

EVALUATION OF THE PRIVATE AND SOCIAL COSTS
OF AN ON-FARM BIODIVERSITY CONSERVATION
PROGRAM IN WESTERN NEW SOUTH WALES

A major dissertation submitted in partial fulfilment of the requirements for the
degree of Master of Economics of the University of New England

by

JONATHAN FRANCIS MOSS
BAppSc(EnvHort) *CSturt*, GDAgEc *UNE*

School of Business, Economics and Public Policy
Faculty of The Professions
University of New England
Armidale NSW 2351

September 2008

CERTIFICATION

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

.....

(Jonathan F. Moss)

ACKNOWLEDGEMENTS

I am indebted to my supervisors Associate Professor Jack Sinden and Richard Stayner who have provided me with indispensable advice, encouragement and notably patient guidance during my period of candidature. I am extremely grateful for the time and opportunity they have afforded me through their mentoring.

In addition, I would like to thank the following people for their contribution to this study: Professor Brian Hardaker for his expert advice on the stochastic simulations; Adjunct Associate Professor Brian Wilson and Dr Ian Oliver from the Department of Environment and Climate Change for their advice on measuring biodiversity in the Western Division; my colleague Mark Blair for his advice on biodiversity change in the EBC conservation areas; former project officers with WEST 2000 Plus Renee Shepherd and Angus Atkinson for their provision of data and background information on the West 2000 Plus EBC scheme; Rory Treweeke from the Western CMA for his comments on the pilot survey; all the participants of the West 2000 Plus Enterprise Based Conservation pilot project for their cooperation and willingness to provide economic data; Dr Ron Hacker and the staff at the Trangie DPI for their advice and provision of parameter sets for the GRASP software; Jeff Thompson from the Institute for Rural Futures for the generation of the map showing the Western Division and location of the EBC participants' properties.

I am grateful to West 2000 Plus and the NSW Department of Natural Resources (now Department of Environment and Climate Change) for the scholarship which enabled me to undertake this study.

Also, I would like to thank John Pearson for his mentoring and encouragement to pursue higher education throughout the years.

Finally, my family and friends for all their support, encouragement and prayers.

ABSTRACT

Native vegetation, and its associated biodiversity, are becoming scarce in Australia and therefore valued resources to society. A significant quantity of native vegetation exists on privately managed farmlands, and so these landholders can play an important role in management and conservation. They do not, however, always conserve biodiversity at a level society desires because they do not receive the appropriate market signals. Consequently, regulations and other policy measures to protect native vegetation on farms have been introduced in all jurisdictions of Australia. But these regulatory policies can impose substantial costs to landholders, and may be ineffective in the provision of biodiversity and environmental outcomes, so they need to be continually reviewed.

Recently the use of Market Based Instruments (MBI's) has received considerable attention. These instruments are based on the premise that the socially optimal level of biodiversity is not being conserved due to market failures. They are used to create a market that provides both incentives and signals to farmers to produce improved levels of environmental goods and services.

The Western Division of New South Wales has primarily been used for grazing sheep on native pasture, and is characterised by large properties and marginal climatic conditions. Environmental issues in the region include soil erosion, encroachment of woody weeds and the decline of the pasture and groundcover conditions. Currently less than eight per cent of the Western Division is formally managed with conservation objectives, however the Western Catchment Management Authority hopes to raise this to 25 per cent conservation by 2035. This, amongst other factors has led to an interest in MBI's as a method of increasing conservation outcomes in this region.

The aim of this study is to undertake an economic assessment of a MBI biodiversity conservation scheme introduced to western NSW. The scheme is the West 2000 Plus Enterprise Based Conservation (EBC) scheme which is a pilot project running from 2003-2008. This scheme created a market for biodiversity by providing landholders with an annual incentive payment, for which they bid, in exchange for the provision of specified environmental services. Two different methods of providing these services were available to landholders. The de-stock approach involves landholders removing all domestic stock

and controlling feral animals, in exchange for an accepted annual incentive payment. The groundcover approach allows landholders to receive annual incentive payments in exchange for ensuring groundcover levels are above a given threshold, regardless of their stocking or management practices.

Any policy which removes land from agricultural production involves opportunity costs to the landholder. The economic analysis derives cumulative cost curves to demonstrate the opportunity costs of supplying levels of biodiversity from the different farms, both from the perspective of the private landholders and the broader society. A deterministic analysis was conducted first to determine these opportunity costs. Given the uncertainty of both the market and climatic conditions, a stochastic analysis was then conducted to determine the implications of this uncertainty.

The stochastic analysis required the development of an existing pasture growth model (GRASP) to allow climatic variables to be treated stochastically. A simulation system, comprising a pasture growth model, a grazing flock dynamics model, an animal consumption model and economic models, was developed to model the EBC policies over the range of climatic and market conditions. The use of this simulation system also allowed for the simulation of, and determination of the costs in, biophysical changes that can be expected as a result of the EBC project.

The results of the deterministic model showed that the average discounted benefit to landholders for their participation from 2003 to 2007 was \$2.36 per hectare, but this ranged from the imposition of a cost of \$30.51 per hectare to a benefit of \$13.04 per hectare. The average discounted social cost for the same time period was \$11.02 per hectare with a range from \$3.00 to \$161.81 per hectare. Simulations with the stochastic analysis estimated that the average discounted benefit to landholders for participation over a five year period to be \$6.61 per hectare with a range between a cost of \$40.53 and a benefit of \$61.59 per hectare.

A major finding from the generation of cumulative cost curves was that a single policy may not be the most efficient method of conserving biodiversity on farms, and that a combination of policies may be more appropriate to obtain the desired levels of biodiversity conservation while meeting budget constraints.

Further, landholders did not necessarily have to make a trade-off between the lower variability of income with the EBC annual incentive payments and the higher incomes from traditional agricultural production. In four of the five case studies, the annual incentive payments were accompanied by less expected variability and a higher expected income than in traditional agricultural production.

In order to present costs in terms of biodiversity benefits, four units were applied to measure biodiversity outputs. These were unadjusted hectares conserved, potential-biodiversity adjusted hectares, additional gain in total standing dry matter, and increase in groundcover levels. An important finding from this study was that the method chosen for measuring biodiversity influenced the shape of the cumulative cost curves and therefore policy recommendations.

A major policy concern is whether landholders undertaking the groundcover approach, in the absence of annual incentive payments, would be economically better off than staying with their traditional approach. Results, from simulations conducted on two case study properties, over a five year period, however, did not show they would be better off.

TABLE OF CONTENTS

| | |
|---|-------------|
| CERTIFICATION | I |
| ACKNOWLEDGEMENTS | II |
| ABSTRACT | III |
| TABLE OF CONTENTS | VI |
| LIST OF TABLES..... | VIII |
| LIST OF FIGURES..... | IX |
| 1. INTRODUCTION | 1 |
| 1.1 BACKGROUND TO THE STUDY..... | 1 |
| 1.2 MARKET FAILURE | 2 |
| 1.3 POLICIES TO ACHIEVE BIODIVERSITY CONSERVATION | 4 |
| 1.4 THE RESEARCH PROBLEM..... | 5 |
| 1.5 OBJECTIVE..... | 6 |
| 1.6 HYPOTHESES | 6 |
| 1.7 OVERVIEW OF THE STUDY..... | 7 |
| 2. THE WESTERN DIVISION OF NSW AND CONSERVATION IN THE REGION..... | 8 |
| 2.1 INTRODUCTION..... | 8 |
| 2.2 OVERVIEW OF THE WESTERN DIVISION..... | 8 |
| 2.3 POLICIES IN THE WESTERN DIVISION | 17 |
| 2.4 THE WEST 2000 PLUS EBC PROJECT | 19 |
| 2.5 CONCLUSIONS | 24 |
| 3. THE ECONOMIC FRAMEWORK | 25 |
| 3.1 INTRODUCTION..... | 25 |
| 3.2 THE ECONOMIC PRINCIPLES..... | 25 |
| 3.3 THE CONCEPT OF COSTS..... | 26 |
| 3.4 MARGINAL COST/SUPPLY CURVES..... | 28 |
| 3.5 SPECIFICATION OF BIODIVERSITY UNITS | 32 |
| 3.6 UNCERTAINTY AND THE SIMULATION OF PASTURE AND ANIMAL GROWTH | 34 |
| 3.7 REGIONAL IMPACTS OF MARKET BASED INSTRUMENTS FOR CONSERVATION | 35 |
| 3.8 DISCUSSION AND CONCLUSIONS | 36 |
| 4. THE ECONOMIC DESIGN..... | 39 |
| 4.1 INTRODUCTION..... | 39 |
| 4.2 CONSTRUCTION OF FARM BUDGETS (DETERMINING THE PRIVATE COSTS)..... | 40 |
| 4.3 DETERMINING SOCIAL COSTS..... | 43 |
| 4.4 DISCOUNTING..... | 44 |
| 4.5 UNITS OF BIODIVERSITY CONSERVATION | 45 |
| 4.6 CONSTRUCTION OF CUMULATIVE COST CURVES | 47 |
| 4.7 DETERMINISTIC AND STOCHASTIC ANALYSES..... | 48 |
| 4.8 CRITERIA FOR ASSESSING THE STOCHASTIC SIMULATIONS..... | 54 |
| 4.9 DATA COLLECTION | 56 |
| 4.10 CONCLUSIONS | 58 |

| | |
|---|------------|
| 5. THE PASTURE GROWTH MODEL | 59 |
| 5.1 INTRODUCTION..... | 59 |
| 5.2 THE GRASP PASTURE GROWTH MODEL | 59 |
| 5.3 PARAMETER SETS..... | 62 |
| 5.4 CHOICE OF PROBABILITY DISTRIBUTIONS..... | 63 |
| 5.5 STOCHASTIC DEPENDENCY | 65 |
| 5.6 RUNNING THE PASTURE GROWTH MODEL..... | 68 |
| 5.7 BIOPHYSICAL OUTPUT | 68 |
| 5.8 CONCLUSIONS | 70 |
| 6. THE GRAZING FLOCK DYNAMICS AND ANIMAL CONSUMPTION MODELS | 71 |
| 6.1 INTRODUCTION..... | 71 |
| 6.2 THE GRAZING FLOCK DYNAMICS MODELS..... | 71 |
| 6.3 THE ANIMAL CONSUMPTION MODEL | 81 |
| 6.4 CONCLUSIONS | 86 |
| 7. RESULTS..... | 87 |
| 7.1 INTRODUCTION..... | 87 |
| 7.2 DETERMINISTIC ANALYSIS..... | 87 |
| 7.3 STOCHASTIC ANALYSIS..... | 92 |
| 7.4 DISCUSSION AND POLICY IMPLICATIONS..... | 100 |
| 7.5 CONCLUSIONS | 110 |
| 8. SUMMARY AND CONCLUSIONS | 111 |
| 8.1 INTRODUCTION..... | 111 |
| 8.2 SUMMARY OF THE KEY FINDINGS | 111 |
| 8.3 HYPOTHESES TESTING..... | 113 |
| 8.4 LIMITATIONS OF THE STUDY | 114 |
| 8.5 SUGGESTIONS FOR FUTURE RESEARCH..... | 116 |
| 8.6 CONCLUSIONS | 117 |
| REFERENCES | 118 |
| APPENDIX 1: SOCIOECONOMIC QUESTIONNAIRE FOR EBC PARTICIPANTS | 127 |
| APPENDIX 2: QUESTIONNAIRE TO OBTAIN DATA FOR STOCHASTIC ANALYSIS | 139 |
| APPENDIX 3: DESCRIPTION OF EQUATIONS IN THE GRASP MODEL..... | 143 |
| APPENDIX 4: PARAMETER SETS USED WITH THE PASTURE GROWTH MODEL | 165 |
| APPENDIX 5: DAILY FEED REQUIREMENTS | 168 |

LIST OF TABLES

| | |
|---|-----|
| TABLE 2.1: Location and dominant species of the vegetation communities present in the Western Division of NSW | 12 |
| TABLE 2.2: Background statistics of the West 2000 Plus EBC scheme..... | 20 |
| TABLE 4.1: Farm budget format..... | 42 |
| TABLE 4.2: Component for government costs added to the farm budgets to determine the social cost..... | 44 |
| TABLE 5.1: Parameter values used in the Gilruth parameter set to describe soil, pasture and nitrogen conditions | 63 |
| TABLE 6.1: Definition of variables used in the LP model to determine optimal stock numbers in a given time period | 77 |
| TABLE 7.1: Private and social costs of the EBC project from 2003 to 2007 (in net present values per hectare)..... | 88 |
| TABLE 7.2 : Sensitivity of calculated net present private and social costs to changes in the discount rate | 89 |
| TABLE 7.3: Private and social costs which may have occurred given the range of climate and market conditions (in net present value per hectare)..... | 92 |
| TABLE 7.4: Total gain per conservation area in terms of expected total standing dry matter gain after five years and social cost in terms of dollars per expected total gain in total standing dry matter after five years..... | 96 |
| TABLE 7.5: Expected levels of groundcover and social cost per increase in groundcover as a result of participating in the EBC project..... | 99 |
| TABLE 7.6: Participants attitudes and perceptions towards their involvement in the EBC project..... | 100 |
| TABLE 7.7: Impact and magnitude of EBC payments to participants | 107 |

LIST OF FIGURES

| | |
|--|----|
| FIGURE 1.1: Market behaviour for the supply of biodiversity from farms, with a positive externality..... | 2 |
| FIGURE 2.1: Location of the Western Division in New South Wales and properties participating in the West 2000 Plus EBC scheme..... | 10 |
| FIGURE 2.2: Minimum groundcover required, in relation to annual rainfall, for groundcover approach participants to receive full annual payment..... | 22 |
| FIGURE 2.3: Maximum cover expected in relation to the annual rainfall, for determining partial payments for groundcover approach participants who fail to achieve full payment groundcover levels... | 23 |
| FIGURE 3.1: Demand and supply diagram..... | 29 |
| FIGURE 4.1: Construction of cumulative cost curves, where projects are arranged in ascending order based on cost per hectare with conservation areas accumulated and plotted on | 47 |
| FIGURE 4.2: General overview of the simulation system | 50 |
| FIGURE 4.3: Tornado graph depicting NPV sensitivity to change in key parameters | 52 |
| FIGURE 4.4: Illustration of second-degree stochastic dominance, where option A dominates alternative option B..... | 56 |
| FIGURE 5.1: The pasture growth (GRASP) model | 60 |
| FIGURE 6.1: The sheep grazing flock dynamics model..... | 72 |
| FIGURE 6.2: The goat grazing flock dynamics model | 80 |
| FIGURE 6.3: Comparison of the relationship between green biomass in the pasture sward and green biomass in sheep and cattle diets | 82 |
| FIGURE 6.4: 23 micron sheep daily feed requirements per hogget, lamb and joined ewe..... | 83 |
| FIGURE 7.1: Cumulative cost curve of the private opportunity costs of undertaking the EBC management activities | 90 |
| FIGURE 7.2: Social cumulative cost curve in terms of area conserved (ha) | 90 |
| FIGURE 7.3: Social cumulative cost curve in terms of potential biodiversity increase..... | 91 |
| FIGURE 7.4: Expected private cumulative cost curve from the stochastic analysis..... | 93 |
| FIGURE 7.5: The private cumulative cost curves showing the most likely cost curve along with the minimum and maximum cost curves | 94 |
| FIGURE 7.6: Expected social cumulative cost curve generated from the stochastic analysis | 94 |
| FIGURE 7.7: Social cumulative cost curves with minimum, mean and maximum costs curves..... | 95 |
| FIGURE 7.8: Social cumulative cost curve of expected additional TSDM gain per property after five years..... | 96 |
| FIGURE 7.9: Expected social cost of potential biodiversity increase from stochastic analysis..... | 97 |

| | |
|--|-----|
| FIGURE 7.10: Probability distributions of total groundcover level after five years for the five case study conservation areas | 98 |
| FIGURE 7.11: Probability of changes in groundcover levels with participation in the EBC project compared to the traditional approach | 99 |
| FIGURE 7.12: E, V analyses for the five case study properties..... | 102 |
| FIGURE 7.13: Cumulative distribution functions for the stochastic efficiency analysis of groundcover approach Case Study 1 | 103 |
| FIGURE 7.14: Cumulative distribution functions used to determine stochastic efficiency of groundcover approach Case Study 2 | 104 |