact of the true net values.

That said, from this investigation, it is apparent that the correct implementation of the agglomeration bonus to the Overberg case study can result in the creation of a contiguous reserve in which a coherent and effective management strategy can be implemented while ensuring both biologically and economically efficient land retirement practices. The challenge is thus not in the mechanism itself, but rather in its implementation.

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Appendix

Appendix A: Illustrative examples

1.1 Example of how treatment 1 is played

Subject 1's grid:

	No	L	M	H	3L/2M	3M/2L	3M/2H	3H/2M
No	85 85	85 95	85 80	85 55	85 89	85 86	85 70	85 65
L	95 85	95 95	95 80	95 55	95 89	95 86	95 70	95 65
M	80 85	80 95	80 80	80 55	80 89	80 86	80 70	80 65
H	55 85	55 95	55 80	55 55	55 89	55 86	55 70	55 65
3L/2H	89 85	89 95	89 80	89 55	89 89	89 86	89 70	89 65
3H/2L	86 85	86 95	86 80	86 55	86 89	86 86	86 70	86 65
3M/2H	70 85	70 95	70 80	70 55	70 89	70 86	70 70	70 65
3H/2M	65 85	65 95	65 80	65 55	65 55	65 86	65 70	65 65

Subject 2's grid:

	No	L	M	H	3L/2M	3M/2L	3M/2H	3H/2M
No	85 85	85 95	85 80	85 55	85 89	85 86	85 70	85 65
L	95 85	95 95	95 80	95 55	95 89	95 86	95 70	95 65
M	80 85	80 95	80 80	80 55	80 89	80 86	80 70	80 65
H	55 85	55 95	55 80	55 55	55 89	55 86	55 70	55 65
3L/2H	89 85	89 95	89 80	89 55	89 89	89 86	89 70	89 65
3H/2L	86 85	86 95	86 80	86 55	86 89	86 86	86 70	86 65
3M/2H	70 85	70 95	70 80	70 55	70 89	70 86	70 70	70 65
3H/2M	65 85	65 95	65 80	65 55	65 55	65 86	65 70	65 65

Combined outcome:

	No	L	M	H	3L/2M	3M/2L	3M/2H	3H/2M
No	85 85	85 95	85 80	[redacted]	85 89	85 86	85 70	85 65
L	95 85	95 95	95 80	95 55	95 89	95 86	95 70	95 65
M	80 85	80 95	80 80	80 55	80 89	80 86	80 70	80 65
H	55 85	55 95	55 80	55 55	55 89	55 86	55 70	55 65
3L/2H	89 85	89 95	89 80	89 55	89 89	89 86	89 70	89 65
3H/2L	86 85	86 95	86 80	86 55	86 89	86 86	86 70	86 65
3M/2H	70 85	70 95	70 80	70 55	70 89	70 86	70 70	70 65
3H/2M	65 85	65 95	65 80	65 55	65 55	65 86	65 70	65 65

Where: No is the strategy played by subject 1

H is the strategy played by subject 2

The area shaded dark grey is the result of the subjects' combined strategies

Appendix B: Actual Results of play (selected)

2.1 Treatment 2, case 2: Actual play pattern for group 7

2	10	5
2	10	5
2	10	5
2	10	5
2	10	5

2	10	5	5	10	2
2	10	5	5	10	2
2	10	5	5	10	2
2	10	5	5	10	2
2	10	5	5	10	2

Appendix C: Experiment Instructions and player grids:

1.1 Instructions: Case one - 30 subjects; Cases 2 and 3 - 15 subjects (Groups 1-5)

You are a landowner who owns a 15 block plot of land. Your land is divided into three with each section having a particular value to you. Each of these values is indicated in each of the 15 blocks:

2	10	5			
2	10	5			
2	10	5			
2	10	5			
2	10	5			

The black line at the edge of your property signifies a fence at which your plot ends and your neighbour's plot begins. Your neighbour's property also has conservation value. You and your neighbour are approached by a representative of a national conservation authority who is interested in the conservation value of your land. She is willing to offer you certain incentives to persuade you to retire (set aside for conservation) certain sections of your land.

Case One:

The conservation representative offers you R4 per section to retire any 5 sections of the 15 sections of land of your choosing, you will play this case over 5 rounds and have a maximum of 120 seconds to make your decision in each round. You may not communicate with the person you are playing with any queries you have must be addressed to the monitor. Make your selections on the grid provided.

Case Two:

The conservation representative still offers you the agreed R4 per section retired, but will pay you an additional R7 bonus for every section of land that you retire that shares a boundary with another retired piece of land that you own. You may retire land at your fence and border it with your neighbours' retired land if you see it fit to do so. The corridor bonus menu will show how the bonus changes if your retired land shares borders with your neighbours retired land. You are required to retire any five (ten if you are the middle player)[1] sections of your land. You may not communicate with the people you are grouped with. All questions should be addressed to the monitor. You will play this scenario over 5 rounds and have a maximum of 120 seconds to make your decision in each round. Make your selection on the grids provided.

	Bonus ↑	
Bonus ←	Retired Land →	Bonus
	↓ Bonus	

(The monitor then provides an illustrative example using the diagram above, a player grid and the payoff menu).

Your land grid has changed, but the value of your land is exactly the same, make your land retirement decision. You may retire any five blocks. The conservation representative still offers you the agreed R4 per section retired, and the additional R7 bonus for every section of land that you retire that shares a boundary with another retired piece of land that you own. You may retire land at your fence and border it with your neighbours' retired land if you see it fit to do so. The windmill bonus menu will show how the bonus changes if your retired land shares borders with your neighbours retired land. You may not communicate with the people you are grouped with. All questions should be addressed to the monitor. You will play this scenario over 5 rounds and have a maximum of 120 seconds to make your decision in each round. Make your selection on the grids provided.

[1] The middle player of each group is advised that they must retire a minimum of five sections of land, but that they are permitted to retire up to a maximum of ten if they wish to.

Case 3:

The same rules as case two apply accept now you are allowed to send one message to the people you are grouped with through your monitor. She will hand you a piece of paper on which you can write one message to your group members. When you have written your message hand the paper back to the monitor, she will show it to your group members. You are allowed to send one message in each round. You will play this scenario for the corridor game over 5 and then for the windmill game over five rounds. All questions should be addressed to the monitor. You have a maximum of 120 seconds to make your decision in each round. Make your selection on the grids provided.

1.2 Instructions: Cases 2 and 3 15 subjects (Groups 6-10)

You are a landowner who owns a 15 block plot of land. Your land is divided into three with each section having a particular value to you. Each of these values is indicated in each of the 15 blocks:

2	10	5			
2	10	5			
2	10	5			
2	10	5			
2	10	5			

The black line at the edge of your property signifies a fence at which your plot ends and your neighbours plot begins. Your neighbour's property also has conservation value. You and your neighbour are approached by a representative of a national conservation authority who is interested in the conservation value of your land. She is willing to offer you certain incentives to persuade you to retire (set aside for conservation) certain sections of your land.

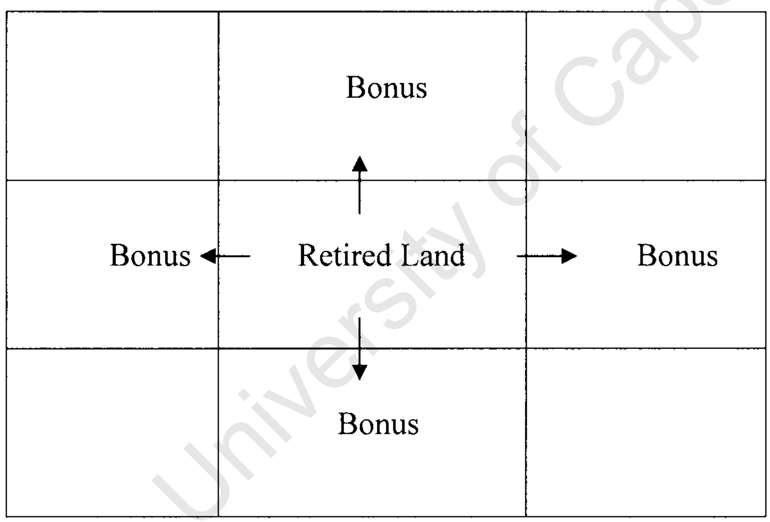
Case One:

The conservation representative offers you R4 per section to retire any 5 sections of the 15 sections of land of your choosing, you will play this case over 1 round and have a maximum of 120 seconds to make your decision in each round.

You may not communicate with the person you are playing with any queries you have must be addressed to the monitor. Make your selections on the grid provided.

Case Two:

The conservation representative still offers you the agreed R4 per section retired, but will pay you an additional R7 bonus for every section of land that you retire that shares a boundary with another retired piece of land that you own. You may retire land at your fence and border it with your neighbours' retired land if you see it fit to do so. The corridor bonus menu will show how the bonus changes if your retired land shares borders with your neighbours retired land. You are required to retire any five (ten if you are the middle player) sections of your land. You may not communicate with the people you are grouped with. All questions should be addressed to the monitor. You will play this scenario over 1 round and have a maximum of 120 seconds to make your decision in each round. Make your selection on the grids provided.



(The monitor then provides an illustrative example using the diagram above, a player grid and the payoff menu).

Your land grid has changed, but the value of your land is exactly the same, make your land retirement decision. You may retire any five blocks. The conservation representative still offers you the agreed R4 per section retired, and the additional R7 bonus for every section of land that you retire that shares a boundary with another retired piece of land that you own.

You may retire land at your fence and border it with your neighbours' retired land if you see it fit to do so. The windmill bonus menu will show how the bonus changes if your retired land shares borders with your neighbours retired land. You may not communicate with the people you are grouped with. All questions should be addressed to the monitor. You will play this scenario over 1 round and have a maximum of 120 seconds to make your decision in each round. Make your selection on the grids provided.

Case 3:

The same rules as case two apply accept now you are allowed to send one message to the people you are grouped with through your monitor. She will hand you a piece of paper on which you can write one message to your group members. When you have written your message hand the paper back to the monitor, she will show it to your group members. You are allowed to send one message in each round. You will play this scenario for the corridor game and then for the windmill game. All questions should be addressed to the monitor. You have a maximum of 120 seconds to make your decision in each round. Make your selection on the grids provided.

1.3 Bonus menu for treatments two and three.

Corridor:

Transfer per section	Own Border Bonus	Row Border Bonus	Column Border Bonus
R 4	R 7	R 14	R 0

Windmill:

Transfer per cell	Own Border	Row Border Bonus	Column Border Bonus
R 4	R 7	R 14	R 14

1.4 Player Grids for treatments 1, 2 and 3.

1.4.1 Treatment 1:

You are the row player, don't be afraid! The monitor will be with you in a moment to show you how to read this grid. When you are confident you understand make your decision on the grid as she described.

	No	L	M	H	3L/2M	3M/2L	3M/2H	3H/2M
No	85 85	85 95	85 80	85 55	85 89	85 86	85 70	85 65
L	95 85	95 95	95 80	95 55	95 89	95 86	95 70	95 65
M	80 85	80 95	80 80	80 55	80 89	80 86	80 70	80 65
H	55 85	55 95	55 80	55 55	55 89	55 86	55 70	55 65
3L/2H	89 85	89 95	89 80	89 55	89 89	89 86	89 70	89 65
3H/2L	86 85	86 95	86 80	86 55	86 89	86 86	86 70	86 65
3M/2H	70 85	70 95	70 80	70 55	70 89	70 86	70 70	70 65
3H/2M	65 85	65 95	65 80	65 55	65 55	65 86	65 70	65 65

1.4.2 Treatment 2:

Did you understand the example the monitor gave? If you have any doubts raise your hand and she will come over and explain again – don't be shy. If you are completely comfortable make your decision in the shaded area of the grid below. Remember, you are playing the corridor game in the bonus menu.

Group:1

Round:1

2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2

Group:1

Round:2

2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2

Group:1

Round:3

2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2

Group:1

Round:4

2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2

Group:1

Round:5

2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2
2	10	5	2	10	5	5	10	2

Each player was randomly allocated a plot of land based on the shaded region on their grids. The grids above are an example of the middle player of group 1's grid.

Now, your grid pattern has changed. Make your selection in the shaded region. Remember the monitor is there to assist you. Don't be shy to ask any questions if you don't understand anything.

You are now playing the windmill game on your bonus menu.

Group:1

Round:1

2	10	5
2	10	5
2	10	5
2	10	5
[redacted]		

2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5

Group:1

Round:2

2	10	5
2	10	5
2	10	5
2	10	5
2	10	5

2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5

Group:1

Round:3

2	10	5
2	10	5
2	10	5
2	10	5
2	10	5

2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5

Group:1

Round:4

2	10	5
2	10	5
2	10	5
2	10	5
2	10	5

2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5

Group:1

Round:5

2	10	5
2	10	5
2	10	5
2	10	5
2	10	5

2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5
2	10	5	2	10	5

The player grids for treatments 2 and 3 are the same for both land grids. The only difference is in the message facility that is included in the third treatment.

1.4.3 In treatment 3 each player was given an A4 piece of paper on which they could write their messages. The bonus menus and player grids are the same for the one round games, except players are only presented with one grid for each case as opposed to five.