LIVESTOCK MANAGEMENT, ECOSYSTEM SERVICES AND SUSTAINABLE LIVELIHOODS

A Dissertation Presented

by

Juan Pablo Alvez da Cruz

to

The Faculty of the Graduate College

of

The University of Vermont

In Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy
Specializing in Natural Resources

May, 2012

Accepted by the Faculty of the Graduate College, The University of Vermont, in partial fulfillment of the requirements for the degree of Doctor of Philosophy specializing in Natural Resources.

Dissertation Examination Committee:

_______________________________________ Advisor
Jon Erickson, Ph.D.

____
Roelof Boumans, Ph.D.

____
Joshua Farley Ph.D.

_______________________________________ Chairperson
V. Ernesto Mendez Ph.D.

_______________________________________ Dean, Graduate College
Domenico Grasso, Ph.D.

February 29, 2012

ABSTRACT

Agroecosystems are frequently degraded beyond their capacity to support vital ecosystem services and thus sustain farmer livelihoods over the long-run. Adopting a more sustainable diary management system is particularly important given the pressure of this dominant human land-use worldwide. This research analyzes farmers' perceptions and the effects of different dairy management methods on ecosystem services provision, milk production, farm quality of life, and environmental awareness in two contrasting studies in Santa Catarina, Brazil and Vermont, U.S. Management intensive grazing (MIG) was found to out produce traditional grazing in Santa Catarina, while contributing to improved biodiversity protection, animal welfare, and ecosystem services from greater pasture coverage and soil restoration. No production differences were found between MIG, confinement and traditional grazing in Vermont, however environmental and social variables saw similar improvements under MIG adoption. Education and access to information was critical for the adoption of better management practices and environmental awareness. Both cases inform integrated policy strategies to address production, conservation and sustainable livelihoods.

ACKNOWLEDGEMENTS

I dedicate this dissertation to my wife Ursula and my daughters, Florencia and Luisa Anahí Alvez Georgeoglou because they endured with me along these years.

I want to express my gratitude to many people and institutions without which, this dissertation research would not be possible. It has been a long productive journey!

First and foremost, I thank my four Dissertation Committee Members, my advisor Dr. Jon Erickson and Drs. Roelof Boumans, Joshua Farley and Ernesto Mendez for their supervision, patience, encouragement and inspiring example. My advisor, Jon Erickson has always been a source of helpful suggestions and critical feedback. Roel always provided me valuable ideas and was a role model on how to live a sustainable life. Josh gave me critical credit and encouragement in difficult times and awareness about ecological economics and unique perspectives on ecosystem services. Ernesto gave me unconditional support and guidance along the process.

My gratitude also goes to:

My mother Graciela, my father Juan Carlos and my siblings, Bernardo, Martin, Mauricio, Rodrigo and Jose Ignacio and their families who believed in my strength and perseverance and never stopped encouraging me.

Bill and Lita Murphy, our best friends for being a safe harbor, opening their doors and hearts to my family.

Robert Costanza for inviting me to the Gund Institute and for familiarizing me with the realm of ecological economics and ecosystem services.

Allen Matthews, a keystone in my Ph.D funding process for enabling funding crucial to start the program and later for providing me with data for my research.

Abdon L. Schmitt Filho, my friend for providing me with data for my research.

All the farmers from Brazil and the US who participated in this study.

Alan Howard, for his support and patience throughout the statistical analyses.

Anjanette De Carlo, for her unconditional supporting and for facilitating me a smooth admission to the Gund Institute.

Gund Fellows and Students for all the knowledge and insights shared which greatly contributed to my intellectual growth.

The Agroecology and Rural Livelihood Group at UVM, for including me in their lab meetings and for helping me with valuable tips in the presentation.

To the staff of the Rubenstein School or Natural and Environmental Resources, especially Isis Erb and Carolyn F. Goodwin Kueffner for their unreserved assistance and straightforward help on administrative matters.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS ii
LIST OF TABLES ix
LIST OF FIGURES........x
Chapter 1: Background........1

1.1. Introduction 1
1.2. Significance and Limitations of This Study........3
1.3. Dissertation Structure and Organization 4
1.3.1. Research Goals........5
1.3.2. Research Objectives 5
1.3.3. Dissertation Chapters 6
1.4. References 8

CHAPTER 2: ECOSYSTEM SERVICES, LIVESTOCK MANAGEMENT AND SUSTAINABLE LIVELIHOODS........11

2.1. Introduction 11
2.2. Ecosystem Services as an Organizing Concept for Agriculture........12
2.3. The Livelihoods Concept and Criteria 16
2.4. The Co-evolution of Agropastoral Systems and Livelihoods 21
2.4.1. Traditional Grazing 22
2.4.2. Conventional Agriculture........23
2.4.3. Management Intensive Grazing........27
2.5. Bridging Livelihoods and Ecosystem Services Through Pasture Management30
2.5.1. Supporting Services........31
2.5.2. Provisioning Services........32
2.5.3. Regulating Services........32
2.5.4. Cultural Services 34
2.6. Conclusion........35
2.7. References 38

CHAPTER 3: FARMER'S PERCEPTIONS ABOUT THE ADOPTION OF VOISIN MANAGEMENT INTENSIVE GRAZING IN SANTA CATARINA, BRAZIL..46
Abstract 46

3.1. Introduction 46

3.2. Study Design and Data Analysis 49
3.3. Results 53
3.3.1. Analysis of Production Variables 54
3.3.2. Analysis of Environmental Variables 59
3.3.3. Relationships Between MIG Adoption and Environmental Variables 61
3.4. Discussion 63
3.4.1. Production Variables 63
3.4.2. Environmental Variables 65
3.5. Implications of Agroecological Practices for the Conservation of Atlantic Forest and Sustainable Livelihoods 67
3.6. References 70

CHAPTER 4: DAIRY MANAGEMENT SYSTEMS COMPARISON ACROSS SUSTAINABILITY INDICATORS 75
Abstract 75

4.1. Introduction 75
4.1.1. Dairy Farm Practice and Sustainability 80
4.2. Methodology 83
4.2.1. Study Area 83
4.2.2. The Dairy Stewardship Alliance Self-Assessment Toolkit 84
4.2.3. Modules (Sustainability Indicators) 85
4.2.4. Data Collection and Analysis 88
4.3. Results 91
4.3.1. First Assessment: Production 91
4.3.2. Analysis of Modules (Sustainability Indicators) 93
4.3.4. Analysis of Questions (Dependent Variables) 94
4.3.5. Second Assessment (29 farms) 95
4.3.6. Comparison Between Variables (Questions) 100
4.4. Discussion 102
4.4.1. Production 104
4.4.2. First Assessment: Analysis of modules (sustainability indicators) 104
4.4.3. First Assessment: Analysis of Variables Across Sustainability Indicators .106
4.4.4. Second Assessment: Analysis of Sustainability Indicators 110
4.4.5. Questions That Improved in the Second Assessment 113
4.4.6. Variables Affected by Management Type Between Assessments 116
4.5. Conclusion 117
4.6. References 119

CHAPTER 5: REFLECTIONS ON THE VIABILITY OF DAIRY MANAGEMENT, ECOSYSTEM SERVICES AND SUSTAINABLE LIVELIHOODS 125
5.1 Introduction 125
5.2. Policy Instruments 127
5.2.1 Payments-For-Performance (PFP) 127
5.2.2 Payments for Ecosystem Services (PES) 129
5.2.3. Instruments available in Brazil 130
5.3. Lessons Learned 133
5.3.1. The Role of Education to Enable Agroecological Practices 133
5.3.2. Rethinking Subsidies, Industrial Agriculture and Agroecology 133
5.4. Final Considerations: How the Results from the Two Studies May Inform Better Policies? 134
5.5. References 136

COMPREHENSIVE BIBLIOGRAPHY 140

APPENDIX A1. CHAPTER 3 160
2. Production 161
3. Environmental Variables 161
APPENDIX A 2. CHAPTER 4 167
Introduction to Dairy Farm Toolkit 169
Introduction 169
Understanding the Toolkit 169

Animal Husbandry 169
Toolkit Summary Results 171
Farm Name or Farm #_______ 171
Description 172
Incentives for Change 173
Assessment Questions 173
Linkages to Other Modules 178
Further Information 179
Other links: 180
Summary of Results For Animal Husbandry 181
Biodiversity Educational Module 182
Description 182
Incentives for Change 183
Assessment Questions 183
Linkages to Other Modules 187

Further Information 187
Summary Results for Biodiversity 189
Community Health Educational Module Description 190
Incentives for Change 190
Assessment Questions 190
Linkages to Other Modules 193
Further Information 193
Summary Results for Community Health 195
Energy Educational Module 196
Description 196
Incentives for Change 197
Assessment Questions 197
Linkages to Other Modules 202
Further Information 202
Farm Financials Educational Module 204
Description 204
Incentives for Change 205
Assessment Questions 205
Linkages to Other Modules 211
Further Information 211
Summary Results for Farm Financials and Quality of Life 214
Nutrient Management Educational Module 215
Description 215
Incentives for Change 215
Assessment Questions 216
Linkages to Other Modules 220
Further Information 221
Summary of Results for Nutrient Management 222
Organic Educational Module 223
Description 223
Incentives for Change 223
Summary of USDA National Organic Program Regulations 224
Linkages to Other Modules 226
Further Information 227
Pest Management Educational Module 228
Description 228
Incentives for Change 228
Assessment Questions 229
Linkages to Other Modules 231

Further Information 232
Summary Results for Pest Management 233
Soil Health Educational Module 233
Description 233
Incentives for Change 234
Linkages to Other Modules 239
Further Information 240
Summary of Results For Soil Health 241
Water Management Educational Module 242
Description 242
Incentives for Change 242
Assessment Questions 243
Linkages to Other Modules 248
Further Information 248
Summary of Results For Water Management 249

LIST OF TABLES

Table 3.1. Comparison and differences in production indicators. 55

Table 3.2. Demographic and production management variables. 56

Table 3.4. Demographic and productive farm analysis by ‘Farm Size’ in Santa Catarina. 59

Table 3.5. Wilcoxon sum-rank test comparison of environmental variables before and after MIG adoption. 60

Table 4.1. Color-coded chart with score ranges to help interpret farm scores 85

Table 4.3. Production data in the first assessment for all 39 farms. 91

Table 4.4. Production and ANOVA by management in the first assessment. (N=39) 92

Table 4.5. First assessment: descriptive figures by module.. 93

Table 4.6. Descriptive figures and ANOVA of modules by management type in the first assessment (N=39)... 94

Table 4.7. First assessment: questions with significant effects at the P ≤ 0.05 Kruskall-Wallis and Mann-Whitney multi comparison test. 95

Table 4.8. Paired sample t-test of first and second assessment between modules (p=0.05). 98

Table 4.9. ANOVA of the difference of the modules between the first and second assessment.. 100

Table 4.10. Comparison of the questions in the second assessment (Wilcoxon Signed-Ranks test p=0.05) 101

Table 4.11. Comparison between first and second assessment: variables (questions) with significant effects at the P ≤ 0.05 Kruskall-Wallis and Mann-Whitney multi comparison test. 101

LIST OF FIGURES

Figure 2.1. Ecosystem Services and dis-services to and from agroecosystems (adapted from Zhang et al., 2007). 15

Figure 2.2. Components and flows in a livelihood (Chambers and Conway, (1991)....... 18

Figure 2.3. Sustainable rural livelihoods (Source: Scoones (1998).......... 19

Figure 2.4. Number of dairy farms declining while average size is increasing (USDA-NASS, (2007).......... 25

Figure 2.5. Forage growth curve indicates how yields, growth and rest periods vary over the growing season (adapted from Voisin (1988).......... 28

Figure 3.1. Location of the State of Santa Catarina Source: IBGE, 2010 50

Figure 4.1. Comparison between averages of first and second assessments and the percent difference by management method.......... 96

Figure 4.2. Average score comparison of the second assessment among management methods across modules. 97

Figure 4.3 Score differences of the modules between the first and second assessments by management type. 99

Chapter 1: Background

1.1. Introduction

In the last decades, population growth (especially in urban centers), coupled with higher living standards is demanding ever increasing amounts of livestock dairy products. Meeting this demand requires intensification of the productive process burdening already degraded ecosystems (DFID 2004). As a result, several studies have shown the consequences of conventional agricultural intensification on forests, biodiversity, soils, water and rural livelihoods (Scherr & Yadav 1996; Rudel 1998; Szott et al. 2000; Sanderson et al. 2002; Steinfeld et al. 2006; Dale & Polasky 2007). In general, conventional agriculture is heavily dependent on unsustainable external inputs such as synthetic fertilizers (especially nitrogen), pesticides and mechanization; these inputs are greatly reliant on fossil fuels causing serious environmental consequences (Vitousek et al. 1997; Pimentel et al. 2005; Spiertz 2010). The Millennium Ecosystem Assessment (2005a) has identified the decline of fifteen ecosystem functions, many of them related to conversion of natural land to agriculture, changes in agricultural practices and changes from agriculture to urban uses. Evidence of climate change, coupled with these consequences, can cause further environmental degradation (Kotschi 2007; Lai 2007; Koneswaran & Nieremberg 2008). Moreover, within this scenario, by 2050 farmers must satisfy food production for nine billion people.

On the other hand, the dairy sector is a major provider of rural livelihoods supporting over one billion people worldwide and generating almost $1.5 trillion annually (LID 1999; IFAD 2004; Steinfeld et al. 2006; Reid et al. 2008). Livelihoods are the "different ways and means of making a living" (Chambers 1995), considering development, equity and environmental aspects in the process in which rural people create livelihoods for their households (Chambers 1989; Chambers & Conway 1991; Scoones 1998). Thereby, while healthy agroecosystems produce essential goods and services such as food, raw materials, fuel and fiber, the dis-services of conventional agricultural practices (Zhang et al. 2007) may alter the carrying capacity of the very ecosystems they depend upon. Ecosystem services are vital benefits all species (included humankind) receive from healthy ecosystems (Costanza et al. 1997b; Daily et al. 1997). Ecosystem services are public goods (and sometimes private in the case of some provisioning services) and unlike most products, they cannot be easily marketed because of their condition of non-rival and non-excludable (Daly & Farley 2010). However, the current status of the planet indicates a sharp decline in several ecosystem services (MEA 2005a). According to Zhang (2007), the cost of agricultural dis-services, as a consequence of conventional agriculture, exceeds costs of transitioning to alternative agriculture. Therefore, achieving the balance between sound dairy practices, sustainable livelihoods and environmental protection has paramount relevance.

Globally, around 38% of earth's land area is under some agricultural use (FAO 2004) and within this context, livestock represents the single largest anthropogenic land use in the world, occupying between 25 to 45% (Asner et al. 2004; Herrero et al. 2009). Conventional dairy (and beef) systems may degrade ecosystems compromising its structure and functions. For example, continuous or traditional grazing, widely practiced worldwide may produce overgrazing, a major cause of environmental impact because it can lead to above and below ground biodiversity and fertility loss, erosion, lower infiltration rates, higher nutrient runoff (Suttie, et al. 2005) and meager revenues. Similarly, confinement operations are largely adopted in industrialized countries and require animals to be housed and fed subsidized high input feed (Hinrichs & Welsh 2003). The result of these practices affect soil, habitat, biodiversity and water quality, causing pollution and reducing environmental health.

To restore the benefits of ecosystems, produce food and improve rural livelihoods in the same land, farmers' need a more benign and agroecological system. The science of Agroecology is an interdisciplinary approach to agriculture which performs under ecological principles in managed agroecosystems (Méndez 2010). Agroecology contemplates the multifunctionality of agroecosystems (Gliessman 2010) and has often been implemented to address the needs of poor farmers in degraded lands. Voisin management intensive grazing is an agroecological system that relies on well-managed pastures and can potentially restore the benefits provided by ecosystems, increasing food production and quality and enhancing rural livelihoods. It consists of a form of management that rationally rotates animals though a subdivided pasture where animals, forage and soil mutually benefit.

1.2. Significance and Limitations of This Study

This research aims to study and promote sustainable dairy practices that take into consideration ecosystem services and equity of rural people in Brazil and in the United States. By confirming most of the research hypotheses and describing an alternative dairy system, the findings of this research can establish a future path for reconciliation between production and conservation. Moreover, the findings can help policymakers in Brazil and in the United States to incentivize agroecological practices that enhance ecosystem services and promote conservation and better dairy farming practices.

Furthermore, by understanding the farmers' and environmental constrains, it seems economically wise to reduce or shift farm subsidies that support conventional agriculture towards farmers who adopt agroecological practices.

In this sense, education and access to information played a very important role in informing farmers about agroecological practices. However, it seems that education and access to information are not enough to achieve conservation of ecosystem service and better rural livelihoods. Sound financing mechanisms and extension services are essential especially to smaller farms in Brazil.

1.3. Dissertation Structure and Organization

This dissertation explored two contrasting case studies. In Santa Catarina Brazil, I assessed dairy farmers' perception about management intensive grazing regarding ecosystem services and environmental awareness. In Vermont United States, I analyzed the effects of three dairy management methods (management intensive grazing, traditional grazing and confinement) on nine sustainability indicators and ecosystem services (soil and nutrient management, water, biodiversity and animal husbandry, energy and community health). Both cases are preceded by a conceptual framework chapter that analyzes aspects of dairy systems, ecosystem services and livelihoods in depth. The last chapter examines different existing policy strategies to reconcile dairy management, ecosystem services and sustainable livelihoods.

1.3.1. Research Goals

The goal of this dissertation was to study the effects of dairy production systems and to find whether Voisin management intensive grazing was capable of promoting and enhancing ecosystem services while creating sustainable conditions for rural livelihoods in two main studies.

1.3.2. Research Objectives

For the Santa Catarina study, my objectives were to determine farmers' perception about the potential of management intensive grazing to:

a. increase farm production;restore ecosystem services;enhance livelihoods and, create environmental awareness to comply with the Brazilian Forest Code. For the Vermont study, the objectives were to assess which of the

three management systems, traditional grazing, management intensive grazing, and confinement:

a. achieved higher production;
b. had higher sustainability indicators;
c. compare a subset of farms that completed two assessments to determine whether educaiton and access to information can improve farmers practices;

1.3.3. Dissertation Chapters

The introductory chapter sets up the background problem, the objectives and the significance of undertaking this study. Subsequent to this introductory chapter the rest of this dissertation is presented in four chapters.

Chapter two lays out the conceptual framework and provides the theoretical foundations of the research problem, to explain the interrelation between different animal management systems, livelihoods and ecosystems and how ecosystems services can benefit from benign agroecological practices and adequate policies.

In addition, chapters three and four were carried out under the overarching conceptual framework. This approach is used to better understand the interactions between farmers and their contiguous environment and will determine which dairy farming practices contribute to the enhancement of ecosystem services and farmer livelihoods.

The first study, chapter three, was carried out in Santa Catarina State in Brazil where I analyzed farmer's perception about the adoption of Voisin management intensive grazing in various aspects of their farms. We assessed significant differences and associations in production, ecosystem services (water, soils, biodiversity), and environmental awareness. The overall results showed that Voisin management intensive grazing improved production, benefited farmer livelihoods, generated ecosystem services, and could be an agroecological tool to alleviate poverty and complement Brazilian conservation efforts. Particularly, I found that farmers, who adopted management intensive grazing, produced more per area and per cow in the same area, doubled the number of animals, and reduced labor and veterinary problems. They also perceived soil improvements, more forage vegetation and biodiversity, and better water quality. Moreover, farmers that initially perceived trees as an obstacle for grazers later reported that shaded pastures resulted in equal or higher production.

Chapter four was carried out in Vermont, United States. This study analyzed how three different dairy systems compare across nine sustainability indicators set by the Dairy Stewardship Alliance. A self-assessment survey about animal husbandry, biodiversity, energy, community health, farm financials, nutrient, pest, water and soils management was assessed twice with the same farmers. Pasture-based farms, particularly management intensive grazing, had significantly fewer cows, less acreage and produced less milk than confinement. However they scored higher sustainability especially on farm financials and soil management indicating higher chances of survival of medium and small pasture based farms. Also, most sustainability indicators improved on the second assessment where management intensive grazing and traditional grazing farms scored above confinement revealing that education and access to information were essential to improve management practices and sustainability.

Finally, chapter five assessed what policy strategies can promote an adequate delivery of ecosystem services and dairy farm sustainability. In this chapter I reviewed existing policies in the United States and in Brazil that can be used by farmers to adopt agroecological practices such as management intensive grazing in order to address conservation and sustainable livelihoods.

1.4. References

Asner, G. P., A. J. Elmore, L. P. Olander, R. E. Martin, and A. T. Harris. 2004. Grazing Systems, Ecosystem Responses, and Global Change. Annual Review of Environment and Resources 29:261-299.

Chambers, R. 1989. Farmer first: a practical paradigm for the third agriculture. Pages 237-244 in M. A. Altieri, and S. B. Hecht, editors. Agroecology and small farm development. CRC Press, Boca Raton, Fla., USA.

Chambers, R. 1995. Poverty and livelihoods : whose reality counts? Institute of Development Studies at the University of Sussex, Brighton, Eng.

Chambers, R., and G. Conway. 1991. Sustainable rural livelihoods: practical concepts for the 21st Century. IDS-University of Sussex, Brighton.

Costanza, R., M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, M. Van den Belt, R. D'Arge, R. De Groot, and S. Farber. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Daily, G. C., Susan Alexander, Paul R. Ehrlich, Larry Goulder, Jane Lubchenco, Pamela A. Matson, Harold A. Mooney, Sandra Postel, Stephen H. Schneider, David Tilman, and G. M. Woodwell. 1997. Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems. Ecological Society of America 2:18 p.

Dale, V., and S. Polasky. 2007. Measures of the effects of agricultural practices on ecosystem services. Ecological Economics 64:286-296.

Daly, H., and J. Farley 2010. Ecological Economics: Principles and Applications: 2nd edition. Island Press, Washington, DC.

DFID. 2004. Agricultural Sustainability. Page 23 in D. f. I. Development, editor. University of Essex, UK.

FAO. 2004. Statistics of the FAOStat. Food and Agriculture Organization of the United Nations, On line: www.faostat.fao.org.

Gliessman, S. 2010. Landscape Multifunctionality and Agriculture. Journal of Sustainable Agriculture 34:465-465.

Herrero, M., P. K. Thornton, P. Gerber, and R. S. Reid. 2009. Livestock, livelihoods and the environment: understanding the trade-offs. Current Opinion in Environmental Sustainability 1:111-120.

Hinrichs, C. C., and R. Welsh. 2003. The effects of the industrialization of US livestock agriculture on promoting sustainable production practices. Agriculture and Human Values 20:125-141.

IFAD. 2004. Livestock services and the poor. Page 152. International Fund for Agricultural Development.

Koneswaran, G., and D. Nieremberg. 2008. Global Farm Animal Production and Global Warming: Impacting and Mitigating Climate Change. Environmental Health Perspectives 116:578-582.

Kotschi, J. 2007. Agricultural biodiversity is essential for adapting to climate change. Gaia-Ecological Perspectives for Science and Society 16:98-101.

Lai, R. 2007. Managing Soils for Food Security and Climate Change. Journal of Crop Improvement 19:49-71.

LID. 1999. Livestock in Development: Livestock in Poverty-Focused Development.95.

MEA 2005. Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: A Framework for Assessment. Island Press, Washington, DC.

Méndez, V. E. 2010. Agroecology. Page in press in B. Warf, editor. Encyclopedia of Geography. Sage Publications, Thousand Oaks, CA.

Pimentel, D., P. Hepperly, J. Hanson, D. Douds, and R. Seidel. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. Bioscience 55:573-582.

Reid, R. S., K. A. Galvin, and R. S. Kruska. 2008. Global Significance of Extensive Grazing Lands and Pastoral Societies: An Introduction. Pages 1-24 in K. A. Galvin, R. S. Reid, R. H. B. Jr, and N. T. Hobbs, editors. Fragmentation in Semi-Arid and Arid Landscapes. Springer Netherlands.

Rudel, T. K. 1998. Is there a forest transition? Deforestation, reforestation, and development. Rural Sociology 63:533-552.

Sanderson, E. A., M. Jaiteh, M. A. Levi, K. H. Redford, A. V. Wannebo, and G. Woolmer. 2002. The Human Footprint and the last of the Wild. Bioscience 52:891-904.

Scherr, S., and S. Yadav. 1996. Land degradation in the developing world: implications for food, agriculture and the environment to 2020, a synthesis of recommendations from an international workshop. Food, Agriculture, and the Environment Discussion Paper No. 14. , Washington, DC.

Scoones, I. 1998. Sustainable rural livelihoods: a framework for analysis. Institute for Development Studies (IDS), Brighton, UK.

Spiertz, J. H. J. 2010. Nitrogen, sustainable agriculture and food security. A review. Agronomy for Sustainable Development 30:43-55.

Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, and C. de Haan. 2006. Livestock Long Shadow: environmental issues and options. Food and Agriculture Organization of the United Nations:408 pg.

Szott, L., M. Ibrahim, and J. Beer. 2000. The Hamburger Connection Hangover. Cattle pasture land degradation and alternative land use in Central América in D. CATIE, GTZ, editor.

Vitousek, P. M., J. D. Aber, R. W. Howarth, G. E. Likens, P. A. Matson, D. W. Schindler, W. H. Schlesinger, and D. G. Tilman. 1997. Human alteration of the global nitrogen cycle: Sources and consequences. Ecological Applications 7:737-750.

Zhang, W., T. Ricketts, C. Kremen, K. Carney, and S. Swinton. 2007. Ecosystem services and dis-services to agriculture. Ecological Economics 64:253-260.

CHAPTER 2: ECOSYSTEM SERVICES, LIVESTOCK MANAGEMENT AND SUSTAINABLE LIVELIHOODS

2.1. Introduction

Livestock in agropastoral systems represents the single largest anthropogenic land use in the world, using 25 to 45% of the earth's surface (Asner et al. 2004; Herrero et al. 2009). Livestock production generates an estimated US$ 1.4 trillion annually, engages about 1.3 billion people worldwide, and supports the livelihoods of 600 million farmers in the developing world (Steinfeld et al. 2006; Reid et al. 2008). Dairy systems in particular are major providers of rural livelihoods, contributing to the livelihoods of 70 to 75% of rural household incomes worldwide (LID 1999; IFAD 2004).

Livestock production systems fundamentally depend on healthy ecosystems for feed, water, and waste absorption, and depending on management type can degrade or enhance ecosystem functions and services (Altieri 1999; Thrupp 2000; Simoncini 2009; Lovell et al. 2010). Numerous researchers emphasize that agriculture both receives and provides a diverse array of services from ecosystems, while also imposing dis-services (or externalities) on ecosystems from production processes (Swinton et al. 2007; Zhang et al. 2007; Porter et al. 2009). The livelihoods of millions of pastoralists worldwide depend on this balance between services and dis-services from livestock systems. Chambers and Conway (1991) describe livelihoods as "adequate stocks and flows of cash to meet basic needs". The livelihoods concept analyzes rural peoples' way of life especially from the perspective of poverty causes (Ashley & Carney 1999), addressing social development and analyzing how different people in different places live (Scoones 2009). Livelihoods dependent on livestock systems and the conservation of the services that livestock-dominated landscape provide (or impair) are interconnected and inseparable.

Nowhere is this inseparability, between livelihood and ecosystem impacts of agricultural systems, more apparent than when comparing different dairy production systems. Dairy (and beef) systems can be managed in confinement operations, pasture-based traditional continuous grazing, or management intensive grazing. In confinement operations, animals are housed in pens or corrals and fed with high concentrate feed. In traditional grazing systems, the most practiced grazing method worldwide, animals are allowed to graze in large undivided areas without frequent rotation. Management intensive grazing uses high stocking rates in short rotations in divided pastures.

In this study, I analyze these three distinct dairy production systems against their potential to both restore and enhance ecosystem services, while also improving the livelihoods and wellbeing of rural communities. The organizing concepts of ecosystem services and sustainable livelihoods are first reviewed, followed by a comparison of livestock production systems through the lens of these environment and development perspectives.

2.2. Ecosystem Services as an Organizing Concept for Agriculture

Perhaps the first insights of mankind's reliance on natural systems date from Plato, around 400 B.C., when he recognized that ecosystems could provide complex services by considering the linkage between deforestation, soil erosion and water scarcity (Daily 1997). Marsh (1864) understood the close interdependence between humans and the natural environment by observing severe shifts in soil fertility and erosion in Europe. More recently, Sears (1956) and Leopold and Schwartz (1989) drew attention to the narrow dependence on the environment by humans. Also, a comprehensive report by the Massachusetts Institute of Technology in 1970 described services such as climate stability, pollination, and flood control as fundamental to human survival.

These and many other pioneering studies laid the foundation for work on ecosystem service valuation (e.g., Costanza et al., (1997a), modeling (e.g., Boumans et al. (2002)), and in general the economic rationale for management of ecosystem services as an organizing framework for resource conservation (e.g., Balmford et al. (2002) and Farber et al. (2006)). The ecosystem service framework has become a cornerstone to 21st century approaches to environmental conservation. The Millennium Ecosystem Assessment (MEA 2005a), a compendium of three volumes dedicated to assessing the current state and trends of ES, was produced in 2005 with contributions from over 1000 scientists worldwide. Most recently, Gomez-Baggethun et al. (2010) reviewed the historic progress of the concept of ecosystem services by examining critical landmarks in economic theory from classical, neoclassical, environmental and ecological economics points of view, as well as the modern history of ecosystem services.

Under the most often cited ecosystem service classification from the MEA, provisioning services include food, fiber and fuel; supporting services consist of soil formation, nutrient cycling, and water supply, among others; regulating services include disease control, climate regulation and biological control; and cultural services comprise aesthetic viewsheds, spiritual and recreation benefits, among others. Fisher and Turner (2008) criticized the MEA approach because they found that this classification does not work well for guiding practical accounting exercises or landscape management, since it mixes 'ends' and 'means'. In contrast, (Boyd & Banzhaf 2007) conceived of ecosystem services as the directly consumed ecological components of ecosystems. More recently, (Farley & Costanza 2010) returned to the early work of Georgescu-Rogen (1971) in strictly defining ecosystem goods as stock-flow resources and ecosystem services as fund-services. In this approach, fund-services can be, for instance, intact soils that provide the services for agricultural production, and stock-flows would be the food provided as consumptive products coming from these soils.

Increasingly, the multifunctionality of agriculture has been framed in the language of ecosystem services (Boody et al. 2005; Groenfeldt 2006; Simoncini 2009; Jordan & Warner 2010) most significantly stemming from the MEA. Wei Zhang et al. (2007) placed agricultural in the context of the four MEA categories as benefiting from, contributing to, and damaging to ecosystem services. Figure 2.1 summarizes specific services and dis-services from and to agriculture. For example, when producing provisioning services in agroecosystems (e.g. food, fuel and fiber) some potential dis-services could result from deforestation, habitat loss, nutrient run-off, and pesticide poisoning of non-target species. These dis-services will negatively affect ecosystems, which in turn produce dis-services to agroecosystems, such as erosion, poorer nutrient cycling, less water supply, and increased pest damage. Turner and Daily (2008) also emphasized the long-term role played by healthy ecosystems in the sustainable provision of human wellbeing, economic development and poverty alleviation worldwide.

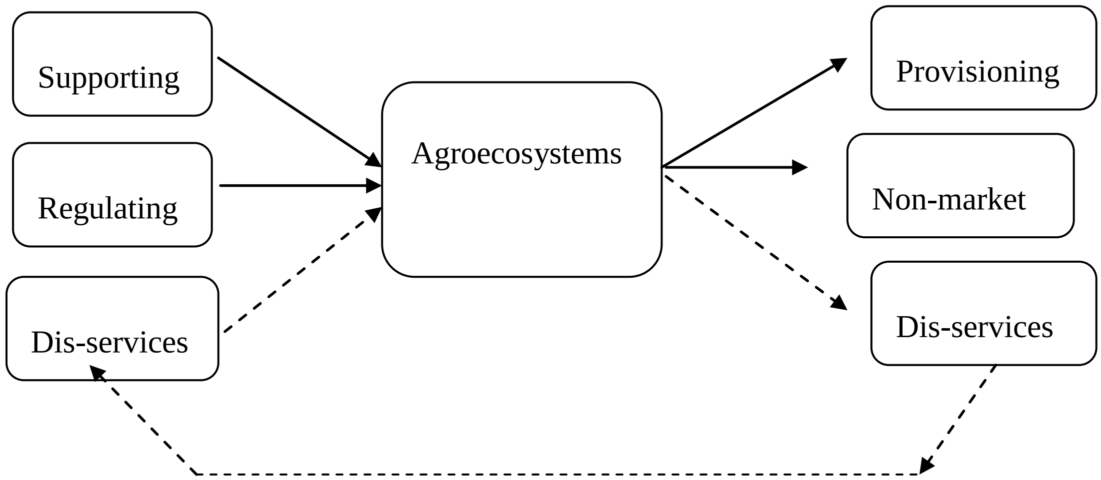


Figure 2.1. Ecosystem Services and dis-services to and from agroecosystems (adapted from Zhang et al. 2007).

Impacts from land conversion for agriculture have been perhaps the most studied trade-off. Several scholars including Dale and Polasky (Scherr & Yadav 1996; Rudel 1998; Szott et al. 2000; Sanderson et al. 2002; Steinfeld et al. 2006; 2007) have analyzed and discussed the interrelatedness of land use change caused by agriculture on forest ecosystem services and rural livelihoods in particular. Recent studies by Foley et al. (2005) and Power (2010) address how land use change can negatively affect the flow of many ecosystem goods and services and its influence on human wellbeing. The MEA (2005a) identified 15 out of 24 ecosystem services that are in global decline as a consequence of changes in land use and land cover more broadly, and a recent synthesis by (Rockström et al. 2009) concluded that humans have surpassed three of the ten planetary ecosystem thresholds: climate change, biodiversity loss, and global changes in nitrogen cycle. Agriculture is one of the main sources of damage and contributes to the others.

2.3. The Livelihoods Concept and Criteria

The literature on ecosystem services has been developing along a parallel course to the literature on sustainable livelihoods, and many synergies are beginning to be explored. Literature on sustainable livelihoods is similarly centered around human needs, however, framed instead on people's skills and means of living, including food, income, and assets (Chambers & Conway 1991). Since it is widely recognized that humans are the direct beneficiaries of ecosystem services (IFAD 2004; MEA 2005a; Herrero et al. 2009), the inclusion of ecosystem services as assets in the sustainable livelihood discussion, particularly concerning the rural poor, seems obvious. Hence, healthier ecosystems will sustain future livlihoods.

The concept of sustainable livelihoods refers to the "different ways and means of making a living" (Chambers 1995) and can be traced back to the World Commission on Environment and Development in 1987 that identified socio-environmental demands of poor people living in areas under environmental difficulty. Walman (1984) approached livelihoods as more than just a matter of having shelter, money, and food to put on the table or to exchange in the market place. The concept evolved during subsequent years in the context of development, situating equity and rural people at the core of an interrelated net of processes which take into account and influence the way people create livelihoods for their households, at the same time as improving their environmental assets (Chambers 1989; Chambers & Conway 1991; Scoones 1998).

The most widely accepted definition of sustainable livelihoods comes from Chambers and Conway (1991) stating that "a livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living." Ellis (2000) suggested a definition of livelihood as "the activities, the assets, and the access that jointly determine the living gained by an individual or household." Livelihood is equally a matter of ownership and circulation of information, management of social relationships, affirmation of personal significance and group identity, and the interrelation of each of these tasks to the other (Ellis 2000). All these productive tasks together are enveloped under the livelihood concept.

Figure 2.2. highlights the Chambers and Conway (1991) framework. In this layout, tangible assets are categorized as stores, including food stocks, cash savings and credit schemes; and resources, including land, water, trees, livestock, machinery and tools. Intangible assets are claims, which comprise several forms such as food, loans, implements and work. Claims can be made on individuals, social groups, neighbors, government agencies or non-government organizations (NGOs). Bebbington (1999) further emphasized the need to expand and improve the way livelihoods was assessed in terms of sustainability. He explored the implications for understanding people's access to the five capital assets, and the way they combine them to meet their material needs.

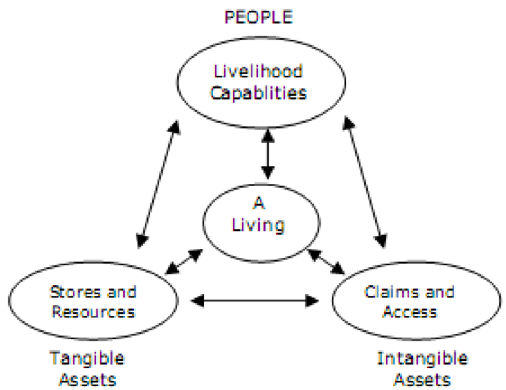


Figure 2.2. Components and flows in a livelihood (Chambers and Conway 1991).

Expanding on this work, Scoones (1998) proposed the Institute for Development Studies sustainable livelihoods framework, outlined in Figure 2.3, which shows an interdependent assortment of livelihood contexts and conditions, resources, institutional processes, strategies, outcomes, and trade-offs. Given a particular socio-economic, environmental or political condition, this framework emphasizes the importance of the combination of livelihood resources in achieving different outcomes.

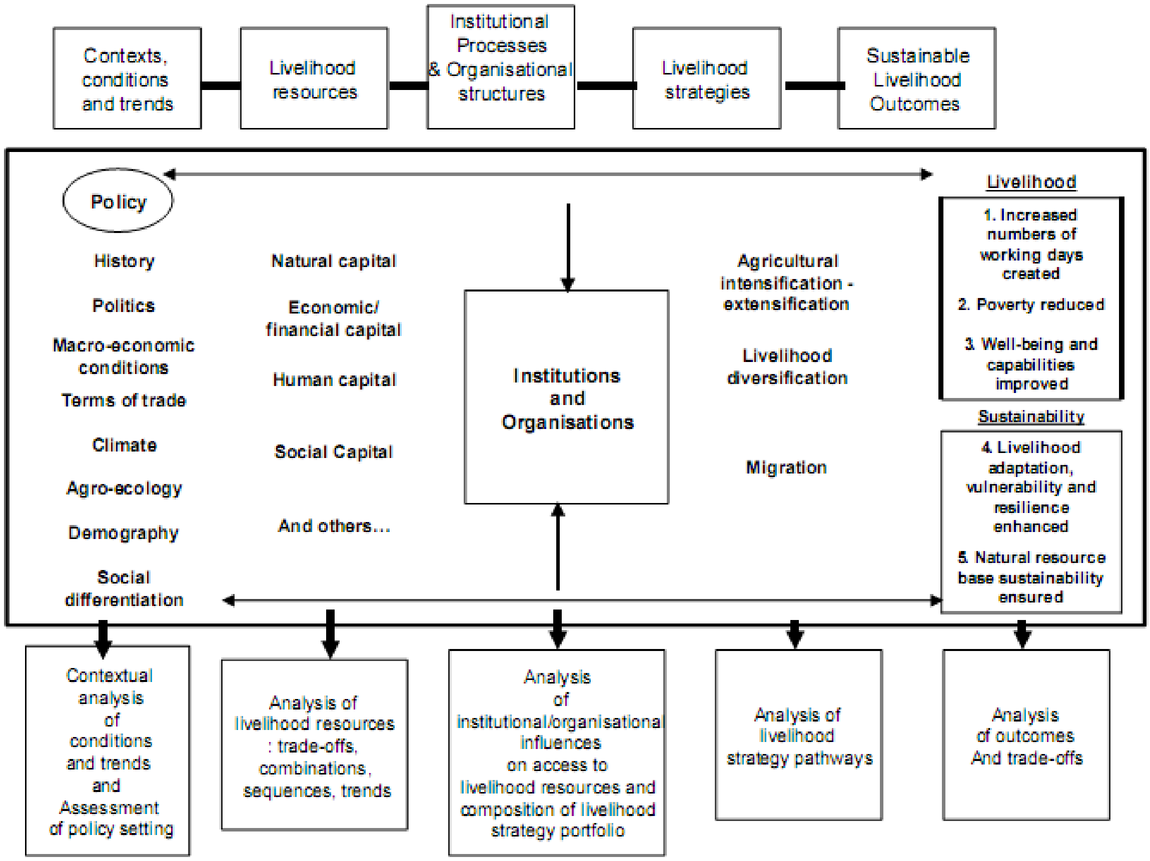


Figure 2.3. Sustainable rural livelihoods (Scoones 1998)

Perhaps most synergistic to the ecosystem service perspective is the approach of Carney et al. (1999) who emphasized that sustainable livelihoods can only be accomplished when the natural environment is sustainably managed. This responsibility relies in the fact that the maintenance of humankind's needs requires a constant food supply, in many cases at the expense of degrading the natural environment. Adams et al. (2004) added that poverty alleviation and biodiversity conservation often pursue opposite goals and there is a need for policy reconciliation.

The synergy between ecosystem services and sustainable livelihood frameworks can perhaps best be seen through the lens of agroecology. Agroecology is an interdisciplinary approach to agriculture under the ecological framework, and it performs according to these principles, inspired by the management of agroecosystems (Méndez 2010). Agroecology contemplates the multifunctionality of agroecosystems (Gliessman 2010) and has often been implemented to address the needs of poor farmers in degraded lands (Altieri 2002). In these regards, agroecological practices can range from soil conservation, crop rotation, integrated pest management, agroforestry systems and mixed crops-livestock methods (Amekawa et al. 2010).

Like all these systems, agroecological principles can also be applied to livestock systems, demonstrating the contribution to both sustainable livelihood development and ecosystem service restoration and promotion (Herrero et al. 2009). Livestock practices have different characteristics under these two frameworks. For example, the development of Voisin management intensive grazing systems as a deliberate agroecological practice has the potential to enhance and restore ecosystem services, especially food provision, nutrient cycling, erosion control and soil formation (Walton et al. 1981; Melado 2007b). These frameworks naturally blend together in the study of dairy production, because livestock play a fundamental role in ecosystems but simultaneously are one of the major reasons for the world's most serious environmental problems (Steinfeld et al. 2006; Pitesky et al. 2009). The next section explores trends in agriculture and pastoralism and the potential of livestock systems to promote both ecosystem service restoration and sustainable livelihood development.

2.4. The Co-evolution of Agropastoral Systems and Livelihoods

Animals have been cooperatively used to encourage grasslands (and discourage forests) for thousands of years. Humans preying on grazing animals followed them and kept trees scarce through fire (Eisenberg 1998). In managing livestock, nomadic shepherds moved grazing animals, in search of fresh pastures, leaving foraged areas resting behind. This relationship between man, perennial grasses, and legumes enabled a more secure source of livelihood, stability of grassland ecosystems, and the first great wave of human-led expansion through the control of savanna grassland ecosystems (Galaty & Johnson 1990). This ultimately allowed for the domestication of livestock and the emergence of a more stationary agricultural system (Eisenberg 1998). Over time, ruminants have been critical to the transformation of nitrogen compounds into plants and then into animal proteins such as meat, milk, wool and hides (Sansoucy et al. 1995), as well as serving as energy converters with the provisioning of mechanical work. Thus, human use of animals in different land uses has co-evolved altering global ecosystems throughout the time. Meanwhile, explosive population growth in the last two-centuries demanded more animal products causing severe environmental constrains. Animals that once grazed freely in open rangelands were fenced out in large pastures. This practice broke the natural roaming behavior of grazers' which then, had to struggle to obtain their forage in a reduced area, a practice currently called extensive, continuous or traditional grazing. Traditional grazing is practiced worldwide. With the affordability of fossil fuels, industrial countries were able to grain feed and confine animals in barns or pens.

However, a visionary called Andre Voisin observed that, in traditional grazing animals were not able to roam the pastures and express their natural behavior. The pastures on the other side were re-grazed several times without resting periods thus, causing overgrazing. The next sections examine how these three livestock systems work.

2.4.1. Traditional Grazing

Traditional grazing is the most widely practiced method in pastoral lands throughout the world. This practice is performed in often large undivided areas throughout the whole season resulting in forage selectivity by grazing animals. When grazing lands are extensive, and stocking rates low, traditional grazing can allow ample time for soils and grasses to recover. But in most parts of the world, a combination of populations pressure and a shrinking land base for agricultural activities from growing urban settlements, protected areas, or any number of human uses has put growing pressure on the agricultural lands that due remain (Robertson & Swinton 2005). Traditional grazing today is more apt to result in very low forage yield and quality due to the lack of pasture rest between grazing periods (Pimentel et al. 1995).

Traditional grazing is broadly adopted because it requires low establishment costs, less work, and little management. Additionally, traditional grazing can provide high animal performance under low stocking rates due to forage selectivity by the animals. Also traditional grazing is usually the default system when land tenure is lacking or when common lands are available for grazing as described by Hardin (1968)

As compared to more management intensive grazing schemes (discussed more below), traditional grazing shows productive disadvantages, especially when productivity is measured per area unit and forage availability is low (Suttie et al. 2005). Perhaps the main disadvantage is that plants are not allowed to recover between grazing periods, resulting in spots of bare soil, the presence of weed lumps due to grazing selectivity, and manure that is slow to decompose (Pinheiro Machado 2004b). Manure (cow pies) that mummifies is a particular indication of low biodiversity activity in the soil resulting from overgrazing (Pinheiro Machado 2004b). If pasture isn't given sufficient rest between grazings, and supplementation is not furnished, then quality and quantity will significantly decline as the season evolves. Consequently, overgrazing can result in significant above and below ground biodiversity and fertility loss, erosion, more weeds, lower infiltration rates, and higher runoff (Pimentel et al. 1995; Suttie et al. 2005).

2.4.2. Conventional Agriculture

In contrast to traditional grazing, what is often called conventional or modern agriculture is highly dependent on nonrenewable inputs from afar in the form of feed, fertilizers, and fuel. Norman Borlaug's "Green Revolution" to improve food security probably most aptly characterizes the modern system. Borlaug developed high-yield cereal varieties of wheat, rice, and corn heavily dependent on fossil fuel inputs for synthetic fertilizers, pesticides, heavier machinery, and irrigation (Glaeser 1987). Hybrid seeds were later created which allowed for privatizing and patenting life through the genetically modified organisms, including animals (Bonny 2003; Salomon 2008).While the intentions behind the Green Revolution to reduce global hunger were admirable, a whole range of social, nutritional, health and environmental problems were created as a result (Glaeser 1987).

The MEA (2005a) found that resource intensive, conventional agriculture has negatively affected soils, water supply, and biodiversity through deforestation, landscape fragmentation, frequent plowing and biological invasion. Since 1945, the land destined to agriculture exceeded the total land allocated to agriculture in the 18^{th} and 19^{th} centuries combined (MEA 2005a). The large and growing portion of global cereal production, in particular, fits under this high-external-input agricultural model and is used to a large extent to feed confined animals. Studies indicate that livestock activities represent the single greatest anthropogenic land use, utilizing up to 45% of the world surface (Asner et al. 2004; Herrero et al. 2009).

High input livestock systems generally require a high capital investment which has meant highly leveraged farms. Consolidation of many small farms into fewer large ones has resulted in order to achieve sufficient economies of scale to service debt. Many rural communities have consequently been transformed into a centralized, high-input, high-capital, high-leverage model of agriculture that has also contributed to the concentration of wealth, land, and often political power in the hands of the very few within the agricultural sector (Glaeser 1987; Ponting 2007). For instance, recent data from USDA-NASS (2007) confirms a sharp decline in the number of U.S. dairy farms from 1970 to 2006, along with increases in the number of cows per farm and increases in production per cow. From 2000 to 2006 farms with less than 100 cows decreased by 29%, while farms with more than 499 cows rose by 44 % (Figure 4). The State of

Vermont followed a similar trend, where the number of dairy farms and milking cows fell about 90% and 46% respectively while total production and productivity per cow increased around 80% and 190% since 1947 (USDA-NASS 2007).

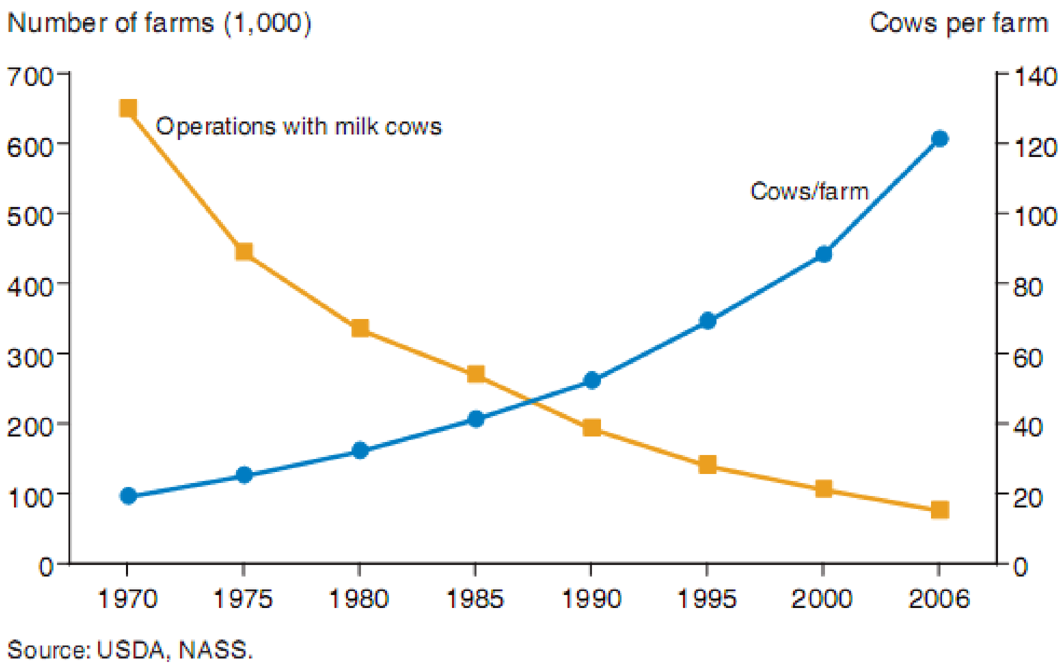


Figure 2.4. Number of dairy farms declining while average size is increasing (USDA-NASS 2007).

Animal confinement operations represent one of the most capitalized versions of what has come to be called modern agriculture. This is generally a method of livestock production that encloses animals in corrals or pens, restricting their free range. Feed, water and minerals are carried to the animals. By definition, animals are confined for 45 days or more in any 12-month period, and crops, forage, or post-harvest residues are not kept over any portion of the confinement facility (USEPA 2011b).

Confinement operations have become the main system of livestock management in industrialized countries. There are almost 5 million confined dairy cows with one company controlling 40% of the US milk market (Food_&_Water_Watch 2010) and 83,000 feedlots and in the US which represent about 30 million animals (Scully 2003).

Currently several developing countries are following the same trend. For instance, by 2006, Brazil had over 2.5 million confined animals (5% of the total, and mostly finishing beef cattle) (Dias 2006). This model is in part possible due to large subsidized grain production surplus that help lower feed costs allowing high outputs per cow (Hinrichs & Welsh 2003).

The main advantage of confinement is that it removes the seasonality placed on pastured animals (Hinrichs & Welsh 2003). The main goal of confinement operations is to optimize the productive process, maximizing profits and production. However it falls short in environmental, financial and social standards as it mostly relies on imported feed, sometimes several hundred miles away from the farm gate (Murphy 1998b). Because confinement operations generally require a large scale to achieve sufficient economies of scale to cover capital investment, several studies have found that higher overall costs makes confinement less profitable than other systems (Hanson et al. 1998; Winsten et al. 2000b; Winsten et al. 2000a; Hinrichs & Welsh 2003; Olsen 2004; Kriegl & McNair 2005; Benson 2008). Other studies have reported that confinement operations can negatively affect the environment (Steinfeld et al. 2006; Arsenault et al. 2009; Cooner et al. 2009; Rotz et al. 2009), quality of life and communities (Murphy 1998a; Schmalzried & Fallon Jr 2007), and animal welfare and health (Holmberg et al. 2004; Thelin et al. 2004; Kaustell et al. 2007) as herd size increases (Albright 1964).

2.4.3. Management Intensive Grazing

Management intensive grazing (MIG) consists of separating a grazing area into several paddocks – preferably with the same size and shape – using electric or other kinds of fencing. Livestock in high stocking rates are rotated through the subdivided pastures for a limited time. This management allows animals to graze only when the forage is at its optimal rest stage to achieve maximum grazing efficiency, as illustrated in Figure 5 (Pinheiro Machado 2004b). Plants then have enough time to re-grow before they are grazed again. Once the area has been grazed to a certain height, sufficient time is needed for the animals to return to the same paddock.

Pasture management was perfected by French biochemist and farmer Andre Voisin (1988) in his book *Grass Productivity*. Voisin documented the effects of flexible periods of pasture rest between grazings, establishing that the smaller the periods of occupation, the higher the yields. Thus, a time factor is the single most important aspect for the success of MIG (Voisin 1988). Voisin proposed the optimal rest period, summarized by his Four Universal Laws of Rational Grazing. These laws considered forages and animals and were valid to any climate, soil type or region (Voisin 1988).

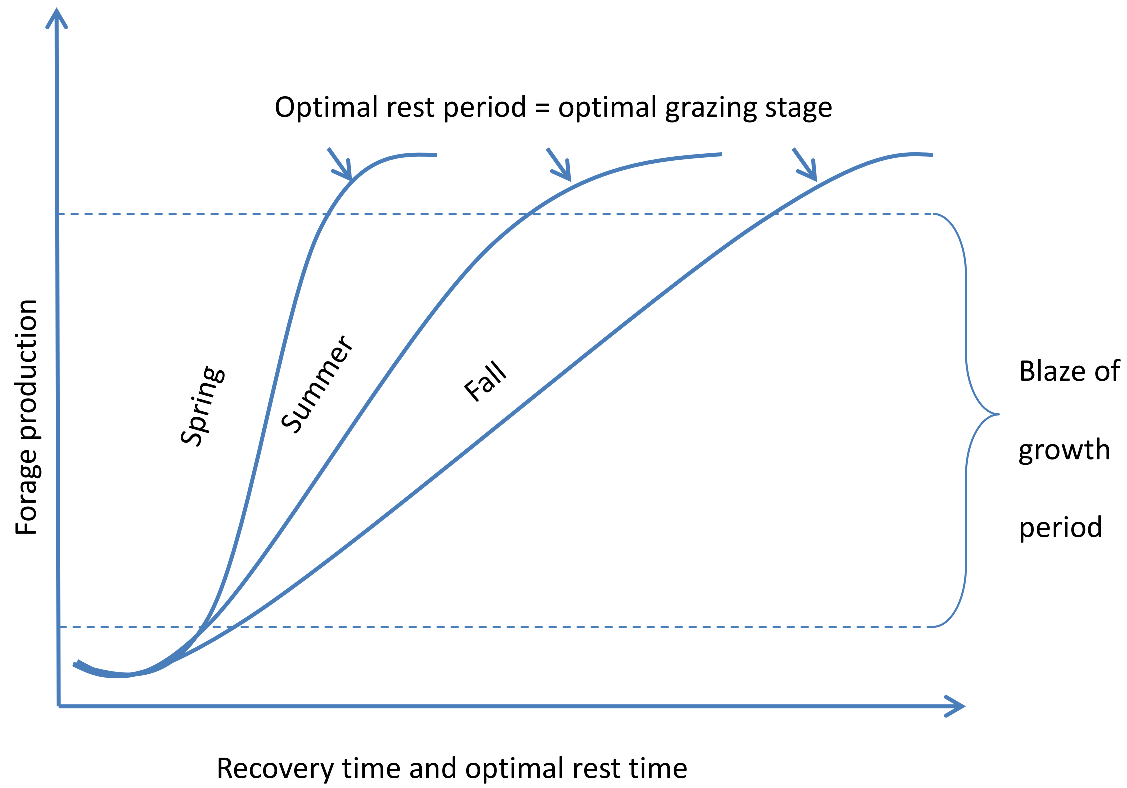


Figure 2.5. Forage growth curve indicates how yields, growth and rest periods vary over the growing season (adapted from Voisin 1988).

In MIG, rest periods are never constant as they depend on the forage vegetative stage which is dynamic and depends on biotic and abiotic factors (Pinheiro Machado 2004b). In his observations, Voisin noted that forage growth at the beginning stages was slow, increasing rapidly in a "blaze of growth" and then slowing down at the maturity stage (Voisin 1988). In MIG, animals must graze at the end of the blaze of growth and before plants become too mature, illustrated by the upper dotted line in Figure 2.5. The grazing period must be short (e.g. 12 hours to 3 days) and animals must graze only when forage height is between 15 to 20 cm for temperate forages, and need to be moved to a new paddock when forage height is approximately 7 cm (Murphy 1998b).

The optimal rest period corresponds with the optimal time to graze, which is when forage plants are at their optimal phenological stage as measured by factors such as height, palatability, and carbohydrates and protein levels (Voisin 1988). Grazing before the optimal rest stage will incur in loss of forage quantity. Grazing after the optimal rest stage, or when forage is too mature, will cause loss of quality and quantity (Pinheiro Machado 2004b). The farmer must observe and recognize which paddocks have reached the optimal rest stage independently of where they are. Voisin called it “the art of skipping” (Pinheiro Machado 2004b).

A similar practice called rotational grazing is often confused with MIG. Rotational grazing is in part, an improvement to traditional grazing, however it does not necessarily follow Voisin’s universal precepts (Voisin 1988; Pinheiro Machado 2004b). In rotational grazing, animals rotate through pastures in a regular or fixed rotation without considering seasonality, forage availability, and recovery periods. This affects the forage growth rate which can negatively influence the quality and quantity of forage causing “untoward acceleration” (Voisin 1988; Murphy 1998b; Pinheiro Machado 2004b). As cows are rotated throughout paddocks that are not fully recovered, pasture availability and quality will decline and will present the same characteristics of traditional grazing.

MIG has several advantages over traditional grazing or animal confinement operations. Numerous studies have found that MIG farms can produce greater quality of life; a closer relationship with the cows, the land and the community (Murphy 1998a); significantly less soil erosion and better water quality; and larger net farm income and higher chances of survival of medium and small farms (Ostrom & Jackson-Smith 2000; Gerrish 2004; Cooner et al. 2009). Moreover, MIG has been found to produce more milk per area compared to traditional grazing, and healthier animals and 10% less greenhouse gas emissions compared to confinement (Phetteplace et al. 2001). MIG can also address equity concerns since the system is more suited for small farmers and reduces the amount of labor needed compared to feedlot systems while consuming significantly less supplementation (Pinheiro Machado 2004b). MIG also eliminates the need for housing during winters. Instead, animals can endure harsh winters out on pasture with the proper supplementation if temperatures do not exceed below freezing marks (Murphy, 1998).

For all the reasons above, MIG has become synonymous with a focus on well managed pastures. These arguments also give sufficient reasons to think that MIG is a proper agroecological practice to address both ecosystem services and sustainable livelihoods.

2.5. Bridging Livelihoods and Ecosystem Services Through Pasture Management

Well managed pastures have the potential to produce and restore ecosystem services while simultaneously providing the basis for sustainable livelihoods (Lyons et al. 2000; Kriegl & McNair 2005). The MEA (2005) classification of ecosystem services into supporting, provisioning, regulating, and cultural provides a useful framework to assess the full costs and benefits of pasture management from traditional grazing to confined operations to management intensive grazing. This final section considers each of these broad service classes in relation to management intensive grazing.

2.5.1. Supporting Services

Soils are the nutrient reservoirs of grazing ecosystems and provide the essential, supporting services for all other services from agroecological systems. An estimated 13 to 75 billion tons of soil are eroded each year from terrestrial ecosystems, much of it related to anthropogenic causes (Pimentel & Kounang 1998). This rate is up to 40 times faster than the rate of renewal. When poorly covered soils are disturbed by action of tillage or overgrazing, erosion occurs reducing organic matter, nutrients, biodiversity and productivity (Pimentel & Kounang 1998). Properly applied MIG can support and increase density and quality of forage swards, reduce erosion, promote nutrient cycling and decrease nutrient runoff into water bodies, thereby enhancing water quality in nearby waterways (Voisin 1988; DeRamus 2004; Pinheiro Machado 2004b) . MIG can also increase and influence biodiversity (Melado 2007b; O'Connor et al. 2010) and promote greater storage of carbon in soils (Murphy 1998b; Pinheiro Machado 2004b; Melado 2007b).

The benefits from MIG come through stimulating the biotic soil factors through systematic increases in organic matter. These increases are directly associated with the amount of excrements (dung and urine) in the soil. On average, an adult bovine excretes approximately 25 kg of dung and 14 liters of urine per day, which is about 1,825 kg of dry matter/year (Pinheiro Machado 2004b). This represents an average of 80 kg of nitrogen, 13 kg of phosphorus, 35 kg of potassium and 32 Kg of calcium returned to the soil by one single adult cow (Pinheiro Machado 2004b). Thus, organic matter acts as a biological catalyzer of soil life.

Studies performed in Brazil, Cuba and Argentina revealed that MIG can dramatically increase soil fertility compared to traditional grazing (Pinheiro Machado 2004b). For example, repeated measurements applied in a sandy soil farm under MIG in Southern Brazil between 1959 to 1999, showed that organic matter rose from 0.19 to 1.5%, phosphorus increased from 0.96 to 28.2 ppm, potassium improved from 2.15 to 59 ppm as well as increases in calcium and magnesium without changes in aluminum percent (Pinheiro Machado 2004b).

2.5.2. Provisioning Services

Grazing cows harvest forage, one of the main provisioning services in the MEA framework. Animal products then support farmer livelihoods. MIG operates at higher stocking rates per hectare, more forage production and consumption, and higher production than traditional grazing (Walton et al. 1981). MIG can potentially produce between 50% to three times more forage yield compared to traditional grazing, and while production per cow can be lower, net farm income per cow and per hectare is significantly greater when compared to both traditional grazing and confinement operations (Pinheiro Machado 2004b; Kriegl & McNair 2005; Winsten et al. 2010). Additionally, forage quality such as digestibility, calcium, magnesium, and crude protein is significantly higher under MIG (Walton et al. 1981).

2.5.3. Regulating Services

The role of livestock systems in regulating greenhouse gasses has been debated for decades. Globally, livestock produce an estimated 80 million tons of methane, accounting for 28% of global methane releases from human-related activities (USEPA 2011a). A recent report from UNFAO argues that livestock is responsible for 18% of anthropogenic greenhouse gas (GHG) emissions (Steinfeld et al. 2006). Another study from California on GHG emissions and sinks from 1990 to 2002 contradicted the UNFAO report, concluding that livestock contributions to climate change was less than 3% of the total global anthropogenic GHG emissions (Pitesky et al. 2009). The difference was the method used, which assigned more weight to the variable “land use change” which was related mostly with deforestation (Pitesky et al. 2009).

Carbon is taken up in growing pastures in any livestock management considered, however depending on pasture management net carbon releases can be positive or negative. With MIG, in spite of large amounts of plant material removed during grazing, adequate resting periods can promote a necessary break and subsequent “blaze of growth” accumulating new carbon stocks in plant’s tissues (Voisin 1988; Murphy 1998b; Pinheiro Machado 2004b). With proper residue accumulation, carbon can also accumulate in soil organic matter.

Soil building through MIG has the potential to be a net carbon sink, but the way the management is performed matters. For instance, some soil carbon advocates support grazing taller than 20 cm because it is believed to build higher carbon stocks in the soil and therefore, further mitigate GHG emissions. However, forage sward is composed by several plant species, which grow at different rates and can be outgrown by certain grasses compromising sward quality if tall grazing is applied (Murphy, 2007, personal communication). Additionally, in taller grazing some forage species are beyond mature stage affecting digestibility and producing higher methane emissions. De Ramus et al. (2003) found that animals under MIG produced 22% less methane while increasing beef production by 29 kg compared to traditional grazing on a three-year experiment.

Another key regulating service of agroecological systems that can be enhanced through pasture management relates to hydrological processes. MIG can benefit water receiving streams and water bodies because it keeps soils well-covered, preventing erosion and nutrient run-off. Additionally, the water infiltration rate is positively influenced by the soil type, texture, structure, biota and organic matter under MIG systems (Melado 2007b). Rotz et al. (2009) found that converting 30 hectares of cropland into all-perennial managed grassland reduced erosion by 87% while sediment bound and phosphorus runoff losses decreased 80 and 23% respectively due to improved water infiltration.

2.5.4. Cultural Services

Grazing cows also produce scenery that attract tourists to the countryside and can potentially generate additional revenue for the farmer's livelihood. For example, in Santa Catarina, Brazil the *agroecotourismo* welcomes tourists and visitors to the *colonia* (rural communities), to areas with traditional agricultural practices, generating extra income to family farms (Toresan et al. 2002), a situation also confirmed by MEA (2005a). Likewise, it is not possible to dissociate grazing cows, covered bridges, old barns or stone walls from Vermont bucolic landscape. They are part of the cultural heritage and generate important revenues to Vermont's economy (Harrison 2006). Murphy et al. (1996) have studied people's perceptions about local family grass-fed farming, finding that it enhances the quality of life of rural communities.

2.6. Conclusion

The often competing goals of dairy production and environmental conservation can pose different challenges on achieving both sustainable livelihoods and ecosystem service protection. Dairy management systems vary widely from traditional grazing to animal confinement to management intensive grazing (MIG), each with different stocking rates, animal welfare implications, cultural attributes, and ultimately impacts on soils and water. Grazing livestock has a profound influence on ecosystem structure as it affects vegetation stratification, biomass density, and species diversity, which in turn alters community organization, soil biota, soil erosion rates, and water supply and quality. Pasture management ultimately affects ecosystem function by altering nutrient cycling, sequestrating carbon, and changing ecological succession and composition.

In the last few decades, the knowledge about ecosystem services has increased dramatically. Through this new lens, modern conventional agricultural practices have increasingly been viewed as limited in producing equity and sustainable development. Livestock systems employ over a billion people and support the livelihoods of 600 million farmers in the developing world. If agricultural practices are to be environmentally and socially sound for future generations, a full analysis of the barriers to adoption at the farm, business, and governmental levels of sound agroecological practices will be necessary.

There are common beliefs that lower stocking rates, such as seen in traditional grazing systems, can cause less environmental damage than higher stocking rates. In fact, evidence is growing that low stocking rates are the leading cause of overgrazing. Overgrazing affects an ecosystem's carrying capacity by inadequately distributing stocking rates. This leads to a major ecosystem disservice from animal grazing that if not addressed, may cause severe vegetation and biodiversity decline, erosion, changes in micro-climate patterns, soil carbon release, and ultimately desertification in the most extreme. Removing grazing animals from grassland systems also isn't the answer, as this can completely alter the dynamics of the system, at times leading to the disappearance of rare plant species.

At the other end of the management spectrum, the ability of high-energy input systems, such as animal confinement operations, to produce enough food globally in the long term without compromising the very same agroecosystems that enable their activity is also questionable.

The dependence of external inputs, many of which are non-renewable, impact on water and soil of concentrated animal feeding, considerations of animal welfare, and the generation of dependence on capital investment through greater farm debt are some of many growing concerns of an industrial agricultural system that is unsustainable in supporting farmer livelihoods and the underlying ecosystem services that make agriculture possible.

Agroecological practices such as MIG present a potential bridge to support livelihoods and restore agro-ecosystems. Managing ruminants under MIG principles is one of the most efficient, economical and environmentally sound practices. Well managed pastures under MIG can produce an array of ecosystem services such as greater animal production per hectare, heavy grazing without permanently damaging plants, sustainable food provisioning, improved nutrient cycling, enhanced soil formation, better erosion control, and greenhouse gas mitigation through carbon sequestration and storage in pasture roots and through less methane production.

Harmonizing ecosystem conservation with sustainable livelihoods requires a great deal of conciliation. Hence, empowering the adoption of agroecological practices through existing and new policy mechanisms and investing in research, education and extension is critical.

2.7. References

Adams, W. M., R. Aveling, D. Brockington, B. Dickson, J. Elliott, J. Hutton, D. Roe, B. Vira, and W. Wolmer. 2004. Biodiversity conservation and the eradication of poverty. Science 306:1146-1149.

Albright, J. L. 1964. Problems in Increasing Size of the Dairy Herd1. Journal of Dairy Science 47:941-943.

Altieri, M. A. 1999. The ecological role of biodiversity in agroecosystems. Agriculture Ecosystems & Environment 74:19-31.

Altieri, M. A. 2002. Agroecology: the science of natural resource management for poor farmers in marginal environments. Agriculture Ecosystems & Environment 93:1-24.

Amekawa, Y., H. Sseguya, S. Onzere, and I. Carranza. 2010. Delineating the Multifunctional Role of Agroecological Practices: Toward Sustainable Livelihoods for Smallholder Farmers in Developing Countries. Journal of Sustainable Agriculture 34:202-228.

Arsenault, N., P. Tyedmers, and A. Fredeen. 2009. Comparing the environmental impacts of pasture-based and confinement-based dairy systems in Nova Scotia (Canada) using life cycle assessment. International Journal of Agricultural Sustainability 7:19-41.

Ashley, C., and D. Carney 1999. Sustainable livelihoods: lessons from early experience. DFID, London.

Asner, G. P., A. J. Elmore, L. P. Olander, R. E. Martin, and A. T. Harris. 2004. Grazing Systems, Ecosystem Responses, and Global Change. Annual Review of Environment and Resources 29:261-299.

Balmford, A., A. Bruner, P. Cooper, R. Costanza, S. Farber, R. E. Green, M. Jenkins, P. Jefferiss, V. Jessamy, J. Madden, K. Munro, N. Myers, S. Naeem, J. Paavola, M. Rayment, S. Rosendo, J. Roughgarden, K. Trumper, and R. K. Turner. 2002. Economic Reasons for Conserving Wild Nature. Science 297:950-953.

Bebbington, A. 1999. Capitals and capabilities: A framework for analyzing peasant viability, rural livelihoods and poverty. World Development 27:2021-2044.

Benson, G. A. 2008. Pasture-Based and Confinement Dairy Farming in the United States: An Assessment. Journal of International Farm Management 04.

Bonny, S. 2003. Why are most Europeans opposed to GMOs?: Factors explaining rejection in France and Europe. Electronic Journal of Biotechnology 6:7-8.

Boody, G., B. Vondracek, D. A. Andow, M. Krinke, J. Westra, J. Zimmerman, and P. Welle. 2005. Multifunctional agriculture in the United States. Bioscience 55:27-38.

Boumans, R., M. A. Wilson, R. Portela, J. Rotmans, F. Villa, M. Grasso, R. Costanza, and J. Farley. 2002. Modeling the dynamics of the integrated earth system and the value of global ecosystem services using the GUMBO model. Ecological Economics 41:529-560.

Boyd, J., and S. Banzhaf. 2007. What are ecosystem services? The need for standardized environmental accounting units. Ecological Economics 63:616-626.

Carney, D., M. Drinkwater, T. Rusinow, K. Neefjes, S. Wanmali, and N. Singh 1999. Livelihood approaches compared. DFID, London.

Chambers, R. 1989. Farmer first: a practical paradigm for the third agriculture. Pages 237-244 in M. A. Altieri, and S. B. Hecht, editors. Agroecology and small farm development. CRC Press, Boca Raton, Fla., USA.

Chambers, R. 1995. Poverty and livelihoods : whose reality counts? Institute of Development Studies at the University of Sussex, Brighton, Eng.

Chambers, R., and G. Conway. 1991. Sustainable rural livelihoods: practical concepts for the 21st Century. IDS-University of Sussex, Brighton.

Cooner, D., D. Rozeboom, and V. Campbell-Arvai. 2009. Literature Review: A Comparison of Dairy Production Systems. Department of CARRS, Michigan State University.

Costanza, R., R. dArge, R. deGroot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. Oneill, J. Paruelo, R. G. Raskin, P. Sutton, and M. vandenBelt. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Daily, G. C., editor. 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, D.C.

Dale, V., and S. Polasky. 2007. Measures of the effects of agricultural practices on ecosystem services. Ecological Economics 64:286-296.

De Ramus, H. A., T. C. Clement, and D. D. Giampola. 2003. Methane Emmissions of Beef Cattle on Forages: Efficiency of Grazing Management Systems. Journal of Environmental Quality 32:269-277.

DeRamus, H. A. 2004. Grazing management of ruminant animals in sustainable agriculture. Outlook on Agriculture 33:93-100.

Dias, F. 2006. Confinamento Brasileiro: Onde Queremos Chegar? Pages Presentation to the Colegio Brasileiro of Animal Nutrition, ESALQ. Associacao Nacional dos Confinadores, Goiania, GO Brasil.

Eisenberg, E. 1998. The ecology of Eden. Alfred A. Knopf.

Ellis, F. 2000. Rural livelihoods and diversity in developing countries. Oxford University Press, Oxford.

Farber, S., R. Costanza, D. L. Childers, J. Erickson, K. Gross, M. Grove, C. S. Hopkinson, J. Kahn, S. Pincetl, A. Troy, P. Warren, and M. Wilson. 2006. Linking ecology and economics for ecosystem management. Bioscience 56:121-133.

Farley, J., and R. Costanza. 2010. Payments for ecosystem services: From local to global. Ecological Economics 69:2060-2068.

Fisher, B., and K. R. Turner. 2008. Ecosystem services: Classification for valuation. Biological Conservation 141:1167-1169.

Foley, J. A., R. DeFries, G. P. Asner, C. Barford, G. Bonan, S. R. Carpenter, F. S. Chapin, M. T. Coe, G. C. Daily, H. K. Gibbs, J. H. Helkowski, T. Holloway, E. A. Howard, C. J. Kucharik, C. Monfreda, J. A. Patz, I. C. Prentice, N. Ramankutty, and P. K. Snyder. 2005. Global Consequences of Land Use. Science 309:570-574.

Food_&_Water_Watch. 2010. Factory Farm Nation: How america Turned Its Livestock Farms into Factories. Food & Water Watch, Washington, DC.

Galaty, J. G., and D. L. Johnson 1990. The World of pastoralism: herding systems in comparative perspective. Guilford Press, London, UK.

Gerrish, J. 2004. Benefits of Management-intensive Grazing. University of Missouri-Forage Systems Research Center, Saint Louis.

Glaeser, B. 1987. The Green Revolution revisited: critique and alternatives. Allen & Unwin.

Gliessman, S. 2010. Landscape Multifunctionality and Agriculture. Journal of Sustainable Agriculture 34:465-465.

Gómez-Baggethun, E., R. de Groot, P. L. Lomas, and C. Montes. 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. Ecological Economics 69:1209-1218.

Groenfeldt, D. 2006. Multifunctionality of agricultural water: Looking beyond food production and ecosystem services. Irrigation and Drainage 55:73-83.

Hanson, G. D., L. C. Cunningham, S. A. Ford, L. D. Muller, and R. L. Parsons. 1998. Increasing intensity of pasture use with dairy cattle: An economic analysis. Journal of Production Agriculture 11:175-179.

Hardin, G. 1968. The Tragedy of The Commons. Science 162:1243-1248.

Harrison, B. A. 2006. The view from Vermont: tourism and the making of an American rural landscape. University of Vermont Press.

Herrero, M., P. K. Thornton, P. Gerber, and R. S. Reid. 2009. Livestock, livelihoods and the environment: understanding the trade-offs. Current Opinion in Environmental Sustainability 1:111-120.

Hinrichs, C. C., and R. Welsh. 2003. The effects of the industrialization of US livestock agriculture on promoting sustainable production practices. Agriculture and Human Values 20:125-141.

Holmberg, S., A. Thelin, E. L. Stiernstrom, and K. Svardsudd. 2004. Psychosocial factors and low back pain, consultations, and sick leave among farmers and rural referents: a population-based study. Journal of occupational and environmental medicine / American College of Occupational and Environmental Medicine 46:993-998.

IFAD. 2004. Livestock services and the poor. Page 152. International Fund for Agricultural Development.

Jordan, N., and K. D. Warner. 2010. Enhancing the Multifunctionality of US Agriculture. Bioscience 60:60-66.

Kaustell, K. O., T. E. Mattila, and R. H. Rautiainen. 2007. Safety performance of animal confinement floors: slip, trip, and fall injuries in Finland. Journal of agricultural safety and health 13:395-406.

Kriegl, T., and R. McNair. 2005. Pastures of Plenty: Financial performance of Wisconsin grazing dairy farms, Madison, Wi.

Leopold, A., and C. W. Schwartz 1989. A Sand County almanac, and sketches here and there. Oxford University Press.

LID. 1999. Livestock in Development: Livestock in Poverty-Focused Development.95.

Lovell, S. T., S. DeSantis, C. A. Nathan, M. B. Olson, V. E. Mendez, H. C. Kominami, D. L. Erickson, K. S. Morris, and W. B. Morris. 2010. Integrating agroecology and landscape multifunctionality in Vermont: An evolving framework to evaluate the design of agroecosystems. Agricultural Systems 103:327-341.

Lyons, J., B. M. Weigel, L. K. Paine, and D. J. Undersander. 2000. Influence of intensive rotational grazing on bank erosion, fish habitat quality, and fish communities in southwestern Wisconsin trout streams. Journal of Soil and Water Conservation 55:271-276.

Marsh, G. P. 1864. Man and Nature. Charles Scribner, New York.

MEA 2005. Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: A Framework for Assessment. Island Press, Washington, DC.

Meister, Kyle and Salviati, Victor (2009), 'O Investimento Privado e a Restauração da Mata Atlântica no Brasil', *Revista Intertox de Toxicologia, Risco Ambiental e Sociedade,* 2 (2).

Melado, J. 2007. Pastagem Ecológica e serviços ambientais da pecuária sustentável. Rev. Bras. de Agroecologia 2.

Méndez, V. E. 2010. Agroecology. Page in press in B. Warf, editor. Encyclopedia of Geography. Sage Publications, Thousand Oaks, CA.

Murphy, B., J. Silman, L. McCrory, S. Flack, J. Winster, D. Hoke, A. Schmitt and B. Pillsbury 1996. Environmental, economic, and social benefits of feeding livestock on well managed pasture. Tufts University Press, Boston.

Murphy, W. M. 1998a. Feeding Livestock on Well-Managed Pasture: Effects on Farm Family, Rural Community, and Landscape. Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY.

Murphy, W. M. 1998b. Greener pastures on your side of the fence: better farming with Voisin management intensive grazing. Arriba Pub, Colchester, VT.

O'Connor, T. G., P. Kuyler, K. P. Kirkman, and B. Corcoran. 2010. Which grazing management practices are most appropriate for maintaining biodiversity in South African grassland? African Journal of Range & Forage Science 27:67-76.

Olsen, J. 2004. "A Summary of Basic Costs and Their Impact on Confinement vs. Managed Intensive Rotational Grazing MIRG) in W. D. Data, editor. University of Wisconsin Center for Dairy Profitability, Madison, WI.

Ostrom, M. R., and D. B. Jackson-Smith. 2000. The Use and Performance of Management Intensive Rotational Grazing Among Wisconsin Dairy Farms in the 1990s. Program on Agricultural Technology Studies research report No. 8. University of Wisconsin, Madison.

Phetteplace, H., D. Johnson, and A. Seidl. 2001. Greenhouse gas emissions from simulated beef and dairy livestock systems in the United States. Nutrient Cycling in Agroecosystems 60:99-102.

Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, S. Crist, L. Shpritz, L. Fitton, R. Saffouri, and R. Blair. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science 267:1117-1123.

Pimentel, D., and N. Kounang. 1998. Ecology of soil erosion in ecosystems. Ecosystems 1:416-426.

Pinheiro Machado, L. C. 2004. Pastoreo Racional Voisin: Tecnologia agropecuaria para el tercer milenio. Hemisferio Sur, Buenos Aires.

Pitesky, M. E., K. R. Stackhouse, and F. M. Mitloehner. 2009. Clearing the Air: Livestock's Contribution to Climate Change. Pages 1-40 in L. S. Donald, editor. Advances in Agronomy. Academic Press.

Ponting, C. 2007. A new green history of the world: the environment and the collapse of great civilizations. Penguin Books.

Porter, J. R., R. Costanza, H. Sandhu, L. Sigsgaard, and S. Wratten. 2009. The Value of Producing Food, Energy, and Ecosystem Services within an Agro-Ecosystem. Royal Academy of Sciences, Ambio 38.

Power, A. G. 2010. Ecosystem services and agriculture: tradeoffs and synergies. Philosophical Transactions of the Royal Society B: Biological Sciences 365:2959-2971.

Reid, R. S., K. A. Galvin, and R. S. Kruska. 2008. Global Significance of Extensive Grazing Lands and Pastoral Societies: An Introduction. Pages 1-24 in K. A. Galvin, R. S. Reid, R. H. B. Jr, and N. T. Hobbs, editors. Fragmentation in Semi-Arid and Arid Landscapes. Springer Netherlands.

Robertson, G. P., and S. M. Swinton. 2005. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. Frontiers in Ecology and the Environment 3:38-46.

Rockström, J., W. Steffen, K. Noone, A. Persson, F. S. Chapin, E. F. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. J. Schellnhuber, B. Nykvist, C. A. de Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sorlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. A. Foley. 2009. A safe operating space for humanity. Nature 461:472-475.

Rotz, C. A., K. J. Soder, R. H. Skinner, C. J. Dell, P. J. Kleinman, J. P. Schmidt, R. B. Bryant, and A. USDA. 2009. Grazing Can Reduce the Environmental Impact of Dairy Production Systems. Forage and grazinglands.

Rudel, T. K. 1998. Is there a forest transition? Deforestation, reforestation, and development. Rural Sociology 63:533-552.

Salomon, J. N. 2008. The GMO’S Quarrel. Sud-Ouest Europeen:25-37.

Sanderson, E. A., M. Jaiteh, M. A. Levi, K. H. Redford, A. V. Wannebo, and G. Woolmer. 2002. The Human Footprint and the last of the Wild. Bioscience 52:891-904.

Sansoucy, R., M. A. Jabbar, S. Ehui, and H. Fitzhugh. 1995. The contribution of livestock to food security and sustainable development in S. E. a. S. M. R Trevor Wilson, editor. Proceedings of the joint FAO/ILRI roundtable on livestock development strategies for low income countries. Food and Agriculture Organization Rome, Italy, Nairobi, Kenya.

Scherr, S., and S. Yadav. 1996. Land degradation in the developing world: implications for food, agriculture and the environment to 2020, a synthesis of recommendations from an international workshop. Food, Agriculture, and the Environment Discussion Paper No. 14. , Washington, DC.

Schmalzried, H. D., and L. F. Fallon Jr. 2007. Large-Scale Dairy Operations: Assessing Concerns of Neighbors About Quality-of-Life Issues. Journal of Dairy Science 90:2047-2051.

Scoones, I. 1998. Sustainable rural livelihoods: a framework for analysis. Institute for Development Studies (IDS), Brighton, UK.

Scoones, I. 2009. Livelihoods perspectives and rural development. Journal of Peasant Studies 36:171-196.

Scully, M. 2003. Dominion: the power of man, the suffering of animals, and the call to mercy. St. Martin's Griffin.

Sears, P. B. 1956. The processes of environmental change by man. Page 1193 in W. L. Thomas, editor. Man’s Role in Changing the Face of the Earth. University of Chicago Press, Chicago.

Simoncini, R. 2009. Developing an integrated approach to enhance the delivering of environmental goods and services by agro-ecosystems. Regional Environmental Change 9:153-167.

Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, and C. de Haan. 2006. Livestock Long Shadow: environmental issues and options. Food and Agriculture Organization of the United Nations:408 pg.

Suttie, J., S. Reynolds, C. Batello, Food, and A. O. o. t. U. Nations 2005. Grasslands of the world. Food and Agricultural Organization of the United Nations.

Swinton, S., F. Lupi, G. Robertson, and S. Hamilton. 2007. Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits☆. Ecological Economics 64:245-252.

Szott, L., M. Ibrahim, and J. Beer. 2000. The Hamburger Connection Hangover. Cattle pasture land degradation and alternative land use in Central América in D. CATIE, GTZ, editor.

Thelin, A., E. Vingard, and S. Holmberg. 2004. Osteoarthritis of the hip joint and farm work. American Journal of Industrial Medicine 45:202-209.

Thrupp, L. A. 2000. Linking agricultural biodiversity and food security: the valuable role of agrobiodiversity for sustainable agriculture. International Affairs 76:265-+.

Toresan, L., T. Guzzatti, D. Nart, and R. Bitencourt. 2002. Levantamento dod Empreendimentos de Turismo no Espaco Rural de Santa Catarina: Loclizacao e Descricao Geral. Page 58 in S. Instituto CEPA, editor, Florianopolis, SC.

USDA-NASS. 2007. 2007 Census Publications.

USEPA. 2011a. 2011 U.S. Inventory of U.S. Greenhouse Gas Emmissions and Sinks: 1990-2009. United States, Environmental Protection Agency, Washington, DC.

USEPA. 2011b. National Pollutant Discharge Elimination System (NPDES) Concentrated Animal Feeding Operation (CAFO) Reporting Rule. Page 65455 in E. P. Agency, editor. USDA/EPA.

Voisin, A. 1988. Grass Productivity. Island Press.

Walman, S. 1984. Eight London households. Tavistock, London.

Walton, P. D., R. Martinez, and A. W. Bailey. 1981. A Comparison of Continuous and Rotational Grazing. Journal of Range Management 34:19-21.

Winsten, J. R., C. D. Kerchner, A. Richardson, A. Lichau, and J. M. Hyman. 2010. Trends in the Northeast dairy industry: Large-scale modern confinement feeding and management-intensive grazing. Journal of Dairy Science 93:1759-1769.

Winsten, J. R., R. L. Parsons, and G. D. Hanson. 2000a. Differentiated dairy grazing intensity in the Northeast. Journal of Dairy Science 83:836-842.

Winsten, J. R., R. L. Parsons, and G. D. Hanson. 2000b. A Profitability analysis of dairy feding systems in the Northeast. Agricultural and Resource Economics Review 29.

Zhang, W., T. Ricketts, C. Kremen, K. Carney, and S. Swinton. 2007. Ecosystem services and dis-services to agriculture. Ecological Economics 64:253-260.

CHAPTER 3: FARMER'S PERCEPTIONS ABOUT THE ADOPTION OF VOISIN MANAGEMENT INTENSIVE GRAZING IN SANTA CATARINA, BRAZIL

Abstract

Pasture-based dairy family farms are challenged to address conservation and improve their livelihoods in the search for a genuine agroecological grazing alternative to restore ecosystem services in the Atlantic Forest of Santa Catarina, Brazil. A random sample of 61 dairy family farms were interviewed and analyzed to determine their perceptions about production and environmental variables after adopting management intensive grazing (MIG). MIG adoption enabled doubling the number of animals, produced more per area and per cow in the same area. Farmers who implemented MIG reduced labor and veterinary problems while also perceiving soil improvements, more forage biomass and biodiversity, and better water quality. Farmers that initially perceived trees as an obstacle for grazing animal production later reported that pasture shading resulted in equal or higher production. The overall results showed that over traditional grazing, MIG improved production, benefited farmer livelihoods, generated ecosystem services, and could be an agroecological tool to alleviate poverty and complement Brazilian conservation efforts.

3.1. Introduction

Continuous or traditional grazing is a widely used technique of dairy livestock management throughout the world (Harris 2000). In Santa Catarina, Brazil, dairy production as an important livelihood source is typical of many landscapes dominated by livestock raising, representing 7% of the State's GDP (ICEPA 2009). However, Santa Catarina is typical of a major challenge of both the long-term viability of livestock systems and the important ecosystem services that they often displace. This region of Brazil was once completely covered by the Atlantic Forest Biome, producing a wide array of ecosystem goods and services such as water supply, climate regulation, food provision, pollination, cultural and spiritual scenery (Silvano et al. 2005; Ditt et al. 2010), which are essential to human wellbeing (Daily et al. 1997; MEA 2005a). Its extension along the Brazilian coast and elevation and climate variation allowed for extraordinary biodiversity with high levels of endemism (Cincotta et al. 2000; Myers et al. 2000b; Costa et al. 2005; Tabarelli et al. 2005; Brooks et al. 2006). The Atlantic Forest is a major biodiversity *hotspot* (Myers et al. 2000a) and was declared a Biosphere Reserve by UNESCO in 1991. This is one of the most threatened biomes worldwide with only around 7% of the original Atlantic Forest remaining in Brazil (Grelle 2003; Tabarelli et al. 2005). Currently, approximately 90% of Santa Catarina's *agricultura familiar* (family agriculture) and dairy farms are located within this biome, with farm sizes typically between 5 to 50 hectares (ICEPA 2009). Net forest loss due to pasture land conversion can directly affect loss of ecosystem structure and its various important functions (Foley et al. 2007). Failure to restore forest coverage and its biodiversity can result in catastrophic loss of ecosystem services because of the current high extinction rate (Metzger, 2009) Livestock grazing itself can also degrade ecosystem functions from soils and grasslands, causing cascading dis-services (Zhang et al. 2007). These dis-services often affect the provision of ecosystem goods and services and ultimately reduce farm capacity to maintain livelihoods over the long-run (MEA 2005b). Examples related to deforestation and overgrazing include biodiversity loss and habitat, impacts on water sources and supply, erosion, nutrient runoff, and loss of soil carbon sequestration.

To prevent irreversible damage to forest cover and limit the ecosystem disservices to agriculture, Federal and State regulation was instituted in the Brazilian Forest Code (BFC) in 1934 (updated repeatedly since 1965). The BFC requires landowners to keep permanent protection areas on hilltops, in high declivity areas, and around water sources and riparian areas. It also mandates farmers to keep "legal reserve" areas on their farms for biodiversity conservation. These areas must and can be managed through agroforestry systems in case of smaller farms, without totally suppressing vegetation (Ditt et al. 2008).

Admittedly, most smallholders in Santa Catarina are not in compliance with the Law because most of the forest has been removed from their farms. If the BFC was enforced, they would face immediate economic problems and completely restoring the forest would force many smaller farms into extreme poverty (Souto 2009). As a result of this dilemma, the past governor of Santa Catarina, in clear defiance to Federal and State regulation institutions, declared: "We must either choose between conservation and farmers swapping their farms for slums" (Souto 2009).

The intent of this paper is to investigate the feasibility of pasture-based dairy production under an agroecological pasture management system called management intensive grazing (MIG) in improving farmer livelihoods while restoring agro-ecosystem services and allowing for greater forest reserve areas. Previous to switching to MIG, these farmers practiced continuous grazing. MIG is a widely known agro ecological alternative with increasing use worldwide (Hopkins and Del Prado, 2007; Mannetje, 2007). Several studies confirm the low environmental effects and the high socio-economic results of accommodating more animals per area, particularly when rotating them rationally along the pastures (Voisin 1988; Murphy 1996; Murphy 1998b; Riethmuller 2003; Pinheiro Machado 2004b; Reynolds 2005; Lund 2007; Melado 2007a; Gibson 2009; Rotz et al. 2009).

Through 61 semi-structured interviews, we investigate the potential for MIG to complement farmers' livelihoods, restore and enhance ecosystem services, while complying with the Forest Code through supporting permanent preservation and legal reserve areas. Specifically, we tested the hypotheses that adoption of MIG by dairy farmers in Santa Catarina, Brazil could improve farm production; reduce sanitary problems with animals; improve ecosystem structure and services such as soil condition, erosion control, enhanced vegetation cover, biodiversity and water quality; and create more environmental awareness and appropriate conditions to comply with the BFC.

3.2. Study Design and Data Analysis

The State of Santa Catarina is located in Southern Brazil between 25 and 29 degrees S and 48 and 53 degrees W (Figure 1). It has 6.12 million inhabitants, 293 administrative municipalities and covers 95,346,181 km^2 (1.3% of the Brazilian territory) (IBGE, 2010). The farms in this study are concentrated in the southeast in 14 municipalities in a region known as "Braço do Norte" or North Arm and were grouped and analyzed under four dairy coops (Darolt, Della Vitta, Doerner Sul and Geracão).

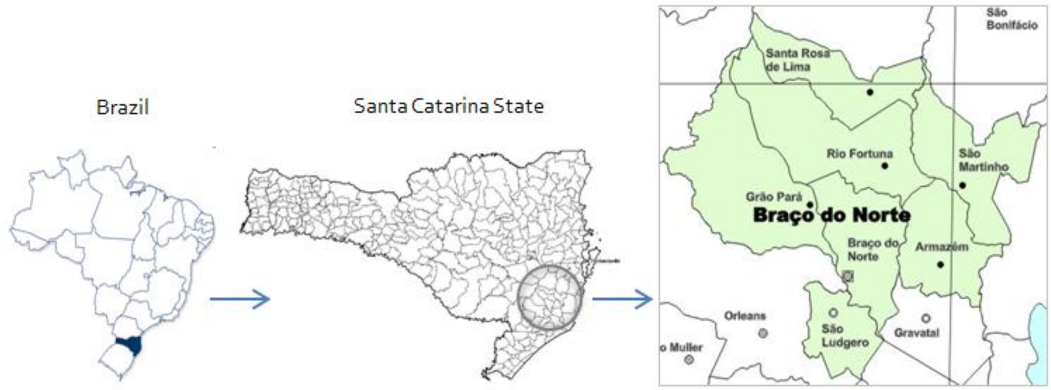


Figure 3.1. Location of the State of Santa Catarina (IBGE 2010)

Santa Catarina has a Cfa subtropical mesothermic humid climate without dry seasons (Köppen-Geiger, 1918). Weather in the region varies widely according to altitude, from sea level in coastal areas to 1,200 m in the mid-western mountains, with the highest peak above 1,800 m (Köppen-Geiger, 1918). The average temperature is 18°C and precipitation is 1,700 mm. Soils in the region are generally poor, acidic and with high declivity. Phosphorus is the limiting element varying from 0.4 to 1.0 ppm, potassium varies from low to medium (54-99 ppm), organic matter reaches up to 2.5%, and pH is generally around 4.6. The vegetation type in the coastal areas is predominantly broadleaf and semi- deciduous broadleaf mixed with conifer *Araucaria angustifolia* in the high-altitude areas accounting for highly complex ecosystem heterogeneity (Brannstrom 2002, Webb et al. 2005). Santa Catarina has approximately 17% of its territory covered with secondary forests and primary forest remnants are rarely found (Tabarelli et al. 2005; Zurita 2006). It currently has the highest absolute levels of deforestation of any Atlantic Forest state (Meister and Salviati 2009). Many generations of farmers have made their living through the goods produced in this biome, either by harvesting timber for industry, or by farming thereafter. From the onset of the Portuguese colonization, the AF has been severely affected by repeated “slash and burn” logging practices for timber and charcoal extraction (Myers 1988). Currently the region has mostly small family farms which practice subsistence agriculture and did extensive dairy not too long ago.

In this context, 61 farms (about 15% of the sample population) were randomly selected from four dairy cooperatives: Darolt (n=15), Della Vitta (n=15), Doerner (n=15) and Geração (n=16). Semi-structured interviews (Rizzoli 2004; Lindlof & Taylor 2010) were conducted *in situ* by the Voisin Grazing Group at the Universidade Federal de Santa Catarina (UFSC). Interviewers asked farmers about their perceptions of the differences between traditional and MIG (i.e., before and after the adoption of MIG). We recognized that farmers’ perceptions can vary among farmers and thus, may not reflect the most accurate results. The questions had several ‘check one’ answer options and some allowed for more than one answer. Farmers had to specifically state their impressions for each “before” and its corresponding “after” question. Four broad topics were addressed: farm demographics, production, ecosystem characteristics (water, soils, erosion, and biodiversity), environmental law and policy (see Appendix A.1: questionnaire). Production and demographic data was supported the by farmer’s records and testimony. For environmental questions, interviewers asked farmers about their perceptions of particular aspects, before and after the adoption of MIG. Farmer’s responses were initially organized in an MS Excel spreadsheet and coded and formatted. Ordinal variables were re-coded in a Likert-type scale using IBM Statistical Package for Social Sciences 20.0 (PASW 2010). Data was then grouped by dairy cooperative, farmer’s age, and farm size. After organizing and summarizing descriptive statistics (including count, means and measures of spread), statistical analyses were performed to assess significant differences and explore relationships in key variables in order to answer the research questions of this study. A one-sample test compared demographic variable means. The paired t-test at $p<0.05$ compared differences in production means before and after MIG adoption. A one-way ANOVA at $p<0.05$ was performed to analyze demographic and production differences. A *post hoc* analysis using Tukey Honest Significance Difference (HSD) at the level of 0.05 assessed multi-comparison effects by dairy coops, farm size and farmer's age.

For the environmental variables, a set of non-parametric tests were applied. The Wilcoxon signed-rank test analyzed whether before and after MIG environmental ordinal variables were significantly different. The McNemar's cross-tabulation also tested associations between before and after MIG variables. Both tests were used to determine whether adoption of MIG improved environmental conditions. A Chi-square (χ^2) test compared differences between expected and observed frequencies to look for associations and the Pearson Chi-square (χ^2) also was used to investigate differences between farm size and farmers' age for interval variables. The Kruskall-Wallis test at $p<0.05$ tested for differences in ordinal variables by stratified variables. Kruskall-Wallis is performed on ranked data, so the measurement observations are converted to their ranks in the overall data set: the smallest value gets a rank of 1, the next smallest gets a rank of 2, and so on (Ott & Longnecker 2008). The Spearman correlation coefficients examined relationships between farmers' age and farm size variables.

3.3. Results

Previous research by (Bauer et al. 2009) suggested that farmers who applied MIG for the three previous years observed improvements in environmental and production variables. Farmers generally reported increases in pasture productivity with 55% reporting a slight increase in pasture area without deforesting new areas. A larger herd size was achieved in 63% of the farms surveyed. Daily total milk production and productivity per animal increased by 80% and 73%, respectively. Improvements in soil cover, soil quality, and soil moisture were reported in 87%, 95%, and 80% of farms surveyed. Farmers also perceived a stabilization and reduction of erosion gullies. Ticks diminished in 73% of the farms, mastitis in 80%, intestinal worms in 67%. Ration fed to animals decreased in 49% of the farms, bedpack manure in the milk parlor fell in 53% and workload fell from 8 to 4 hours per day in 66% respectively. Consequently, 67% of the farms reported better quality of life. Pesticide use dropped in 60% of farms, electric fencing restricted animal access to rivers which decreases in 59% of farms, while riparian buffers increased in 22% of the properties. Thus, perceived water quality improved for 29% of interviewees. Lastly, economic return was optimal or within expectations for 67% of farmers and production costs fell according to 34% of interviewees. If we can accurately corroborate the findings of this previous study with careful statistical analysis, then policymakers may be able to target specific groups of farmers to apply agroecological practices to harmonize conservation of ecosystem functions and sustainable livelihoods. Correspondingly, I assessed how a variety of factors (production, demographic and environmental indicators) can anticipate the possibility to which farmers would adopt alternative agroecological practices such as MIG.

3.3.1. Analysis of Production Variables

Assessing production variables offers evidence of how they varied after adopting MIG. Table 3.1 highlights the production variables with reported significant improvement after MIG was applied. For instance, average daily production, number of heifers, and income each more than doubled after adopting MIG.

Table 3.1. Comparison and differences in production indicators.

Variables[a]	n	Mean (SD)	% change	Paired *t*-test p<0.05
Área used for activities before MIG (ha)	56	10.4(8.9)	8.9	**0.000**
Área used for activities after MIG (ha)	56	11.3(8.8)		
Milking cows before MIG (heads)	56	15.7(9.6)	67.2	**0.000**
Milking cows after MIG (heads)	56	26.3(11.6)		
Young stock before MIG (heads)	41	8(5.7)	104.5	**0.000**
Young stock after MIG (heads)	54	16.4(8.8)		
Production per cow before MIG (l/cow/day)	47	6.5(2.9)	28.6	**0.000**
Production per cow after MIG (l/cow/day)	55	8.3(3.5)		
Ave daily production before MIG (l)	50	105.8(74.7)	102.6	**0.000**
Ave daily production after MIG (l)	57	223.9(123.3)		
Income generated before MIG (USD) (yr)	49	9,981(7,044)	128.6	**0.000**
Income generated after MIG (USD) (yr)	49	21,122(11,632)		

[a] The same data analyzed by dairy cooperatives yielded differences in all variables except, *Area used for activities* in Darolt (p=0.177), Doerner (p=0.683) and Geração (p=0.435) and *Production per cow* in Della Vitta (p=0.105) and Doerner (p=0.832).

Table 3.2 shows differences in demographic and production variables. For example, MIG implementation enabled farmers to greatly increase the number of paddocks, while also reducing the manure in the milk parlor.

Table 3.2. Demographic and production management variables.

Variables	n	Mean (SD)	*t*-test p<0.05
Farmer's age	54	45.6(12)	**0.004**
Family members working in the farm	61	2.5(1.4)	0.785
When did you start using MIG (yrs)	58	3.5(2)	**0.042**
Payment of investments (months)	49	16.6(14.8)	0.224
No. Paddocks	58	41.3(18.6)	**0.000**
For how long using homeopathy on animals? (yrs)	42	13.8(16.3)	0.275
Manure reduction in milk parlor? (%)	31	61(19.6)	**0.000**
Cow pies degradation in the pastures (days)	14	31(13.8)	**0.002**

Table 3.3 shows demographic and production descriptive figures segmented by dairy coops. No differences were hypothesized in variables between different coops, however the ANOVA at $p<0.05$ detected significant differences among eight variables. When analyzing results by stratified dependent variables, Geração farmers were the youngest with an average of 40 years old, and Doerner were the oldest averaging 50 years old. Household size across coops averaged 4. Darolt farmers seemed to have larger herds, higher production and income than the other cooperatives. Repayment periods for the investment greatly varied among cooperatives where Darolt farmers recovered their investments in less than one year, while farmers at Geração needed almost 30 months. Naturally, larger farms had larger herds and produced more after MIG, however no differences were found in production per cow or in income due to farm size. Darolt farmers used homeopathy in animals for the longest time (32 years). Cow pies took longer to degrade in Geração and Doerner farms, 45 and 46 days respectively. In terms of production, Darolt and Doerner produced more milk per day, and along with Della Vita

had higher milk production per cow before MIG, p=0.06. All farms were able to significantly increase their herd sizes and income by 128.6%, however, Doerner farmers had the least number of milking cows, p=0.013 and Darolt and Della Vita had more heifers, p=0.006 (Table 3.3).

Table 3.4 shows results analyzed by farm size with small, medium, and large farms at 0-5 ha, 6-15 ha, and larger than 15 ha, respectively. Cow pie degradation in the pastures differed among farm size, where smaller farms reported twice as much time for the cow pies to decompose in the fields. Larger farms used more area for activities than medium and small ones, however, the overall average area increase after MIG was 8.9%. Smaller farms also produced less milk, had fewer cows in MIG, had fewer heifers, and used less area both before and after MIG respectively.

The same variables found in Table 3.4 were re-grouped by age ("youngest through 34", "34 to 49", and "older than 50") and analyzed using ANOVA. Results revealed that only *age of farmer*, ($F_{2, 53}$ = 89.26, p=0.000), was highly significant.

Table 3.3. Demographic and productive farm analysis by Dairy Coop. in Santa Catarina, Brazil.

Variables	Dairy Cooperative Means (SD)				ANOVA p<0.05
	Darolt (n=15)	Della Vita (n=15)	Doerner (n=15)	Geracao (n=15)	
Age (yrs.)	45(12.6)	45 (10.5)	50(14.6)	40(8.7)	.283
Household size (people)	4.5(1.2)	4.5 (1.5)	3.9(2.1)	4.4(1.5)	.603
Number of paddocks (units)	37(13)	41(10)	48(29)	40(17)	.440
Time using MIG (Yrs)	3.2(.8)	3(1.2)	3.3(1.7)	4.7(3.1)	.069
Payment of investment (mo)	8.5(6)b	16.4(12)ab	13.8(17.5)b	29.5(16.8)	**.003**
Manure reduction in milk parlor (%)	62(17.2)	59(27.6)	60(19.5)	n/a	.943
Use of homeopathy (Yrs)	32(10.3)a	9.8(19)b	2.4(1.4)b	4.7(2.7)b	**.000**
Cow pie degradation (days)	26(11)b	22.6(7)b	46.7(14.4)a	45a	**.034**
Production before MIG (l)	158(59)a	78(75)b	101(80)ab	70(57)b	**.04**
Production after MIG (l)	300(139)a	206(141)ab	162(89)b	167(96)bc	**.01**
Production per cow before MIG (l/cow/day)	7.7(2.7)a	5.5(2.8)ab	8.2(2.9)a	4.5(2)b	**.06**
Production per cow after MIG (l/cow/day)	9.9(3.2)	7.7(4.3)	7.9(4)	7(2.6)	.211
Milking cows before MIG (heads)	21(7.5)a	15(11)a	10(5.4)b	14(9.8)a	**.013**
Milking cows after MIG (heads)	30(11)	26(12)	21(10)	25(12)	.183
Heifers before MIG (heads)	10(5)	9(6)	6(6)	5(3)	.106
Heifers after MIG (heads)	21(6)a	16(8)ab	11(8)b	12(7)b	**.006**
Area before MIG (ha)	9.6(4.5)	13.7(15.2)	9.3(7.6)	9.6(7)	.613
Area after MIG (ha)	10.5(4.6)	13.8(12.8)	9.2(8.1)	10.5(6.3)	.516
Income before MIG (US$ x1,000)	13,5(1,9)	9,7(2)	9,1(2,3)	6,6(1,5)	.080
Income after MIG (US$ x1,000)	25,3(3,2)	21,9(4)	15,9(2,1)	15,8(2,5)	.095

[a] In the letter designations "a" represents highest means, "b" indicates the next highest mean and so forth to denote multi-comparison analyses. Means followed by the same letter in the same row did not significantly differ between dairy coops by Fisher Tukey (p≤0.05).

[b] Sample size denotes the maximum number of farms sampled within each cooperative. Not every farm answered every question.

Table 3.4. Demographic and productive farm analysis by 'Farm Size' in Santa Catarina.

Variables	Farm Size Means (std. dev.)			ANOVA p<0.05
	Small	Medium	Large	
Age (yrs)	41(14)	49(12)	45(11)	.284
Household size (people)	4(1)	4.4(1.4)	4.8(1.5)	.229
Number of paddocks (units)	37(19)	37(11)	47(22)	.152
Time using MIG (yrs)	3(1.8)	3.2(1.3)	4.2(2.3)	.137
Payment of investment (months)	24(21)	15(14)	15.5(13)	.309
Manure reduction in milk parlor (%)	70(14)	61(20)	57(21)	.487
Use of homeopathy (yrs)	5.5(9)	15(13.6)	17.5(20)	.318
Cow pie degradation (days)	52(6)a	25(10)b	25(7.5)b	**.002**
Production before MIG (l)	63(57)	132(91)	105(66)	.112
Production after MIG (l)	114(69)b	227(120)a	253(140) a	**.014**
Production per cow before MIG (l/cow/day)	7(3.7)	7.7(3.3)	6.5(2)	.081
Production per cow after MIG (l/cow/day)	7.2(2)	9.3(4.6)	8(3.4)	.333
Milking cows before MIG (heads)	9(5.7)b	15(9.5)ab	20(9.5)a	**.005**
Milking cows after MIG (heads)	16(4.6)b	24(9.5)b	32(11.8)a	**.000**
Heifers before MIG (heads)	4(2)b	8(5)ab	11(6.5)a	**.013**
Heifers after MIG (heads)	8(5.4)c	15(7.3)a	19(8)a	**.004**
Area before MIG (ha)	3.8(2.1)c	6(2.9)bc	16.8(10)a	**.000**
Area after MIG (ha)	3.9(1.3)c	7.3(1)bc	17(9.5)a	**.000**
Income before MIG (US$)	8,413	12,106	9,207	.330
Income after MIG (US$)	19,673	22,525	17,509	.357

[a] In the letter designations "a" represents highest means, "b" indicates the next highest mean and so forth to denote multi-comparison analyses. Means followed by the same letter in the same row are not significantly different between farm size by Fisher Tukey ($p \leq 0.05$).

[b] Farm sample size varies by variable because not every farm answered every question.

3.3.2. Analysis of Environmental Variables

Interviewees were asked about their perceptions on the effects of MIG adoption on their farms in relation to environmental variables (soils, water, biodiversity, pasture coverage, forest remnants, etc.). As in the case of production variables, the intention was to verify whether the adoption of MIG had significant differences in generating conditions for ecosystem services. Table 3.5 summarizes differences in environmental variables before and after MIG implementation using Wilcoxon sum-rank test.

Table 3.5. Wilcoxon sum-rank test comparison of environmental variables before and after MIG adoption.

Variables[a]	n	Mean ranks	Z	p<0.05
Was there any kind of forest remnant and water preservation? Is there any kind of forest remnant and water preservation?	60	10.5 10.5	-4.025	**0.000**
Were water sources protected? Are water sources protected?	33	5.5 5.5	-1.696	0.090
Were riparian buffers protected? Are riparian buffers protected?	58	20.0 20.0	-4.003	**0.000**
Animals had access to APP[a] Animals have access to APP[a]	42	1.0 .0	-1.000	0.317
Which was the frequency of pasture renovation? Which is the frequency of pasture renovation?	59	13.06 20.08	-.258	0.797
Did you over seed grasses and legumes for winter pasturing? Do you over seed grasses and legumes for winter pasturing?	47	21.43 18.5	-4.527	**0.000**
Did you observe microfauna on your pastures? Do you observe microfauna on your pastures?	46	0.0 14.5	-5.209	**0.000**
Which was the frequency of pasture burn? Which is the frequency of pasture burn?	61	1.0 0.0	-1.000	0.317

[a] APP: (Areas de Preservação Permanente) Permanent Preservation Areas.

About 32% of farms perceived significant improvement in forest remnants and water source preservation after MIG. Around 55% protected buffers after MIG compared to 12% before MIG. Over 74% of farmers over seeded grass/legume mixtures for winter pasturing, while almost 13% does it currently. Sixty one percent of the respondents stated that they observed micro fauna (insects, worms, etc.) on the pastures compared to previous continuous grazing system.

A Kruskal-Wallis test further evaluated differences on mean changes in different environmental variables between the four dairy cooperatives surveyed. Kruskal-Wallis evaluates ranks which represents the mean rank of the variable scores for each cooperative group. When analyzed by farmer's age, *preservation of forest and water remnants*, *protection of water sources, improvements in water quality*, *frequency of pasture renovation, change in erosion gullies* and *milk increase per cow* all differed at $p<0.05$ Further Kruskal-Wallis tests found no differences due to farm size.

3.3.3. Relationships Between MIG Adoption and Environmental Variables

Association between variables was tested using the McNemar, the Pearson chi square and Spearman correlation tests. The McNemar chi-square found that before adoption of MIG, 83% of farms surveyed stated that *animals had access to permanent preservation areas*, while none accessed these areas after MIG ($p=0.000$). There was also a significant association between *forest remnants* and *preservation of water sources* after MIG adoption ($p=0.000$). When asked whether water source protection after MIG was *in accordance to the law*, most respondents agreed ($p=0.040$). Almost 64% of farmers *over seed grasses and legumes for winter pasturing* versus 6.4% before MIG adoption ($p=0.000$). Over 34% observed *macroinvertebrates* (beetles, worms, etc.) in their pastures before MIG while 58.7% observed after. Except for one farmer, no one practiced pasture burning.

A Pearson chi-square test evaluated the relationship between farmers' age and farm size. *Change in erosion gullies* differed by farmers' age, (χ^2(2, n=27) = 6.034, p=0.049) where farmer ages 35-49 and over 50 observed stabilization of their erosion gullies. *Frequency of pasture renovation* also differed by farmers' age, (χ^2(6, n=54) = 14.225, p=0.027) where 78% of the farmers between 35 and 49 years old have never renovated their pastures.

A Spearman correlation was also calculated to test the association between variables by farm size and by farmers' age. There was a significant negative correlation between farmers' age and *changes in erosion gullies* (ρ(n=27) = -0.454, p=0.017), where the younger the farmer, the higher the likelihood for the farm to have erosion gullies. About 59% of mid-age and older farmers (34-49 y/o and 50+ y/o) reported that erosion gullies were stabilizing and 33.3% said they were decreasing (p=0.049). *Frequency of pasture renovation* and age of the farmer had a negative correlation (ρ(n=54) = -0.301, p=0.027). This means that the younger the farmer, the lower the *frequency of pasture renovation*. In fact, 75% of younger and 77% of mid age (34-49 y/o) farmers said they have never renovated their pastures. There was a negative correlation (ρ(n=40) = -0.342, p=0.031) between farmers' age and *winter grass/legume over seeding after MIG*. In contrast, there was a positive correlation (ρ(n=51) = 0.325, p=0.020) between *milk increase per cow after MIG* and farmers' age. Lastly, a negative correlation (ρ(n=55) = -0.278, p=0.04) between farm size and *winter grass/legume over seeding before MIG* suggesting that fewer smaller farms adopted the practice.

3.4. Discussion

The goal of this research was to determine the effects of MIG on production, pest incidence, environmental variables and environmental awareness. One of the most significant results of this study was demonstrating the effectiveness of MIG on increasing production while reducing pest incidence variables. MIG implementation also led to improved environmental awareness and soil quality indicators and data partially supported an improvement in water quality indicators. The following discussion considers the changes of both production and environmental variables in comparison with before and after the adoption of MIG practices.

3.4.1. Production Variables

Farmers who adopted MIG raised the number of animals, daily production, productivity per cow and income, while barely increasing the total land area used for grazing (Table 3.1). Maraschin (1994) points out that traditional grazing can produce more per cow than rotational grazing during the highest producing season, however, in this study cows produced 28% more on average after MIG. Similarly, numerous other studies have found significant production increases per area after switching from continuous grazing to MIG (P. D. Walton 1981; Murphy et al. 1986; Romero 1994; Pinheiro Machado 2004b). The likely explanation for this improved production is the higher pasture production caused by change in grazing management (Walton et al. 1981). According to Pinheiro Machado (2004b), well managed pastures under MIG can potentially produce up to eight times more than continuous grazing. Bauer and others

(2009) also found that feed supplementation dropped in 49% of the farms that adopted MIG after three years.

Perhaps one of the keys for the success of the production variables was the careful implementation of the Four Universal Laws of MIG (Voisin 1988), supervised by the Voisin Grazing Group. These laws address forage and animal needs. The First Law or “Rest Law” states that forage must be managed in such a way that recovery periods between grazings are long enough to restore forage to an optimum height. In this stage, carbohydrates are replenished in the roots (Voisin 1988). The Second Law emphasizes that occupation periods (of the pasture paddocks) must be short enough so that the grass regrowth is not re-grazed. The Third Law states that animals with higher nutritional requirements need to graze the greatest amount of high quality forage. To accomplish the Fourth Law, animals that produce regular yields must not stay longer than three days on the same pasture (Voisin 1988). This is achieved by concentrating high-stock animal density in limited areas for a short period of time. Reardon et al. (1972) suggested that grazers can stimulate plant growth through thiamine (Vitamin B_1) present in cows’ saliva, which is interpreted as an evolutionary mutualism between grasses and grazers by Owen and Wiegart (1981). By subdividing grazing areas into an average of 41 paddocks amongst the surveyed farms (compared to ten or less paddocks before MIG), animals were more likely to graze high quality forage. This allows high concentrations of organic matter (via manure and urine) directly over the pastures, boosting soil biodiversity and fertility, thereby increasing forage production.

Higher soil biodiversity also decomposes cow pies faster and manure droppings in the milk parlor were reported to be drastically reduced. This may have reduced the incidence of flies and mastitis, and thus bacterial infection (Table 3.6). Despite the fact that most farms reduced pesticide applications, pest incidence (*ticks, worms*, *flies*, and *other sanitary problems*) decreased across farms after MIG. This is possibly due to the break in the pest cycle caused by well-managed pastures. With short occupations and long rest periods, each paddock is only occupied for a half a day average, a total of only a few days in a year. This gives each paddock plenty of time to recover. Consequently, some pests will potentially not be able to complete their life cycle without a host (the cow) especially during long winter rest periods, explaining the drop in pest incidence.

3.4.2. Environmental Variables

Environmental variables such as soil moisture, forage cover, and management of forest remnants all demonstrated improvement after MIG. However, water quality variables and the status of permanent preservation areas did not show similar improvements, especially amongst smaller farms located in sensitive ecological areas. Table 3.5 highlights significant changes in *winter grasses/legume over seeding* and *presence of microfauna* (both at $p < 0.000$), after MIG adoption. The presence of micro fauna denotes the existence of habitat for biodiversity, an important ecosystem service. This is due to the high-stock density which deposits large amounts of manure and urine which play a key role in feeding soil microorganisms and boosting soil fertility causing a chain reaction effect in the rest of organisms (Sjodin et al. 2008; Giraldo et al. 2011).

Most survey participants observed more humidity in their soils due to more soil cover. Consequently, after the implementation of MIG, erosion gullies stabilized and in some cases were reduced. This is because MIG takes into account the needs of soil, plants and animals, and promotes the conservation of ecosystem services more generally (Melado 2007a).

Farmers also had a positive attitude about the presence of trees on pasture. However, while forest remnants and water sources preservation and buffer protection, after MIG, were highly significant, it was found that some farmers do not (or cannot) protect water sources and buffers, supporting the findings of Bilotta et al. (2007). The main reason is that a large percentage of their farms are inconveniently located in these sensitive areas, owing to the steep terrain with numerous waterways, thereby interfering with the generation of ecosystem services. Occupying permanent preservation areas such as hilltops and riparian buffers and areas with sources of water may impair ecosystems affecting the flow of services to agriculture as indicated by Zhang et al. (2007).

Environmental awareness variables improved after MIG according to the perceptions of interviewed farmers. Most respondents said that they would not be willing to recover damaged permanent preservation areas ($p<0.000$); but most farmers asserted that if they received compensation, they would change their behavior. When asked, "would you be willing to receive a compensation to conserve forest and adopt better management practices", most would accept a compensation for preserving permanent preservation areas. Similarly, Costa Rica compensate farmers through payments for ecosystem services for complying with the Law and preserving forests (Pagiola, 2008).

3.5. Implications of Agroecological Practices for the Conservation of Atlantic Forest and Sustainable Livelihoods

MIG is increasingly becoming a common practice among farmers, largely motivated by its potential to lower costs, increase production per unit land area, and thus increase net revenues (Winsten et al. 2000b). These production improvements can also come along with improvements in environmental management, with a broader group of beneficiaries beyond the farm-level. The results of this study confirmed that MIG increased production, decreased pests, and enhanced environmental variables, supporting the case for a viable production system to improve the sustainability of farmers' livelihoods and complement environmental conservation efforts. These results also support the work of numerous studies (P. D. Walton 1981; Murphy et al. 1986; Voisin 1988; Murphy 1996; Winsten 1999; Pinheiro Machado 2004b; Rotz et al. 2009; Farley et al. 2011b).

Despite the potential environmental improvements of MIG over traditional grazing, there still remains the question of the appropriate scale of agriculture in the Atlantic Forest, a biodiversity hotspot. The original 1.5 million km^2 forest has been almost entirely deforested to satisfy both urban and agricultural expansion (Schäffer & Prochnow 2002). Balmford et al. (2002) have argued the case for the conservation of nature, but current population growth trends continue to place greater and greater demands on the food system and supporting ecosystem services. Creation of new public protected areas have been greatly constrained by a lack of government funds (McNeely & Miller 1984). As a result, most of the non-protected Atlantic Forest remains fragmented and is seriously threatened by land use changes. In this respect, the creation of protected areas seems essential for developing national and regional biodiversity conservation strategies and policies. An instrument, the BFC has sought to regulate Brazil's natural resources along a protection gradient as a common national interest. The code categorized four types of forests areas: (1) productive (by permit); (2) protective, specifically, forests protecting watersheds, soils, water bodies, biodiversity and cultural aspects; (3) replanted forests; and (4) forest remnants, meaning forests in national, state and municipal areas. The categories "protective" and "remnant" were set aside for permanent protection creating 16 national parks (Baptista 2008). In 1965 the BFC was updated introducing the concept of "permanent protection areas" (APP) and recognized Brazil's biomes as national patrimony. It also demanded a minimum preservation of 20% of native vegetation in farms in the Atlantic Forest (in Amazon region 80% preservation has been required since 1996 among other regulations, licensing penalties, and creation of protected areas (Baptista 2008).

However, a fragmented system of protected areas alone is insufficient to improve biodiversity conservation of this hotspot (Mesquita 1999; Morsello 2001; Câmara 2002; Mesquita 2002; Milano 2002). Also, conservation laws fail to recognize potential complementarities to forest protection that can come from farming practices that increase beneficial ecosystem services and take pressure off further deforestation by improving farm productivity and sustainable livelihoods. The 2008 version to the forest code allowed small farmers agroforestry practices in the APPs, .

In this study, most smaller farms were located in permanent preservation areas (e.g., hilltops, water sources, and riparian areas), clearly infringing on the BFC regulations. The current Government of Santa Catarina is then faced with a choice between allowing farming in strictly protected areas or displacing farmers and negatively impacting farmer livelihoods and communities. Despite significant improvements in some ecosystem services after MIG adoption, MIG alone cannot fully restore ecosystem structure or forest loss. However, MIG could help to limit (or even reverse) deforestation. Survey results found that farmers doubled milk production and nearly doubled the number of animals without significantly increasing their farming area. Also, most farmers (particularly the smaller ones) were not fond of the idea of protecting and conserving forest remnants and permanent preservation areas but were favorable to receiving a compensation for this effort. Since most farmers perceived trees on pasture as an advantageous feature, the complement between MIG and trees in a silvo-pastoral or agroforestry arrangement seems to be an obvious immediate solution. Furthermore, the re-incorporation of native trees on pasture and the restoration of riparian areas with native species contributed to increasing biodiversity without reducing (and perhaps increasing) dairy production.

Additionally, the idea of a co-investment in stewardship scheme could support farmer's adoption of these agroecological practices in an arrangement similar to the one proposed by Farley et al. (2011b) where payments are used to finance the adoption of agroecological practices. Our results suggested that smaller farmers would still need further technical and financial support in order to cope with the BFC because of the location of their farms and as a poverty alleviation solution. In this respect, ideas such as "Bolsa Floresta" or forest stipend program, directed to poor family farms as seen in the Amazon State, can be viable alternatives to reduce both deforestation and poverty.

3.6. References

Balmford, A., A. Bruner, P. Cooper, R. Costanza, S. Farber, R. E. Green, M. Jenkins, P. Jefferiss, V. Jessamy, J. Madden, K. Munro, N. Myers, S. Naeem, J. Paavola, M. Rayment, S. Rosendo, J. Roughgarden, K. Trumper, and R. K. Turner. 2002. Economic Reasons for Conserving Wild Nature. Science 297:950-953.

Baptista, S. R. 2008. Forest Recovery and Just Sustainability in the Florianopolis City-Region. Page 406. Geography. Rutgers, The State Unuversity of New Jersey, New Brunswick, NJ.

Bauer, E., A. L. Schmitt F, J. Epping, and J. Farley. 2009. Dairy Production in Florianópolis: Farmers' Perceptions about the Transition from Conventional Dairy to Voisin Management Intensive Grazing. Pages 2716-2720. Resumos do VI CBA e II CLAA. Rev. Bras. De Agroecologia, Curitiba, Brazil.

Bilotta, G. S., R. E. Brazier, and P. M. Haygarth. 2007. The Impacts of Grazing Animals on the Quality of Soils, Vegetation, and Surface Waters in Intensively Managed Grasslands. Pages 237-280 in L. S. Donald, editor. Advances in Agronomy. Academic Press.

Brooks, T. M., R. A. Mittermeier, G. A. B. da Fonseca, J. Gerlach, M. Hoffmann, J. F. Lamoreux, C. G. Mittermeier, J. D. Pilgrim, and A. S. L. Rodrigues. 2006. Global biodiversity conservation priorities. Science 313:58-61.

Câmara, I. d. G. 2002. A política de unidades de conservação: uma visão pessoal in M. S. o. Milano, editor. Unidades de conservação: atualidades e tendências. Fundação O Boticário de Proteção à Natureza, Curitiba, PR Brazil.

Cincotta, R. P., J. Wisnewski, and R. Engelman. 2000. Human population in the biodiversity hotspots. Nature 404:990-992.

Costa, L. P., Y. L. R. Leite, S. L. Mendes, and A. D. Ditchfield. 2005. Mammal Conservation in Brazil:672-679.

Daily, G. C., Susan Alexander, Paul R. Ehrlich, Larry Goulder, Jane Lubchenco, Pamela A. Matson, Harold A. Mooney, Sandra Postel, Stephen H. Schneider, David

Tilman, and G. M. Woodwell. 1997. Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems. Ecological Society of America 2:18 p.

Ditt, E. H., J. D. Knight, S. Mourato, C. V. Padua, R. R. Martins, and J. Ghazoul. 2008. Defying legal protection of Atlantic Forest in the transforming landscape around the Atibainha reservoir, south-eastern Brazil. Landscape and Urban Planning 86:276-283.

Ditt, E. H., S. Mourato, J. Ghazoul, and J. Knight. 2010. Forest conversion and provision of ecosystem services in the Brazilian Atlantic Forest. Land Degradation & Development 21:591-603.

Farley, J., A. Schmitt Filho, Juan Alvez, and N. Ribeiro de Freitas, Jr. 2011. How Valuing Nature Can Transform Agriculture. Solutions 2:64-73.

Foley, J. A., G. P. Asner, M. H. Costa, M. T. Coe, R. DeFries, H. K. Gibbs, E. A. Howard, S. Olson, J. Patz, N. Ramankutty, and P. Snyder. 2007. Amazonia revealed: forest degradation and loss of ecosystem goods and services in the Amazon Basin. Frontiers in Ecology and the Environment 5:25-32.

Gibson, D. J. 2009. Grasses and grassland ecology. Oxford University Press.

Giraldo, C., F. Escobar, J. D. CharÁ, and Z. Calle. 2011. The adoption of silvopastoral systems promotes the recovery of ecological processes regulated by dung beetles in the Colombian Andes. Insect Conservation and Diversity 4:115-122.

Grelle, C. E. V. 2003. Forest Structure and Vertical Stratification of Small Mammals in a Secondary Atlantic Forest, Southeastern Brazil. Studies on Neotropical Fauna & Environment 38:81.

Harris, P. S. 2000. Grassland resource assessment for pastoral systems in FAO, editor. Fao Plant Production and Protection Paper. Food and Agriculture Organization of the United Nations, Rome.

ICEPA. 2009. Síntese Anual da Agricultura de Santa Catarina 2008-2009 in I. C. C. d. S. e. P. Agricola, editor.

Lindlof, T. R., and B. C. Taylor 2010. Qualitative Communication Research Methods. SAGE Publications.

Lund, H. G. 2007. Accounting for the World’s Rangelands. Rangeland:3-10.

Maraschin, G. E. 1994. Sistemas de Pastejo. Pages 337-376 in A. M. Peixoto, Moura, J.C. de, e Faria, V.P., editor. Pastagens: Fundamentos da Exploracao Racional. FEALQ, Piracicaba.

McNeely, J. A., and K. R. Miller 1984. National Parks, Conservation and Development: the Role of Protected Areas in Sustaining Society. Smithsonian Institution, USA.

MEA 2005a. Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: A Framework for Assessment. Island Press, Washington, DC.

MEA 2005b. Millennium Ecosystem Assessment: Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Melado, J. 2007. Pastagem ecológica e serviços ambientais da pecuaria sustentavel. Revista Brasileira de Agroecologia 2.

Mesquita, C. A. B. 1999. Conservación privada en América Latina: el caso de las Reservas Particulares del Patrimonio Natural, Brasil. II Congreso Interamericano de Conservación Privada, Sarapiquí, Costa Rica.

Mesquita, C. A. B. 2002. Capacitação como meio para conservar terras privadas. Anais do III Congresso Brasileiro de Unidades de Conservação. Rede Pró-Unidades de Conservação.

Metzger, J. P. 2009. Conservation issues in the Brazilian Atlantic forest. Biological Conservation 142:1138-1140.

Fundação O Boticário de Proteção à Natureza, Brazil.

Milano, M. S. 2002. Por que existem as unidades de conservação? in M. S. o. Milano, editor. Unidades de conservação: atualidades e tendências. Fundação O Boticário de Proteção à Natureza, Curitiba, PR Brazil.

Morsello, C. 2001. Áreas protegidas públicas e privadas: seleção e manejo. Annablume e Fapesp, São Paulo, Brasil.

Murphy, B., J. Silman, L. McCrory, S. Flack, J. Winster, D. Hoke, A. Schmitt and B. Pillsbury 1996. Environmental, economic, and social benefits of feeding livestock on well managed pasture. Tufts University Press, Boston.

Murphy, W. M. 1998. Greener pastures on your side of the fence: better farming with Voisin management intensive grazing. Arriba Pub, Colchester, VT.

Murphy, W. M., J. R. Rice, and D. T. Dugdale. 1986. Dairy farm feeding and income effects of using Voisin grazing management of permanent pastures. American Journal of Alternative Agriculture 1:147-152.

Myers, N. 1988. Threatened biotas: "Hot spots" in tropical forests. The Environmentalist 8:187-208.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, and J. Kent. 2000a. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. d. Fonseca, and J. Kent. 2000b. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

Ott, L., and M. Longnecker 2008. An introduction to statistical methods and data analysis. Brooks/Cole Cengage Learning.

Owen, D. F., and R. G. Wiegert. 1981. Mutualism between Grasses and Grazers: An Evolutionary Hypothesis. Oikos 36:376-378.

P. D. Walton, R. M., A. W. Bailey. 1981. A Comparison of Continuous and Rotational Grazing. Journal of Range Management 34:3.

Pagiola, S. 2008. Payments for environmental services in Costa Rica. Ecological Economics 65:712-724.

PASW. 2010. PASW Statistical Package. SPSS, Inc., Chicago, IL.

Pinheiro Machado, L. C. 2004. Pastoreo Racional Voisin: Tecnologia agropecuaria para el tercer milenio. Hemisferio Sur, Buenos Aires.

Reardon, P. O., C. L. Leinweber, and L. B. Merrill. 1972. The effect of bovine saliva on grassess. Pages 206-210. Proc. West. Sec. Am Soc. Anim. Sci.

Reynolds, S. G. a. J. F. 2005. Grasslands: developments, opportunities, perspectives in S. P. Inc, editor. Enfield, and FAO, Rome, Italy.

Riethmuller, P. 2003. The social impact of livestock: A developing country perspective. Animal Science Journal 74:245-253.

Rizzoli, A. 2004. Grupo de Pastoreio Voisin: Resultados de Parcerias entre EPAGRI, Acadêmicos e Professores da UFSC e Unisul, Prefeituras Municipais, Sindicatos e ONGs. Departamento de Zootecnia. Universidade Federal de Santa Catarina, Florianopolis, SC Brasil.

Romero, N. F. 1994. Alimente seus pastos com seus animais. Livraria e Editora Agropecuária Ltda., Guaíba - RS.

Rotz, C. A., K. J. Soder, R. H. Skinner, C. J. Dell, P. J. Kleinman, J. P. Schmidt, R. B. Bryant, and A. USDA. 2009. Grazing Can Reduce the Environmental Impact of Dairy Production Systems. Forage and grazinglands.

Schäffer, W. B., and M. Prochnow. 2002. A Mata Atlântica e você: como preservar, recuperar e se beneficiar da mais ameaçada floresta brasileira. Page 156 pp. in Apremavi, editor, Brasília, Brasil.

Silvano, R. A. M., S. Udvardy, M. Ceroni, and J. Farley. 2005. An ecological integrity assessment of a Brazilian Atlantic Forest watershed based on surveys of stream health and local farmers' perceptions: implications for management. Ecological Economics 53:369-385.

Sjodin, N. E., J. Bengtsson, and B. Ekbom. 2008. The influence of grazing intensity and landscape composition on the diversity and abundance of flower-visiting insects. Journal of Applied Ecology 45:763-772.

Souto, L. E. 2009. Código (anti) ambiental de Santa Catarina. O Eco on-line: http://www.oeco.com.br/convidados/64-colunistas-convidados/21295-codigo-anti-ambiental-de-santa-catarina.

Tabarelli, M., L. P. Pinto, J. M. C. Silva, M. Hirota, and L. Bede. 2005. Challenges and Opportunities for Biodiversity Conservation in the Brazilian Atlantic Forest. Conservation Biology 19:695-700.

Voisin, A. 1988. Grass Productivity. Island Press.

Walton, P. D., R. Martinez, and A. W. Bailey. 1981. A Comparison of Continuous and Rotational Grazing. Journal of Range Management 34:19-21.

Winsten, J. 1999. The profitability of management-intensive grazing for northeastern dairy farms. American Journal of Agricultural Economics 81:1296-1296.

Winsten, J. R., R. L. Parsons, and G. D. Hanson. 2000. A Profitability analysis of dairy feding systems in the Northeast. Agricultural and Resource Economics Review 29.

Zhang, W., T. Ricketts, C. Kremen, K. Carney, and S. Swinton. 2007. Ecosystem services and dis-services to agriculture. Ecological Economics 64:253-260.

Zurita, G. A., N. Rey, D. M. Varela, M. Villagra, and M. I. Bellocq. 2006. Conservation of the Atlantic Forest into native and exotic tree plantations: effects on bird communities from the local and regional perspectives. Forest Ecology and Management 235:164-173.

CHAPTER 4: DAIRY MANAGEMENT SYSTEMS COMPARISON ACROSS SUSTAINABILITY INDICATORS

Abstract

Fifty-two Vermont dairy farms were mailed a self-assessment survey to evaluate how their farming practices compare economically, socially, and environmentally between three management practices. The survey included nine sections on animal husbandry, biodiversity, community health, energy, farm financials, nutrient management, pest management, soil health, and water management. The three management methods included traditional grazing, management intensive grazing and confinement operations. Following a farm education component, the same farms were re-assessed two years later to investigate any changes in practice and topics of concern. Pasture-based farms, particularly those implementing management intensive grazing, had significantly fewer cows, less acreage, and produced less milk than confinement operations, however they scored higher on farm financials and soil management. Most indicators improved on the second assessment for all management types, demonstrating an impact from education and access to information on improving management practices and sustainability.

4.1. Introduction

The dairy industry in the United States has changed dramatically in the last fifty years, shifting from an extensive system of small and medium-sized farms owned by family farmers, to a system of large, intensive operations where cattle are housed and fed in confined structures. There has been a consequent sharp decline in the number of dairy farms. These changes have brought about significant yield improvements, but have also created new challenges in dairy management with environmental performance, public health, farm finance, rural community stability, and the health and well-being of livestock (PewCommision 2008).

High yields in agricultural systems can often be credited to irrigation and agrichemical inputs (fertilizer, pesticides), which are highly dependent on fossil fuels, leveraged capital, externalizing wastes, and often poor treatment of animals (MEA 2005a; Mooney et al. 2005; Jackson et al. 2007). Livestock systems are major drivers of environmental change in particular, affecting the sustainability of farming livelihoods, communities, and ultimately the critical resources of water and soil (MEA 2005a; Steinfeld et al. 2006; Koneswaran & Nieremberg 2008; Pelletier & Tyedmers 2010). According to Steinfeld et al. (2006) livestock systems represent only 1.5% of all world gross domestic product (GDP) and provide 8% of all calories. Yet they contribute 18% of total anthropogenic greenhouse gas, take up 35% of all arable land for feed, are responsible for 58% of the anthropogenic biomass appropriation, consume 8% of the planet's fresh water, and occupy 26% for pasture (Steinfeld et al. 2006).

Within the global livestock sector, dairy production was about 710.3 million tons in 2010, a growth of 1.6% compared to the same period of 2009 and a rise of 2.1% in the last decade (Hemme & Otte 2010). However, between 2002 to 2007, global milk production grew by 13%, driven by increases in production in China, India and Pakistan, which rely predominantly on smallholder production (Hemme & Otte 2010). The major global milk production regions are Asia and EU-25, accounting for 44% (23% and 21%, respectively), the US 12%, Latin America and Russian Federation 10% each, East and South East Asia 8%, Africa 5%, Oceania and Near and Middle East 4% each. Prices reached a peak in 2008 when they were 20% higher than in 2010, and twofold compared to the period between 2002 and 2004 (Hemme & Otte 2010).

An inter-regional competitiveness cross-country comparison report of dairy farming showed that, in general, most Western European countries were unprofitable with the exceptions of very large dairy farms (Heinrich & Hinrichs 2000). Ireland and the United Kingdom benefit from relatively low labor, building and forage costs; Belgian and Swedish farmers were the most successful due to high yields, direct marketing and high milk and heifer prices. Hungary and Poland had lower productivity and the lowest wage rates. New Zealand farmers on the other hand, produce milk at the lowest cost in the world due to weather conditions but mainly because of their dairy management system where cows graze in fenced areas year round (Heinrich & Hinrichs 2000).

In the United States the latest trends show that farms are getting larger with more cows and each cow is producing more milk. The number of US dairy farms has decreased by 38.9% while the number of milking cows went down by 12.8% from 1997 to 2007 and production per cow has increased steadily since 1970 to 2006. Also, between 2000 to 2006, farms with less than 100 cows decreased by 29%, while farms with more than 499 cows rose by 44 % (USDA-NASS 2007).

Between 1960 and 2006, the total number of dairy farms in Northeastern United States (including New York, Vermont, Pennsylvania, Maryland, New Hampshire, Massachusetts, Rhode Island, Connecticut, and Maine) has decreased by 83%. The number of milking cows in the region has increased by 49%. Yet, the average milk production per cow has more than doubled over this period (USDA, NASS, 2007). The present tendency is consolidating fewer but larger farms (Figure 2) (Mac Donald et al., 2007) which is also confirmed by Hinrichs & Welsh (2003). Moreover, although the average herd size in the U.S. dairy is only 80 cows, industrial dairy herd size ranges between 500 and over 1,000 cows (Hinrichs & Welsh 2003). Dairy size is known to be directly related to the dairy system management and quality of life of surrounding communities (Hinrichs & Welsh 2003). Many researchers found an inverse relation between dairy size operation, the quality of life of the community and the profitability of dairy farms while comparing small and medium size farms who practice management intensive grazing with conventional dairy (Murphy 1998b; Hinrichs & Welsh 2003; Foltz & Lang 2005).

Dairy industry largely dominates commodity production in Vermont. There are over 64 thousand milking cows in 864 dairy farms with up to 99 cows, while there are over 171 thousand milking cows in 370 dairy farms with a herd size ranging from 100-2,500 (USDA-NASS 2007). The census data also indicates that the median farm size in Vermont has systematically decreased 10% from the last census in 2002 from 100 to 90 acres, being Essex, Orleans and Addison the counties that had the biggest acreage decrease (-41.9%, 24.3% and 20% respectively). Only Grand Island and Rutland counties increased farm acreage (12.4% and 9.9% respectively) (USDA-NASS 2007).

In these circumstances, the need for intensification to meet the demand for dairy products must take into consideration the environment and the rural communities. Yet, it must follow agroecological principles that promote benefits to farmers, ecosystems and society. For example, dairy farming is an activity that relies typically on supplemental feed produced usually away from the farm in an unsustainable manner (Steinfeld et al., 2006). Supplemental feed, most of the time, is not sustainable because it has to travel long distances to the farm gate increasing costs, using fossil fuels and lowering overall efficiency (Steinfeld et al., 2006). In these conditions, grain fed animals and humans are set to compete for the same feed, land and water resources (Koneswaran & Nieremberg 2008). Hence, the sustainability of dairy farms plays a very important social, economic, and environmental role in the future of the US and Vermont dairy sector. Throughout the world, the critical role of livestock and its contribution to the livelihoods of 70 to 75% of rural household incomes and rural communities is undeniable (LID 1999; IFAD 2004). For example, livestock animals help to maintain crop yields by enabling the flux of nutrients in mixed crop-livestock systems. However, some dairy practices are known for having more significant effects on social, economic, and environmental sustainability aspects than others. In light of these dairy management contributions to environmental degradation, it is necessary to discuss a more sustainable and appropriate dairy industry, beginning by looking at dairy farms and their farming methods.

The focus of this study was to assess which dairy management systems, included traditional grazing, management intensive grazing and confinement operations, could provide a more sustainable outcome among nine sustainability modules: animal husbandry, biodiversity, community health, energy, farm financials, nutrient management, pest management, soil health, and water management. Furthermore, I assessed whether the scores of the nine modules improved over time after access and participation to information and educational workshops to farmers.

4.1.1. Dairy Farm Practice and Sustainability

The move towards more sustainable dairy is a systemic activity that affects ecosystems and rural livelihoods and is influenced by several dynamic factors. Sustainable dairy management considers its effects on soils, water, biodiversity, and energy use, as well as social dimensions of farmer livelihoods and rural community well-being. To measure and manage for sustainability typically involves a range of economic, social, and environmental indicators. This study considers a range of sustainability indicators across three diary management practices in Vermont: traditional grazing, confinement operations, and management intensive grazing.

One of the most widely practiced methods in the world in pastoral lands is continuous (or traditional) grazing. This practice is performed throughout the whole season, in often large, undivided areas resulting in reduced forage yield and quality due to the lack of pasture rest between grazing periods. Continuous grazing shows disadvantages compared to rotational grazing especially when forage availability is low (Suttie, et al. 2005). The main agronomic disadvantages of traditional grazing is that plants are not allowed sufficient time to recover between grazings, often resulting in spots of bare soil, presence of weed lumps due to grazing selectivity by the animals, and cow pies that delay to decompose. When cow pies delay to decompose it indicates low biodiversity activity in the soil (Pinheiro Machado 2004b). Pasture quality and quantity often declines as the season evolves and can ultimately lead to overgrazing and undernourished animals. Overgrazing is a major cause of environmental impact because it can cause above and below ground biodiversity and fertility loss, erosion, more weeds, lower infiltration rates, and higher runoff (Suttie, et al. 2005).

Rotational grazing (not to be confused with management intensive grazing) is a partial improvement to traditional grazing. Animals are rotated through pastures in a fixed rotation without considering seasonality, forage availability and recovery periods. This affects the forage growth rate, which negatively influences the quality and quantity of forage causing “untoward acceleration” where at certain point of the process, forage becomes scarcer reducing production (Voisin 1988; Murphy 1998b; Pinheiro Machado 2004b). As cows are rotated throughout paddocks that are not fully recovered, pasture availability and quality will decline and can present the same characteristics of continuous grazing.

According to standards of the Norheast Organic Farming Association, management intensive grazing (MIG) consists of following a pasture plan where animals aged six month or older are required to be placed on a minimum of 0.75 acres of pasture per lactating animal pasture during the growing season (NOFA, 2007). These animals must receive at least 30 percent forage feed over no less than 120 days a year and must have access to the outdoors on a daily basis. MIG pastures are managed in ways that prevent erosion and water quality problems as riparian zones must be fenced out to stabilize banks and avoid erosion and runoff (NOFA, 2007). MIG principles allocate several animals in small pastures (called paddocks), for short periods of time (up to three days) providing them with high quality forage and keeping them healthy by providing ample exercise and sunshine (Pinheiro Machado 2004b). MIG is particularly suitable for small farmers because it reduces the amount of labor and capital needed compared to feedlot systems while consuming significantly less hay and producing higher output per area compared to continuous grazing (Pinheiro Machado 2004b). Environmentally, MIG produces significantly less soil erosion and less greenhouse gas emissions, averaging 10 percent improvements when compared with confinement (Phetteplace et al. 2001). In some cases, MIG has been found to eliminate the need for winter housing as cows can manage on pasture with proper supplementation (Murphy, 1998).

On the other end of the spectrum of management intensity are animal confinement operations. Confinement is the main system of livestock management in the United States (Hinrichs & Welsh 2003) with 5 million confined dairy cows with one company controlling 40% of the US dairy market (Food_&_Water_Watch 2010). Beef cattle operations confine 30 million animals in 83,000 feedlots (Scully 2003). Confinement encloses animals in corrals or pens restricting their free range. Feed, water and minerals are carried to the animals and placed in feeders and water tanks. The USDA (2008) defines confinement as an operation that keeps animals for between 45 days or more in any 12-month period. Forage, vegetation or post-harvest residues are not available in the facility. The main advantage of confinement is that it removes the seasonality imposed on pastured animals (Hinrichs & Welsh 2003).

This study aimed to analyze sustainability indicators across this spectrum of management methods on dairy farms in Vermont. The specific research objectives were to (1) measure on-farm sustainability through a self-assessment toolkit; (2) compare sustainability scores between traditional grazing, confinement, and MIG operations; and

(3) assess the impact of an education intervention on the adoption of farm sustainability practices.

4.2. Methodology

4.2.1. Study Area

All farms analyzed were located in the Vermont counties of Franklin, Lamoille, Orleans, Essex, Addison, Rutland, Chittenden, Windsor, and Bennington. Vermont is situated in Northeastern United States between latitude 44° 2’ 26” N and longitude 72° 42’ 33” W, with a surface area of 24,000 km^2. The total population is 626,431 (2011 estimate), with an economy composed of government (13.9%), real estate (12.3%), agriculture and tourism (16%), manufacturing (25%), health care and trade (11.4%). The dairy sector accounts for 75% of VT agricultural income. (US Census Bureau, 2009).

Vermont has temperate climate with pleasant summers and cold, snowy winters. The weather has four seasons with average temperatures ranging from -7.8 °C in January to 21.4 °C in July with an annual mean of 7.3 °C which also varies mostly according to elevation factors. The average annual precipitation is 1016 mm and it is higher in the mountains (NCDC/NOAA 2010).

Vermont soils generally belong to a Turnbridge *series* which occur in mountainous areas of the State except for one county. These soils are loamy, well-drained and formed in Wisconsin-age glacial till. These soils are 0.5 to 1.0 m deep over schist, gneiss, phyllite or granite bedrock. The surface layer is very dark brown with partially decomposed organic matter. The sub-surface layer is grey, fine sandy loam. Tupper subsoil is dark brown fine, sandy loam. The lower sub-soil is brown fine, sandy loam. (NRCS. 2010).

The farms selected by the Alliance encompassed 4,964 ha (owned and rented) and 13,656 cows (including young stock). All of them sold milk to Saint Albans Dairy Cooperative, which processes milk for Ben and Jerry's Ice Cream. Fifty two farms were randomly selected from a population of 520. The selection was inclusive and did not discriminate for size, organic, or management practices. Twenty four reported that they owned their farms, three rented, and 12 both owned and rented farmland. Nine (19%) used rotational grazing, 11 (23.4%) used traditional grazing, and 19 (57.5%) used confinement, 31 (71.8%) were non organic, three (18%) were certified organic and 5 (10.2%) were transitioning to organic, or did not respond (Matthews, 2010 personal communication).

4.2.2. The Dairy Stewardship Alliance Self-Assessment Toolkit

The first section of the toolkit described demographic and productivity data, such as contact and personal information, milk produced per cow (kg), herd size, and hectares of land. The next part contained nine sustainability indicator modules, with 6 to 10 questions each. The modules were: 1) animal husbandry; 2) biodiversity; 3) community health; 4) energy; 5) farm financials; 6) nutrient management; 7) pest management; 8) soil health; and 9) water management (Table 4.2). For multiple choice questions, the response number served as the score for that category (i.e. choice # 2, equaled two points). When a question required "all that apply," the score was obtained by adding up the answers and recording the total. The maximum score of each indicator was variable

(Appendix A2). The toolkit had a color-coded chart to help farmers interpret results and determine which areas needed attention (Table 4.1).

Table 4.1. Color-coded chart with score ranges to help interpret farm scores.

Modules	Problems detected	Attention needed	Desirable management
	Red	Yellow	Green
Animal Husbandry	9-24	25-34	35-41
Biodiversity	6-15	16-20	21-25
Community Health	12-19	19-22	23-27
Energy	6-13	14-15	16-20
Farm Financials	6-19	20-27	28-33
Nutrient Management	7-15	16-20	21-25
Pest Management	5-17	18-25	26-30
Soil Health	6-14	15-20	21-24
Water Management	7-20	20-26	27-32

4.2.3. Modules (Sustainability Indicators)

The *Animal husbandry* or animal welfare module encompassed all aspects of animal wellbeing such as proper housing, nutrition management, disease prevention and treatment, responsible care, humane handling, slaughter, and humane euthanasia, when necessary. Animals are more productive when they are well cared for. The three main areas observed were nutrition, living conditions, and overall health (Asch et al. 2004). *Biodiversity* referred to the biotic interactions among humans, animals, plants, microorganisms, and overall management found in functional ecosystems. This module assessed the effects of genetically modified organisms (GMO) decreasing the scores of farms that used them. *Biodiversity* also accounted for the influence of sustainable agricultural practices such as MIG, cover crops and no-till cropping, and management of riparian and adjacent areas for conservation. *Community Health* consisted of the strength, relationship, and other aspects that contribute to quality of life in the farmer's community and its effect on the surrounding rural environment (Asch et al. 2004). *Energy* considered the efficient use of energy in dairy operations and the adoption of renewable energy sources (Asch et al. 2004). *Farm Financials* referred to the balance between the financial performance of a farming enterprise and appropriate business management necessary to accomplish healthy work-life stability and environmental health. This balance is an essential aspect of quality of life (Asch et al. 2004). *Nutrient Management* emphasized the importance of managing nutrients sustainably to avoid contamination and reduce costs, as feed and fertilizer purchases account for large portion of farm costs. The adoption of sustainable nutrient management practices helps improve water quality (Asch et al. 2004). *Pest Management* considered the growing concern over widespread use of pesticides and its influence on environmental health, including human health. This concern has led to an alternative approach called integrated pest management (IPM). IPM focuses on long-term prevention through different techniques such as monitoring, establishing pest thresholds, and using the least hazardous pesticides when strictly necessary (Asch et al. 2004). *Soil Health* referred to physical and chemical soil characteristics such as organic matter, pH, salinity, water holding capacity, and erosion levels. Soil contributions to farm production constitute important ecosystem services that could be compromised if unsustainable practices are used (Asch et al. 2004). *Water Management* emphasized that available clean, high-quality water is essential to life. Vermont's Lake Champlain receives nutrient runoff from non-point source agricultural pollution. Preventing water pollution through best management practices is critical for healthy ecosystems (Asch et al. 2004).

Some modules were related to other modules directly or indirectly (Table 4.2). The goal of the toolkit was to provide farmers with information about current practices and compare them economically, socially and environmentally to best management practices. Farmers could then identify areas to improve and transition to desirable farming practices (Asch et al. 2004). (More information about the toolkit can be found in Appendix A2).

Table 4.2. Modules (sustainability indicators) and questions in the DSA toolkit.

Module	Question
Animal husbandry	Herd Nutrition
	Overall Health
	Health of Incoming/Outgoing Animals
	Milk Quality
	Lactation Management
	Housing/Handling Areas
	Stalls
	Pasturing
	Milk Equipment
	Calf Raising Conditions
Biodiversity	Genetic Diversity of Crops
	Natural Area Conservation
	Management of Riparian Areas
	Pasture Management
	Crop Field Management
	Adjacent Area Management
	GMOs
Comm. Health	Community Relations
	Documented Labor
	Child Labor
	Base Wage
	Worker Sanitation
	General Safety
Energy	Percentage of Income
	Lighting
	Milking (Variable Speed Driver)
	Ventilation
	Milk Cooling
	Renewable Energy
Soil health	Soil Organic Matter
	Use of Cover Crops & Vegetative Areas
	Crop Rotations
	Tillage Practices
	Soil Conservation & Erosion Prevention
	Soil Quality Monitoring

Module	Question
Farm Financials	Current Ratio
	Equity to Asset Ratio
	Rate of Return on Farm Assets
	Term Debt & Capital Lease Coverage Ratio
	Operating Expense Ratio
	Farm Income
	Work/Life Balance
	Attitude Towards Adopting New Practices
	Planning for the Future
Nutrient management	Nutrient Management & Record Keeping
	Manure Application Rate
	Commerical Ferilizer Application Rate
	Manure & Phosp Applic Timing/Technique
	Nitrogen Fertilizer Application Timing/Techniques
	Fertilizer & Manure Application Equipment
	Use of Phosphorous Supplements
Pest management	Pest Identification
	Pesticide Selection
	Timing of Pesticide Application
	Weather Conditions
	Record Keeping
	Specific Management Practices (Flies)
	Specific Management Practices (Weeds)
Water Management	Livestock Yard Management
	Manure Storage System
	Fertilizer Storage System
	Silage Storage System
	Milkhouse Waste
	Protecting On-Farm Water Sources
	Water Use Plan
	Water Use Management Strategies

4.2.4. Data Collection and Analysis

Overall, the study was divided into two broad analyses: (a) first assessment of 39 farms, which looked for differences among three management methods across all modules and within modules; and (b) evaluation of differences between first and second assessments across modules and within modules.

Sixty seven questions were collected twice between 2004 and 2008 and organized on a Guttman scale. Guttman scale or cumulative scaling consists of a list of questions where any respondent who agrees with any specific question on a list would also agree with the previous ones (Guttman 1944). Data was initially collected from the mailed responses and transcribed into a Microsoft Access database. Spreadsheet data was transferred to Statistical Package for social Sciences (SPSS) (PASW 2010) for statistical analysis. The goal was to initially collect from 10 pilot farms, extending it later to 52 participating farms by the end of 2008. However, only 39 farms responded consistently to the first assessment, and only 29 responded to both assessments. Farmers completed a toolkit in 2005 and they were reassessed in 2008, rating themselves with scores according to their farming practice perceptions. The toolkit was 91 pages long with information, questions, and resources for the farmers. Farmers received a postage-paid return envelope. A second identical self-assessment was mailed in 2007 to all participating farmers.

Upon receiving and organizing the farmers' surveys, data were analyzed in two main sections: first assessment (39 farms) and second assessment (29 farms).

First assessment: Data were analyzed using SPSS, PASW (2010). Descriptive statistics were used to display the data on production variables, modules (sustainability indicators) and questions. One way ANOVA was performed to analyze differences in production and module variables (Ott & Longnecker 2008). Subsequently to the

ANOVA, the Levine's test of homogeneity of variances was applied to test for equal or heterogeneous variances. Furthermore, a multi comparison *post hoc* analysis using Tukey HSD or Games-Howell test at the level of 0.05 was used to assess the effects between the management types. Both tests compare all possible ranges of means of every module but Tukey HSD assumes equal variances and Games-Howell assumes unequal variances (Ott & Longnecker 2008).

Furthermore, the questions within each module were analyzed utilizing a non-parametric Kruskal-Wallis Test at the significance level of 0.05. Mann-Whitney post-hoc test analyzed statistical differences on management type among the ordinal variables indicated by different letters (Ott & Longnecker 2008).

Second assessment. Farmers who responded to the second assessment were first evaluated through descriptive statistics of the modules. A Paired Samples T-Test checked for differences in modules between the 29 farms that completed first and second assessment. This test does not factor in management type, only whether a module was significantly different in the second assessment compared to the first (Ott & Longnecker 2008).

An ANOVA test was performed to determine whether there were statistical differences among modules that could suggest management type differences.

Wilcoxon Signed-Rank Test (2-related samples) was used to analyze overall improvements in the questions within each module, compared to the first assessment, (Ott & Longnecker 2008). Lastly, a multivariate Kruskall-Wallis test was performed on the 29 farms at the 0.05 level to determine differences in the questions of each module that can be induced by management type. A Mann-Whitney post-hoc test analyzed statistical differences between management types indicated by different letters (Ott & Longnecker 2008).

4.3. Results

4.3.1. First Assessment: Production

Table 4.3 shows production values for 39 dairy farms in Vermont.

Table 4.3. Production data in the first assessment for all 39 farms.

Variable	N	Mean	Min.	Max.	Std. Deviation
Milk and dry cows	39	188	27	800	166
Heifers	39	121	0	600	138
Total Cows	39	286	42	1,400	281
Production (Kg/yr) (in millions)	38	3,761,206	20,160	21,280,000	4,251,318
Production (Kg/cow/yr) (in thousands)	38	20,994	4,088	29,680	5,729
Area owned (ha)	35	137	0	457	101.6
Area rented (ha)	23	56.4	0	440	92
Area cropped (ha)	33	105.6	0	440	95.2
Area pastured (ha)	35	23.2	0	110	232

Table 4.4 shows production data by management type, allowing for additional insight related to these variables. Data showed that CF farms had the most cows, followed by TG farms, and lastly those using MIG. Farms using CF had double the amount of heifers when compared to TG; Confinement farms had the highest total milk production (kg/year), followed by TG farms, and MIG farms. Milk production per cow did not differ across management methods. MIG farms ranked lowest in production per

year. In terms of land use and production, MIG or TG farms cropped the same area of land, which was about 58 ha less than that on CF farms. MIG farms used more pastureland than CF and TG farms, and had the least total number of cows that produced the least amount of milk (Table 4.4). To estimate the differences in the production variables, ANOVA was used at the significance level of p=0.05 (Table 4.4).

Table 4.4. Production and ANOVA by management in the first assessment. (N=39)

Variable	MIG	TG	CF	F	p-Value.
Milking and dry cows	93 (± 75)b	124 (±117)b	270 (±185)a	5.743	0.007[1]
Heifers	74 (± 67)	90 (±77)	189 (±172)	2.827	0.074
Total Cows	115 (±72)b	170 (±122)b	435 (±332)a	6.899	0.003[2]
Production (Kg/yr) (10^6)	1,47(±1,27)b	2,49 (±2,45) b	7,66 (±8,14)a	4.444	0.019[2]
Production (Kg/cow/yr) (10^3)	19 (± 2,2)	22,5 (±5,8)	21,5 (±6,4)	0.872	0.427
Area owned (ha)	118.4(±39)	134 (±77)	184 (±132)	1.374	0.27
Area rented (ha)	50.7 (±28)	64 (±47)	51 (±24)	0.225	0.802
Area cropped (ha)	78.9 (±40)	81.6 (±56)	138 (±117)	1.71	0.201
Area pastured (ha)	28.9 (± 14)	18 (±23)	26.6 (±31)	0.541	0.589

a: Means followed by the same letter in the same row are not significantly different between management types (p≤0.05).

b 1: Analyzed with Tukey HSD

c 2: Analyzed with Games-Howell.

CF was significantly different than MIG and TG on *milking and dry cows*, *total* (number of) *cows*, and (milk) *Production* (kg/yr). No differences were detected between MIG and TG. Results revealed that CF manages almost three times the number of *milking and dry cows*, four times the *total* (number of) *cows* and over six times more milk production if compared to MIG and over twice of TG farms.

4.3.2. Analysis of Modules (Sustainability Indicators)

Modules analyses are shown in Table 4.5.

Table 4.5. First assessment: descriptive figures by module.

Module	N	Mean	Color	Min.	Max.	Std. Deviation
Animal Husbandry	39	30.9	Y	23	38	4.053
Biodiversity	39	16.5	Y	9	25	3.727
Community Health	39	17.9*	R	10	24	3.872
Energy	39	12.4*	R	1	19	4.564
Farm Financials	39	20.4	Y	1	32	9.775
Nutrient Management	39	19.1	Y	1	25	4.884
Pest Management	39	19.9	Y	1	29	6.521
Soil Management	39	16.5	Y	1	24	4.424
Water Management	39	23.1	Y	13	31	4.952

In this first assessment, there were nine MIG farms, 11 TG farms, and 19 CF farms. MIG farms had higher average scores in the modules than TG and CF farms in most of the modules except in *Energy* and *Farm Financials* modules, where CF scores were slightly higher (Table 4.6).

Table 4.6. Descriptive figures and ANOVA of modules by management type in the first assessment (N=39).

Variable	MIG	TG	CF	F	p-Value.
Animal Husbandry	32.6 (±5.5)	31.5 (±2.7)	29.7 (±3.8)	1.695	.198
Biodiversity	18.4 (±5.2)	17.2 (±4.4)	15.2 (±1.5)	2.906	.068
Community Health	19.4 (±3.6)	17.6 (±3.8)	17.3 (±564.0)	.956	.394
Energy	13.3* (±2.7)	12.4* (±3.2)	14.1 (±2.8)	1.135	.334
Farm Financials	24.2 (±4.8)	22.8 (±3.2)	25.0 (±5.6)	.649	.530
Nutrient Management	20.8 (±3.5)	18.4 (±4.9)	19.7 (±3.3)	.945	.398
Pest Management	22.9 (±6.1)	19.5 (±6.2)	20.1 (±5.3)	.930	.404
Soil Management	19.5 (±3.9)	17.3 (±3.4)	15.7 (±2.9)	3.847	.031
Water Management	23.6 (±4.8)	22.3 (±5.2)	23.3 (±5.1)	.233	.793

Even though MIG had higher average scores than TG and CF, ANOVA of the modules determined that only *Soil Management* ($F_{2, 35}$ = 3.847, p=0.031) differed (Table 4.6. Tukey test found a management effect in *Soil Management* where MIG scores was higher than CF, p=0.025.

4.3.4. Analysis of Questions (Dependent Variables)

According to the Kruskal-Wallis test shown on Table 4.7, management methods differed for eight variables. The main assumption H_0 was that the mean scores were equal. However, at the significance level p≤0.05, there was enough evidence to conclude that there were differences among the three management methods based on the test scores and, therefore, the null was rejected. Multi comparison using Mann-Whitney at p=0.05 detected significant differences (Table 4.7) with letter designations, where “a” represents highest means, “b” indicates the next highest mean, etc.

Table 4.7. First assessment: questions with significant effects at the P ≤ 0.05 Kruskall-Wallis and Mann-Whitney multi comparison test.

Question (Module)	Mean (S.D)	Median (ranked)			χ^2	DF	P ≤ 0.05
		MIG	TG	CF			
Pasturing (A.H.)	2.03*(±1.2)	21.1ab	25.8a	15.9b	5.860	2	0.050
Pasture management (Bio.)	2.51(±1.1)	24.1a	25.7a	15.8b	7.119	2	0.028
Renewable energy (Ener.)	1.40†(±0.6)	20.0a	25.1a	13.8b	10.367	2	0.006
Operating expense ratio (F.F.)	1.88‡(±0.8)	20.5a	16.5ab	10.3b	7.394	2	0.025
Fert. and manure application equip. (N.M.)	2.47*(±0.6)	24.5a	24.0a	15.6b	7.261	2	0.027
Crop rotation (S.H.)	3.24*(±0.9)	24.3a	24.8a	15.4b	7.441	2	0.024
Livestock yard management (W.M.)	3.16§(±0.8)	21.9ab	24.7a	15.4b	5.933	2	0.051
Silage storage system (W.M.)	3.18(±1)	16.8b	27.9a	18.0b	6.697	2	0.035

a: Medians followed by the same letter in the same row are not significantly different between management types (p≤0.05).

b: ‡: n=32; †: n=35; §: n37; *: n=38; no mark: n=39

4.3.5. Second Assessment (29 farms)

Average scores between the first and the second assessment sorted by management method across all modules showed an increase for all methods in the second assessment. Education and access to information between assessments by the way of workshops, meetings and information located in the toolkit allowed farmers to improve their farming practices in the second assessment. This increase was greatest in MIG farms, 12.5%, (20.8 to 23.4), followed by TG farms, 6.1%, (19.7 to 21) and CF farms, 3%, (19.8 to 20.4) (Figure 4.1).

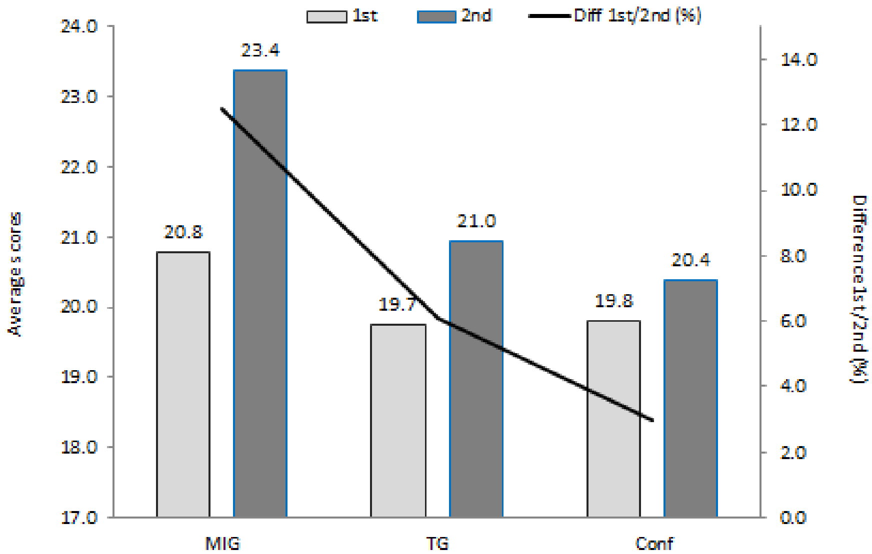


Figure 4.1. Comparison between averages of first and second assessments and the percent difference by management method.

Moreover, all module scores improved compared to the first assessment, revealing that some level of improvement had been applied since the first assessment. Some modules increased more than others, specifically, *Biodiversity* (12.7%), *Nutrient Management* (12.7%), *Energy* (12.5%), *Soil Health* (11.3%) and *Community Health* (9.6%). The modules of *Farm Financials* (6.4%) and *Pest Management* (4.6%) had the lowest improvement in the second assessment, compared to the first one.

Figure 2 shows the score comparison of each module by management type in the second assessment. When assessing score differences between the two assessments sorted by management type, mixed results are present, yet some results stand out: MIG scores were higher than TG and CF scores, and the overall mean except for the *Energy* module. In *Farm Financials*, MIG scores were positive, and TG and CF scores were lower in the second assessment, and even negative when comparing the two assessments.

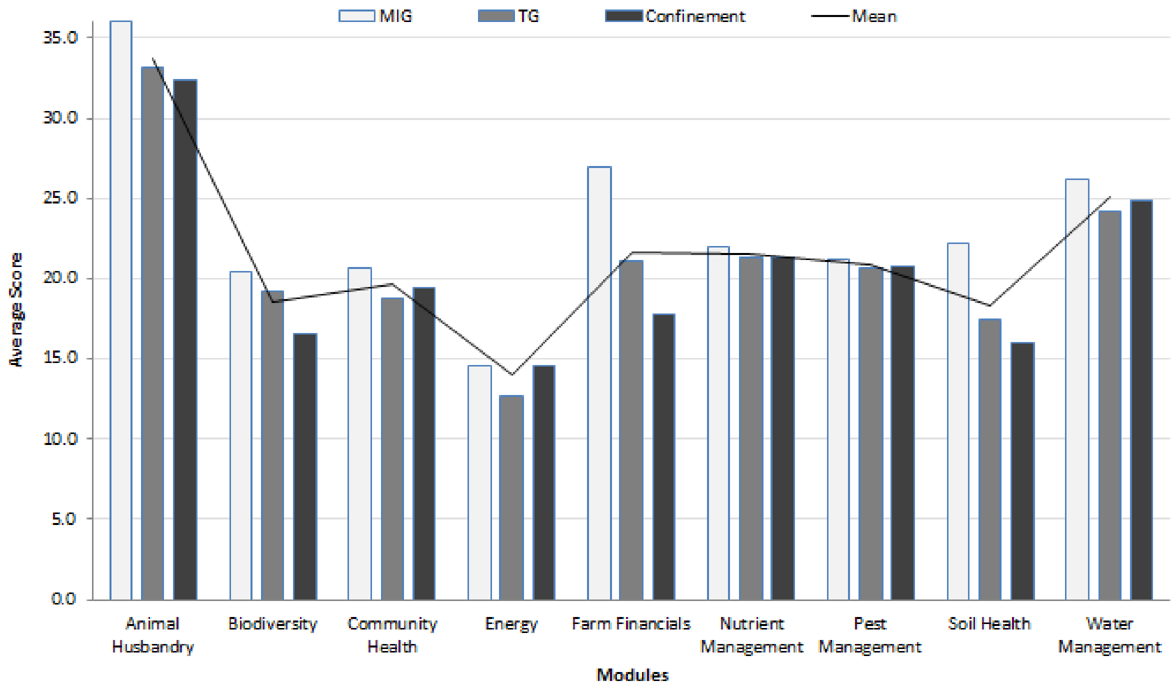


Figure 4.2. Average score comparison of the second assessment among management methods across modules.

To determine whether the two assessments differed, modules were analyzed using Paired Samples T-Test at the level of 0.05 (Table 4.8). This test however does not infer which management methods differ.

Table 4.8. Paired sample t-test of first and second assessment between modules (p=0.05).

Module pairs	Mean (SD)	T	df	Sig. (2 tailed)
Animal Husbandry	-2.586 (±3.3)	-4.192	28	.000
Biodiversity	-1.414(±2.8)	-2.722	28	.011
Community Health	-1.929(±4.2)	-2.426	27	.022
Energy	-.321(±2.1)	-.793	27	.435
Farm Financials	.231(±4.6)	.254	25	.802
Nutrient Management	-1.286(±2.9)	-2.353	27	.026
Pest Management	-1.481(±5)	-1.532	26	.138
Soil Management	-1.815(±2.9)	-3.241	26	.003
Water Management	-1.793(±3.6)	-2.654	28	.013

When plotting the differences between the averages of the two assessments, MIG farms showed advantages compared to the other management types in *Animal Husbandry*, *Biodiversity*, *Farm Financials*, *Soil Health* and *Water Management*. MIG farms were the only ones with positive scores in Farm Financials while TG and CF farms were most notable for their negative Farm Financial score. TG farms scored higher than MIG and CF farms in *Nutrient Management.* (Figure 4.3).

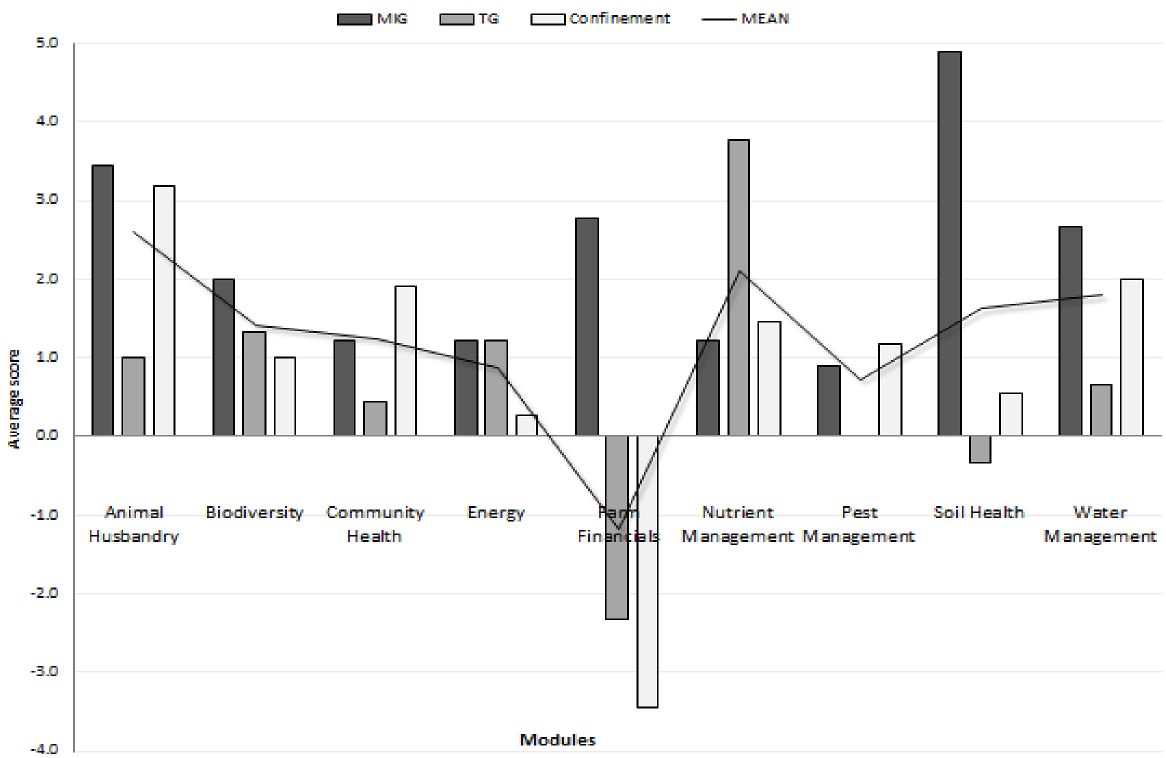


Figure 4.3 Score differences of the modules between the first and second assessments by management type.

To assess the difference in management type between the two assessments, ANOVA was performed (Table 4.9).

Although it was demonstrated that most of the modules had improved in the second assessment (Table 4.8), the comparison considering management type only showed significant differences in *Farm financials* p=0.042 (Table 4.9). Levene test of homogeneity of Variances demonstrated that this module lacked equal variance, therefore Games-Howell post-hoc analysis was performed to do multi-comparison between management types. In evaluating the difference between assessment one and two for *Farm Financials*, MIG farms [M=2.78, (SD=3.63)] differed (p=0.037) from CF farms [M=-1.25, (SD=2.19)], but not from TG farms [M=-2.33, (SD=5.79)] (Table 4.9).

Table 4.9. ANOVA of the difference of the modules between the first and second assessment.

Modules	F	Sig. (p=0.05)
Animal Husbandry	1.563	.228
Biodiversity	.306	.739
Community Health	1.231	.309
Energy	1.653	.212
Farm Financials	3.660	.042
Nutrient Management	.031	.970
Pest Management	.171	.844
Soil Management	2.267	.125
Water Management	.693	.509

4.3.6. Comparison Between Variables (Questions)

In the second assessment, variables were assessed to evaluate changes with respect to the first assessment. A Wilcoxon Signed-Ranks test at the 0.05 level indicated that several variables differed (Table 4.10).

Table 4.10. Comparison of the questions in the second assessment (Wilcoxon Signed-Ranks test p=0.05).

Variable (module)	Z	p≤0.05
Herd Nutrition (A.H.)	-2.40	0.016
Overall Health (A.H.)	-2.24	0.025
Health of incoming/outgoing animals (A.H.)	-2.88	0.004
Lactation management (A.H.)	-2.11	0.035
Milk Equipment (A.H.)	-3.28	0.001
Management riparian areas (Bio.)	-2.58	0.010
Pasture management (Bio.)	-2.46	0.014
Nutrient mgmt. & record keeping (N.M.)	-3.15	0.002
Use of phosphorus supplements (N.M.)	-2.24	0.025
Use of cover crops & vegetative areas (S.H.)	-3.53	0.000
Tillage practices (S.H.)	-2.37	0.018
Water use plan (W.M.)	-2.48	0.013
Water use mgmt. practices (W.M.)	-2.71	0.007

First and second assessments were also compared question by question using Kruskal- Wallis Test of the differences between management types (Table 4.11). None of the other variables were significant at 0.05 level.

Table 4.11. Comparison between first and second assessment: variables (questions) with significant effects at the P ≤ 0.05 Kruskall-Wallis and Mann-Whitney multi comparison test.

Question (module)	Mean (SD)	Median (ranked)			χ^2	DF	P ≤ 0.05
		MIG	TG	Conf.			
Soil organic matter (S.H.)	0.47(±0.7)	14.50a	8.70ab	6.44b	8.163	2	0.017
Soil quality monitoring (S.H.)	0.21(±1.1)	10.83a	5.50ab	4.50b	7.489	2	0.024

[a]: Medians followed by the same letter in the same row are not significantly different between management types (p≤0.05).

4.4. Discussion

Most literature on sustainability discusses the lack of consensus on its definition. Identifying proper indicators of sustainability, however, can help farmers improve their farming practices, which will reflect on ecosystems and in their own quality of life. Numerous authors have identified sustainability indicators related to dairy farming (Rigby et al. 2001; Pacini 2003; Meul et al. 2009).

Many changes have happened in the dairy sector over the last decades. Unquestionably, the most fundamental issue was the increasing pursuit of financial business efficiency, vertical production, and spreading production costs over more animals and land. In the early '70's, the USDA Secretary of Agriculture Earl Butz coined the idea of "get big or get out", ignoring the biophysical limits of planet earth. As a result, agricultural practices and livestock production have been blamed as the main contributors to unprecedented environmental degradation, biodiversity loss, and land use changes due to conversion of farmland (Green et al. 2005; Steinfeld et al. 2006). This productive approach at any cost results in poor dairy cow health and longevity, thereby increasing culling rates and the dependency on external inputs produced unsustainably at high costs. "Get big or get out" has become "get big and get out!" according to Eliot Coleman. Production costs higher than income have driven many dairy farmers out of business (Murphy 1998b). The number of dairy farms has decreased from about 11,000 in 1950 to less than 1,000 in 2011 (ERS & USDA 2005; McGilvery 2011) confirmed by ERS & USDA (2005).

Farmers, government agencies, consumers, and university researchers finally are becoming more interested in improving dairy sustainability throughout the production chain. Sustainability not only affects dairy activity, but the community and the environment where the farm is located (Tilman et al. 2002). Sounder dairy farming practices can generate a positive "cascading effect" along the way creating sustainable livelihoods, healthier ecosystems, and quality dairy products. Dairy operations managed sustainably can also increase efficiency, reduce costs, and improve environmental and social conditions.

Ecosystems respond to agricultural practices in numerous ways and can significantly contribute to agricultural productivity (Zhang et al. 2007); simultaneously, ecosystem health deeply depends upon sustainable farming practices. The potential for increasing dairy sustainability is intrinsically reliant on an array of factors and the kind of management definitely has an influence on sustainability indicators. Arguably, when common sense is adopted, dairy farming has the potential to promote ecosystem services such as soil formation, biodiversity, improved gas regulation through less carbon emissions and carbon sequestration, food provision and water supply and regulation as well as, supporting rural livelihoods (Melado 2007a).

The three major areas areas evaluated by this research— production, analysis of sustainability indicators, and comparison of sustainability indicators between first and second assessment—are discussed in more detail below.

4.4.1. Production

Overall, CF farms had larger herds (*total cows*) than TG (p=0.012) and MIG (p=0.002) farms, needing to manage almost three times the number of cows of MIG farms and over twice that of TG farms. This confirmed trends in the last US census (USDA-NASS 2007). These findings coincide with others who have stated that CF farms must rely on large scale to try to overcome high production costs (Winsten 1999; Parsons et al. 2004; Wise & Starmer 2007; Winsten et al. 2010).

The number of cows that a grazing farm can support is directly related to its forage availability. The amount and quality of the forage sward depends on the management applied to it (Murphy 1998b; Pinheiro Machado 2004b). In general, MIG farms can support more animals than TG farms per area unit without harming or even enhancing pastures if Voisin principles are correctly applied (Murphy 1998b). On MIG farms, animals are managed over rotational paddocks to allow forage rest and recovery (Murphy 1998b; Gerrish 2004; Pinheiro Machado 2004b; Winsten et al. 2010). TG farms do not allow for pasture rotation, but create a continuous grazing situation that eventually affects pasture quantity and quality, and ultimately lowers milk production. Confinement farms rely heavily on concentrated feed (grain) produced away from the farm (Murphy et al. 1986; Murphy 1998b; Winsten 1999).

4.4.2. First Assessment: Analysis of modules (sustainability indicators)

Overall, only two sustainability indicators evaluated in the first assessment (*Community Health and Energy)* scored low (red), meaning that farms needed attention in these modules (Table 4.5). When sorting the data by management type, most modules exhibited higher scores under MIG, except *Energy* and *Farm Financials* which showed slightly higher scores under CF (Table 4.6). CF farms have higher energy and financial costs than grazing farms because more money is spent in labor, fuel, producing, transporting, storing, and administering feed and removing manure. For these reasons in general, CF farms have higher costs and need to rely on large scale to spread these costs (Winsten et al. 2000a).

Community Health and *Energy* modules scored low under TG and *Energy* scored low in MIG farms (Table 4.6). This meant that MIG and TG farms needed attention in these areas.

MIG farms differed from CF farms in Soil Health (Table 4.6). The *Soil Health* module addresses important environmental and agronomic best management practices that are essential for overall farm viability and erosion and pollution reduction. The module focuses primarily on soil organic matter, vegetative covered areas, rotation of crops, usage of tillage practices, conservation, erosion prevention and monitoring (Appendix A1). According to the results of the ANOVA, it became evident that MIG farmers have better soil practices than the CF farms. Rotating animals through the pasture keep soils constantly covered, which enables MIG to protect soil structure and avoid erosion. CF farming practices explains most of the causes of soil deterioration (Magdoff 2007). Protecting soils with vegetation as on MIG farms, rather than having bare soils during much of the year as occurs under tillage on CF farms, reflects on ecosystem structure and services such as habitat for soil biodiversity and water quality. The

Millennium Ecosystem Assessment found that erosion due to soil degradation is on the list of 15 ecosystem services –provisioning, regulating and cultural- that have been used unsustainably (MEA 2005a). The most cogent argument for protecting soil health is the high replacement cost of the benefits it provides to society (Salzman 2005). Numerous scholars found that MIG kept soil covered, thereby reducing soil erosion (Parker et al. 1992; Franzluebbers 2010).

In addition, CF farms heavily depend on external inputs such as concentrated feed supplements. These supplements are produced using large amounts of energy inputs (synthetic fertilizer, fuel for moving machinery and transportation) and degrade soil structure and leave soils bare, open to wind and water erosion (Murphy 1998b; Pimentel et al. 2005). None of the other eight modules were significantly affected by the type of management in the first assessment.

4.4.3. First Assessment: Analysis of Variables Across Sustainability Indicators

The analysis of individual questions (Table 4.7) showed that MIG farm scores were higher than TG and CF farms on nine variables: *Pasturing*, *Milk equipment*, *Pasture management*, *Renewable energy*, *Operating expense ratio*, *Fertilizer and manure application equipment*, *Crop rotation*, *Livestock yard management* and *Silage storage system*. CF farms scored lower than MIG and TG farms in all questions.

For the question *Pasturing*, MIG and TG farms had adequate forage allowance for the animals. MIG farms particularly used multiple pasture division to allow for more efficient forage intake. Also, animal welfare was provided through the provision of water and shelter during severe weather. In addition, rotations were planned to maximize adequate regrowth and forage quality. Most CF farms do not use pasture as important feed, but rather as exercise areas. On TG farms, continuously grazed pasture soon becomes unproductive after the spring flush of growth. Consequently, large amounts of supplemental feed are also needed on TG farms.

Pasture management (p=0.028) of course showed that CF farms do not use managed pasture grazing as an important source of forage but rather use pasture merely for exercise purposes. CF farms use corn and alfalfa as their sources of forage.

Renewable energy (p=0.006) measured the implementation of alternative energy sources (wind, photovoltaic panels, biodiesel or methane recovery). The adoption of technologies such as methane digesters can have important positive effects on farm costs and greenhouse gas emissions. In general, manure is placed in large open pits to be collected and sprayed later on crops or pasture. This produces ammonia volatilization, nitrous oxide, and high methane emissions that are released to the atmosphere. In addition, this requires the use of heavy machinery that causes soil compaction, (Murphy 1998b). Steinfeld and others (2006) found livestock responsible for 18% of the total anthropogenic greenhouse gas emissions. TG farms ranked best in adoption of renewable energy; CF farms ranked lowest (Table 4.7).

Operating expense ratio (p=0.025), referred to the generation of farm revenue and profit (Table 4.7). The threshold between healthy finances and problematical ones is between 65 and 80 %, where 80 % indicates profitability problems and 65 % and below usually shows sounder financial management. MIG farms ranked best, compared to TG and CF farms. Numerous scholars have attributed better financial performance to MIG farms, when compared to CF farms because confinement production costs exceed revenues (White et al. 2002; Benson 2008; Winsten et al. 2010)

Fertilizer and manure application equipment described the efforts to match nutrient application to the calibration reliability of the equipment to avoid spillages, waste, and pollution. Pasture-based farms (p=0.027) ranked higher than CF farms (Table 4.7). This probably was due to much less manure needing to be spread on pasture-based farms than on CF farms. During 6 months of the year, at least, animals spread their own manure while grazing on pasture-based farms.

Crop rotation (p=0.024) scores for MIG and TG farms were higher than for CF farms. The rotation of crops aims for nutrient availability and pest control, and to help achieve greater quality and quantity of soil organic matter. When crops are not rotated, two main problems develop: (a) more dependence on synthetic fertilizer and, (b) increased pest problems. Various rotations also help reduce risks. In contrast, growing continuous corn quickly depletes soil organic matter and nutrients.

CF farms depend on corn silage. This trend started after World War II with the availability of inexpensive inputs (energy, pesticides, fertilizers, and mechanization), which for a time provided higher farm profits (Pimentel et al. 2005). The wide adoption of corn silage enabled development of livestock confinement feeding. Large corn subsidies helped CF farmers save about $35 billion between 1997 and 2007 (Wise & Starmer 2007). These subsidized inputs not only increased milk production per cow, but replaced pasture in the production process, thereby enabling the preponderance of confinement dairy production throughout the US (Murphy, 1994). Furthermore, this may explain why confinement livestock production at industrial scale has grown at twice the rate of mixed farming and over six times the rate of production based on pasture grazing (PewCommision 2008).

Livestock yard management (p=0.051), discussed areas where animals concentrate (i.e.: barnyards and holding areas) in relation to the protection of water quality. Cow manure has an oxygen depleting potential 200 times that of untreated municipal sewage, which can cause eutrophication, thereby impairing water bodies (Asch et al. 2004). The proximity to water and the possibility for water and ground water contamination with nitrates and bacteria is higher if the yard areas are not roofed. Also these facilities must be at least, 100 feet from waterways and without concrete or fine-textured soils. In addition, yard management areas must be cleaned weekly and provide protection barriers to avoid runoff and incoming rain water. TG farms scored highest and CF farms lowest in this respect (Table 4.7). This follows from manure management and quantities of manure on the different kinds of farms. Pature-based farms accumulate and concentrate less manure than CF farms.

For the question *silage storage system*, (p=0.035) TG farms ranked highest and MIG farms ranked lowest. This indicated that farmers who practice traditional grazing do a better job at sealing their silos and avoiding leakage and runoff pollution into water bodies, than other farms. Silage leachate has an oxygen depleting potential 140 times of untreated municipal sewage, which can cause eutrophication detrimental to water bodies

(Asch et al. 2004). There was an imperative need for MIG and CF farmers to improve their *silage storage systems* marks.

4.4.4. Second Assessment: Analysis of Sustainability Indicators

Six modules improved between assessments: *Animal Husbandry*, *Biodiversity*, *Community Health*, *Nutrient Management*, *Soil Health* and *Water Management*, (Table 4.8). These findings confirmed that education and information provided by the Alliance helped to enhance most sustainability indicators. The average scores sorted by management type improved for all the three management methods, where MIG farms had the greatest increase 12.5%, TG farms 6.1%, and CF farms 3% (Figure 4.1). Also, all the module scores improved, except *Farm Financials*. In addition, the comparison across modules (Figure 4.2) revealed that MIG farms showed greater scores than TG and CF farms, except on *Energy.* However, the differences between modules over the two assessments (Figure 4.3) also indicated advantages for MIG farms, except for *Community Health, Nutrient and Pest Management*. In *Farm Financials*, the difference between methods was the greatest where TG and CF farms scored negative (Figure 4.3). This was further confirmed by the ANOVA (Table 4.9) which revealed that MIG financial scores differed from CF, thus confirming that MIG had economic advantages over confinement. Other studies have shown higher profit margins per cow and per unit of milk sold for pasture-based farms under MIG, compared to CF (Winsten 1999; Benson 2008; Winsten et al. 2010). This can represent a great disadvantage to CF because, if a management method is not profitable, it cannot be sustainable and will not be used by farmers.

MIG costs are lower, resulting in higher profitability compared to CF and TG due to: (a) lower inputs (fertilizer, pesticides, energy, machinery) because animals harvest most of their own high-quality forage and spread their own manure (Pinheiro Machado 2004b); (b) it has a positive energy balance because its main input comes from the sun and forage plants are managed for maximum photosynthesis (Machado, 2004) and, (c) protection and enhancement of the environment (Melado 2007a). Smaller pasture-based farms under MIG have greater quality of life, larger net farm income, closer relationship with the cows, the land and the community and higher chances of survival of medium and small farms (Ostrom & Jackson-Smith 2000; Gerrish 2004; Cooner et al. 2009).

On the other hand, CF and TG farms have much higher costs due to:

Greater need for supplemental feed purchased off farm. TG farms incur much of these same costs because they operate almost like CF farms, in that they don't rely on pasture as an important source of forage, but really only use it as exercise areas (Murphy 1998b). Most TG farms feed the same total mixed ration (TMR) year-round, regardless of pasture availability (Soder & Rotz 2003). TG cows probably are healthier than their CF counterparts because they do get out on pasture. High CF culling rates (50%) due to unhealthy conditions and hormone use exceeds eight times the rate of culling for mastitis in comparison to pasture based methods (Washburn et al. 2002) This, ultimately forces CF farms to replace all cows every 2 years at a cost of $2000 per heifer.

Higher energy costs for soil tillage, planting, harvesting. This implies higher machinery and equipment costs, greater use of fertilizers, pesticides, and seed (Winsten et al. 2000b; Pimentel 2004). The immediate consequence is loss of soil organic matter and nutrients from more tillage without crop rotation and having bare soils exposed to erosion (Weil & Magdoff 2004).

Greater infrastructure costs such as, barns, silos, feed storage and manure pits. Manure spreading happens along the year, many times on wet soils, which compacts soils, resulting in lower corn and alfalfa yields, thereby requiring more land or more forage purchases.

Transportation of crops from field to storage, and feeding out of storage, ventilation of barns, running milking equipment, and lights.

Higher veterinary costs due to unhealthy conditions of confined cows, and forcing cows to produce more milk with hormones (Winsten et al. 2000b. Overusing antibiotics and hormones in livestock increase costs and can build pathogen resistance and ultimately affect humans (Mathew et al. 2007) .

Greater labor costs (Winsten et al. 2000b) to produce the feed, feed the cows, and milk the cows! Many CF farms use illegal immigrants to do this work, because not enough Americans are available to do the work (Maloney 2002). CF farmers, in effect, become labor managers, with all of its problems, because of the larger number of people needed to do the work (Maloney 2002).

MIG farms are more profitable per unit area because they are able to avoid most of these costs.

4.4.5. Questions That Improved in the Second Assessment

Thirteen variables showed improvements on the second assessment, compared to the first. Most of the differences were in *Animal Husbandry, Biodiversity*, *Nutrient*, *Soil* and *Water Management* modules (Table 4.10).

Animal Husbandry showed differences for Herd nutrition, Overall health, Overall health of incoming and outgoing animals, Lactation management and Milk equipment. Animal Husbandry refers to animal welfare, including all the necessary conditions for animal well-being, such as proper housing, adequate nutrition, disease prevention, humane handling management and care. Thanks to the pioneer work of Dr. Temple Grandin on animal behavior, it is known that well-handled animals are healthier and more productive (Rushen et al. 1999; Hemsworth 2000, 2003; Garry 2004).

These results showed that access to information enabled improvements in animal welfare. For instance, animal nutritional information and records were used by farmers to make the connection between metabolic diseases, nutritional needs, and values for more efficient digestion (Table 4.10). *Overall health* accounted for individual, routine health checkups, body condition, appropriate treatment for sick animals, and preventive measures to avoid suboptimal health conditions (Table 4.10). Similarly, the *health of incoming and outgoing animals* was affected where known health status, observation and quarantine, hygiene of visitors' boots or shoes and additional biosecurity measures were practiced (Table 4.10). The number of cows' lactations and replacement rates were more carefully monitored and recorded. In some cases, culling rates dropped from above 35% to less than 20%. Culling rates refer to the removal of animals due to disease, poor performance, failure to reproduce, and death. Confinement operations negatively affect animal welfare, thereby increasing culling rates, compared to pasture-based farms (Murphy 1998b).

Milking equipment and parlor refers to the adequacy of milking installations which also improved in the second assessment where milking coolers and equipment were frequently thoroughly tested, repaired, cleaned, and monitored. Additionally, because cows are milked twice or three times a day, well-working equipment and a clean parlor are essential for animal comfort, milk quality, and minimal pathogen contamination.

Biodiversity, *Management of riparian areas* (p=0.010) and *Pasture management* (p=0.014) presented significant changes compared to the first assessment, confirming that access to information also improved these variables. In the case of the riparian areas, better conditions were achieved where livestock drinking sites were placed away from streams and cows were not allowed in streams, reducing pollution and contamination. Stream banks were managed and fenced, and animals had limited and restricted access to them. Adequate bank angles and vegetation reduced erosion and sedimentation, and encouraged promoted habitat conditions for biodiversity. *Pasture management* also improved where forage species were carefully considered, adjustments in rotations and consideration for environmental and conservation practices were implemented.

Nutrient Management and record keeping were based on soil testing every 1 to 3 years and recommendations were followed. Also, recommendations usually were not exceeded and nutrient records were used to guide future farm management plans (Table

4.10). Farms improved in the *use of phosphorus supplements.* In the second assessment, this variable was closely regulated and monitored to maintain production levels. Careful diets ensured that animals received no more phosphorus than what was recommended by the National Research Council (NRC 2001). This particular variable is critically important to reduce the amount of phosphorus leaving farms and polluting waters (MEA 2005a).

In *Soil Health, use of more cover crops & vegetative areas* reduced bare soil exposure. Cover crops were used more wisely in accordance to soil type and farm characteristics. Buffer strips, perennial crops and pasture to protect soil were also used. *Tillage practices* and soil conservation practices were implemented, minimizing tillage and, in some cases, no-till practices and the use of perennial crops were used to compensate soil benefits (Table 4.10).

Lastly, *Water Management, Water use plan* (p=0.013) attempted to improve water conservation practices by means of recycling or adopting more efficient management. The improvements also enhanced efficiency of water use and minimized loss and runoff, which are potential causes of erosion and pest problems (Table 4.10). In that respect, *water use management,* (p=0.007) also experienced improvements due to better access to information. Farmers who scored higher in this variable also addressed the efficiency in the use of water and pointed to details such as running a water pipe through the cooler plate while, at the same time, used that heated water as drinking water for cows. Another practice was the use of housing that keeps cows cleaner, thereby saving extra water. Also, the adoption of management techniques such as seasonal dairying and pasture feeding helped reduce water use.

4.4.6. Variables Affected by Management Type Between Assessments

Only *Soil organic matter* (p=0.017), and *Soil quality and monitoring* (p=0.024), were statistically different in the comparison of questions between assessments. In both cases MIG farms scored higher than TG and CF farms (Table 4.11). *Soil organic matter* is indispensable to maintain the services provided by soil. High levels of organic matter can sustain high productivity standards (NRC 2001). According to Altieri (1999), soil biota provides a diverse array of benefits (or services) such as recycling of nutrients, controlling the physical structure of the soil, and improving plant health and nutrient uptake by plants. *Soil organic matter's* highest concentration is found in the top two to eight inches of soil. The top soil is where most of the biological activity happens. Some conventional agricultural practices like tillage, over use of synthetic fertilizers or overgrazing can greatly affect soil organic matter by increasing the rate of decomposition of organic material and reducing its amount. Gliessman (2007) pointed out that about 0.5 to 1.5 t of topsoil is formed per hectare annually in production areas of the Midwest, while on average, 5 to 6 t of soil per acre are lost to erosion. In some acute cases, soil erosion exceeds 15 t per hectare yearly. The renewability of soils occurs very slowly. From natural processes, it can take from 100 to 250 years to form 2.5 cm of topsoil (Tilman 1987, 1990). The estimated annual cost of public and environmental health loses from soil erosion exceed $45 billion (Pimentel et al. 2005). Soil loss is an extremely important ecosystem dis-service (Zhang et al. 2007). Furthermore, soil erosion is one of the 15 ecosystem services managed unsustainably according to MEA (2005a).

Performing soil testing regularly and following recommendations is important to ensure that soil nutrient levels stay balanced and productive. Monitoring also assesses compaction, runoff, soil biota, and root health. *Soil quality and monitoring* mean was low (M=0.21), meaning that soil testing was not a common practice in general among the surveyed farmers (Table 4.11).

4.5. Conclusion

MIG farms provided higher sustainability indicator scores than confinement and traditional grazing operations. Vermont pastures are suitable for dairy production and if well managed, can sustain adequate levels of production. Traditional grazing must be carefully monitored because it can cause overgrazing, harming pastures, increasing erosion and lowering soil biodiversity. This will affect benefits provided by ecosystems, will create fossil fuel dependency and will ultimately lower sustainability.

Access to information and education helped to achieving better farming practices. When comparing modules between assessments, results showed that six indicators (of nine) differed in the second assessment.

Confinement and traditional grazing farms are not sustainable, as shown clearly by their negative farm financial scores. Their production costs are much higher than their incomes. Costs such as energy, supplemental feed, and labor are increasing, even as the price farmers receive for milk decreases, making their situation less tenable as time passes. Any gains from applying new information cannot offset the cost/price squeeze (reflected in the Farm Financials module) that is forcing some farms out of business.

The low-to-negative scores that confinement and traditional grazing farms had for soil health achieved in the difference between the two assessments, indicates that their practices may have already damaged their soils.

Ideally, it would be better for all concerned if confinement and traditional grazing farmers would change their farming method before they damage soils, watersheds, and local communities. But, unfortunately, that is not likely to happen. Most farmers exhaust every possibility of remaining in business, except changing to pasture-based farming, before quitting. By that time, their families, farms, and soils are ruined. When farms go bankrupt, they usually damage local businesses to which the farmers were indebted, thereby harming the local community.

The only dairy farms that can survive the cost/price squeeze are those that can reduce production costs to a minimum by changing to feeding on well-managed, permanent pasture as much as possible. This study showed that MIG farms are profitable, even though the study included some farms in the MIG category that were using rotational grazing, which is not as efficient and productive as MIG.

MIG farmers can add more value to their farms by seeking organic certification and producing cheese, yogurt and butter with their milk. MIG farmers constitute the only hope for continuing, viable dairy farming in Vermont.

4.6. References

Altieri, M. A. 1999. The ecological role of biodiversity in agroecosystems. Agriculture Ecosystems & Environment 74:19-31.

Asch, A., A. Matthews, and D. Bothfeld, editors. 2004. Dairy Stewardship Alliance: an on-farm self-assessment for farmers. Ben & Jerry's, Burlington, VT.

Benson, G. A. 2008. Pasture-Based and Confinement Dairy Farming in the United States: An Assessment. Journal of International Farm Management 04.

Cooner, D., D. Rozeboom, and V. Campbell-Arvai. 2009. Literature Review: A Comparison of Dairy Production Systems. Department of CARRS, Michigan State University.

ERS, and USDA. 2005. Number of Farms in relation to average farm size. Economic Research Service, Census of Agriculture.

Food_&_Water_Watch. 2010. Factory Farm Nation: How america Turned Its Livestock Farms into Factories. Food & Water Watch, Washington, DC.

Franzluebbers, A. J. 2010. Achieving Soil Organic Carbon Sequestration with Conservation Agricultural Systems in the Southeastern United States. Soil Science Society of America 74:347-357.

Garry, F. B. 2004. An overview of animal welfare in the US dairy industry. Bovine Practitioner, Vol 38 No 1 38:1-22.

Gerrish, J. 2004. Benefits of Management-intensive Grazing. University of Missouri-Forage Systems Research Center, Saint Louis.

Gliessman, S. R. 2007. Agroecology: the ecology of sustainable food systems. CRC Press/Taylor & Francis, Boca Raton, FL.

Green, R. E., S. J. Cornell, J. P. W. Scharlemann, and A. Balmford. 2005. Farming and the fate of wild nature. Science 307:550-555.

Guttman, L. 1944. A Basis for Scaling Qualitative Data. American Sociological Review 9:139-150.

Hemsworth, P. H. 2000. The human factor: Influence on livestock performance and welfare. Proceedings of the New Zealand Society of Animal Production 60:237-240.

Hemsworth, P. H. 2003. Human-animal interactions in livestock production. Applied Animal Behaviour Science 81:185-198.

Hinrichs, C. C., and R. Welsh. 2003. The effects of the industrialization of US livestock agriculture on promoting sustainable production practices. Agriculture and Human Values 20:125-141.

IFAD. 2004. Livestock services and the poor. Page 152. International Fund for Agricultural Development.

Jackson, L. E., U. Pascual, and T. Hodgkin. 2007. Utilizing and conserving agrobiodiversity in agricultural landscapes. Agriculture Ecosystems & Environment 121:196-210.

Koneswaran, G., and D. Nieremberg. 2008. Global Farm Animal Production and Global Warming: Impacting and Mitigating Climate Change. Environmental Health Perspectives 116:578-582.

LID. 1999. Livestock in Development: Livestock in Poverty-Focused Development.95.

Magdoff, F. 2007. Ecological agriculture: Principles, practices, and constraints. Renewable Agriculture and Food Systems 22:109.

Maloney, T. R. 2002. Management of Hispanic Employees on New York Dairy Farms: a Survey of farm Managers. Pages 67-78 in J. L. Findeis, editor. The dynamics of hired farm labour: constraints and community responses. CABI.

Mathew, A. G., R. Cissell, and S. Liamthong. 2007. Antibiotic Resistance in Bacteria Associated with Food Animals: A United States Perspective of Livestock Production. Foodborne Pathogens and Disease 4:115-133.

McGilvery, K. 2011. Fewer than 1,000 dairy farms now left in Vt. WCAX News, Burlington

MEA 2005. Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: A Framework for Assessment. Island Press, Washington, DC.

Melado, J. 2007. Pastagem ecológica e serviços ambientais da pecuaria sustentavel. Revista Brasileira de Agroecologia 2.

Meul, M., F. Nevens, and D. Reheul. 2009. Validating sustainability indicators: Focus on ecological aspects of Flemish dairy farms. Ecological Indicators 9:284-295.

Mooney, H., A. Cropper, and W. Reid. 2005. Confronting the human dilemma. Nature 434:561-562.

Murphy, W. M. 1998. Greener pastures on your side of the fence: better farming with Voisin management intensive grazing. Arriba Pub, Colchester, VT.

Murphy, W. M., J. R. Rice, and D. T. Dugdale. 1986. Dairy farm feeding and income effects of using Voisin grazing management of permanent pastures. American Journal of Alternative Agriculture 1:147-152.

NCDC/NOAA. 2010. National Climatic Data Center

National Oceanic and Atmospheric Administration.

NRC. 2001. Nutrient Requirements of Dairy Cattle in N. R. Council, editor. National Academy of Sciences, Washington, DC.

NRCS., U. 2010. Vermont State Soil: Turnbridge Series in U. S. D. o. A. N. r. C. Service, editor.

Ostrom, M. R., and D. B. Jackson-Smith. 2000. The Use and Performance of Management Intensive Rotational Grazing Among Wisconsin Dairy Farms in the 1990s. Program on Agricultural Technology Studies research report No. 8. University of Wisconsin, Madison.

Ott, L., and M. Longnecker 2008. An introduction to statistical methods and data analysis. Brooks/Cole Cengage Learning.

Pacini, C. 2003. Evaluation of sustainability of organic, integrated and conventional farming systems: a farm and field-scale analysis. Agriculture, Ecosystems & Environment 95:273-288.

Parker, W. J., L. D. Muller, and D. R. Buckmaster. 1992. “Management and Economic Implications of Intensive Grazing on Dairy Farms in the Northeastern States. J. Dairy Sci.:2587-2597.

Parsons, R. L., A. E. Luloff, and G. D. Hanson. 2004. Can we identify key characteristics associated with grazing-management dairy systems from survey data? Journal of Dairy Science 87:2748-2760.

PASW. 2010. PASW Statistical Package. SPSS, Inc., Chicago, IL.

Pelletier, N., and P. Tyedmers. 2010. Forecasting potential global environmental costs of livestock production 2000–2050. Proceedings of the National Academy of Sciences 107:18371-18374.

PewCommision. 2008. Pew Commision on Industrial Farm Animal Production. Putting Meat on the Table: Industrial Farm Animal Production in America. Pew Charitable Trust and the Johns Hopkins Bloomberg School of Public Health

Phetteplace, H., D. Johnson, and A. Seidl. 2001. Greenhouse gas emissions from simulated beef and dairy livestock systems in the United States. Nutrient Cycling in Agroecosystems 60:99-102.

Pimentel, D. 2004. Livestock Production and Energy Use. Pages 671-676 in J. C. Cutler, editor. Encyclopedia of Energy. Elsevier, New York.

Pimentel, D., P. Hepperly, J. Hanson, D. Douds, and R. Seidel. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. Bioscience 55:573-582.

Pinheiro Machado, L. C. 2004. Pastoreo Racional Voisin: Tecnologia agropecuaria para el tercer milenio. Hemisferio Sur, Buenos Aires.

Rigby, D., P. Woodhouse, T. Young, and M. Burton. 2001. Constructing a farm level indicator of sustainable agricultural practice. Ecological Economics 39:463-478.

Rushen, J., A. A. Taylor, and A.-M. de Passille. 1999. Domestic animal's fear of humans and its effect on their welfare. Cahiers Agricultures 8:461-470.

Salzman, J. 2005. Creating Markets for Ecosystem Services: Notes From the Field New York University Law Review 80:84.

Scully, M. 2003. Dominion: the power of man, the suffering of animals, and the call to mercy. St. Martin's Griffin.

Soder, K. J., and C. A. Rotz. 2003. Economic and Environmental Impact of Utilizing a Total Mixed Ration in Pennsylvania Grazing Dairy Herds. The Professional Animal Scientist 19:304-311.

Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, and C. de Haan. 2006. Livestock Long Shadow: environmental issues and options. Food and Agriculture Organization of the United Nations:408 pg.

Tilman, D. 1987. Secondary succession and the pattern of plant dominance along experimental nitrogen gradients. Ecological Monographs 57:189-214.

Tilman, D. 1990. Constraints and tradeoffs - toward a predictive theory of competition and succession. Oikos 58:3-15.

Tilman, D., K. G. Cassman, P. A. Matson, R. Naylor, and S. Polasky. 2002. Agricultural sustainability and intensive production practices. Nature 418:671-677.

USDA-NASS. 2007. 2007 Census Publications.

Voisin, A. 1988. Grass Productivity. Island Press.

Washburn, S. P., S. L. White, J. T. Green, and G. A. Benson. 2002. Reproduction, mastitis, and body condition of seasonally calved Holstein and Jersey cows in confinement or pasture systems. Journal of Dairy Science 85:105-111.

Weil, R. R., and F. Magdoff. 2004. Significance of Soil Organic Matter to Soil Quality and Health in R. R. Weil, and F. Magdoff, editors. Soil organic matter in sustainable agriculture. CRC Press.

White, S. L., G. A. Benson, S. P. Washburn, and J. T. Green Jr. 2002. Milk Production and Economic Measures in Confinement or Pasture Systems Using Seasonally Calved Holstein and Jersey Cows. Journal of Dairy Science 85:95-104.

Winsten, J. 1999. The profitability of management-intensive grazing for northeastern dairy farms. American Journal of Agricultural Economics 81:1296-1296.

Winsten, J. R., C. D. Kerchner, A. Richardson, A. Lichau, and J. M. Hyman. 2010. Trends in the Northeast dairy industry: Large-scale modern confinement feeding and management-intensive grazing. Journal of Dairy Science 93:1759-1769.

Winsten, J. R., R. L. Parsons, and G. D. Hanson. 2000a. Differentiated dairy grazing intensity in the Northeast. Journal of Dairy Science 83:836-842.

Winsten, J. R., R. L. Parsons, and G. D. Hanson. 2000b. A Profitability analysis of dairy feding systems in the Northeast. Agricultural and Resource Economics Review 29.

Wise, T. A., and E. Starmer. 2007. Industrial Livestock Companies' Gains from Low Feed Prices, 1997-2005. Page 3 in G. D. a. E. Institute, editor. Tufts University.

Zhang, W., T. Ricketts, C. Kremen, K. Carney, and S. Swinton. 2007. Ecosystem services and dis-services to agriculture. Ecological Economics 64:253-260.

CHAPTER 5: REFLECTIONS ON THE VIABILITY OF DAIRY MANAGEMENT, ECOSYSTEM SERVICES AND SUSTAINABLE LIVELIHOODS

5.1 Introduction

In this dissertation I presented analyses of different dairy management methods in two similar studies. The methods studied weremanagement intensive grazing (MIG), confinement and traditional grazing. These studies showed how access to information and education influenced the provision of ecosystem services and sustainable livelihoods in two different sites.

I found that when education and access to information was provided to farmers, they improved their farming practices. It was clearly shown in the results that pasture-based dairy farms, especially MIG farms, showed greater sustainability than confinement and traditional grazing farms. MIG practices also enhanced environmentally degraded agroecosystems by improving soils, water quality, vegetation, and biodiversity, while enhancing farmers' livelihoods and demanding fewer investments. Year-round confinement produced more milk but required a larger scale, used more external inputs, had higher costs and lower revenues; thereby exposing farmers to greater debt. Additionally, confinement caused more environmental degradation and returned lower overall quality of life to farmers, compared to MIG. This indicated that MIG dairy farms were safer and a more viable agroecological practice. However, traditional grazing (and also MIG) must be carefully monitored because it can cause overgrazing, harming pastures, increase erosion and lower soil biodiversity. Because of its lower sustainability, traditional grazing can negatively affect the ecosystem's carrying capacity and create fossil fuel dependency.

Based on the findings previously described, and in the merit of the topic, this chapter reviews existing policies, discusses lessons learned and possible recommendations for dairy farming and conservation.To do this, it is important to revisit the justification for my research, in terms of the problems that it sought to address. First, early deforestation by the first settlers in Santa Catarina, Brazil depleted 83% of forest cover in its original area, mainly replacing it with livestock production systems. The Brazilian Forest Code (BFC) of 1965 dictated that farmers must leave 30% of their farms between permanent preservation and RL. Therefore, most smallholders in Santa Catarina are presently violating the BFC and, under current traditional agricultural practices, they face dramatic challenges related to overcoming ecological and poverty thresholds through agroecological practices.

In the second case study analyzing grazing in Vermont, reveals a sharp decline in the number of dairy farms during the last decades, with fewer but more productive milking cows under confinement (ERS & USDA 2005). As a result, less than 1,000 dairy farms remain in Vermont, and the survival of the industry largely depends on its adaptation to more sustainable practices.

5.2. Policy Instruments

In this section I assess two existing and well-known policy instruments that might serve U.S. and Brazilian decision-makers to promote incentives and desirable changes oriented to developing more sustainable grazing practices. The two instruments reviewed are payments for performance (PFP) and payments for ecosystem services (PES).

5.2.1 Payments-For-Performance (PFP)

Performance based incentives are conservation instruments used by the USDA's Natural Resource Conservation Service (NRCS). They address agricultural non-point-source-pollution related to soil and water quality issues and total maximum daily load (TMDL) nutrient runoff. PFP rewards farmers for quantifiable conservation outcomes (Winsten & Hunter 2011).

USDA conservation programs pay about $5 billion yearly to voluntary programs available to farmers' through NRCS and the Farm Service Agency (FSA). Programs include soil, water, air and wildlife conservation and use the following approaches: (a) land retirement and restoration; (b) project based working lands conservation and (c) whole-farms working lands conservation (Winsten & Hunter 2011). Some programs pay for removing agricultural lands from production such as:

Conservation Reserve Program (CRP) administered by FSA, aims at marginal pasture and croplands to reduce erosion and sedimentation, improve water quality, establish wildlife, restore floodplains and enhance forests and wetlands. Eligible CRP practices are riparian, wetland and wildlife buffers, living fences, shelterbelts, filter strips, and wetlands restoration,. The CRP ranks and selects qualified farmers to receive annual payments for 10 to 15 years, based on soil productivity. There is 50% cost sharing for approved conservation practices. An additional 25% can be approved for wetland restoration (USDA-NRCS 2011).

Wetlands Reserves Program (WRP), along with CRP promotes conservation and provides incentives by removing agricultural land from production and returning it to perennial plants or wetlands. This program has three options: (a) Permanent Easement, which pays 100% of the easement value and 100% of restoration costs; (b) 30-Year Easement, which expires after 30 years and USDA pays up to 75% of the easement and of the restoration costs, plus costs and fees; (c) Restoration Cost-Share Agreement, which does not involve easements, and USDA pays 75% of the restoration costs (USDA-NRCS 2011).

Grassland Reserve Program (GRP) promotes grazing operations and offers farmers the possibility to improve and restore natural grasslands that are vulnerable to agricultural conversion or to other land use changes, helping to keep environmental quality and a sound livestock activity. GRP compensates enrolled farmers on a "per-acre-per-year" basis, in the following categories: grazing productivity, wildlife habitat and carbon sequestration (USDA-NRCS 2011).

Farm Ranch Lands Program (FRLP) offers up to 50% of matching funds for purchasing development rights to keep productive farmland in agricultural uses (USDA-NRCS 2011). To meet the requirements, farmland must be privately owned, be large enough to sustain production, have a conservation plan for highly erodible land, and have adequate infrastructure.

Environmental Quality Incentives Programs (EQIP) offers up to 10 years of financial and technical assistance to implement conservation practices (soil, plant, animal, air and other issues related to agricultural, non-industrial private land). EQIP has paid over $514 million, covering 7.5 million acres, to over 24 thousand contracts on a whole range of working lands conservation practices, from integrated pest management to manure lagoons (USDA-NRCS 2011).

Conservation of Private Grazing Land (CPGL) is not a cost sharing program and offers technical assistance to grazing farms.

5.2.2 Payments for Ecosystem Services (PES)

Wunder (2005) defines PES as voluntary and mutually beneficial market instruments where there is at least one provider and one buyer to promote conservation of natural resources. Providers are often the land owners and the beneficiaries encompass the society from private to global public. PES assumes that those who provide environmental services (providers) usually hold the property rights over them and should be compensated for the loss of profit of the reserved area set aside for conservation. Simultaneously, those who receive the services (beneficiaries) should pay for the provision of them. Furthermore, PES is a well defined environmental service or a form of land use likely to secure that service (Wunder 2005). However, not every smallholder are able to meet these conditions.

Funding for PES may come from user fees, taxes, voluntary deductions or the private sector (Wunder et al. 2008). In contrast, Farley et al. (2011a) support PES schemes as a public sector to public sector transfer of resources. Public funding is the main PES financer (except for the carbon markets) enabling conservation, sustainable use and poverty alleviation. However the scheme does not require agroecological practices to work.

There has been substantial discussion about the effectiveness of PES as a conservation tool. As a result, marketing nature has gained its critics because some have pushed ecosystem services into the market, prioritizing efficiency rather than acknowledging the biophysical limits of each ecosystem (Farley & Costanza 2010). It is possibly that PES would help diminish rural poverty (Pagiola et al. 2005). However, PES seldom cover the cost of service provision (Lockie & Carpenter 2010).Yet, Redford and Adams (2009) point out some possible pitfalls with PES systems: (a) are PES a competitive alternative to other economic land uses? (b) can PES enhance ecosystem services? (c) to what extent is PES a long term strategy or a short period fix in terms of sustaining community livelihoods and promoting conservation? Additionally, Farley and Costanza (2010) argue whether payments should be voluntary or coerced which will depend on the type of resource since many of nature’s services are non-excludable and/or non-rival public goods.

5.2.3. Instruments available in Brazil

ICMS Ecológico (ICMS-e), which derives from the Brazilian Value Added Tax. Approximately 75% of the collected ICMS is allocated to the State and 25% goes to municipalities which assign ICMS-e 0.5 to 5% of the total ICMS (TheNatureConservancy 2011). Only 14 Brazilian States have implemented ICMS-e, however Santa Catarina has not approved it yet. Municipalities use payments for conservation of protected areas and to invest in infrastructure, sewage, waste management and incentives to ecotourism.

Programa Produtor de Agua (PPA), or Water Production Program, reward farmers that adopt conservation practices, such as erosion control to ensure water quality. Compensations are given by federal, state, municipal or international agencies and are proportional to erosion abatement and related to certain land uses. Rural extension is available and agricultural practices are flexible and MIG was proven to be a superior agroecological method to control erosion (ANA-MMA 2009).

Servidão Florestal (SF) or Conservation Easement, establishes that private owners can offer to sell (temporarily or permanently) Permanent Preservation Areas (APP) or Legal Reserve Areas (RL) of their farms to third party farmers that lack these conservation areas in their own farms. Both farms must belong to the same watershed.

Reducing Emissions from Deforestation and Forest Degradation (REDD+)

According to van der Werf et al. (2009), 15% of global C emissions occur due to deforestation and forest degradation. REDD+ multibillion dollar fund, provides financial incentives to reduce and mitigate forest loss by increasing C stocks by means of reducing emissions from deforestation and forest degradation in developing countries. Restoration of existing and new Atlantic Forest would reestablish ecosystem services. MIG is an agroecological alternative that can be used in REDD^{+} projects to reduce poverty because it does not require a large area and it has the potential to triple dairy outputs (Pinheiro Machado 2004a). However, there are some critiques to REDD+ which refer to the lack of participation of local communities, specially indigenous and smallhoders, in the process as well as, missing evidences on the drivers of deforestation, lax accounting of land tenure and carbon rights (Freudenthal, et al., 2011).

Bolsa Floresta or Forest Stipend or Allowance, is an environmental welfare program implemented in 15 conservation units (10 million ha) of the Brazilian Amazon, aiming to stop deforestation. The program has social, income, family and association components that reward traditional and indigenous populations for the maintenance of ecosystem services and as a poverty reduction mechanism. In 2010, *Bolsa Floresta* invested $777.00 per family/year reaching over 7 thousand families (ASF 2010).

Santa Catarina also adopted a PES program last year.

In spite of the incentives to address conservation, these instruments are far from perfect because they are not able to reach most farmers and the payments received are not always appealing. For example, farmers would rather have their farmland occupied with livestock or a crop than idle, even if receiving monetary compensations for addressing conservation (Jeff Carter 2011, personal communication). This illustrates the crucial importance of education and access to information about conservation to avoid certain disservices from agroecosystems.

5.3. Lessons Learned

5.3.1. The Role of Education to Enable Agroecological Practices

This research suggests that education and access to information are essential to improve farm sustainability. When comparing sustainability indicators between the two assessments in Vermont, results showed that all indicators improved in the second assessment and most were significantly different, suggesting that access to information and education had positive effects on dairy farming practices. Similarly, in Brazil, extension support, frequent educational workshops and farmer-to-farmer sharing experiences by the Voisin Grazing Group proved to be highly effective in transmitting the right agroecological knowledge. Thus, combining agroecological extension -to promote agroecological practices such as MIG- and financing these practices through public-sector-to-public-sector PES systems seems to be a win-win scheme (Farley et al. 2011a). Furthermore, it seems that the bigger challenge currently is to assist Santa Catarina's institutions to put it in practice.

5.3.2. Rethinking Subsidies, Industrial Agriculture and Agroecology

During the 20th century, agricultural policies have favored a farming model that produced a few key commodity crops, which also supply livestock feed. This model has encouraged subsidies endorsed in the Farm Bill, enabling farmers to produce at lower costs and consumers to pay less for their food. However, the actual system is a market failure because it stimulates overproduction, causing dumping and ignoring social and environmental costs. Soil loss to erosion, water quality, pollution mitigation, habitat and biodiversity loss are not taken into consideration (Myers & Kent, 2001). Farmers usually have to face mitigation costs of their farmland using taxpayer's money from the Federal Conservation Programs (Winsten & Hunter 2011). Figures from the Environmental Working Group (EWG, 2011) suggest that between 1995 and 2010 conservation payments were only 15% of the payments to dairy program subsidies in Vermont (EWG 2011c). Subsidies also failed in safeguarding farmers and their rural life since 1995, 74% of the subsidies were received by only 10% of the wealthiest farmers (EWG 2011d). Additionally, city dwellers who invest in industrial farming also receive a check from the Federal Government (EWG 2011a), while 62% of US farmers do not receive any subsidy whatsoever (EWG 2011b). These figures can also explain the disparity in the adoption of dairy management methods as confinement operations enjoyed direct and indirect agricultural subsidies despite social and environmental negligence (Wise & Starmer 2007; PewCommision 2008). While MIG is cost-effective compared to traditional grazing and confinement, it has not benefitted equally from government payments as only 2% of farms received 30% of the subsidies (Steiner & Franzluebbers 2009).

5.4. Final Considerations: How the Results from the Two Studies May Inform Better Policies?

The model of dairy intensification through confinement operations seeks to maximize production and profits but it neglects farm sustainability, livelihoods and ecosystems (Rivera-Ferre 2008). Healthy ecosystems provide critical services for poverty alleviation (MEA 2005a; Carpenter et al. 2006). Concomitantly, policy-makers face the dilemma of how to best balance the socio-economic survival of farms and the protection of ecosystem services (Idol et al. 2011). However, since there is not a one-size-fits-all policy strategy, crafting the best stratagem for addressing these complex socio-environmental situations for the dairy sector is pressing.

The problem is often the lack of commitment for long-term investments in natural resources which affects the way agroecosystems are managed (Strauch et al. 2009). Arguably, these resources are commonly shared but inadequately handled since they are managed for immediate gains because farmers are encouraged to produce global-market commodities instead of local food (Rosegrant & Cline 2003). Besides, resources are often “borrowed” from future generations to fulfill immediate needs (Howarth & Norgaard 1990), without considering how their scarcity will affect future generations (Heal 1993).

The creation of a Federal framework to facilitate markets for ecosystem services in 2008, by the USDA Farm Bill, Section 2709 (USDA-OEM 2008) is an attempt to mitigate these asymmetries. The market framework includes greenhouse gases, water quality credits, wetland mitigation banking and conservation banking (biodiversity). Incentives can be issued for specific services (stacked) or in a bundle (conservation easements, wetlands, etc.). Brazil has also a legal ES conservation framework. In 2010, Santa Catarina established the ES policy (Law 15.133) which created and regulated the State Program on PES (Law 14.675) (Government-Santa-Catarina 2010). This Law comprises provisioning and regulating services and sets rules for beneficiaries and providers. It also promulgated PES as an instrument for sustainable development, recognizing the contribution of family agriculture and indigenous communities towards environmental conservation (Government-Santa-Catarina 2010).

It seems clear that the main challenge is to avoid the long-term decline of ecosystem structure, which might generate environmental degradation. This would decrease agricultural productivity, thereby increasing dairy farm decline and affecting entire rural communities (Daily et al. 1997; Martinez et al. 2009; Strauch et al. 2009).

Pastures in Vermont and Santa Catarina are suitable for sustainable dairy practices. They would improve with minimum environmental and social detrimental treatment and sustain adequate levels of production, if conducted under improved management.The findings in this dissertation provide data that could inform policymakers when they assess their support for sustainable agroecological practices, such as MIG. Ideally, programs should be adjusted to reduce or end harmful subsidies to industrial farming, while at the same time, increase incentives for agroecological practices. Although some progress has been made, there is much to do to re-envision current agricultural and environmental policy to re-direct its investments to support more sustainable practices that will also conserve ecosystem services.

5.5. References

ANA-MMA. 2009. Programa Produtor de Agua, in: A. N. d. Aguas (Ed.), Ministerio do Meio ambiente, Brasilia.

ASF. 2010. Fundação Amazônia Sustentável. Annual Report, Making forest worth more standing than cut, Manaus, Brazil

Carpenter S.R., DeFries R., Dietz T., Mooney H.A., Polasky S., Reid W.V., Scholes R.J. 2006. Millennium ecosystem assessment: research needs. Science 314:257-258.

Daily G.C., Susan Alexander, Paul R. Ehrlich, Larry Goulder, Jane Lubchenco, Pamela A. Matson, Harold A. Mooney, Sandra Postel, Stephen H. Schneider, David Tilman, Woodwell G.M. 1997. Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems. Ecological Society of America 2:18 p.

ERS, USDA. 2005. Number of Farms in relation to average farm size, Economic Research Service, Census of Agriculture.

EWG. 2011a. City Slickers Continue To Rake In Farm Payments, Environmental Working Group.

EWG. 2011b. Farms Getting Government Payments, by State, according to the 2007 USDA Census of Agriculture, Environmental Working Group.

EWG. 2011c. Vermont Farm Subsidy Database, Environmental Working Group.

EWG. 2011d. Why The Farm Bill Matters, Environmental Working Group.

Farley J., Costanza R. 2010. Payments for ecosystem services: From local to global. Ecological Economics 69:2060-2068. DOI: DOI: 10.1016/j.ecolecon.2010.06.010.

Farley J., Schmitt F A.L., Alvez J.P., Ribeiro de Freitas N. 2011. How Valuing Nature Can Transform Agriculture. Solutions Journal.

Freudenthal, E.; Nnah, S.; Kenrick, J. 2011. REDD and Rights in Cameron: A review of the treatment of indigenous peoples and local communities in policies and projects. Forest Peoples Programmes. UK.

Government-Santa-Catarina. 2010. Politica estadual de servicos ambientais e pagamentos por servicos ambientais, Lei 15.133, in: A. N. d. Agua (Ed.), Government of Santa Catarina, Florianopolis, Santa Catarina.

Heal G. 1993. The Optimal Use of Exhaustible Resource Use, in: A. V. K. J. B. Sweeney (Ed.), Handbook of Natural Resource and Energy Economics, Elsevier, Amsterdam.

Howarth R.B., Norgaard R.B. 1990. Intergenerational Resource Rights, Efficiency, and Social Optimality. Land Economics 66:1-11.

Idol T., Haggar J., Cox L. 2011. Ecosystem Services from Smallholder Forestry and Agroforestry in the Tropics, in: W. B. Campbell and S. Lopez Ortiz (Eds.), Integrating Agriculture, Conservation and Ecotourism: Examples from the Field, Springer Netherlands. pp. 209-270.

Lockie S., Carpenter D. 2010. Agriculture, biodiversity and markets: livelihoods and agroecology in comparative perspective Earthscan.

Martinez M.L., Perez-Maqueo O., Vazquez G., Castillo-Campos G., Garcia-Franco J., Mehltreter K., Equihua M., Landgrave R. 2009. Effects of land use change on biodiversity and ecosystem services in tropical montane cloud forests of Mexico.

Forest Ecology and Management 258:1856-1863. DOI: 10.1016/j.foreco.2009.02.023.

MEA. 2005. Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: A Framework for Assessment Island Press, Washington, DC.

Pagiola S., Arcenas A., Platais G. 2005. Can payments for environmental services help reduce poverty? an exploration of the issues and the evidence to date from Latin America. World Development 33:237-253.

PewCommision. 2008. Pew Commision on Industrial Farm Animal Production, Putting Meat on the Table: Industrial Farm Animal Production in America, Pew Charitable Trust and the Johns Hopkins Bloomberg School of Public Health

Pinheiro Machado L.C. 2004. Pastoreio racional voisin: tecnologia agroecológica para o terceiro milênio. Cinco Continentes, Porto Alegre.

Redford K.H., Adams W.M. 2009. Payment for Ecosystem Services and the Challenge of Saving Nature. Conservation Biology 23:785-787. DOI: 10.1111/j.1523-1739.2009.01271.x.

Rivera-Ferre M.G. 2008. The future of agriculture. EMBO Rep 9:1061-1066.

Rosegrant M.W., Cline S.A. 2003. Global Food Security: Challenges and Policies. Science 302:1917-1919. DOI: 10.1126/science.1092958.

Steiner J.L., Franzluebbers A.J. 2009. Farming with grass—for people, for profit, for production, for protection. Journal of Soil and Water Conservation 64:75A-80A. DOI: 10.2489/jswc.64.2.75A.

Strauch A.M., Kapust A.R., Jost C.C. 2009. Impact of livestock management on water quality and streambank structure in a semi-arid, African ecosystem. Journal of Arid Environments 73:795-803. DOI: 10.1016/j.jaridenv.2009.03.012.

TheNatureConservancy. 2011. ICMS Ecologico, in: G. Baggio (Ed.), Curitiba, PR.

USDA-NRCS. 2011 Natural Resources Conservation Services: Conservation Programs, in: USDA (Ed.), Washington D.C.

USDA-OEM. 2008 The Food, Conservation, and Energy Act of 2008. H.R. 2419. Section 2709: Environmental Services Markets in: USDA (Ed.), Washington D.C. pp. 1.

Winsten J.R., Hunter M. 2011. Using pay-for-performance conservation to address the challenges of the next farm bill. Journal of Soil and Water Conservation 66:111A-117A. DOI: 10.2489/jswc.66.4.111A.

Wise T.A., Starmer E. 2007. Industrial Livestock Companies' Gains from Low Feed Prices, 1997-2005, in: G. D. a. E. Institute (Ed.), Tufts University. pp. 3.

Wunder S. 2005. Payment for environmental services: some nuts and bolts, Center for International Forestry Research. pp. 26.

Wunder S., Engel S., Pagiola S. 2008. Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. Ecological Economics 65:834-852.

COMPREHENSIVE BIBLIOGRAPHY

Adams, W. M., R. Aveling, D. Brockington, B. Dickson, J. Elliott, J. Hutton, D. Roe, B. Vira, and W. Wolmer. 2004. Biodiversity conservation and the eradication of poverty. Science 306:1146-1149.

Albright, J. L. 1964. Problems in Increasing Size of the Dairy Herd1. Journal of Dairy Science 47:941-943.

Altieri, M. A. 1999. The ecological role of biodiversity in agroecosystems. Agriculture Ecosystems & Environment 74:19-31.

Altieri, M. A. 2002. Agroecology: the science of natural resource management for poor farmers in marginal environments. Agriculture Ecosystems & Environment 93:1-24.

Amekawa, Y., H. Sseguya, S. Onzere, and I. Carranza. 2010. Delineating the Multifunctional Role of Agroecological Practices: Toward Sustainable Livelihoods for Smallholder Farmers in Developing Countries. Journal of Sustainable Agriculture 34:202-228.

ANA-MMA. 2009. Programa Produtor de Agua in A. N. d. Aguas, editor. Ministerio do Meio ambiente, Brasilia.

Arsenault, N., P. Tyedmers, and A. Fredeen. 2009. Comparing the environmental impacts of pasture-based and confinement-based dairy systems in Nova Scotia (Canada) using life cycle assessment. International Journal of Agricultural Sustainability 7:19-41.

Asch, A., A. Matthews, and D. Bothfeld, editors. 2004. Dairy Stewardship Alliance: an on-farm self-assessment for farmers. Ben & Jerry's, Burlington, VT.

ASF. 2010. Fundação Amazônia Sustentável. Annual Report. Making forest worth more standing than cut, Manaus, Brazil

Ashley, C., and D. Carney 1999. Sustainable livelihoods: lessons from early experience. DFID, London.

Asner, G. P., A. J. Elmore, L. P. Olander, R. E. Martin, and A. T. Harris. 2004. Grazing Systems, Ecosystem Responses and Global Change. Annual Review of Environment and Resources 29:261-299.

Balmford, A., A. Bruner, P. Cooper, R. Costanza, S. Farber, R. E. Green, M. Jenkins, P. Jefferiss, V. Jessamy, J. Madden, K. Munro, N. Myers, S. Naeem, J. Paavola, M. Rayment, S. Rosendo, J. Roughgarden, K. Trumper, and R. K. Turner. 2002. Economic Reasons for Conserving Wild Nature. Science 297:950-953.

Baptista, S. R. 2008. Forest Recovery and Just Sustainability in the Florianopolis City-Region. Page 406. Geography. Rutgers, The State Unuversity of New Jersey, New Brunswick, NJ.

Bauer, E., A. L. Schmitt F, J. Epping, and J. Farley. 2009. Dairy Production in Florianópolis: Farmers' Perceptions about the Transition from Conventional Dairy to Voisin Management Intensive Grazing. Pages 2716-2720. Resumos do VI CBA e II CLAA. Rev. Bras. de Agroecologia, Curitiba, Brazil.

Bebbington, A. 1999. Capitals and capabilities: A framework for analyzing peasant viability, rural livelihoods and poverty. World Development 27:2021-2044.

Benson, G. A. 2008. Pasture-Based and Confinement Dairy Farming in the United States: An Assessment. Journal of International Farm Management 04.

Bilotta, G. S., R. E. Brazier, and P. M. Haygarth. 2007. The Impacts of Grazing Animals on the Quality of Soils, Vegetation, and Surface Waters in Intensively Managed Grasslands. Pages 237-280 in L. S. Donald, editor. Advances in Agronomy. Academic Press.

Bonny, S. 2003. Why are most Europeans opposed to GMOs?: Factors explaining rejection in France and Europe. Electronic Journal of Biotechnology 6:7-8.

Boody, G., B. Vondracek, D. A. Andow, M. Krinke, J. Westra, J. Zimmerman, and P. Welle. 2005. Multifunctional agriculture in the United States. Bioscience 55:27-38.

Boumans, R., M. A. Wilson, R. Portela, J. Rotmans, F. Villa, M. Grasso, R. Costanza, and J. Farley. 2002. Modeling the dynamics of the integrated earth system and the value of global ecosystem services using the GUMBO model. Ecological Economics 41:529-560.

Boyd, J., and S. Banzhaf. 2007. What are ecosystem services? The need for standardized environmental accounting units. Ecological Economics 63:616-626.

Brooks, T. M., R. A. Mittermeier, G. A. B. da Fonseca, J. Gerlach, M. Hoffmann, J. F. Lamoreux, C. G. Mittermeier, J. D. Pilgrim, and A. S. L. Rodrigues. 2006. Global biodiversity conservation priorities. Science 313:58-61.

Câmara, I. d. G. 2002. A política de unidades de conservação: uma visão pessoal in M. S. o. Milano, editor. Unidades de conservação: atualidades e tendências. Fundação O Boticário de Proteção à Natureza, Curitiba, PR Brazil.

Carney, D., M. Drinkwater, T. Rusinow, K. Neefjes, S. Wanmali, and N. Singh 1999. Livelihood approaches compared. DFID, London.

Carpenter, S. R., R. DeFries, T. Dietz, H. A. Mooney, S. Polasky, W. V. Reid, and R. J. Scholes. 2006. Millennium ecosystem assessment: research needs. Science 314:257-258.

Chambers, R. 1989. Farmer first: a practical paradigm for the third agriculture. Pages 237-244 in M. A. Altieri, and S. B. Hecht, editors. Agroecology and small farm development. CRC Press, Boca Raton, Fla., USA.

Chambers, R. 1995. Poverty and livelihoods : whose reality counts? Institute of Development Studies at the University of Sussex, Brighton, Eng.

Chambers, R., and G. Conway. 1991. Sustainable rural livelihoods: practical concepts for the 21st Century. IDS-University of Sussex, Brighton.

Cincotta, R. P., J. Wisnewski, and R. Engelman. 2000. Human population in the biodiversity hotspots. Nature 404:990-992.

Cooner, D., D. Rozeboom, and V. Campbell-Arvai. 2009. Literature Review: A Comparison of Dairy Production Systems. Department of CARRS, Michigan State University.

Costa, L. P., Y. L. R. Leite, S. L. Mendes, and A. D. Ditchfield. 2005. Mammal Conservation in Brazil:672-679.

Costanza, R., R. dArge, R. deGroot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. Oneill, J. Paruelo, R. G. Raskin, P. Sutton, and M. vandenBelt. 1997a. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Costanza, R., M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, M. Van den Belt, R. D'Arge, R. De Groot, and S. Farber.

1997b. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Daily, G. C., editor. 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, D.C.

Daily, G. C., Susan Alexander, Paul R. Ehrlich, Larry Goulder, Jane Lubchenco, Pamela A. Matson, Harold A. Mooney, Sandra Postel, Stephen H. Schneider, David Tilman, and G. M. Woodwell. 1997. Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems. Ecological Society of America 2:18 p.

Dale, V., and S. Polasky. 2007. Measures of the effects of agricultural practices on ecosystem services. Ecological Economics 64:286-296.

Daly, H., and J. Farley 2010. Ecological Economics: Principles and Applications: 2nd edition. Island Press, Washington, DC.

De Ramus, H. A., T. C. Clement, and D. D. Giampola. 2003. Methane Emmissions of Beef Cattle on Forages: Efficiency of Grazing Management Systems. Journal of Environmental Quality 32:269-277.

DeRamus, H. A. 2004. Grazing management of ruminant animals in sustainable agriculture. Outlook on Agriculture 33:93-100.

DFID. 2004. Agricultural Sustainability. Page 23 in D. f. I. Development, editor. University of Essex, UK.

Dias, F. 2006. Confinamento Brasileiro: Onde Queremos Chegar? Pages Presentation to the Colegio Brasileiro of Animal Nutrition, ESALQ. Associacao Nacional dos Confinadores, Goiania, GO Brasil.

Ditt, E. H., J. D. Knight, S. Mourato, C. V. Padua, R. R. Martins, and J. Ghazoul. 2008. Defying legal protection of Atlantic Forest in the transforming landscape around the Atibainha reservoir, south-eastern Brazil. Landscape and Urban Planning 86:276-283.

Ditt, E. H., S. Mourato, J. Ghazoul, and J. Knight. 2010. Forest conversion and provision of ecosystem services in the Brazilian Atlantic Forest. Land Degradation & Development 21:591-603.

Eisenberg, E. 1998. The ecology of Eden. Alfred A. Knopf.

Ellis, F. 2000. Rural livelihoods and diversity in developing countries. Oxford University Press, Oxford.

ERS, and USDA. 2005. Number of Farms in relation to average farm size. Economic Research Service, Census of Agriculture.

EWG. 2011a. City Slickers Continue To Rake In Farm Payments. Environmental Working Group.

EWG. 2011b. Farms Getting Government Payments, by State, according to the 2007 USDA Census of Agriculture. Environmental Working Group.

EWG. 2011c. Vermont Farm Subsidy Database. Environmental Working Group.

EWG. 2011d. Why The Farm Bill Matters. Environmental Working Group.

FAO. 2004. Statistics of the FAOStat. Food and Agriculture Organization of the United Nations, On line: www.faostat.fao.org.

Farber, S., R. Costanza, D. L. Childers, J. Erickson, K. Gross, M. Grove, C. S. Hopkinson, J. Kahn, S. Pincetl, A. Troy, P. Warren, and M. Wilson. 2006. Linking ecology and economics for ecosystem management. Bioscience 56:121-133.

Farley, J., and R. Costanza. 2010. Payments for ecosystem services: From local to global. Ecological Economics 69:2060-2068.

Farley, J., A. L. Schmitt F, J. P. Alvez, and N. Ribeiro de Freitas. 2011a. How Valuing Nature Can Transform Agriculture. Solutions Journal.

Farley, J., A. Schmitt Filho, Juan Alvez, and N. Ribeiro de Freitas, Jr. 2011b. How Valuing Nature Can Transform Agriculture. Solutions 2:64-73.

Fisher, B., and K. R. Turner. 2008. Ecosystem services: Classification for valuation. Biological Conservation 141:1167-1169.

Foley, J. A., G. P. Asner, M. H. Costa, M. T. Coe, R. DeFries, H. K. Gibbs, E. A. Howard, S. Olson, J. Patz, N. Ramankutty, and P. Snyder. 2007. Amazonia revealed: forest degradation and loss of ecosystem goods and services in the Amazon Basin. Frontiers in Ecology and the Environment 5:25-32.

Foley, J. A., R. DeFries, G. P. Asner, C. Barford, G. Bonan, S. R. Carpenter, F. S. Chapin, M. T. Coe, G. C. Daily, H. K. Gibbs, J. H. Helkowski, T. Holloway, E. A. Howard, C. J. Kucharik, C. Monfreda, J. A. Patz, I. C. Prentice, N. Ramankutty, and P. K. Snyder. 2005. Global Consequences of Land Use. Science 309:570-574.

Foltz, J., and G. Lang. 2005. The adoption and impact of management intensive rotational grazing (MIRG) on Connecticut dairy farms. Renewable Agriculture and Food Systems 20:261-266.

Food_&_Water_Watch. 2010. Factory Farm Nation: How america Turned Its Livestock Farms into Factories. Food & Water Watch, Washington, DC.

Franzluebbers, A. J. 2010. Achieving Soil Organic Carbon Sequestration with Conservation Agricultural Systems in the Southeastern United States. Soil Science Society of America 74:347-357.

Freudenthal, E.; Nnah, S.; Kenrick, J. 2011. REDD and Rights in Cameron: A review of the treatment of indigenous peoples and local communities in policies and projects. Forest Peoples Programmes. UK.

Galaty, J. G., and D. L. Johnson 1990. The World of pastoralism: herding systems in comparative perspective. Guilford Press, London, UK.

Garry, F. B. 2004. An overview of animal welfare in the US dairy industry. Bovine Practitioner, Vol 38 No 1 38:1-22.

Gerrish, J. 2004. Benefits of Management-intensive Grazing. University of Missouri-Forage Systems Research Center, Saint Louis.

Gibson, D. J. 2009. Grasses and grassland ecology. Oxford University Press.

Giraldo, C., F. Escobar, J. D. CharÁ, and Z. Calle. 2011. The adoption of silvopastoral systems promotes the recovery of ecological processes regulated by dung beetles in the Colombian Andes. Insect Conservation and Diversity 4:115-122.

Glaeser, B. 1987. The Green Revolution revisited: critique and alternatives. Allen & Unwin.

Gliessman, S. 2010. Landscape Multifunctionality and Agriculture. Journal of Sustainable Agriculture 34:465-465.

Gliessman, S. R. 2007. Agroecology: the ecology of sustainable food systems. CRC Press/Taylor & Francis, Boca Raton, FL.

Gómez-Baggethun, E., R. de Groot, P. L. Lomas, and C. Montes. 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. Ecological Economics 69:1209-1218.

Government-Santa-Catarina. 2010. Politica estadual de servicos ambientais e pagamentos por servicos ambientais, Lei 15.133 in A. N. d. Agua, editor. Government of Santa Catarina, Florianopolis, Santa Catarina.

Green, R. E., S. J. Cornell, J. P. W. Scharlemann, and A. Balmford. 2005. Farming and the fate of wild nature. Science 307:550-555.

Grelle, C. E. V. 2003. Forest Structure and Vertical Stratification of Small Mammals in a Secondary Atlantic Forest, Southeastern Brazil. Studies on Neotropical Fauna & Environment 38:81.

Groenfeldt, D. 2006. Multifunctionality of agricultural water: Looking beyond food production and ecosystem services. Irrigation and Drainage 55:73-83.

Guttman, L. 1944. A Basis for Scaling Qualitative Data. American Sociological Review 9:139-150.

Hanson, G. D., L. C. Cunningham, S. A. Ford, L. D. Muller, and R. L. Parsons. 1998. Increasing intensity of pasture use with dairy cattle: An economic analysis. Journal of Production Agriculture 11:175-179.

Hardin, G. 1968. The Tragedy of The Commons. Science 162:1243-1248.

Harris, P. S. 2000. Grassland resource assessment for pastoral systems in FAO, editor. FAO PLANT PRODUCTION AND PROTECTION PAPER. Food and Agriculture Organization of the United Nations, Rome.

Harrison, B. A. 2006. The view from Vermont: tourism and the making of an American rural landscape. University of Vermont Press.

Heal, G. 1993. The Optimal Use of Exhaustible Resource Use in A. V. K. J. B. Sweeney, editor. Handbook of Natural Resource and Energy Economics. Elsevier, Amsterdam.

Heinrich, I., and P. Hinrichs. 2000. Inter-regional competitiveness: a cross-country comparison of dairy farming, paper presented in Vienna Workshop 18-20 June, Refinement of a typology for describing the regional differences in livestock systems within EU. Institute of farm Management and Rural Studies (BAL), Braunschweig, Germany.

Hemme, T., and J. Otte. 2010. Pro-Poor Livestock Policy Initiative: Status and Prospects for Smallholder Milk Production

A Global Perspective in F. a. A. O. o. t. U. Nations, editor. FAO, Rome.

Hemsworth, P. H. 2000. The human factor: Influence on livestock performance and welfare. Proceedings of the New Zealand Society of Animal Production 60:237-240.

Hemsworth, P. H. 2003. Human-animal interactions in livestock production. Applied Animal Behaviour Science 81:185-198.

Herrero, M., P. K. Thornton, P. Gerber, and R. S. Reid. 2009. Livestock, livelihoods and the environment: understanding the trade-offs. Current Opinion in Environmental Sustainability 1:111-120.

Hinrichs, C. C., and R. Welsh. 2003. The effects of the industrialization of US livestock agriculture on promoting sustainable production practices. Agriculture and Human Values 20:125-141.

Holmberg, S., A. Thelin, E. L. Stiernstrom, and K. Svardsudd. 2004. Psychosocial factors and low back pain, consultations, and sick leave among farmers and rural referents: a population-based study. Journal of occupational and environmental medicine / American College of Occupational and Environmental Medicine 46:993-998.

Howarth, R. B., and R. B. Norgaard. 1990. Intergenerational Resource Rights, Efficiency, and Social Optimality. Land Economics 66:1-11.

ICEPA. 2009. Síntese Anual da Agricultura de Santa Catarina 2008-2009 in I. C. C. d. S. e. P. Agricola, editor.

Idol, T., J. Haggar, and L. Cox. 2011. Ecosystem Services from Smallholder Forestry and Agroforestry in the Tropics. Pages 209-270 in W. B. Campbell, and S. Lopez Ortiz, editors. Integrating Agriculture, Conservation and Ecotourism: Examples from the Field. Springer Netherlands.

IFAD. 2004. Livestock services and the poor. Page 152. International Fund for Agricultural Development.

Jackson, L. E., U. Pascual, and T. Hodgkin. 2007. Utilizing and conserving agrobiodiversity in agricultural landscapes. Agriculture Ecosystems & Environment 121:196-210.

Jordan, N., and K. D. Warner. 2010. Enhancing the Multifunctionality of US Agriculture. Bioscience 60:60-66.

Kaustell, K. O., T. E. Mattila, and R. H. Rautiainen. 2007. Safety performance of animal confinement floors: slip, trip, and fall injuries in Finland. Journal of agricultural safety and health 13:395-406.

Koneswaran, G., and D. Nieremberg. 2008. Global Farm Animal Production and Global Warming: Impacting and Mitigating Climate Change. Environmental Health Perspectives 116:578-582.

Kotschi, J. 2007. Agricultural biodiversity is essential for adapting to climate change. Gaia-Ecological Perspectives for Science and Society 16:98-101.

Kriegl, T., and R. McNair. 2005. Pastures of Plenty: Financial performance of Wisconsin grazing dairy farms, Madison, Wi.

Lai, R. 2007. Managing Soils for Food Security and Climate Change. Journal of Crop Improvement 19:49-71.

Leopold, A., and C. W. Schwartz 1989. A Sand County almanac, and sketches here and there. Oxford University Press.

LID. 1999. Livestock in Development: Livestock in Poverty-Focused Development.95.

Lindlof, T. R., and B. C. Taylor 2010. Qualitative Communication Research Methods. SAGE Publications.

Lockie, S., and D. Carpenter 2010. Agriculture, biodiversity and markets: livelihoods and agroecology in comparative perspective. Earthscan.

Lovell, S. T., S. DeSantis, C. A. Nathan, M. B. Olson, V. E. Mendez, H. C. Kominami, D. L. Erickson, K. S. Morris, and W. B. Morris. 2010. Integrating agroecology and landscape multifunctionality in Vermont: An evolving framework to evaluate the design of agroecosystems. Agricultural Systems 103:327-341.

Lund, H. G. 2007. Accounting for the World's Rangelands. Rangeland:3-10.

Lyons, J., B. M. Weigel, L. K. Paine, and D. J. Undersander. 2000. Influence of intensive rotational grazing on bank erosion, fish habitat quality, and fish communities in southwestern Wisconsin trout streams. Journal of Soil and Water Conservation 55:271-276.

Magdoff, F. 2007. Ecological agriculture: Principles, practices, and constraints. Renewable Agriculture and Food Systems 22:109.

Maloney, T. R. 2002. Management of Hispanic Employees on New York Dairy Farms: a Survey of farm Managers. Pages 67-78 in J. L. Findeis, editor. The dynamics of hired farm labour: constraints and community responses. CABI.

Maraschin, G. E. 1994. Sistemas de Pastejo. Pages 337-376 in A. M. Peixoto, Moura, J.C. de, e Faria, V.P., editor. Pastagens: Fundamentos da Exploracao Racional. FEALQ, Piracicaba.

Marsh, G. P. 1864. Man and Nature. Charles Scribner, New York.

Martinez, M. L., O. Perez-Maqueo, G. Vazquez, G. Castillo-Campos, J. Garcia-Franco, K. Mehltreter, M. Equihua, and R. Landgrave. 2009. Effects of land use change on biodiversity and ecosystem services in tropical montane cloud forests of Mexico. Forest Ecology and Management 258:1856-1863.

Mathew, A. G., R. Cissell, and S. Liamthong. 2007. Antibiotic Resistance in Bacteria Associated with Food Animals: A United States Perspective of Livestock Production. Foodborne Pathogens and Disease 4:115-133.

McGilvery, K. 2011. Fewer than 1,000 dairy farms now left in Vt. WCAX News, Burlington

McNeely, J. A., and K. R. Miller 1984. National Parks, Conservation and Development: the Role of Protected Areas in Sustaining Society. Smithsonian Institution, USA.

MEA 2005a. Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: A Framework for Assessment. Island Press, Washington, DC.

MEA 2005b. Millennium Ecosystem Assessment: Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Meister, Kyle and Salviati, Victor (2009), 'O Investimento Privado e a Restauração da Mata Atlântica no Brasil', *Revista Intertox de Toxicologia, Risco Ambiental e Sociedade*, 2 (2).

Melado, J. 2007a. Pastagem ecológica e serviços ambientais da pecuaria sustentavel. Revista Brasileira de Agroecologia 2.

Melado, J. 2007b. Pastagem Ecológica e serviços ambientais da pecuária sustentável. Rev. Bras. de Agroecologia 2.

Méndez, V. E. 2010. Agroecology. Page in press in B. Warf, editor. Encyclopedia of Geography. Sage Publications, Thousand Oaks, CA.

Mesquita, C. A. B. 1999. Conservación privada en América Latina: el caso de las Reservas Particulares del Patrimonio Natural, Brasil. II Congreso Interamericano de Conservación Privada, Sarapiquí, Costa Rica.

Mesquita, C. A. B. 2002. Capacitação como meio para conservar terras privadas. Anais do III Congresso Brasileiro de Unidades de Conservação. Rede Pró-Unidades de Conservação. Fundação O Boticário de Proteção à Natureza, Brazil.

Metzger, J. P. 2009. Conservation issues in the Brazilian Atlantic forest. Biological Conservation 142:1138-1140.

Meul, M., F. Nevens, and D. Reheul. 2009. Validating sustainability indicators: Focus on ecological aspects of Flemish dairy farms. Ecological Indicators 9:284-295.

Milano, M. S. 2002. Por que existem as unidades de conservação? in M. S. o. Milano, editor. Unidades de conservação: atualidades e tendências. Fundação O Boticário de Proteção à Natureza, Curitiba, PR Brazil.

Mooney, H., A. Cropper, and W. Reid. 2005. Confronting the human dilemma. Nature 434:561-562.

Morsello, C. 2001. Áreas protegidas públicas e privadas: seleção e manejo. Annablume e Fapesp, São Paulo, Brasil.

Murphy, B., J. Silman, L. McCrory, S. Flack, J. Winster, D. Hoke, A. Schmitt and B. Pillsbury 1996. Environmental, economic, and social benefits of feeding livestock on well managed pasture. Tufts University Press, Boston.

Murphy, W. M. 1998a. Feeding Livestock on Well-Managed Pasture: Effects on Farm Family, Rural Community, and Landscape. Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY.

Murphy, W. M. 1998b. Greener pastures on your side of the fence: better farming with Voisin management intensive grazing. Arriba Pub, Colchester, VT.

Murphy, W. M., J. R. Rice, and D. T. Dugdale. 1986. Dairy farm feeding and income effects of using Voisin grazing management of permanent pastures. American Journal of Alternative Agriculture 1:147-152.

Myers, N. 1988. Threatened biotas: "Hot spots" in tropical forests. The Environmentalist 8:187-208.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, and J. Kent. 2000a. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. d. Fonseca, and J. Kent. 2000b. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

NCDC/NOAA. 2010. National Climatic Data Center

National Oceanic and Atmospheric Administration.

NRC. 2001. Nutrient Requirements of Dairy Cattle in N. R. Council, editor. National Academy of Sciences, Washington, DC.

NRCS., U. 2010. Vermont State Soil: Turnbridge Series in U. S. D. o. A. N. r. C. Service, editor.

O'Connor, T. G., P. Kuyler, K. P. Kirkman, and B. Corcoran. 2010. Which grazing management practices are most appropriate for maintaining biodiversity in South African grassland? African Journal of Range & Forage Science 27:67-76.

Olsen, J. 2004. "A Summary of Basic Costs and Their Impact on Confinement vs. Managed Intensive Rotational Grazing MIRG) in W. D. Data, editor. University of Wisconsin Center for Dairy Profitability, Madison, WI.

Ostrom, M. R., and D. B. Jackson-Smith. 2000. The Use and Performance of Management Intensive Rotational Grazing Among Wisconsin Dairy Farms in the 1990s. Program on Agricultural Technology Studies research report No. 8. University of Wisconsin, Madison.

Ott, L., and M. Longnecker 2008. An introduction to statistical methods and data analysis. Brooks/Cole Cengage Learning.

Owen, D. F., and R. G. Wiegert. 1981. Mutualism between Grasses and Grazers: An Evolutionary Hypothesis. Oikos 36:376-378.

P. D. Walton, R. M., A. W. Bailey. 1981. A Comparison of Continuous and Rotational Grazing. Journal of Range Management 34:3.

Pacini, C. 2003. Evaluation of sustainability of organic, integrated and conventional farming systems: a farm and field-scale analysis. Agriculture, Ecosystems & Environment 95:273-288.

Pagiola, S. 2008. Payments for environmental services in Costa Rica. Ecological Economics 65:712-724.

Pagiola, S., A. Arcenas, and G. Platais. 2005. Can payments for environmental services help reduce poverty? an exploration of the issues and the evidence to date from Latin America. World Development 33:237-253.

Parker, W. J., L. D. Muller, and D. R. Buckmaster. 1992. "Management and Economic Implications of Intensive Grazing on Dairy Farms in the Northeastern States. J. Dairy Sci.:2587-2597.

Parsons, R. L., A. E. Luloff, and G. D. Hanson. 2004. Can we identify key characteristics associated with grazing-management dairy systems from survey data? Journal of Dairy Science 87:2748-2760.

PASW. 2010. PASW Statistical Package. SPSS, Inc., Chicago, IL.

Pelletier, N., and P. Tyedmers. 2010. Forecasting potential global environmental costs of livestock production 2000–2050. Proceedings of the National Academy of Sciences 107:18371-18374.

PewCommision. 2008. Pew Commision on Industrial Farm Animal Production. Putting Meat on the Table: Industrial Farm Animal Production in America. Pew Charitable Trust and the Johns Hopkins Bloomberg School of Public Health

Phetteplace, H., D. Johnson, and A. Seidl. 2001. Greenhouse gas emissions from simulated beef and dairy livestock systems in the United States. Nutrient Cycling in Agroecosystems 60:99-102.

Pimentel, D. 2004. Livestock Production and Energy Use. Pages 671-676 in J. C. Cutler, editor. Encyclopedia of Energy. Elsevier, New York.

Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, S. Crist, L. Shpritz, L. Fitton, R. Saffouri, and R. Blair. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science 267:1117-1123.

Pimentel, D., P. Hepperly, J. Hanson, D. Douds, and R. Seidel. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. Bioscience 55:573-582.

Pimentel, D., and N. Kounang. 1998. Ecology of soil erosion in ecosystems. Ecosystems 1:416-426.

Pinheiro Machado, L. C. 2004a. Pastoreio racional voisin: tecnologia agroecológica para o terceiro milênio. Cinco Continentes, Porto Alegre.

Pinheiro Machado, L. C. 2004b. Pastoreo Racional Voisin: Tecnologia agropecuaria para el tercer milenio. Hemisferio Sur, Buenos Aires.

Pitesky, M. E., K. R. Stackhouse, and F. M. Mitloehner. 2009. Clearing the Air: Livestock's Contribution to Climate Change. Pages 1-40 in L. S. Donald, editor. Advances in Agronomy. Academic Press.

Ponting, C. 2007. A new green history of the world: the environment and the collapse of great civilizations. Penguin Books.

Porter, J. R., R. Costanza, H. Sandhu, L. Sigsgaard, and S. Wratten. 2009. The Value of Producing Food, Energy, and Ecosystem Services within an Agro-Ecosystem. Royal Academy of Sciences, Ambio 38.

Power, A. G. 2010. Ecosystem services and agriculture: tradeoffs and synergies. Philosophical Transactions of the Royal Society B: Biological Sciences 365:2959-2971.

Reardon, P. O., C. L. Leinweber, and L. B. Merrill. 1972. The effect of bovine saliva on grassess. Pages 206-210. Proc. West. Sec. Am Soc. Anim. Sci.

Redford, K. H., and W. M. Adams. 2009. Payment for Ecosystem Services and the Challenge of Saving Nature. Conservation Biology 23:785-787.

Reid, R. S., K. A. Galvin, and R. S. Kruska. 2008. Global Significance of Extensive Grazing Lands and Pastoral Societies: An Introduction. Pages 1-24 in K. A. Galvin, R. S. Reid, R. H. B. Jr, and N. T. Hobbs, editors. Fragmentation in Semi-Arid and Arid Landscapes. Springer Netherlands.

Reynolds, S. G. a. J. F. 2005. Grasslands: developments, opportunities, perspectives in S. P. Inc, editor. Enfield, and FAO, Rome, Italy.

Riethmuller, P. 2003. The social impact of livestock: A developing country perspective. Animal Science Journal 74:245-253.

Rigby, D., P. Woodhouse, T. Young, and M. Burton. 2001. Constructing a farm level indicator of sustainable agricultural practice. Ecological Economics 39:463-478.

Rivera-Ferre, M. G. 2008. The future of agriculture. EMBO Rep 9:1061-1066.

Rizzoli, A. 2004. Grupo de Pastoreio Voisin: Resultados de Parcerias entre EPAGRI, Acadêmicos e Professores da UFSC e Unisul, Prefeituras Municipais, Sindicatos e ONGs. Departamento de Zootecnia. Universidade Federal de Santa Catarina, Florianopolis, SC Brasil.

Robertson, G. P., and S. M. Swinton. 2005. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. Frontiers in Ecology and the Environment 3:38-46.

Rockström, J., W. Steffen, K. Noone, A. Persson, F. S. Chapin, E. F. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. J. Schellnhuber, B. Nykvist, C. A. de Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sorlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. A. Foley. 2009. A safe operating space for humanity. Nature 461:472-475.

Romero, N. F. 1994. Alimente seus pastos com seus animais. Livraria e Editora Agropecuária Ltda., Guaíba - RS.

Rosegrant, M. W., and S. A. Cline. 2003. Global Food Security: Challenges and Policies. Science 302:1917-1919.

Rotz, C. A., K. J. Soder, R. H. Skinner, C. J. Dell, P. J. Kleinman, J. P. Schmidt, R. B. Bryant, and A. USDA. 2009. Grazing Can Reduce the Environmental Impact of Dairy Production Systems. Forage and grazinglands.

Rudel, T. K. 1998. Is there a forest transition? Deforestation, reforestation, and development. Rural Sociology 63:533-552.

Rushen, J., A. A. Taylor, and A.-M. de Passille. 1999. Domestic animal's fear of humans and its effect on their welfare. Cahiers Agricultures 8:461-470.

Salomon, J. N. 2008. THE GMOs QUARREL. Sud-Ouest Europeen:25-37.

Salzman, J. 2005. Creating Markets for Ecosystem Services: Notes From the Field New York University Law Review 80:84.

Sanderson, E. A., M. Jaiteh, M. A. Levi, K. H. Redford, A. V. Wannebo, and G. Woolmer. 2002. The Human Footprint and the last of the Wild. Bioscience 52:891-904.

Sansoucy, R., M. A. Jabbar, S. Ehui, and H. Fitzhugh. 1995. The contribution of livestock to food security and sustainable development in S. E. a. S. M. R Trevor Wilson, editor. Proceedings of the joint FAO/ILRI roundtable on livestock development strategies for low income countries. Food and Agriculture Organization Rome, Italy, Nairobi, Kenya.

Schäffer, W. B., and M. Prochnow. 2002. A Mata Atlântica e você: como preservar, recuperar e se beneficiar da mais ameaçada floresta brasileira. Page 156 pp. in Apremavi, editor, Brasília, Brasil.

Scherr, S., and S. Yadav. 1996. Land degradation in the developing world: implications for food, agriculture and the environment to 2020, a synthesis of recommendations from an international workshop. Food, Agriculture, and the Environment Discussion Paper No. 14. , Washington, DC.

Schmalzried, H. D., and L. F. Fallon Jr. 2007. Large-Scale Dairy Operations: Assessing Concerns of Neighbors About Quality-of-Life Issues. Journal of Dairy Science 90:2047-2051.

Scoones, I. 1998. Sustainable rural livelihoods: a framework for analysis. Institute for Development Studies (IDS), Brighton, UK.

Scoones, I. 2009. Livelihoods perspectives and rural development. Journal of Peasant Studies 36:171-196.

Scully, M. 2003. Dominion: the power of man, the suffering of animals, and the call to mercy. St. Martin's Griffin.

Sears, P. B. 1956. The processes of environmental change by man. Page 1193 in W. L. Thomas, editor. Man's Role in Changing the Face of the Earth. University of Chicago Press, Chicago.

Silvano, R. A. M., S. Udvardy, M. Ceroni, and J. Farley. 2005. An ecological integrity assessment of a Brazilian Atlantic Forest watershed based on surveys of stream health and local farmers' perceptions: implications for management. Ecological Economics 53:369-385.

Simoncini, R. 2009. Developing an integrated approach to enhance the delivering of environmental goods and services by agro-ecosystems. Regional Environmental Change 9:153-167.

Sjodin, N. E., J. Bengtsson, and B. Ekbom. 2008. The influence of grazing intensity and landscape composition on the diversity and abundance of flower-visiting insects. Journal of Applied Ecology 45:763-772.

Soder, K. J., and C. A. Rotz. 2003. Economic and Environmental Impact of Utilizing a Total Mixed Ration in Pennsylvania Grazing Dairy Herds. The Professional Animal Scientist 19:304-311.

Souto, L. E. 2009. Código (anti) ambiental de Santa Catarina. O Eco on-line: http://www.oeco.com.br/convidados/64-colunistas-convidados/21295-codigo-anti-ambiental-de-santa-catarina.

Spiertz, J. H. J. 2010. Nitrogen, sustainable agriculture and food security. A review. Agronomy for Sustainable Development 30:43-55.

Steiner, J. L., and A. J. Franzluebbers. 2009. Farming with grass—for people, for profit, for production, for protection. Journal of Soil and Water Conservation 64:75A-80A.

Steinfeld, H., P. Gerber, T. Wassenaar, V. Castel, M. Rosales, and C. de Haan. 2006. Livestock Long Shadow: environmental issues and options. Food and Agriculture Organization of the United Nations:408 pg.

Strauch, A. M., A. R. Kapust, and C. C. Jost. 2009. Impact of livestock management on water quality and streambank structure in a semi-arid, African ecosystem. Journal of Arid Environments 73:795-803.

Suttie, J., S. Reynolds, C. Batello, Food, and A. O. o. t. U. Nations 2005. Grasslands of the world. Food and Agricultural Organization of the United Nations.

Swinton, S., F. Lupi, G. Robertson, and S. Hamilton. 2007. Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits☆. Ecological Economics 64:245-252.

Szott, L., M. Ibrahim, and J. Beer. 2000. The Hamburger Connection Hangover. Cattle pasture land degradation and alternative land use in Central América in D. CATIE, GTZ, editor.

Tabarelli, M., L. P. Pinto, J. M. C. Silva, M. Hirota, and L. Bede. 2005. Challenges and Opportunities for Biodiversity Conservation in the Brazilian Atlantic Forest. Conservation Biology 19:695-700.

Thelin, A., E. Vingard, and S. Holmberg. 2004. Osteoarthritis of the hip joint and farm work. American Journal of Industrial Medicine 45:202-209.

TheNatureConservancy. 2011. ICMS Ecologico in G. Baggio, editor, Curitiba, PR.

Thrupp, L. A. 2000. Linking agricultural biodiversity and food security: the valuable role of agrobiodiversity for sustainable agriculture. International Affairs 76:265-+.

Tilman, D. 1987. Secondary Succession and the Pattern of Plant Dominance Along Experimental Nitrogen Gradients. Ecological Monographs 57:189-214.

Tilman, D. 1990. Constraints and Tradeoffs - Toward a Predictive Theory of Competition and Succession. Oikos 58:3-15.

Tilman, D., K. G. Cassman, P. A. Matson, R. Naylor, and S. Polasky. 2002. Agricultural sustainability and intensive production practices. Nature 418:671-677.

Toresan, L., T. Guzzatti, D. Nart, and R. Bitencourt. 2002. Levantamento dod Empreendimentos de Turismo no Espaco Rural de Santa Catarina: Loclizacao e Descricao Geral. Page 58 in S. Instituto CEPA, editor, Florianopolis, SC.

USDA-NASS. 2007. 2007 Census Publications.

USDA-NRCS. 2011. Natural Resources Conservation Services: Conservation Programs in USDA, editor, Washington D.C.

USDA-OEM. 2008. The Food, Conservation, and Energy Act of 2008, H.R. 2419. Section 2709: Environmental Services Markets Page 1 in USDA, editor, Washington D.C.

USEPA. 2011a. 2011 U.S. Inventory of U.S. Greenhouse Gas Emmissions and Sinks: 1990-2009. United States, Environmental Protection Agency, Washington, DC.

USEPA. 2011b. National Pollutant Discharge Elimination System (NPDES) Concentrated Animal Feeding Operation (CAFO) Reporting Rule. Page 65455 in E. P. Agency, editor. USDA/EPA.

Vitousek, P. M., J. D. Aber, R. W. Howarth, G. E. Likens, P. A. Matson, D. W. Schindler, W. H. Schlesinger, and D. G. Tilman. 1997. Human alteration of the global nitrogen cycle: Sources and consequences. Ecological Applications 7:737-750.

Voisin, A. 1988. Grass Productivity. Island Press.

Walman, S. 1984. Eight London households. Tavistock, London.

Walton, P. D., R. Martinez, and A. W. Bailey. 1981. A Comparison of Continuous and Rotational Grazing. Journal of Range Management 34:19-21.

Washburn, S. P., S. L. White, J. T. Green, and G. A. Benson. 2002. Reproduction, mastitis, and body condition of seasonally calved Holstein and Jersey cows in confinement or pasture systems. Journal of Dairy Science 85:105-111.

Weil, R. R., and F. Magdoff. 2004. Significance of Soil Organic Matter to Soil Quality and Health in R. R. Weil, and F. Magdoff, editors. Soil organic matter in sustainable agriculture. CRC Press.

White, S. L., G. A. Benson, S. P. Washburn, and J. T. Green Jr. 2002. Milk Production and Economic Measures in Confinement or Pasture Systems Using Seasonally Calved Holstein and Jersey Cows. Journal of Dairy Science 85:95-104.

Winsten, J. 1999. The profitability of management-intensive grazing for northeastern dairy farms. American Journal of Agricultural Economics 81:1296-1296.

Winsten, J. R., and M. Hunter. 2011. Using pay-for-performance conservation to address the challenges of the next farm bill. Journal of Soil and Water Conservation 66:111A-117A.

Winsten, J. R., C. D. Kerchner, A. Richardson, A. Lichau, and J. M. Hyman. 2010. Trends in the Northeast dairy industry: Large-scale modern confinement feeding and management-intensive grazing. Journal of Dairy Science 93:1759-1769.

Winsten, J. R., R. L. Parsons, and G. D. Hanson. 2000a. Differentiated dairy grazing intensity in the Northeast. Journal of Dairy Science 83:836-842.

Winsten, J. R., R. L. Parsons, and G. D. Hanson. 2000b. A Profitability analysis of dairy feding systems in the Northeast. Agricultural and Resource Economics Review 29.

Wise, T. A., and E. Starmer. 2007. Industrial Livestock Companies' Gains from Low Feed Prices, 1997-2005. Page 3 in G. D. a. E. Institute, editor. Tufts University.

Wunder, S. 2005. Payment for environmental services: some nuts and bolts. Page 26. Center for International Forestry Research.

Wunder, S., S. Engel, and S. Pagiola. 2008. Taking stock: A comparative analysis of payments for environmental services programs in developed and developing countries. Ecological Economics 65:834-852.

Zhang, W., T. Ricketts, C. Kremen, K. Carney, and S. Swinton. 2007. Ecosystem services and dis-services to agriculture. Ecological Economics 64:253-260.

Zurita, G. A., N. Rey, D. M. Varela, M. Villagra, and M. I. Bellocq. 2006. Conservation of the Atlantic Forest into native and exotic tree plantations: effects on bird communities from the local and regional perspectives. Forest Ecology and Management 235:164-173.

APPENDIX A1. CHAPTER 3

Diagnostic of family farmers description and their perceptions on the implementation of Voisin management intensive grazing (MIG) and its effect on environmental services and awareness silvopastoral system.

Collaborators: UFSC, GPVoisin, UVM Gund Institute USA CIDASC, Lat. Darolt, Lat. Dellavita, Lat. Modern, PMSR, SRAW, EPAGRI.

1 – Identification, Demographic Information, Work and Gender

1. Name:	Date of Birth:
2. Name of spouse:	Date of Birth:
3. Community:	City:
4. Watershed:	
5. Georeferencing (WGS84): Lat Long	
6. Interviewers:	Date of interview:
7. The Dairy Project:	Total area of property:

8. How many and what are the age and gender of persons making up the family?

Sexo	Up to 10 years	11 to 20 years	21 to 30 years	31 to 40 years	41 to 50 years	51 to 60 years	61 or more
Female							
Male							

9. Has a family member any economic activity outside the farm? A. Yes B. No

10. How many family members are working exclusively on the farm?

11. How many family members are working part time in the farm?

12.Do you hire people to work in the fam? b. a.Sim. Which months?

13. How many retired people are in the family?

14. How many family members left the farm? a. Fem b. Male c. Who?_____________

2. Production

15. How many young stock BEFORE MIG (heads)
16. How many young stock AFTER MIG (heads)
17. When did you started using MIG (yrs)
18. How many paddocks (pastures) do you have?
19. For how long have you been using homeopathy on your animals (months)
20. How log did it take yoo to pay for the implementation of the project (months)
21. How much silage/day WAS used
22. How much silage/day IS currently used
23. How much ration/day/cow WAS used
24. How much ration/day/cow IS used
25. How much manure reduction in the milk parlor (% est)
26.How many days did it take for cow pies to degrade

3. Environmental Variables

(447) Animals had access to the permanent preservation areas?

a) Yes; b) No; c) Don't know.

(448) Animals have access to the permanent preservation areas?

a) Yes; b) No; c) Don't know.

(449) Was there any kind of preservation of the forest remnants and water sources?

a) Yes; b) No; c) Don't know.

(450) Is there any kind of preservation of the forest remnants and water sources?

a) Yes; b) No; c) Don't know.

(457) Would you be willing to recover the permanent preservation areas?

a) Yes; b) No; c) Maybe; d) Don't know.

(458) If you would receive a compensation, would you be willing to preserve the permanent preservation areas?

a) Yes; b) No; c) Maybe; d) Don't know.

(459) Would you be willing to receive a compensation to conserve the forest and to adopt better management practices?

a) Yes; b) No; c) Maybe; d) Don't know.

(415) Currently, after MIG, which is the water source for the animals

a) Water tanks in the milk parlor; b) Rivers, streams; c) Water tanks in the paddocks

(416) Was there any protected buffers before MIG

a) Don't know; b) Was not protectedc) Yes, but not in accordance to the law; d) Yes, in accordance to the law

(417) Were the riparian buffers protected?

a) No; b) Only part; c) Yes, but not in accordance to the law; d) Yes, in accordance to the law; e) No, because it is an important productive area; f) Don't know

(418) Water sources were protected before MIG;

a) None; All according to the law; c) Don't know; d) Some protected but not according to the law; e) Some, according to the law.

(419) Water soures are protected after MIG.

a) None; All were protected; c) Don't know; d) Some protected but not according to the law; e) Some, according to the law.

(420) Was there any change in the erosion of the river margins;

a) Less erosion; b) More erosion; c) unchanged; d) Don't know.

(421) Was there any changes in the appearance of the water in the rivers?

a) Darker; b) Presents coloration; c) Changes in transparencies; d) None; e) Don't know.(422) Was there any difference in the quantity of fish in the rivers

a) Decreased; b) Greatly decreased; c) Ended; d) Unchanged; e) Don't know

(423) Was there any change in the appearance of the waters of ponds and lakes?

(424) Was there any change in the quality of the wells?

a) Increassed; b) Decreased; c) greatly decreased; d) Remained unchanged.

(425) Was there any change in the quality of the water in your farm?

a) No; b) Yes, it presents coloration; c) Lost coloration; d) Lost taste; e) It has certain taste; f) It has color and lost taste; g) it has certain taste and color; h) it has certain taste and lost color.

(206) Water quality: improved or worsened in this period?

a) Improved; b) Worsened; c) Remained constant.

(214) Does your farm have any spring?

a) No; b) Yes, but not protected; c) Yes, protected

(429) What was done with the milk parlor's residues (feces, urine, water)?

a) farm waste; b) Sold; c) Composted; d) Ran off to water sources; e) Spread on pasture; f) Don't know.

(430) What is done with the milk parlor's residues (feces, urine, water)

a) farm waste; b) Sold; c) Composted; d) Ran off to water sources; e) Spread on pasture; f) Don’t know.

(431) Did the "cow pie" degradation time in the fields changed?

a) Continued the same time; b) It is lower; c) Much lower; d) Hgher; e) Don’t know;

(432) Were there any gullies/erosion on the pastures?

a) Yes; b) No; c) Don’t know.

(433) Was there any change in the gullies/erosion?

a) Stabilizing; b) Worsening; c) Constant; d) Increase the number; e) Decrease the number; f) Don’t know.

(434) Was there any erosion control method in place?

a) Yes; b) No; c) Don’t know.

(435) Which was the frequency of pasture renovation?

a) None; b) less than 1 year; c) Yearly; d) Every two years; e) Every 3 years; f) Never done it; g) Don’t know.

(436) Which is the current frequency of pasture renovation?

a) Not renovated and never will; b) Yearly; c) Every 2 years; d) every 3 years; e) Intends to do it; f) Don’t know.

(451) How was the soil covered pastures?

a) Good coverage; b) a few uncovered ares; c) was completely covered; d) Uncovered, unprotected.

(452) How is the soil covered pastures?

a) Good coverage; b) a few uncovered ares; c) was completely covered; d) Uncovered, unprotected.

(453) How was the soil quality in the pastures?

a) Excellent; b) good; c) Not ideal; d) bad.

(454) How is the soil quality in the pastures ?

a) Excellent; b) good; c) Not ideal; d) bad.

(437) Which was the burning frequency?

a) yearly; b) every 2 years; c) Every 3 years; d) Don’t burn; e) Don’t know.

(438) Which is the burning frequency?

a) yearly; b) every 2 years; c) Every 3 years; d) Don’t burn; e) Don’t know.

(49) Did the MIG adoption enable increasing the number of animals.

a) Yes; b) No; c) Don't know

(50) MIG increased productivity of milk per cow.

a) Yes; b) Greatly; c) Remained constant; d) lowered; e) greatly lowered; f) don't know

(51) After MIG implementation, the quantity of milk per day increased.

a) Increased; b) Remained constant; c) Lowered; d) Greatly lowered; e) Don't know.

(52) After MIG implementation, what happened with work load?

a) Greatly increased; b) Remained constant; c) Lowered; d) Greatly lowered; e) Same but les laborious; f) Don't know.

(53 What happened with animal behavior when appliying MIG

a) remained the same; b) more docile; c) easier to handle; d) difficult to handle; e) don't know.

(54 What happened with pastures after applying MIG?

a) worsened; b) improved; c) unchanged; d) greatly increased quantity and quality; e) lowered quantity and quality.

(55) What happened with ticks infections?

a) greatly increased; b) Increased; c) remained constant; d) Lowered; e) Greatly lowered. f) Stopped; g) negligible; h) Negligible.

(57) What happened with fly occurrences?

a) greatly increased; b) Increased; c) remained constant; d) Lowered; e) Greatly lowered. f) Stopped; g) negligible.

(59) What happened with worm occurrences?

a) greatly increased; b) Increased; c) remained constant; d) Lowered; e) Stopped; f) negligible; g) Don't know;

(62) What happened with mastitis occurrences?

a) Increased; b) greatly increased; c) remained constant; d) Lowered; e) Lowered about 50%; f) Previous average; g) Current average.

(67) What other sanitary problems occured with your dairy cows;

a) greatly increased; b) Increased; c) remained constant; d) Lowered; e) Greatly lowered. f) Don't know

(439) Did you overseed grasses and legume forages for winter pasturing?

a) No; b) Grasses and Legumes; c) Grasses; d) Legumes; e) Don't know

(440) Do you overseed grasses and legume forages for winter pasturing?

a) No; b) Grasses and Legumes; c) Grasses; d) Legumes; e) Don’t know

236 Animal quantity was reduced or modified over the last few years

a) decreased; b) unchanged; c) Increased; d) Some animals increased while others decreased.

445 Did you observe micro fauna on the pastures (worms, beetles, etc.)?

a) Yes; b) No; Don’t know

446 Do you observe micro fauna on the pastures (worms, beetles, etc.)?

a) Yes; b) No; Don’t know

443 Were there changes in the shade availability after the pasture division?

a) Remained the same; b) Increased; c) decreased; e) Greatly decreased; f) Don’t know.

444 Were there changes in drought effect after pasture division?

a) Soil turned drier; b) Unchanged; c) Soil has more moisture; d) Don’t know.

306 Do you have trees in your paddocks?

a) No; b) Yes, only the ones that were in the paddocks previously; c) Yes, I planted them in the paddocks.

307 How did you plant the trees?

a) Isolated trees in the paddocks; b) Intensive silvopastoral system; c) Trees and bushes planted in alleys in the paddocts; d) Don’t kknow; e) Paddocks with live fences; f) Wind brakes in the paddocks.

(312) What is the proportion of native and exotic trees in your pastures;

a) Exotic species; b) Native species; c) 50% exotics and 50% native; d) More exotica; e) More natives.

(313) Do you think that the trees could cause any problems to the soil, the pasture or the cows?

a) I don’t think so; b) animals will graze less; c) cow will graze close to trees; d) Grass does not grow under trees; e) Cows wil stay under trees most of the time; f) Cows can get intoxicated from trees; g) Manure gets concentrated around trees; h) Interferes with mowing.

(314) Can trees on pasture affect cow's wellbeing?

a) No; b) Yes,only during winter; c) Always; d) Sometimes; d) Yes, year round; e) Only in the summer; f) Don’t know.

(315) Can tree effects in the paddocks change the amount of milk?

a) no; b) increase, especially in the summer; c) Decrease; d) Greatly decrease; e) Increase; f) Don’t know; g) Greatly increase.

(316) Do you think that trees in the paddocks could modify the amount of forage?

a) No; b) Decrease; c) Greatly decrease; d) Increase; e) Greatly increase; g) Don't know.

208 Does your farm have riparian buffer areas?

a) No; b) Yes

209 Does your upstream neighbors have riparian buffer areas?

a) No; b) Yes

213a Are you willing to keep these riparian buffer area?

a) No; b) Only smaller; c) To avoid the fine; d) Yes; e) Don't have one; f) No, it is to large; g) No, it is too large for a small farm; h) No, It is an absurd.

219Are you willing to keep and preserve water source areas?

a) No; b) I don't have one; c) Yes; d) Yes, To avoid the fine; e) Yes, it is the right thing; f) I will have a smaller area.

225Are you willing to keep and protect areas with high declivity?

a) Yes; b) No, because it is most of my farm; c) Yes, to avoid fine; d) Yes, if they are infertile; e) Yes, they are hard to work on; f) Yes, only where there is forested.

APPENDIX A 2. CHAPTER 4

DAIRY STEWARDSHIP ALLIANCE: AN ON-FARM SELF-ASSESSMENT FOR FARMERS

Instructions

For each of the following Education Modules, carefully read the introductions and background information. For all the assessment questions, choose the categories that best identify your current management practices. Use the summary sheet on the last page of each section to evaluate your practices. Once you have completed each section, use the Overall Summary of Results (Table 1) to track your current farm practices. Fill in completely both copies of the individual module summaries, as well as the overall summary. It is important to maintain a copy of the assessment results for your own records for use in the future. Use the Assessment Checklist on page 3 to easily identify the completion of each of the steps of the toolkit. Return the completed sheet to the St. Albans Coop.

Background Information Data Sheet

The information provided by this data sheet (found on page 4) is critical in ensuring accurate analysis of herd and farm information, as well as documenting accurate contact information of the farmer. Please completely fill out the form and send it along with the completed Assessment Module Toolkit Summary to the St. Albans Coop. If any of the information is not relevant to you or your farm please indicate so in the proper space or leave blank.

Assessment Checklist

Place a check mark in each box after you have successfully completed each task. Please note that the individual assessments can be done in any order when time allows. Only after you have completed each individual assessment can the Overall Summary of Results be completed.

Assessment Task to be completed	**Original Copy** (to be sent to the St. Albans Coop.)	**Duplicate Copy** (for my records)
Animal Husbandry		
Biodiversity		
Community Health		
Energy		
Farm Financials		
Nutrient Management		
Pest Management		
Soil Health		
Water Management		
Overall Summary		
Data Sheet		

Background Information Data Sheet

Farm Name ____

Farmer's Name ____

Owner 1 ____

Owner 2 ____

Relationship to owner ____

Street 1 ____

Street 2 ____

City ____

County ____

State ____

Zip Code ____

Phone number ____

Email address ____

Web address of farm ____

Is your farm organic, in transition, or conventional? ________________________________

Do you own or rent? ____

Circle the age range of the farmer: (17-25) (26-35) (36-45) (46-55) (56-65) (65+)

How old is the farm itself? ____

How many milking and dry animals are on the farm?

How many young stock are on the farm? ____

What are the total pounds of milk produced on the farm? ____________________

What are the average pounds of milk per cow in a year? ___________________________

What is the rolling herd average on the farm? In thousands of lbs. milk/yr/cow: <7000 lbs. 7,000-12,000 lbs. 12,000-17,000 lbs. 17,000-22,000 lbs. >22,000 lbs. What is the best way to contact you? (Email) (post mail) (telephone) (other) (if other, please specify)

____

How many acres do you own/rent? ____

How many acres are cropped? ____

How many acres are pastured? ____

INTRODUCTION TO DAIRY FARM TOOLKIT

Introduction

This Toolkit is designed to provide the Vermont dairy farmer with information on how his or her current practices compare economically, socially and environmentally to best management practices. Additional resources are provided on how to improve upon these practices, if desired.

Understanding the Toolkit

When farms are operated in balance with the earth's natural systems such as air, water, energy and nutrients, nature's principles are applied to sustain a farm's natural resources. Sustainable dairy farming strives to protect and enhance the natural environment, Animal Husbandry, and local communities, while striving for profitability and providing a high quality of life for farmers and their families. This Toolkit contains ten Educational Modules, each of which covers a topic critical to sustainable dairy farming in Vermont. These ten modules focus on:

Animal Husbandry	Nutrient Management
Biodiversity	Organic
Community Health	Pest Management
Energy	Soil Health
Farm Financials	Water Management

The modules are designed to be reviewed one by one, and in no particular order. This way, you have the flexibility to focus on areas of interest as time permits. Each module focuses on either an economic, environmental, or social issue and contains the following parts:

- **Description.** Provides an explanation of the topic and its relevance to dairy farming. Any unusual terms that may be used are also clarified in this section.
- **Incentives for Change.** This section addresses the benefits you can expect by improving practices within each area. Such benefits may include cost savings, improved human health and environment, improved public image, and regulatory compliance.
- **Assessment Questions.** You will be asked to answer approximately five to ten questions regarding the topic area. The majority of questions are multiple-choice with the first possible answer a status quo baseline practice and the last possible answer a best practice. Each question or set of questions is followed by a brief discussion that provides an explanation of desirable practices and connections between the listed practices in relation to the indicator topic.

Linkages to Other Modules. The topics in a given module are often linked to topics in other modules. This section outlines where related topics are covered in different modules. A chart displaying the linkages can also be seen below:

	Animal Husbandry	Biodiversity	Community Health	Energy	Farm Financials	Nutrient Management	Organic	Pest Management	l Health Management	Water Management
Anima Husbandry	X	X			X	X	X		X	X
Biodiversity		X	X		X	X	X	X	X	X
Community Health			X		X		X	X		X
Energy				X	X	X	X			X
Farm Financials					X	X	X	X	X	X
Nutrient Management						X	X		X	X
Organic							X	X	X	X
Pest Management								X	X	X
Soil Health Management									X	X
Water Management										X

- **Further Information.** After completing the Educational Modules, you may find that you would like to gain additional information on the subject. This section includes additional information including helpful websites, organizations, and other resources.
- **Summary of Results.** This section summarizes your responses and rates your overall performance according to a 'stop light' system. A "Green" score means that you are utilizing best practices; a "Yellow" score means that while some good practices are being used, there are some key areas that to improve upon; and a "Red" score means that you should carefully review your practices and make an effort to improve your practices in the topic area.

The goal of this program is to introduce farmers to best management practices as they relate to sustainable dairy farming. While many farmers may already be operating at a 'best practice' level, others may benefit from making changes to existing practices. The anticipation is that this program will be a continual work in progress and may run for numerous years, as change, especially on a farm, takes time, and as farmers find that they could improve their processes. The general process is anticipated as the following:

1. Evaluate your farms on a module-by-module basis, as time permits.
2. Meet with a representative from the Dairy Stewardship Alliance Team to review assessment results and discuss which areas are of top importance. Also, discuss alternative practices within the specific area of focus and any limitations or concerns that are specific to your farm.
3. Make modifications to farm practices with assistance from the representative and/or additional information sources.
4. Steps 2 – 5 should continue on an on-going basis, with periodic updates to the modules.

These steps and resulting changes in on-farm practices will help to transition the farm from existing practices to desirable practices oriented towards sustainable dairy farming. Gradual change is anticipated.

Toolkit Summary Results

Farm Name or Farm #_______

After you have answered the questions and filled in the summary sheet for each educational module, record your results from each in the Table 1 below by placing a checkmark in the appropriate column. By recording how you performed for all of the modules on this page, you can easily identify the key topic areas to address.

Please note, the Organic Module provides guidance into what practices are required to be certified organic and does not contain Assessment Questions, hence the "N/A" as noted below.

Table 1: Overall Summary of Results

	Green	Yellow	Red
1. Animal Husbandry			
2. Biodiversity			
3. Community Health			
4. Energy			
5. Farm Financials			
6. Nutrient Management			
7. Organic	N/A	N/A	N/A
8. Pest Management			
9. Soil Health			
10. Water Management			

Areas to Focus on Immediately (Red):

____

____

____

Areas to Focus on in Near Future (Yellow):

____

____

____

ANIMAL HUSBANDRY EDUCATIONAL MODULE

DESCRIPTION

The terms animal husbandry and animal welfare are often interchangeable. Animal welfare is defined by the American Veterinary Medical Association as the "human responsibility that encompasses all aspects of animal well-being, including proper housing, management, nutrition, disease prevention and treatment, responsible care, humane handling, slaughter and, when necessary, humane euthanasia."[1] Cows are most productive when their needs are provided for in optimal ways." Cows thrive with comfort and consistency. While dairy farmers inherently know that animal welfare should be a top concern, significant pressure to increase profits may encroach on this consideration as a trade-off for short-term gain. To be successful in the long term, a farmer must provide for appropriate animal health, as "any animal will perform well below potential wherever under nutrition or stress is present."[2]

In most cases a farmer only makes a decision that decreases animal well-being under one of two conditions: he/she doesn't have time to do the right thing for the animal or he/she lacks the resources (financial or physical) to improve the situation. This may present a bit of a catch 22 since the farmer needs to build up resources to make structural changes. On the way to building a better-designed facility, the cows are going to be overcrowded in the current facility.

Three main areas should be reviewed in order to ensure optimal performance: nutrition, living conditions, and overall health. Animal nutrition refers to the type and quality of feed that are provided to the dairy cows. They should receive a well-balanced portion of grain to ensure enough energy for milk production and fiber to ensure proper digestion.[3] An imbalance will result in poor milk production and/or health concerns. Living conditions refer to the general comfort of the animal. This includes the quality, size, and cleanliness of the living and milking space. The frequency in incidence of diseases, such as mastitis, lameness, infertility, and certain metabolic disorders can be used as a way to assess impacts on herd health. Nutritional intake and living conditions are important determinants of herd health.

Optimal well-being manifests as good health and high productivity. The ration fed certainly plays a role in maintenance of health and well-being. Sufficient fiber is required to maintain the health of the rumen. Fiber that is more digestible can be consumed in greater quantities and support higher levels of milk production. The protein and non-protein nitrogen sources must be balanced to match the digestibility of the carbohydrates in the ration. Acidosis, ketosis, milk fever and other metabolic disorders are usually related to dietary formulation. Mastitis may reflect overall immune status but is usually related to cleanliness of stall bedding and sometimes to milking routine. Heat stress can contribute to depression of immune function and an increase in mastitis, reduction in feed intake and consequent reduction in milk production and potentially a higher incidence of metabolic disease, and also lower fertility. Retained placenta and infertility may also have nutritional causes. Incidences of lameness and displaced abomasums are among the best indicators of herd nutritional health. Lameness may have infectious causes and foot bath management is critical to controlling this problem in many herds.

INCENTIVES FOR CHANGE

- **Net Profit.** When pressured to increase cash flow, farmers tend to focus on increasing volume rather than on decreasing operating costs. By increasing milk volumes through unnatural means such as adding growth hormones to increase production (rbST), unbalanced feed, encouraging higher consumption, etc., animal welfare may suffer and cost as much or more than the increase in profits due to associated production costs, health treatment costs and management demands.[4] "Heating up" a ration is usually a bad idea. Using rbST without providing additional feed can cause problems. Feeding a more digestible, balanced ration is always more beneficial when addressing milk production levels. For example, as milk yields increase, diseases, such as lameness, mastitis or fertility problems, also increase.[5] The greater the work demands on the cow, the more susceptible they are to disease and stress. Proper nutrition and living conditions can stave off disease, via prevention. The focus needs to be on removing road blocks to optimal performance. Do the cows have ready access to adequate and clean water? Do the cows have ready access to adequate well-balanced feed? Do the cows have clean, comfortable stalls to rest in. Given the high costs associated with disease, such as vet costs, and lost revenues due to decreased milk production, farmers should investigate ways to prevent disease or other detriments to herd health. It is important to balance and understand the connection between high production and the maintenance of herd health.

- **Improved public image.** Farmers are unfortunately under critical review by the public that may not truly understand the actual needs of the animals. Due to the increasing threat of unwanted attention from animal activist groups, a number of organizations are taking independent steps to ensure animal health such as Temple Grandin's efforts to improve animal welfare in slaughterhouses—including those where old dairy cows go. Another example comes from Heifer International. This non-profit group provides a heifer to a family that is struggling to make ends meet. They recently developed guidelines regarding animal welfare practices for their receiving families. Similarly, the farmer that proactively modifies his or her practices potentially improves animal health, on their farm.

ASSESSMENT QUESTIONS

For all questions, please choose the categories that best identify your current management practices. Use the summary sheet on the last page of this module to evaluate overall performance.

➢ HERD NUTRITION[6]

1. Herd nutrition is inadequate or not monitored.
2. Farmer works with supplier or farm advisor that has nutritional expertise and determines appropriate balance for cows.
3. In addition to #2, farmer understands connection between metabolic diseases (such as ketosis, retained placenta, infertility, etc.) and nutritional needs. Records are routinely kept regarding feed rations, their nutritional value, their relation to milk production and herd health issues.

4. In addition to #3, rations are regularly modified through signs of efficient digestion. Well-balanced rations are identified and changed periodically.

The level of understanding and monitoring involved in herd nutrition is important because it has significant implications for milk production and herd health.[7] By keeping records regarding changes in diet, patterns may emerge that will help to identify best nutrients for a specific herd. The closer the farmer and/or nutritionist can get to meet each cow's exact needs, the more sustainable the process will be.

- **OVERALL HEALTH**[8]

1. Herd health is inadequate.
2. Herd health is recorded for each cow, by milk production, body condition, diseases, foot and leg problems, vaccinations and medications. Veterinarians make monthly visits to inspect animals and sick animals are given appropriate medications and antibiotics.
3. In addition to #2, herd health is visually checked daily. Sick cows are housed and milked separately from the herd, or after the rest of the herd in the same parlor
4. In addition to #3, the farmer focus is to determine causes of sub-optimal health issues and implement preventative measures, with help from specialists, like veterinarians.

Understanding and monitoring herd health is critical to understand the condition of your cows. In order to ensure each cow is in optimal health and the quality of the milk, it is important to analyze and track cows individually. Similarly, it is important to separate sick cows from the rest of the group to minimize the spread of disease. Taking preventative measures is a best practice as problems are corrected before they start.

- **HEALTH OF INCOMING/OUTGOING ANIMALS**[9]

1. Incoming animals (including bulls) without known health histories are brought directly onto farm.
2. Incoming animals are from herds with known health status and effective vaccination programs.
3. In addition to #2, incoming animals are carefully examined for health concerns and are thoroughly washed before bringing them onto the farm. And quarantined for observation Visitors wear booties or clean their boots prior to entering the barn.
4. In addition to #3, animal delivery to renderers and cattle dealers is done outside of barns, without contact between these individuals and other animals. Additional bio-security measures, such as farm signage instructing visitors how to proceed onto the farm, are taken.

Just as there is concern regarding the spread of disease within the farm, steps should also be taken to decrease the chance of spreading disease among farms. A few simple precautions regarding animal transportation and integration of new animals to the herd can minimize the potential risk of spreading diseases.

- **MILK QUALITY**

1. While milk quality, as measured by somatic cell count (SCC), is reported, there is no time to review this information.
2. Milk quality is periodically monitored through SCC. Farmer understands milk quality and health implications of high SCC, and monthly average is less than 350,000.
3. SCC counts are monitored regularly, and farmer has acceptable target range of SCC. Average monthly SCC is less than 250,000.
4. In addition to #3, the average monthly SCC is less than 150,000.

The farmer has more data at his/her disposal than just SCC (at least from most handlers). Raw, pre-incubation, and pasteurized counts can help pinpoint the source of trouble when total SCC is elevated. An economic consideration via price premiums is determined in part by SCC, as set by the farmer's Co-op. Somatic Cell Count (SCC) indicates infection and possibility of the presence of mastitis, which usually decreases milk production and may be contagious. In terms of managing mastitis, early identification is best to prevent spreading, and various management practices can reduce the likelihood of this infection. For example, some farmers have seen a decrease in mastitis incidence when they increase the amount of time their cows are outside on pasture. This pasturing assumes optimal outdoor conditions, such as well-drained pastures to minimize mud. This helps to deal effectively with environmental pathogens that cause mastitis. However, pasture has been associated with higher levels of infection with a type of environmental mastitis. Another cause of mastitis, contagious pathogens, can be decreased by correctly managing milking procedures.[10] culture monitoring and sensitivity testing can be used to choose treatments appropriately. Milking management alone is often not enough to eliminate many contagious organisms.

- **LACTATION MANAGEMENT/ CULL RATES**[11] Dairies should endeavor to milk each cow until she has reached her maximum production in 3rd or 4th lactation. An excellent heifer rearing program will naturally reduce the overall age of the herd unless the farmer markets heifers..

1. Farmer does not monitor the number of lactations per cow, and is unaware of his herd replacement rates.
2. Farmer monitors number of lactations and milk production. Cull rate averages greater than 35%.
3. Farmer monitors number of lactations per cow and herd average cull rate is 25 % to 35% per year .
4. Farmer monitors number of lactations per cow and herd average cull rate is less than 20%

"Most modern dairy cows have a life span of less than four lactations."[12] Cows that are stressed or treated only to optimize milk production typically have a shorter productive life span. A farm that consistently strives to produce more milk, but may have higher operating costs related to more frequent heifer replacement, or losing cows to preventable causes.

- **HOUSING/HANDLING AREAS**[13]
  1. Housing and handling areas are inadequate, causing undue stress. Walking areas are poor quality, either wet and slippery or too rough. Water stations are limited, and cattle are confined to limited movement.
  2. Housing and handling areas are maintained in clean and dry conditions with adequate clean bedding, feeders and water stations.
  3. In addition to #2, housing and handling areas are large enough to allow normal interactions and social behaviors and to minimize cow stress.
  4. In addition to #3, new or renovated housing/handling areas implement advanced design features to minimize stress by aligning cow movement patterns to match a cow's own natural tendency.

Stress levels of a cow can not only impact productivity and depressed social behavior, but also overall health. Housing features significantly impact stress levels. The types of flooring in walking and standing areas, as well as the amount of time standing on concrete, also have large impacts on the incidence of lameness. Additionally, clean, dry bedding is critical to prevent mastitis.

- **STALLS**
  1. Stalls are inadequate, tight and do not allow sufficient room for relaxing, causing undue stress.
  2. Stall dimensions are large enough for cows to lie comfortably, including sufficient width, headroom and clean bedding.
  3. In addition to #2, cows use stalls as designers intended. Each stall has a slight slope to the stall, dry and regularly cleaned bedding, appropriate lighting or sufficient ventilation.
  4. In addition to #3, there is 5% more stall space in the barn than there are cattle, enabling normal social behaviors and minimizing cattle stress. There are open, exercise areas for cows with enough space for cows to lie comfortably.

Cows, especially in confinement operations, spend a significant amount of time in their stalls. Ensuring that the cow can maneuver around comfortably is critical to its health. If a stall is not designed properly, the cow may be forced to behave in non-natural ways (such as standing for long time periods). Sometimes the physical design of the stall is sufficient; however, social relations among cows may disrupt optimal behavior. For example, it is not uncommon to see lower social standing cows forced to stand for long periods of time, mainly because the only place to lie down is close to a dominant cow. This, too, results in an increase in health problems and a decrease in milk production. By providing additional stalls, the farmer allows a comfortable place for these lower social standing cows. Sufficient space provides an advantage for separating first lactation cows from older cows, and reduces competition in pre-fresh cow group.

➢ **PASTURING**[14] (IF COWS ARE NOT PASTURED, MARK "1" IN THE SUMMARY SHEET)

Pasture is a management decision and to work well must be managed well. Not all farms choose to emphasize pastures.

1. Pastures if available, are openly-grazed, undivided and primarily used as exercise areas.
2. Pastures have adequate forage for all pasturing cows. If cows are wintered outside, conditions are carefully monitored and provisions are made to ensure adequate food, water, bedding and shelter during severe weather; shelter and teat care are adequate to prevent frostbite; sufficient extra feed is provided to maintain body condition; cows are clean and dry when turned out after milking; and manure from wintered cattle is not allowed to contaminate surface water.
3. In addition to #2, multiple paddock divisions are maintained and cows are moved at least daily. Rotations are scheduled to maintain adequate re-growth.
4. In addition to #3, forage species are managed for maximum, vegetative production. Fields are allowed sufficient rest and regrowth periods between grazings Supplemental feed, water and shelter sites within paddocks are also rotated to prevent erosion and reduce compaction in these areas.

While mixed opinions exist regarding herd health benefits of pasturing, this topic was included for completeness as optimal pasturing conditions lead to improved herd health. The greatest benefit is often in hoof health. Pasturing cows allows them the freedom to exercise and live in a more natural environment. Again, as with confinement, certain provisions must be considered for this method to be optimally beneficial for both the cows and the land.

➢ **MILKING EQUIPMENT AND PARLOR**[15]

1. Milking equipment and facilities are often in need or repair or breakdown.
2. Milking equipment and facilities are adequate and in good working order. Milking system and coolers are monitored and cleaned routinely.
3. Milking equipment is tested for proper function. Facilities are designed and maintained for animal comfort. Milking area is clean and well ventilated. Bacteria results are tested, documented, and monitored on a monthly basis.
4. In addition to #3, equipment is thoroughly cleaned and maintained as part of the regular weekly routine and monitoring results have been maintained at acceptable level

Given that cows are typically milked twice a day, it is critical to the comfort of the animal that the milk equipment is functioning properly. The milking facility is also an area where contagious diseases can be spread. By increasing the cleanliness and ventilation in these areas, the likelihood of spreading diseases is decreased.

➢ **CALF RAISING CONDITIONS** (Please check all that apply. For scoring, add 1 for each box checked)

- ☐ Calves consume colostrum within 2 hours or birth. The calf cannot absorb immunoglobulin after 24 hours.
- ☐ Calves are fed concentrate to develop their rumen.
- ☐ Sufficient space is provided for calves to lie comfortably and as needed..
- ☐ Calves are provided clean, dry, and well-ventilated housing.
- ☐ Calves' navels umbilicus are dipped in tincture of iodine.

Special attention is required early in the life of a cow in order to ensure an optimally healthy life. The calf cannot absorb immunoglobulin after 24 hours. The calf must get adequate volume as soon as possible. Best practice is within 2 hours of birth. Must be fed colostrums or will have high level of failure of passive transfer. Colostrum quality should be monitored as well.

Just as with mature cows, nutrition and living conditions must be considered in overall calf health. For calves, nutritional concerns revolve around consuming colostrum shortly after birth and roughage within the first two weeks. Living conditions for calves should be clean, dry and well ventilated with sufficient room for movement and to lie comfortably. Just as for older cows, living conditions can help to discourage (or encourage if not appropriate) disease incidence. One final practice to ensure optimal health for the calf is dipping the umbilical cord in iodine. The umbilical cord is a hollow tube and if not treated properly, pathogens which cause disease can enter the calf's circulatory system. This can result in mortality or naval infection. Iodine serves to clean, sanitize and dry the end of the umbilical cord, which in turn closes the tube quicker, thereby decreasing the chance of pathogens entering the calf's system.[16]

LINKAGES TO OTHER MODULES

While the questions above cover the basics of animal husbandry, other practices also have impacts. Please review your practices regarding the following topics in the Educational Modules listed below.

ANIMAL HUSBANDRY TOPIC	OTHER MODULE(S)
Manure Management	Nutrient Management
Clean Water	Water Management
Potential Erosion	Soil Health
Cooling	Energy

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following programs.

> **Appropriate Technology Transfer for Rural Areas (ATTRA).** "Sustainable Agriculture: An Introduction." http://attra.ncat.org. ATTRA specializes in developing sustainable agricultural information and tools. For a summary of the practices they advocate regarding animal welfare, see "Sustainable Agriculture: An Introduction" at http://attra.ncat.org/attra-pub/PDF/sustagintro.pdf. Contact: Ann Wells, phone: 1-800-346-9140.

University of Vermont Extension Dairy Specialist
Department of Animal Science
113 Terrill Hall, 570 Main Street, Burlington, VT 05405
Phone: 802-656-4496 **Website:** www.uvm.edu/ extension

> **On Farm Assessment and Environmental Review (OFAER) program:**
> http://www.acwf.org/docs/forma.pdf

> **The Food Alliance.** http://www.thefoodalliance.org/. This organization certifies producers, which use socially and environmentally responsible farming practices. The certification process includes sections on natural area management, watershed management, crop management, pest management, pastureland management, and animal husbandry.

- **Farm Animal Welfare Council (FAWC).** This organization was established by the United Kingdom government but is an independent advisory board that is active in reviewing the welfare of farm animals. They produced a report, "Report on the Welfare of Dairy Cattle by Farm Animal Welfare Council," which identifies a number of concerns and solutions regarding dairy cattle. http://www.fawc.org.uk/reports/dairycow/dcowrtoc.htm.

- **Facility Designs that Minimize Stress.** Dr. Temple Grandin, as Associate Professor of Animal Science at Colorado State University, has conducted research regarding the design of cow facilities and how to minimize stress on the animal. Specific topics and links with additional information are:
  a. Non-slip flooring: http://www.grandin.com/design/non.slip.flooring.html
  b. Livestock handling systems: http://www.grandin.com/design/design.html
  c. Handling and transport: http://www.grandin.com/behaviour/transport.html

- **Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska - Lincoln.** www.ianr.unl.edu/pubs/animaldisease/g1032.htm#nutritionally. This website, titled "Dairy Cow Health and Metabolic Disease Relative to Nutritional Factors," contains information provided by a veterinarian and dairy specialist.

OTHER LINKS:

Certified Human Raised and Handled
www.certifiedhumane.com
Parameters were developed with organic production in mind.

DQA self evaluation (Milk and Dairy Beef Quality Assurance Program)
http://www.dqacenter.org/dcare/dcare00.htm
Caring for Dairy Animals Technical Reference Guide and
On-The-Dairy Self-Evaluation Guide

CA Dairy Quality Assurance Program
http://www.cdqa.org/ahw/
Assessment used as marketing tool

Validus (formerly Environmental Management Solutions)
AWARE program scores 10 areas (Animal Welfare Assurance Review and Evaluation)
http://www.emsllc.org/aware04/awaredefaultpage04.asp
see http://www.mvma.org/Proceedings/bovine/Issues%20in%20Food.html

NCCR/FMI – Animal Welfare Audit Program (AWAP)
SES, Inc. (SES) has been contracted by the National Council of Chain Restaurants and the Food Marketing Institute to develop a voluntary animal welfare audit program for their members.
www.ses-corp.com
http://www.awaudit.org/DesktopDefault.aspx?tabindex=0&tabid=1
FACTA Farm Animal Care Training and Auditing
www.factallc.com/
Provides auditing services for livestock

Ontario Ministry of Agriculture, Food and Rural Affairs.
http://www.gov.on.ca/OMAFRA/english/. Excellent reference for stall design.

SUMMARY OF RESULTS FOR ANIMAL HUSBANDRY

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that applies questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

QUESTION		ANSWER/SCORE
1.	Herd Nutrition	
2.	Overall Health	
3.	Health of Incoming/Outgoing Animals	
4.	Milk Quality	
5.	Lactations/ Cull Rates	
6.	Housing/Handling Areas	
7.	Stalls	
8.	Pasturing	
9.	Milking Equipment	
10.	Calf Raising Conditions (Add 1 for each box checked)	
Total Score (Out of Possible 41)		

Interpretation: The next step in understanding your farm's performance in the category of Animal Husbandry is to compare your results to best practices. Below is a table that ranks your performance from best practices (green) to practices that require improvement (red). Compare the number of points you received for your farm compared to optimal practices.

	Point Range	**Interpretation**
Green	35 – 41	Best practices regarding Animal Husbandry are currently being employed on this farm.
Yellow	25 – 34	Farm is using some good practices regarding Animal Husbandry; however there are some key areas that should be improved upon.
Red	9 – 24	Animal Husbandry practices should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

BIODIVERSITY EDUCATIONAL MODULE

DESCRIPTION

Biodiversity refers to all plants, animals, and microorganisms existing and interacting within an ecosystem.[17] In an agricultural setting, biodiversity can be viewed in layers: microorganisms and worms living in the soil; native plants, crops, and trees growing on top of the soil; and insects, birds, and animals inhabiting the plants, crops, and trees. The greater the number of microorganisms, plants, and animals in an ecosystem, the higher the level of biodiversity is. Humans also live within and alter natural ecosystems.

Biodiversity levels are rapidly declining globally due to increased development by humans. The World Wildlife Fund reports that within the next 30 years, as much as 20% of the world's species will go extinct.[18] Within the United States alone, as of 2003, the Fish and Wildlife Service has classified a total of 1,821 species as threatened or endangered.[19] Other organizations estimate that up to one-third of all plants and animals within the US are at risk.[20] Vermont is also affected by declining biodiversity levels. Vermont has an estimated 2,274 species.[21] Currently, the State of Vermont's Nongame and Natural Heritage Program has identified 28 fish, 19 amphibians and reptiles, 16 mammals, 59 birds, 83 invertebrates (mostly beetles), 20 moths and 12 mollusks as rare and uncommon.[22] The number comprises almost 10% of all species in Vermont. Moreover, eight of these species are listed as threatened or endangered under the Endangered Species Act.[23]

Plant and animal species fulfill a number of important roles in regulating the natural and agricultural environment. Microorganisms and worms in the soil convert nitrogen and other nutrients into a usable form for plants and trees. Plants help to manage water runoff, filter impurities and toxins from water sources, cycle oxygen, and provide habit for animals. Animals, such as bats, spiders, birds and other insects help regulate insect and rodent pests. Insects such as bees help to pollinate crops and wild plant species. Many of these species interact and depend upon one another, making high levels of biodiversity important for the functioning of the entire system.

Agriculture, no matter how small the farm, alters the biodiversity in a landscape through the development of pastureland, crop fields and new structures. Oftentimes, farms are built in floodplains or along rivers and streams, areas typically highest in terms of biodiversity.[24] The implementation of highly managed monoculture systems or development of pastureland displaces native species and reduces the biodiversity upon which the ecological functioning of an ecosystem depends. Genetically modified organisms (GMO) can also displace native species or have adverse impacts on native populations. An example is one strain of *Bacillus thuringiensis* (Bt) corn, Bt 176. This strain, which is resistant to the European corn borer (a pest which costs US farmers approximately $1 billion in lost crop yields and crop protection costs), led to a severe decline in populations of monarch butterflies.[25] Luckily the effects of the strain were small-scale in that only an estimated 2% of GMO corn was Bt 176 compared to strain MO810, which accounts for almost 95% of planted GMO corn.[26] While this particular strain has since been removed from the marketplace, new GMOs may also have negative, unintended consequences.

Sustainable agricultural processes that foster biodiversity through natural means and low-impact management practices provide an alternative. These processes help restore ecosystem functioning and increase biodiversity levels.[27] Practices such as low-till and no-till farming of feed crops, inter-species plantings, grazing-based management, integrated pest management techniques and other practices allow farmers to decrease use of costly external inputs such as fertilizers, pesticides, and GMO seed and replace these inputs with natural processes.[28]

INCENTIVES FOR CHANGE

- **Decrease in expensive external inputs.** The benefits of increasing biodiversity are most readily seen when the farm is viewed as part of an ecosystem. The key is to "identify and exploit combinations of crops, plants, animals, and practices that increase above- and below-ground diversity and foster proper ecosystem functioning."[29] For example, the use of no or low-till cropping practices maintains soil structure in the top layers of the soil surface, which provides habitat for species which recycle nutrients for plants. One square meter may contain 10,000 species with high population densities.[30] These species assist plants in nutrient uptake and protect plants from disease.[31] If destroyed by tillage practices and the application of certain pesticides, these species must be replaced by costly fertilizers as a means of maintaining production levels.

- **Marketing opportunity.** Certifications for environmentally and socially responsible agricultural production, awarded by groups such as the Food Alliance program (www.thefoodalliance.org), require that farmers work to enhance biodiversity. This sustainable farming certificate may allow farmers to receive a premium for their practices. Genetic biodiversity is also marketable. Most dairy farmers focus on the genetic lineage of their cows or utilize different cultivars when growing crops. Registering cows to certify genetic lineage may allow a farmer to receive higher prices for heifers sold in the marketplace.

ASSESSMENT QUESTIONS

For all questions, please choose the categories that best identify your current management practices. Use the Summary sheet on the last page of this module to evaluate overall performance.

➢ GENETIC DIVERSITY OF CROPS

1. I have primarily grown the same crops in my fields for years, and follow manufacturer's recommendations for applications of fertilizers, pesticides, herbicides and fungicides.
2. I rotate different crops throughout my fields each year, and follow manufacturer's recommendations for applications of fertilizers, pesticides, herbicides and fungicides.
3. I rotate different crops throughout my fields each year, and regularly use soil tests to decide on the levels of nutrients and fertilizers needed in each field, and limit applications of pesticides, herbicides and fungicides.
4. I utilize cover crops and include fallow fields within my crop rotation plans to help build soil health. I rotate different crops throughout my fields each year, regularly

use soil tests to help determine the levels of nutrients and fertilizers needed in each field, and limit applications of pesticides, herbicides and fungicides through use of Integrated Pest Management practices..

Chromosomes, genes, and DNA "determine the uniqueness" of each individual within a species. Having an array of unique individuals or a genetically diverse number of seed types is important to protect crops from disease and other natural events such as drought that may wipe them out.[32] Increasing the number and types of crops throughout the farm's field also provides habitat for species, which increases biodiversity as well as encourages inhabitation by beneficial species such as spiders and birds.

- **NATURAL AREA CONSERVATION**[33]

1. Few, if any, wild habitat areas exist around fencerows, fields or wooded areas to provide habitat for birds, mammals, or other wildlife.
2. Fencerows, fields and other areas are managed to provide limited wildlife habitat. Any pastures on the farm are in good health and provide limited wildlife habitat.
3. Fencerows, fields and other areas are managed to provide wildlife habitat. A percentage of pastures, rest pads, ditches and other wild areas are not grazed or mowed until grassland bird nesting is complete. Pastures and fields are managed to promote for multiple (domestic and wild) species.
4. Fencerows, fields and other areas are managed to encourage wildlife habitat. Specific actions are planned and have been taken to improve and enhance wildlife habitat on the farm. Wildlife Habitat Improvement Plan (WHIP) has been developed and approved by USDA-NRCS.

Management for natural areas provides habitat for beneficial organisms and other forms of wildlife. While many farmers in the Champlain Valley may already utilize hedgerows and the natural features of the land to provide habitat for biodiversity, farmers in Northern and Southern Vermont may not. Well-structured habitat management plans help ensure higher levels of biodiversity.

- **MANAGEMENT OF RIPARIAN AREAS**[34]

Riparian areas are "the edges of streams, wet weather creeks, ditches, or any other area where water flows at various times of the year."[35] If you have a riparian area on your property, please indicate how you manage your cows:

1. Pastures and confinement areas are less than 50 feet from surface water sources. Cow access to surface water sites is only limitedly restricted.
2. Pastures and confinement areas are at least 50 feet from surface waters. Cow access to surface water sites is restricted by fencing or vegetation.
3. Pastures and confinement areas are at least 50 feet from surface waters. Cow access to water sites is restricted to ensure healthy stream bank vegetation, adequate bank

angles, and natural water habitat conditions without visible signs of erosion, sedimentation, and manure deposition in water.

4. Watering sites are developed and located away from stream courses, and cows are not allowed direct access to streams. Cow access to water sites is restricted to ensure healthy stream bank vegetation, adequate bank angles, and natural water habitat conditions without visible signs of erosion, sedimentation, and manure deposition in water.

Riparian areas on farms provide unique habitats for a diverse set of plants and organisms and are often the most diverse in a given ecosystem.[36] They are therefore a priority for managing biodiversity on a farm. Cows around water bodies can cause erosion, trample diverse populations of aquatic vegetation, and cause high nutrient levels in streams due to uncontained manure. Management of cows to prevent water body damage increases ecosystem health and biodiversity levels.

- **PASTURE MANAGEMENT**[37]

1. I do not use pasture grazing on my farm.
2. Pastures, if available, are managed as "exercise areas" with limited emphasis on nutritional quality or environmental impact.
3. Beneficial natural plant varieties are established and maintained. Any planted varieties are selected to promote integration in the existing pasture in order to establish a more nutritional pasture base. However, pasture plays only a limited part in overall farm plan.
4. Pasture site and plant varieties are carefully selected and play a significant role in overall farm plan and are designed for optimum nutrition and environmental conservation practices. Animals are regularly rotated to different pastures. Managed Intensive Grazing (MIG) practices are used on a regular basis.

- **CROP FIELD MANAGEMENT**[38]

1. New plantings are established following manufacturer's recommendations for applications of fertilizers, pesticides, herbicides and fungicides with limited regard to environmental impact.
2. Varieties and planting systems are selected that are compatible with current Integrated Crop and Pest Management methods. No-till <u>or minimum tillage</u> planting is often used to reduce soil erosion.
3. Varieties and planting systems are selected and designed as above, with at least some of the acreage in (non-GMO) pest-resistant varieties and/or designed to maximize habitat for beneficial organisms. Chemical pre-plant fumigants or other pesticides, herbicides or fungicides, if used, follow a Integrated Pest Management Plan to reduce their overall impact on the environment, an if used are applied by a certified custom applicator.

4. Above practices are followed to encourage optimum production with minimal agrochemical inputs. Sites are selected or otherwise prepared to avoid harmful nematodes or pre-existing disease conditions. Cover crops, no-till practices and crop rotations incorporated within whole farm plan which does not use genetically engineered seed in the system. The edge of croplands are "buffered" from surface water by a strip of non-cropped vegetation.

Depending upon land management practices, species may be displaced or even lost. Managing pasture and crop field lands in ways that enhance habitat increases production while only minimally impacting biodiversity. Herbicides and fungicides can kill not only pests, but also beneficial plants and fungi that may enhance nutrient uptake and provide disease resistance.

- **ADJACENT AREA MANAGEMENT (LANDS SURROUNDING YOUR CROPLAND)**[39]

1. Areas adjacent to cropland or pasture are not included within the farm plan.
2. Wooded and other areas adjacent to cropland or pasture under the control of the farmer are managed in response to known pest problems.
3. In addition to #2, adjacent areas are managed to reduce potential for pest immigration as well as pesticide and fertilizer movement off-site and to encourage wildlife.
4. In addition to # 3, adjacent areas are planted with hedgerows, windbreaks, or other low-maintenance plantings to encourage specific beneficial organisms and/or native wildlife.

While land ownership stops at property lines, ecosystems function across ownership boundaries. Managing what comes into and flows off your property can adversely or beneficially impact biodiversity.

- **GMOS** (Please check all that apply)

- [ ] I do not use rBST.
- [ ] I do not use GMO crops.

Genetically modified organisms (GMOs) are defined as "organisms in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating or natural recombination."[40] The Genomes Project of the US Department of Energy Office of Science cites that some potential benefits associated with GMOs include: improved quality and taste, increased yields due to decreased loss from pests and disease, increased disease resistance (which decreases the need for costly herbicides and insecticides), and new products. While this may be true, the risks associated with GMO use are also large. Some potential risks include production of new allergens, loss of flora and fauna biodiversity, unintended cross-pollination with natural crops, and problems associated with access to intellectual property.

Controversies over the use of GMOs have been especially strong in Europe where strict regulations have been instituted for approval of GMOs.[41,42] The newest directive, Directive

2001/18/EC, requires in-depth environmental assessments and public comment on the approval and release of any new GMOs. Public backlash against GMOs has caused concern both in the US and Europe. As early as 1999, Archer-Daniels-Midland asked US producers to separate GMO and non-GMO stock due to increasing demands for non-GMO products in Europe and Asia.[43] This trend against the use of GMO-altered crops and animal products may indicate a growing social backlash and financial risk to farmers using GMOs. Vermont itself has a number of active pieces of legislation trying to limit the use of GMO seed.[44] Given these developments and potential negative consequences, a better alternative may be the implementation of an integrated pest management plan, which utilizes natural pest management methods and limited pesticide use instead of GMOs.

rBST is one controversial GMO also known as bovine growth hormone (BGH), or bovine somatotropin (BST), is produced by the pituitary gland in cows and affects milk production. Genetically engineered microorganisms have been developed to produce an almost identical hormone [recombinant bovine growth hormone (rBGH)] that when injected into dairy cattle, can increase milk production by 10% to 15%.[45] While the increase in production is large, rBST when injected into cows, can also be passed into offspring and create genetic modifications in the strains.[46] Other potential negative effects of rBST include excess milk production and probable udder pain for cows, increased udder infections, bacteria, pus, and antibiotic resistance.[47] These impacts in cows can be passed on to humans with links to increased risk of cancer and antibiotic resistance.[48] Due to controversy surrounding the hormone, rBST has been banned in Europe and rejected by a number of companies including Ben & Jerry's.

LINKAGES TO OTHER MODULES

Water quality issues are tied to Soil, Animal Husbandry, and Pest Management. The table below identifies where you can find more information on some of the topics mentioned in this module.

BIODIVERSITY TOPIC	OTHER MODULE(S)
Cover Crops	Soil Health
Pasturing	Animal Husbandry
Crop/Pasture Insect Pests	Pest Management
Weeds	Animal Husbandry

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following programs or sources.

- **Altieri, Miguel.** "The ecological role of biodiversity in agroecosystems." Agriculture, Ecosystems and Environment 74 (1999) 19-31. This article details how biodiversity is essential to a healthy and naturally-functioning agricultural system. It also describes management practices for enhancing biodiversity and restoring ecosystem function to farm lands.

- **Appropriate Technology Transfer for Rural Areas** (ATTRA) "Sustainable Agriculture: An Introduction." http://attra.ncat.org. ATTRA specializes in developing sustainable agricultural information and tools. For a summary of the practices they advocate regarding biodiversity, see "Sustainable Agriculture: An Introduction" at http://attra.ncat.org/attra-pub/PDF/sustagintro.pdf.

- **The Food Alliance.** http://www.thefoodalliance.org/. This organization certifies producers, which use socially and environmentally responsible farming practices. The certification process includes sections on natural area management, watershed management, crop management, pest management, pastureland management, and animal welfare. Details on biodiversity are included under wildlife habitat.

- **Center for Sustainable Agriculture**, University of Vermont. http://www.uvm.edu/sustainableagriculture. The Center for Sustainable Agriculture was established in 1994 as a unit within the University of Vermont to integrate university and community expertise to promote sustainable farming systems throughout Vermont and the region.

SUMMARY RESULTS FOR BIODIVERSITY

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that apply questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

QUESTION	ANSWER/SCORE
1. Genetic Diversity of Crops	
2. Natural Area Conservation	
3. Management of Riparian Areas (If you don't have any riparian areas on your property, give yourself 4 points)	
4. Pasture Management	
5. Crop Field Management	
6. Adjacent Area Management	
7. GMOs (Add 1 for each box checked)	
Total Score (Out of Possible 26)	

Interpretation: The next step in understanding your farm's performance in the category of Biodiversity is to compare your results to best practices. Below is a table that ranks your performance from best practice (green) to practices that require improvement (red). Compare the number of points you received for your practices compared to optimal practices.

	Point Range	**Interpretation**
Green	21 – 26	Best practices regarding Biodiversity are currently being employed on this farm.
Yellow	16 – 20	Farm is using some good practices regarding Biodiversity; however there are some key areas that should be improved upon.
Red	6 – 15	Biodiversity management practices should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

COMMUNITY HEALTH EDUCATIONAL MODULE DESCRIPTION

Community health is defined as the strength of the community in which a farmer operates. Strong community relations and respect for agriculture can lead to a better quality of life for farmers. Research shows that the support received from a community can significantly impact a farmer's job satisfaction.[49] Similarly, the interests of community groups and local inhabitants must be considered by the farmer during the planning and development stages of agricultural activities, including the hiring of migrant labor, when these developments directly affect the community.

Agricultural employment plays an important role in the maintenance of viable farming populations and communities. Ensuring the health and safety of the employees is an important social concern leading to an increasing number of worker safety programs and standards.[50] Recent market conditions have resulted in the decrease of a permanent agricultural labor, from 9.9 million in 1950 to only 2.8 million in 1998.[51] The results include sourcing of undocumented labor, impacting the stability of farming and its nearby communities.

Consequently, this module evaluates a farmer's working environment through two main criteria: community relations and protection of labor supply.

INCENTIVES FOR CHANGE

- **Benefits to farmers.** In most dairy operations, labor accounts for 15% to 20% of total costs.[52] Identifying and hiring only documented labor will help the farmers and the community in the long term. Replacing undocumented labor is costly and inefficient to farmers. Additionally, hiring undocumented labor is illegal across the United States and can result in significant fines. One of the most extreme cases was a farmer in Florida who was fined $150,000 for hiring undocumented workers, and then an additional $120,000 for firing forty workers who presented what appeared to be adequate paperwork.[53]

- **Benefits to community.** Strong community relations and a dependable labor supply help the success of a farmer. Since Vermont dairy farmers contribute 80% of all farming revenues in the state, the stability of these farmers is important to the community and state economy.[54] The hiring of documented or even permanent labor force will have positive repercussions on the community. These laborers are likely to have greater loyalty to the community, contributing to its economic and social viability.

ASSESSMENT QUESTIONS

For all questions, please choose the answers that best identify your current management practices. Use the summary sheet on the last page of this module to evaluate overall performance.

Community Relations

Community Involvement. What community groups are **you** and/or your family involved in? (Please check all that apply. The maximum number of points is 7)

	Self	Spouse	Children	Parent
4H	☐	☐	☐	☐
School board	☐	☐	☐	☐
Fire Department	☐	☐	☐	☐
Young Cooperators	☐	☐	☐	☐
Town Government	☐	☐	☐	☐
[Other]	☐	☐	☐	☐
[Other]	☐	☐	☐	☐

- **The following describes my involvement in the community:**
  1. Unfortunately, I do not have any time for community activities.
  2. Either my spouse or I am involved in one local community organization.
  3. Either my spouse or I are involved in more than one community organization.
  4. In addition to #3, my children and/or my parents are involved in either one or more community activity.

- **When it comes to the community's involvement on my farm:** (Check all that apply. For scoring, add 1 for each box checked)

☐ I host visitors/tourists on the farm at least once a year.
☐ I host educational trips for children from local schools.
☐ Members of the community visit our farm through corporate outreach programs.

Research trends show that a farmer's job satisfaction is strongly tied to his relationship to the community as well as his own personal life. Advocating community building has several benefits including offering variety to a farmer's day, exposing farmers to different professions and other farmers, and increasing the success of local farmer's markets (indirectly improving business relations).[55] Corporations, such as Stonyfield Farms, have established community outreach programs entitled, "Have a Cow." For a price of $6, consumers can adopt a cow, receive regular updates, and visit their cows on the farm.[56] This is an additional method of community outreach from the farmer.

PROTECTION OF LABOR SUPPLY

- **Documented Labor. When it comes verifying documentation for new labor:**
  1. I do not check whether they have authorized paperwork.
  2. I am satisfied when they tell me they have authorized paperwork.

3. I am satisfied after I have examined and verified the paperwork is legal. Or, we don't hire outside labor
4. Employees are documented and in possession of appropriate identification. Employers are participating in migrant training programs.

It is against the law to hire undocumented labor in the United States. Unfortunately, labor trends have resulted in a growth of this type of labor in the agricultural arena. With the reduction of the American labor supply, U.S. farmers requested the Department of Labor to issue H2A guest - worker visas that allow foreigners to enter the United States to perform seasonal agricultural labor.[57] However, tedious and complicated paperwork often leads workers to enter illegally. The U.S. Department of Labor estimated that in 1998, 52% of the agricultural labor force lacked documentation to work. Hispanic workers comprise 36% of the hired wage and salary farm workers in the U.S. Of these, approximately 75% of Hispanic farm workers were not U.S. citizens, compared to 28% of all hired farm workers and 7% of all wage and salary workers in the United States.[58]

- **Child Labor. My hiring policies regarding child labor are:**
1. I do employ legal minors, but only during non-school hours.
2. In addition to #1, I offer special training for minors.
3. In addition to #2, I train others, or I am capable of the special management needs of minors.
4. In addition to #3, I communicate with the parents of minors regarding their work. Or, we don't hire child labor.

According to the US Child Labor Law,[59] the minimum age for general employment in non-agricultural sectors is 14 years old and 18 years old for hazardous work. In agriculture specifically, the minimum age of employment is 11 for non-hazardous work and 16 for hazardous work. During school hours, a child must be 16 years old to work during school hours and at least 14 to work outside school hours. However, a child at the age of 12 or 13 may also be employed with written consent of the minor's parent or guardian. A child under the age of 12 may be employed by a parent or guardian on a farm owned or operated by that person.[60]

- **BASE WAGE. How much do you pay your farm workers?**
1. I pay my workers the legal, minimum wage according to Vermont State Law.
2. I pay my workers the legal, minimum wage with scheduled increases.
3. In addition to #2, I assist them with one of the following: housing, a pasture for the employee's livestock, personal use of the equipment, garden space, or daily meals.
4. In addition to #2 or #3, I assist them with buying health insurance, or I don't have any employees

The consensus among farmers these days is “a good worker is hard to find.” In 1999, an average wage paid on dairy farms was $17,000,[61] compared to the poverty line of $15,000. Vermont’s current minimum wage rate is $6.25 per hour, but will increase to $6.75 on January 1, 2004 and to $7.00 on January 1, 2005.[62] Providing additional benefits, such as partial health care costs, housing, and food, to farm workers is a common trend, which helps to ensure the consistency and dependability of a good laborer.

- **Worker Sanitation. What precautions do you take regarding worker sanitation?** (Check all that apply. For scoring, add 1 for each box checked)
  - ☐ I provide all employees with clean drinking water, clean latrines, and hand washing stations.
- ☐ All hand washing stations have soap and water.
- ☐ Upon inspection, all facilities are clean.
- ☐ I provide a shower facility with warm water for employees to wash and change after the workday.

- **What precautions do you take regarding general safety?** (Check all that apply. For scoring, add 1 for each box checked)
- ☐ I provide general safety training to all employees when they are hired.
  - ☐ I provide general safety training conducted by professional firms to provide safety training.
  - ☐ I have developed training checklists for each job to ensure each employee receives appropriate training.
- ☐ I have set goals for safety and track success.
- ☐ I reward my employees with bonuses when safety goals are met.

According to the Cooperative Extension Service at the University of Nebraska, poor employee management causes more safety problems than any other factor. Proper monitoring of worker sanitation and general safety can prevent unnecessary sicknesses and injuries, both of which can result in expensive costs to the farmer.[63]

LINKAGES TO OTHER MODULES

While the questions above cover some of the basics regarding financial and quality of life management, other practices also impact farm financials. Please review your practices regarding the following topics in the Educational Modules listed below.

COMMUNITY HEALTH TOPIC	OTHER MODULE(S)
Community Relations	Farm Financials
Protection of Labor Supply	Farm Financials

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following sources:

- **US Department of Labor.** The Department of Labor promotes the welfare of the labor pool of the United States by improving working conditions, advancing opportunities for profitable employment, protecting retirement and health care benefits, helping employers find workers, strengthening free collective bargaining, and tracking changes in employment, prices, and other national economic measurements.
  - Address: Frances Perkins Building, 200 Constitution Avenue, NW Washington DC, 20210
  - 1-877-889-5627
  - www.dol.gov

- **Department of Labor at Vermont.** The Department of Labor & Industry provides for the safety, protection and welfare of people where they work, live and play, in a manner that is fair, consistent, supportive and professional. It also provides historical and current wage information to employees in Vermont.
  - Address: National Life Building, Drawer 20, Montpelier, Vermont 05620-3401
  - Phone: (802) 828-2288
  - http://www.state.vt.us/labind/

➢ **University of Vermont Extension**, The Farm Business Management Specialist. UVM Extension strives to be a state leader in promoting agricultural business in Vermont through the provision of information and educational programs for diverse audiences. www.uvm.edu/extension

Summary Results for Community Health

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that apply questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

Question		Answer/Score
1.	Community Relations (7 points total possible)	
2.	Documented Labor	
3.	Child Labor	
4.	Base Wage	
5.	Worker Sanitation (Add 1 for each box checked)	
6.	General Safety (Add 1 for each box checked)	
Total Score (Out of Possible 27)		

Interpretation: The next step in understanding your farm's performance in the category of Community Health is to compare your results to best practices. Below is a table that ranks your performance from best practices (green) to practices that require improvement (red). Compare the number of points you received for your practices compared to optimal practices.

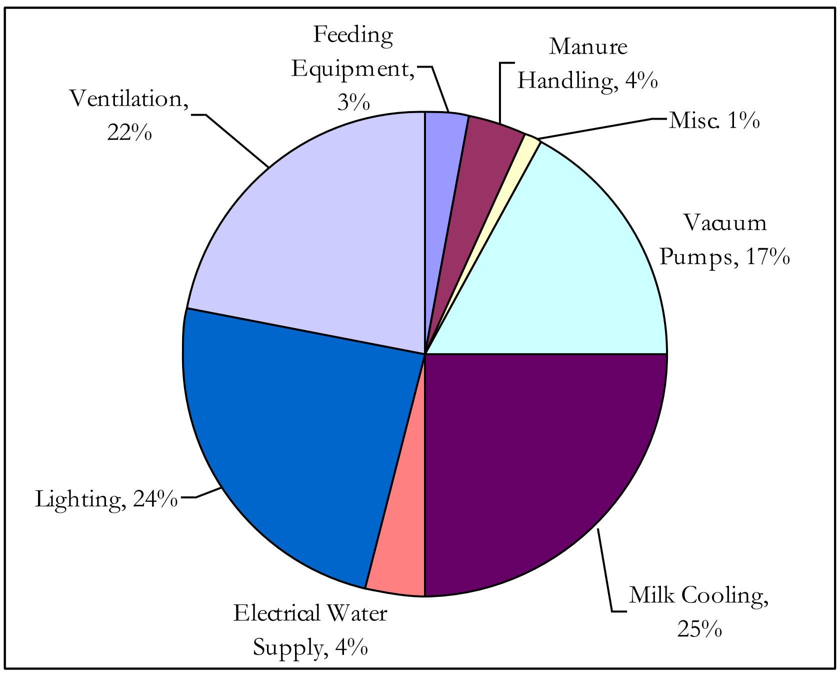
	Point Range	**Interpretation**
Green	23 - 27	Best practices regarding Community Health are currently being employed on this farm.
Yellow	19 - 22	Farm is using some good practices regarding Community Health; however there are some key areas that should be improved on.
Red	12 - 19	Community Health practices should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

ENERGY EDUCATIONAL MODULE

DESCRIPTION

There are two main types of energy: renewable and non-renewable. As the name implies, a non-renewable energy source is an energy resource that is not replaced or is replaced only very slowly by natural processes. Primary examples of non-renewable energy resources are the *fossil fuels*--oil, natural gas, and coal. Fossil fuels are continually produced by the decay of plant and animal matter, but the rate of their production is extremely slow, very much slower than the rate at which we use them. Any non-renewable energy resources that we use are not replaced in a reasonable amount of time (a lifetime or that of the next generation) and are thus considered "used up", not available to us again.[64] This category can be further broken down into direct and indirect energy. Electricity is a major use of direct energy farms. Milk cooling, lighting, ventilation and vacuum pumps account for 88% of all direct energy used on dairy farms.[65] Typically, total annual energy used by dairy farms is equal to 3.4 million kWh/year divided into energy intensive components as described in Figure 1.

Figure 1: Typical Energy Use by Equipment on a Dairy Farm[66]



Indirect energy use is comprised of the following sources: fertilizer type or nutrient quantity; chemical pesticides, seeds, feed that was bought-in from outside or sold, and grazing-off recorded by number of animals and time away from the property.[67] The manufacturing of chemical fertilizers and pesticides makes up almost 40% of the energy allocated to agricultural production.

Renewable energy on the other hand, is “any energy resource that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy)."[68] The most relevant form of renewable energy for dairy farmers is methane recovery. Methane is found in manure can be converted to renewable energy through specific technologies, such as anaerobic digesters, resulting in cost savings to those farmers and a reduction in emissions of greenhouses gases to the environment. Biodiesel is another renewable energy source on the farm. It is a clean burning alternative fuel produced from domestic, renewable resources, contains no petroleum, but can be blended at any level with petroleum diesel to create a biodiesel blend. Biodegradable, nontoxic, and essentially free of sulfur and aromatic, over the course of its production and use, biodiesel produces 78% less carbon dioxide emissions and almost 100% less sulfur dioxide, according to joint study commissioned by the US Department of Energy and the US Department of Agriculture,[69] biodiesel already meets the new EPA standards for low-sulfur diesel fuel mandated for introduction in 2006.[70]

Current agricultural practices, including those on dairy farms, emit a large amount of greenhouse gases globally. Generated through the combustion of fossil fuels, electricity contributes to the emissions of greenhouse gases such as methane, nitrous oxide, and carbon monoxide. These gases, once emitted into the atmosphere, trap heat in the atmosphere, potentially causing global warming.[71]

INCENTIVES FOR CHANGE

In order to gain maximum farmer participation in adopting best management practices, it is necessary to outline how the dairy farmer benefits from managing their energy use.

- **Cost Savings.** Vermont's electricity rates are among the highest in the country.[72] Energy efficient lighting and equipment can make a substantial difference in reducing monthly energy bills. According to Efficiency Vermont, and as seen below, a farmer can reduce milk cooling costs by 50% with plate-type milk pre-cooler; reduce vacuum pump energy costs by up to 66% with a variable speed drive pump; and save as much as 65% on lighting costs by switching to energy saving lighting.[73]

ASSESSMENT QUESTIONS

For all questions, please choose the answer(s) that best identify your current management practices. Use the Summary sheet on the last page of this module to evaluate overall performance.

➢ **Calculate the amount you spend on energy and machinery as a percentage of gross income:**

Part 1: From your Schedule F Income Tax Filing add items in the table below.

Part 2: Divide Part 1 by gross income.

Items	**Dollar Amount ($)**
Milk house cleaners	
Custom hire (machine work)- fertilizer, pesticides/herbicides and planting or harvesting.	
Depreciation on buildings and equipment	
Own application of fertilizer, pesticides/herbicides	
Fuel	
Rent or lease of vehicles, machinery and equipment	
Repairs and maintenance	
Utilities	
Total Dollars Spent:	
Total Gross Income:	
Total Dollars Spent/Total Gross Income x 100 =	**%**

➢ **Percentage of Total Income**

1. My total dollars spent per total gross income is greater than 50%.
2. My total dollars spent per total gross income is between 25% and 50%.
3. My total dollars spent per total gross income is between 10% and 25%.
4. My total dollars spent per total gross income is less than 10%.

Recording the amount of money spent on electricity and other energy sources can help homeowners and business managers understand just how much they spend on energy-related services, often prompting a move towards increasing energy efficiency to reduce costs.[74]

➢ **When it comes to lighting:**[75]

1. I use only standard lighting in my barns and outbuildings (i.e. mercury vapor yard lights).
2. I have converted a portion of my lights to more energy efficient alternatives, such as high-pressure sodium yard lights. And I have worked with Efficiency Vermont for assistance.
3. I have converted all of my lights to energy efficient models (such as high pressure sodium yard lights).

- **When it comes to milking cows:**

1. I use a traditional vacuum pump.
2. I am saving money to buy a variable speed drive controller.
3. I use a variable speed drive controller.

According to one farmer member in the St. Albans Coop, the use of a variable speed pump has reduced somatic cell count in his milk, upgraded the quality of milk and increased the dollar value he receives for the milk.[76]

➢ **When it comes to ventilation in the barn:**

1. I use the standard (i.e. fans), mechanical equipment that is not energy efficient.
2. I am saving money to be able to convert to more energy efficient equipment.
3. I have converted a portion of my barn to be ventilated by more energy efficient equipment.
4. I have converted my barn(s) to be ventilated by more energy efficient equipment.

In recent years, mechanical ventilation in large freestall barns has become one of the largest peak energy users on dairy farms. Switching to efficient fans can produce savings of 12% to 15% in both smaller barns and large freestall barns.[77]

➢ **When it comes to milk cooling equipment:**

1. I use the standard, milk cooling equipment.
2. I am saving money to use a 'plate milk pre-cooler'.
3. I have converted to using a plate milk pre-cooler to reduce my energy usage during milk cooling.

Energy conservation measures on farms include variable speed pumps, plate milk pre-coolers and energy efficient lighting technology. According to farm surveys conducted by EnSave, a Vermont based electric company, the two main areas of resistance to adopting these technologies include labor shortages and high upfront costs.[78] However, as indicated in the table below, the upfront costs of installing new technology can be offset over on the average of five years. For example, a variable speed pump drive will cost a farmer approximately $3401 to install. However, by installing this technology, the farmer will save almost 10,000 kWh, or $1061/year in energy bills. At this savings rate, the cost of installing the pump will be returned to the farmer within five years on average. Data detailing these savings is listed in Table 2.

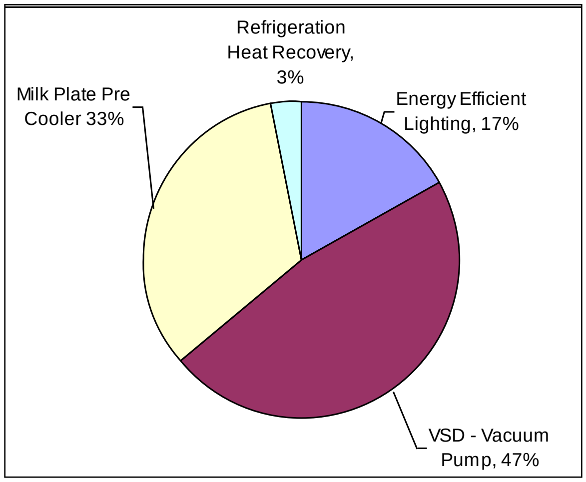
Table 2: Summary of Energy Savings for Energy Conservation Measures[79]

	Annual kWh	**Estimated Annual Savings**	**Estimated Installed Cost**	**Average Payback Years (range)**
Install VSD on Vacuum Pump	9,988	$1,061	$3,401	4.73 years
Add Refrigeration Heat Recovery	5,781	$579	$2,861	5.00 years
Install Plate Milk Pre-cooler	9,414	$948	$2472	4.22 years
Install Energy Efficient Lighting	3,491	$344	$1,473	4.50 years
Total Savings	**28,674**	**$2,931**	**$10,207**	**4.6 years**

*These numbers are based on the average costs in the northeast region in 2002.

These energy conservation measures result in the savings by percentage as shown in Figure 2.

Figure 2: Energy Savings per Area[80]



- **When it comes to renewable energy:**

1. I do not use any renewable energy measures on my farm.
2. I plan to implement wind, solar, biodiesel or methane recovery as a renewable technology measures on my farm as soon as I save enough money or I have received funding.
3. I have already started using Biodiesel or Methane Recovery as a renewable energy technology because it makes sense for my size farm.

The use of methane recovery technology, such as anaerobic digesters, has significant improvements in cost efficiency, manure management efficiency, and a reduction in the need of direct energy. However, the practicality of it must be determined on an individual farm basis. The costs of an anaerobic digester to break methane down into energy depend on specific farm conditions. Moreover, the average pay back can range from a few years to more than ten years. According to the Wisconsin Public Service Commission, a minimum herd size of 300 dairy cows is needed to make such a system feasible,[81] while other estimates are in the range of 5000 cows. However, money isn't the only consideration. It takes approximately 45 minutes of daily maintenance, including inspection, mixing and pumping manure into a digester twice a day, and checking and recording gauges to measure biogas and electricity output, in order to keep an anaerobic digester working smoothly. Generator engines also require monthly maintenance including oil changes, valve adjustments and spark plug cleaning.[82] Currently, the Vermont Department of Public Service and the Vermont Department of Agriculture have received a total of $695,000 from the federal government to promote the use of methane recovery technology on Vermont dairy farms.[83] The project has been designed to consider methane recovery in a broad context, taking into account its potential benefits as a component of a comprehensive nutrient management system, as a renewable energy source and as a strategy for greenhouse gas reduction.

Biodiesel is a clean air, renewable energy source that is more expensive than petroleum diesel, however it is the least cost strategy when compared with other alternative fuel systems.

Consumer benefits include the following: 1) because it is more lubricating than petroleum diesel fuel, biodiesel can extend the life of diesel engines; 2) it does not require any major engine modifications or special storage/handling procedures; 3) it can be made from domestically produced, renewable oilseed crops such as soybeans, as well as from recycled vegetable oil that has already used for frying; and 4) when burned in a diesel engine, biodiesel replaces the exhaust odor of petroleum diesel with the pleasant smell of popcorn, French fries, or donuts.[84]

LINKAGES TO OTHER MODULES

While the questions above cover some of the basics regarding energy management, other practices also impact energy use. Please review your practices regarding the following topics in the Educational Modules listed below.

ENERGY TOPIC	OTHER MODULE(S)
Energy	Farm Financials
Product Quality	Animal Husbandry
Manure Management	Nutrient Management

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following sources:

- **EnSave Energy Performance Inc.** This energy calculator shows farmers all the aspects that can lead to energy savings on the farm.
  - Address: 65 Millet Street, Suite 105, Richmond, VT 05477
  - Tel: 800-732-1399; Fax: 802-434-7011
  - http://www.ensave.com/EnergyCalculators.htm/

- **Efficiency Vermont.** This is a source of quick information about lowering costs with energy efficiency in new equipment or in existing or new building designs. It recently began to provide 0% financing to supplement financial incentives and technical assistance for dairy farms.
  - Address: 255 S. Champlain Street, Suite 7, Burlington VT 05401
  - 1-888-921-5990
  - http://www.efficiencyvermont.com/

- **Consumer's Guide to Small Wind Electric Systems in Vermont**
  - http://www.eere.energy.gov/windpoweringamerica/pdfs/small_wind/small_wind_vt.pdf/

- **Renewable Energy Vermont.**
  - P.O. Box 1036; Montpelier, VT 05601;
  - Phone/Fax (802) 229-0099
  - Andrew Perchlik: E-Mail perchlik@REVermont.org
  - http://www.REVermont.org

- Appropriate Technology Transfer for Rural Areas – ATTRA . www.attra.ncat.org

- **Vermont Alternative Energy Council.**
  - 147 Allen Brook Lane, Suite 104, Williston, VT 05495
  - (P) 802.879.4896/ (F) 802.879.5486
  - http://www.vaec2000.com/

  - **SUMMARY RESULTS FOR ENERGY**

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that apply questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

QUESTION	ANSWER/SCORE
1. Percentage of Income	
2. Lighting	
3. Milking (Use of Variable Speed Driver)	
4. Ventilation	
5. Milk Cooling Equipment	
6. Renewable Energy	
Total Score (Out of Possible 20)	

Interpretation: The next step in understanding your farm's performance in the category of Energy Module is to compare your results to best practices. Below is a table that ranks your performance from best practice (green) to practices that require improvement (red). Compare the number of points you received for your practices compared to optimal practices.

	Point Range	**Interpretation**
Green	16 - 20	Best practices regarding Energy are currently being employed on this farm.
Yellow	14 – 15	Farm is using some good practices regarding Energy; however there are some key areas that should be improved on.
Red	6 – 13	Energy practices should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

Farm Financials Educational Module

Description

Farm Financials is a module designed to assess the financial performance of a farming enterprise. Through the use of key ratios, and the quality of life the farmer leads, this section describes the merits of monitoring financial performance of the farms. Monitoring financial performance can help farmers control their costs for managing and perhaps even growing their businesses. Appropriate business management that allows for a healthy work-life balance is also integral to a farmer's well-being and overall quality of life. Quality of life is not only influenced by personal wealth, but also by a farmer's ability to spend time with family, friends or helping the community.

According to the Farm Financial Standards Council (FFSC), there are five main areas that are used to assess the financial health and stability of a farm. These five areas can be determined by sixteen different financial ratios. For the purposes of this module, we will focus on the five ratios most commonly used by farmers and lending institutions when applying for loans.[85]

Term	Definition	Financial Ratio
1. Liquidity	Does a farmer have the ability to pay his or her bills and interest payments on time without affecting business?	Current Ratio
2. Solvency	Does a farmer have the ability to repay all his or her debt if all his or her assets were sold? In weak economic times, usually leading to an increase in debt, can a farmer continue to conduct business?	Equity to Asset Ratio
3. Profitability	Does a farmer have the ability to make a profit from selling his or her goods?	Rate of Return on Farm Assets
4. Repayment Capacity	Can a farmer make the payments on his or her term farm debt?	Term Debt and Capital Lease Coverage
5. Financial Efficiency	Does a farmer generate the maximum amount of revenues and profits possible on his or her farm?	Operating Expense Ratio

A farmer can assess his or her financial performance in two ways: using the cash method or an accrual accounting method. Using the cash method, a farmer calculates his or her financial position based upon his or her bank account balance. For example, if a farmer buys a tractor for $80,000 today, he or she pays $80,000 out of his or her bank account. While this is a dependable method for households, when it comes to businesses, the benefits of this tractor can be extended over ten years, reducing the financial burden to only $8,000 in any single year. This ability to account for changes in inventory and supplies over time is known as the accrual method.

A balance sheet lists a farm's assets (the value of a farm's financial resources), liabilities (the financial claims of lenders, input suppliers, etc.), and equity (the owner's financial stake in the business) at a specific date in time. An income statement lists a farm's revenue and expenses over a period of time. And finally, a cash flow statement lists a farm's cash supply over a period of time.

INCENTIVES FOR CHANGE

- **Long Term Cost Reductions.** Strategic money management can allow for new capital expenditures on the farm, leading to an increase in efficiency and a long-term decrease in costs. This type of investment can span a number of areas including new barns, new tractors, tilling equipment, milk equipment, and energy saving cooling.

- **Quality of Life Improvements.** Financial planning, dual incomes, and health insurance can mitigate the pressures and stress on the average U.S. farmer. Moreover, a balanced work schedule provides the farmer and his or her family time to spend on non-farming activities, which include community involvement, time with family, vacations, and personal hobbies.

ASSESSMENT QUESTIONS

For all questions, please choose the categories that best identify your current management practices. Use the Summary sheet on the last page of this module to evaluate overall performance.

FINANCIAL STABILITY

The following ratios are used to assess financial stability and are calculated based on FFSC definitions. Sources of the financial information come from one of three places: (1) the balance sheet, (2) the income statement, or 3) the cash flow or earnings statement.

➢ **CURRENT RATIO**[86] (Please fill in the following information)

	Amount ($)	**Source**
(1) Total current farm assets?		Balance Sheet
(2) Total current farm liabilities?		Balance Sheet
Divide (1)/(2) =		

PLEASE SELECT THE APPROPRIATE ANSWER BASED UPON YOUR RESULTS:

1. My current ratio is less than 1.
2. My current ratio is between 1 and 1.50.
3. My current ratio is greater than 1.50.

As a measurement of liquidity, the current ratio measures whether or not a farmer has the ability to pay the bills and interest payments on time without affecting business. This ratio is calculated using the following equation:

Total current farm assets / Total current farm liabilities.

Farms enjoying a competitive position generally have a current ratio of greater than 1.50 whereas farms with a current ratio of less than 1 should seek financial guidance to improve performance.[87]

➢ **EQUITY TO ASSET RATIO**[88] (Please fill in the following information)

	Amount ($)	Source
(1) Total farm equity?		Balance Sheet
(2) Total farm assets?		Balance Sheet
Divide (1)/(2) x 100 =		

PLEASE SELECT THE APPROPRIATE ANSWER BASED UPON YOUR RESULTS:

1. My equity to asset ratio is less than 30%.
2. My equity to asset ratio is between 30% and 70%.
3. My equity to asset ratio is greater than 70%.

As a measure of solvency, the equity to asset ratio measures the proportion of total farm assets financed by the farmer's own equity (as opposed to financed by debt). This ratio is calculated using the following equation:

Total farm equity / Total farm assets.

Farms enjoying a competitive position generally have an equity to asset ratio of greater than 70% whereas farms with an equity to asset ratio of less than 30% should seek financial guidance to improve performance.[89]

- **RATE OF RETURN ON FARM ASSETS**[90] (Please fill in the following information)

	Amount ($)	Source
(1) Net income (excluding gains/losses from sale of assets)		Income Statement
(2) Farm interest expense		Income Statement
(3) Owner withdrawals for unpaid labor and management		cash flow
(4) Average total farm assets		Balance Sheet
(5) Calculate: (1) +(2) – (3)		
Divide (5)/(4) x 100 =		

PLEASE SELECT THE APPROPRIATE ANSWER TO ONE OF THE FOLLOWING QUESTIONS BASED UPON YOUR RESULTS.

I own or hold a mortgage for most of my assets and:

1. My rate of return on farm assets is less than 1%.
2. My rate of return on farm assets is between 1% and 5%.
3. My rate of return on farm assets is greater than 5%.

I lease or rent most of my assets and:

1. My rate of return on farm assets is less than 3%.
2. My rate of return on farm assets is between 3% and 12%.
3. My rate of return on farm assets is greater than 12%.

Rate of Return on Farm Assets measures the amount of profit from goods sold. This metric is calculated using the following equation:

(Net farm income from operation + Farm interest expense – Owner withdrawals for unpaid labor and management)/Average total farm assets.

The "average rate of return on farm assets for farms in the US is between 3-6%".[91] Farms (with mostly owned assets) enjoying a competitive position generally have a rate of return on farm assets ratio of greater than 5% whereas farms with a rate of return on farm assets of less than 1% should seek financial guidance to improve performance.[92] Farms (with mostly leased or rented assets) enjoying a competitive position generally have a rate of return on farm assets ratio of greater than 12% whereas farms with a rate of return on farm assets of less than 3% should seek financial guidance to improve performance.[93]

- **TERM DEBT & CAPITAL LEASE COVERAGE RATIO**[94] (Please fill in the following information)

	Amount ($)	Source
(1) Net income from operations (excluding gains/losses from sale of assets)		Cash Flow or Earnings Statement
(2) Total miscellaneous revenue (if not included in net income from operations)		Cash Flow or Earnings Statement
(3) Total miscellaneous expense (if not included in net income from operations)		Cash Flow or Earnings Statement
(4) Total non farm income		Cash Flow or Earnings Statement
(5) Depreciation/amortization expense		Cash Flow or Earnings Statement
(6) Interest on term debt		Cash Flow or Earnings Statement
(7) Interest on capital lease		Cash Flow or Earnings Statement
(8) Total income tax expense		Cash Flow or Earnings Statement
(9) Total owner withdrawals		Cash Flow or Earnings Statement
(10) Annual scheduled principal and interest payments on term debt		Cash Flow or Earnings Statement
(11) Annual scheduled principal and interest		Cash Flow or Earnings

payments on capital leases		Statement
(12) Calculate: (1) +(2) – (3) +(4) +(5) +(6) +(7) –(8) –(9)		
(13) Calculate: (10) + (11)		
Divide: (12)/(13) =		

PLEASE SELECT THE APPROPRIATE ANSWER BASED UPON YOUR RESULTS:

1. My term debt & capital lease ratio is less than 110%.
2. My term debt & capital lease ratio is between 110% and 150%.
3. My term debt & capital lease ratio is greater than 150%.

Better known as Repayment Capacity, this ratio measures whether or not a farmer can repay term farm debt. This ratio is calculated using the following equation:

> (Net farm income from operations +/- total miscellaneous revenue/expense + total non-farm income + depreciation/amortization expense + interest on term debt + interest on capital leases – total income tax expense – owner withdrawals (total))/ (Annual scheduled principal and interest payments on term debt + annual scheduled principal and interest payments on capital leases).

Farms enjoying a competitive position generally have a term debt and capital lease ratio of greater than 150% whereas farms with a term debt and capital lease ratio of less than 110% should seek financial guidance to improve performance.[95]

- **OPERATING EXPENSE RATIO**[96] (Please fill in the following information)

	Amount ($)	Source
(1) Total Operating Expenses		Income Statement
(2)Depreciation and Amortization Expense plus interest		Income Statement
(3) Revenues		Income Statement
(4) Calculate: (1) – (2)		Income Statement
Divide: (4)/(3) =		

PLEASE SELECT THE APPROPRIATE ANSWER TO ONE OF THE FOLLOWING QUESTIONS BASED UPON YOUR RESULTS.

I own or hold the mortgage on most of my assets and:

1. My operating expense ratio is greater than 80%.
2. My operating expense ratio is greater than 65% but less than 80%.
3. My operating expense ratio is less than 65%.

I lease or rent most of my assets and:

1. My operating expense ratio is greater than 85%.
2. My operating expense ratio is greater than 75% but less than 85%.

3. My operating expense ratio is less than 75%.

This ratio measures whether a farmer generates the maximum amount of revenues and profits possible from the farm. This metric is calculated using the following equation:

(Total operating expenses – depreciation and amortization expense)/ Revenues.

"A benchmark for the operating expense ratio is between 65-80%--a ratio over 80% often indicates profitability problems, while less than 65% indicates great efficiency."[97] Farms (with mostly owned assets) enjoying a competitive position generally have an operating expense ratio of less than 65% whereas farms with an operating expense ratio of greater than 80% should seek financial guidance to improve performance.[98] Farms (with mostly leased or rented assets) enjoying a competitive position generally have an operating expense ratio of less than 75% whereas farms with a ratio of greater than 85% should seek financial guidance to improve performance.[99]

➢ **FARM INCOME** (Fill in the chart below and answer the following question)

Gross	**Income ($)**	**Off Farm**
My Income		
Spouse's Income		
Other Income		
Total Income		
My Income/ Total Income (%)		
Spouse's Income/Total Income (%)		

➢ **OUR FAMILY'S INCOME IS SUFFICIENT FOR PAYING FOR** (Please check all that apply):

- ☐ Food
- ☐ Clothing
- ☐ Mortgage and monthly bills
- ☐ Health insurance
- ☐ A savings account

Milk price fluctuations have contributed greatly to the rise in off-the-farm family income. Additional income can provide several benefits such as: 1) offsetting low farm returns; 2) providing for basic necessities such as health insurance and maintenance of the farm; and 3) possibly raising living standards and protecting against fluctuations in farm income. In recent years, almost 60% of US Farm households had either the farmer, spouse, or both employed in off-farm work.[100] Moreover, approximately 80% had higher cash incomes from off-farm earnings (including wages, rent, interest) than from farming operations.[101]

WORK/LIFE BALANCE (Please fill in the following information and answer the following question)

	MON	TUES	WED	THURS	FRI	SAT	SUN	Total Hours
# hrs working on farm								
# of hours spent with family								
# of hours of spent on leisure activities								
Total Hours								

PLEASE CHECK ALL THAT APPLY:

- ☐I work more than 70 hours/week on the farm.
- ☐I spend more than 10 hours/week with my family each week.
- ☐I spend more than 5 hours/week on leisure activities such as hunting, snow mobiling, volunteering, etc.
- ☐I have taken a vacation in the past year with my family.

A farmer must consider his or her financial stability in relation to his or her work/life balance. While the appropriate amount of time to spend with family is based upon individual preference, the general consensus is that the more "family time" a person can accumulate, the happier he or she will be. The response from farmers is overwhelmingly that spending time with children is an esteemed goal and influences a farmer's participation in farming practices that lead to a reduction of labor time required on the farm.[102]

- **ATTITUDE TOWARDS ADOPTING NEW PRACTICES**

  2. New farming practices are costly and risky. Therefore I have not considered them in a while.
  3. I would like to implement new farming techniques and have done a lot of reading on different options; however, based on completed financial evaluation, money is a constraint.
  4. I am very open to new farming technology and seek out new information. When a new technology makes sense for my farm, I implement it.

- **PLANNING FOR THE FUTURE** (Please check all that apply)[103]

  ☐ I am not involved with the future planning of the farm; decisions are made by my family.

- I am in the process of improving the current conditions of the barn for the cows.
- I want to increase the number of cows on the farm.
- I am considering additional crops on the farm to diversify sources of income.
- I have a plan for when milk prices fluctuate greatly.
- I am constantly looking for ways to save money on the farm.

To increase the stability of his or her enterprise, a farmer should investigate new practices and complete business plans, similar to any other business. According to ATTRA, farm planning and production goals are on-going processes that require farm families to define a goal as well as a path to achieve those goals.[104] Research indicates that simply by taking the time to consider long term business planning can be motivation enough to affect change.[105] These actions are increasingly important given current low milk prices. Since 1960, Vermont has lost over 80% of its dairy farms primarily due to changing prices of milk and competing uses for land and labor.[106] While production per cow has risen steadily, farmers' profits have been squeezed, since the costs of producing milk have increased at a substantially faster rate than the price of milk.[107] Therefore business planning must account for rapid changes in order to ensure a farmer's success.

LINKAGES TO OTHER MODULES

While the questions above cover some of the basics regarding financial and quality of life management, other practices also impact farm financials. Please review your practices regarding the following topics in the Educational Modules listed below.

FARM FINANCIAL TOPIC	OTHER MODULE(S)
Term Debt	Energy
Quality of Life	Community Health

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following programs or sources.

- Center for Farm Financial Management, University of Minnesota. http://www.cffm.umn.edu/. This website provides information on financial and business planning.

- Doehring, Todd A. "Analyzing the Efficiency of Your Operation," AEC, 2001 http://www.centrec.com/resources/Articles/FinAnalysisFarmRanches/Efficiency.pdf. This document walks through how to calculate and measure each FFSC metric for efficiency.

- Doehring, Todd A. "Analyzing the Profitability of Your Operation," AEC, 2001 http://www.centrec.com/resources/Articles/FinAnalysisFarmRanches/Profitability.pdf. This document walks through how to calculate and measure each FFSC metric for profitability.
- Pennsylvania State University. "Green Milk Successfully Test-Marketed at Mid-Atlantic Stores." http://aginfo.psu.edu/news/may00/greenmilk.html. This article describes a program which pays farmers a premium if they produce milk using environmentally friendly

management practices. The program, called the Environmental Quality Initiative Inc., is a joint venture of the Chesapeake Bay Foundation, Pennsylvania State University, the Rodale Institute, the Pennsylvania Association for Sustainable Agriculture and the US EPA. The program pays farmers a five-cent premium per half gallon to encourage participation and offset any costs incurred due to changes in management practices. .

- Purdue University Cooperative Extension Service. "Farm Business Management for the 21st Century. Measuring and Analyzing Farm Financial Performance." http://www.agecon.purdue.edu/extension/programs/fbm21/EC712entry.htm This site provides additional measures for farm financial performance including cash flow analysis, debt service analysis, and information on how to respond to financial difficulty.

- Virginia Cooperative Extension Service. http://www.ext.vt.edu/resources/. This page includes information on a variety of topics related to farm financials. Sections of interest include Financial Management and Farm Business Management and Marketing. These sections cover specific financial topics such as estate planning, equipment leasing economics, and much more.

Kohl, David. *Summary of Key Ratios and Benchmarks*. Not dated. This table developed by David Kohl and shown on the following page summarizes additional key financial ratios, their calculations, and corresponding benchmarks for the agriculture industry. It includes fifteen of the sixteen farm financial ratios advocated by the FFSC plus one additional ratio. This additional ratio, the California Working Capital Rate, is used to calculate liquidity.

- Farm Management Specialist, UVM Extension. Information on farm financials and management. Burlington, VT 05405-0106 Phone: 802-656-2109 http://www.uvm.edu/extension

Summary of Key Ratio Calculations and Benchmarks

Repayment Analysis	Calculation	Green	Yellow	Red
Term Debt and Lease Coverage Ratio	[(NFIFO* + Gross Non-Farm Revenue + Depreciation Expense + Interest on Term Debts and Capital Leases) - Income Tax Expense - Family Living Withdrawals] / Scheduled Annual Principal and Interest Payments on Term Debt and Capital Leases	>150%	110% to 150%	<110%
Debt Payment / Income Ratio**	Scheduled Annual Principal and Interest Payments on Term Debt and Capital Leases / (NFIFO* + Gross Non-Farm Revenue + Depreciation Expense + Interest on Term Debts and Capital Leases)	<25%	25% to 50%	>50%
Liquidity Analysis				
Current Ratio	Total Current Farm Assets / Total Current Farm Liabilities	> 1.50	1.00 to 1.50	< 1.00
Working Capital	Total Current Farm Assets - Total Current Farm Liabilities	compare to business expenses, absolute amount depends on scope of operation		
California Working Capital Rule**	Working Capital / Total Expenses	> 50%	20% to 50%	<20%
Solvency Analysis				
Debt / Asset Ratio	Total Farm Liabilities / Total Farm Assets	<30%	30% to 70%	>70%
Equity / Asset Ratio	Total Farm Equity / Total Farm Assets	>70%	30% to 70%	<30%
Debt / Equity Ratio	Total Farm Liabilities / Total Farm Equity	<42%	42% to 230%	>230%
Profitability Analysis				
Rate of Return on Farm Assets (ROA) (mostly owned)	(NFIFO* + Farm Interest Expense - Operator Management Fee) / Average Total Farm Assets	>5%	1% to 5%	<1%
Rate of Return on Farm Assets (ROA) (mostly rented / leased)	(NFIFO* + Farm Interest Expense - Operator Management Fee) / Average Total Farm Assets	>12%	3% to 12%	<3%
Rate of Return on Farm Equity (ROE)	(NFIFO* - Operator Management Fee) / Average Total Farm Equity	look at trends and compare to other farm and non-farm investments		
Operating Profit Margin Ratio	(NFIFO* + Farm Interest Expense - Operator Management Fee) / Gross Revenue	>25%	10% to 25%	<10%
Financial Efficiency				
Asset Turnover Ratio	Gross Revenue / Average Total Farm Assets	depends heavily on type of operation and whether it is owned / leased		
Operating Expense / Revenue Ratio (mostly owned)	Operating Expenses [excluding interest and depreciation] / Gross Revenue	<65%	65% to 80%	>80%
Operating Expense / Revenue Ratio (mostly rented / leased)	Operating Expenses [excluding interest and depreciation] / Gross Revenue	<75%	75% to 85%	>85%
Depreciation Expense Ratio	Depreciation Expense / Gross Revenue	compare to capital replacement and term debt repayment margin		
Interest Expense Ratio	Interest Expense / Gross Revenue	<12%	12% to 20%	>20%
Net Farm Income From Operations Ratio	NFIFO* / Gross Revenue	look at trends, varies due to cyclical nature of agricultural prices and incomes		

* NFIFO = Net Farm Income From Operations excluding gains or losses from the disposal of farm capital assets
** Not a ratio recommended by the Farm Financial Standards Taskforce and Council, but widely used

SUMMARY RESULTS FOR FARM FINANCIALS AND QUALITY OF LIFE

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that apply questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

QUESTION		ANSWER/SCORE
1.	Current Ratio	
2.	Equity to Asset Ratio	
3.	Rate of Return on Farm Assets	
4.	Term Debt & Capital Lease Coverage Ratio	
5.	Operating Expense Ratio	
6.	Farm Income (Add 1 for each box checked)	
7.	Work/Life Balance (Add 1 for each box checked)	
8.	Attitude Towards Adopting New Practices	
9.	Planning for the Future (Add 1 for each box checked)	
Total Score (Out of Possible 33)		

Interpretation: The next step in understanding your farm's performance in the category of Farm Financials and Quality of Life Module is to compare the results to best practices. Below is a table that ranks your performance from best practice (green) to practices that require improvement (red). Compare the number of points you received for your farm to optimal practices.

	Point Range	**Interpretation**
Green	28 – 33	Best practices regarding Farm Financials are currently being employed on this farm.
Yellow	20 – 27	Farm is using some good practices regarding Farm Financials; however there are some key areas that should be improved on.
Red	6 – 19	Farm Financials should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

Nutrient Management Educational Module

Description

Nutrients are needed to sustain healthy animals and crops. Overuse or mismanagement of nutrients, in particular nitrogen and phosphorus, can lead to nutrient pollution of ground or surface waters. Purchased feed and fertilizer are by far the largest sources of nutrient imports onto a farm, accounting for 89.5% of imported nitrogen and 96% of imported phosphorus.[108] Reliance on these external nutrient sources is becoming problematic in that 59-81% of the imported nitrogen and phosphorus remain on a dairy farm over a year's time.[109] This can result in a build-up of nutrients in the soil and an increased chance that nutrients will be transported to water sources, resulting in environmental harm to surface and ground water.

While Vermont dairy farms are certainly not the only source of this pollution, contributions from farmland can be significant and participation from the dairy farmer community is therefore essential to improve overall water quality. In Vermont, Lake Champlain, a critical water resource, is experiencing a serious decline in water quality, in part due to sediment and nutrients from agricultural runoff from barnyards, manured and fertilized fields and cropland erosion. Also, many drinking water wells on farms have been found to have nitrate-nitrogen levels exceeding the Vermont public health standard.[110]

Adopting best practices for nutrient management is important to maintaining ground water that is safe for drinking and surface waters that can support healthy aquatic ecosystems, function as industrial and commercial water supplies, and provide recreational enjoyment. This module is devoted to properly managing nutrient applications to fields. Recommendations regarding nutrient management plans, use of fertilizer and manure, and use of dietary phosphorus supplements are intended as an introduction to best management practices to improve farm performance and environmental health. Actual on-farm development and implementation of nutrient management plans should be made in cooperation with experts, such as UVM Extension representatives, feed or fertilizer specialists, or other consultants. Controlling water pollution from other nutrient sources, such as manure or silage storage areas, is addressed in the Water Management module.

Incentives for Change

- **Cost savings.** Appropriate nutrient management can reduce unnecessary feed and fertilizer purchases, improving crop production efficiency and farm profitability. The Vermont Dairy Farm Sustainability Project found that, by reducing phosphate fertilizer application by 40% (average reduction over a 3 year period), farms could reduce total fertilizer expenditures by an average of $2800/farm or $27/acre, while maintaining farm yields.[111] One farm decreased phosphate fertilizer use by 8.3 tons/year for savings of $4200/year.[112]

- **Improved on-farm water quality.** Minimizing impact on surface and ground water is beneficial to the extent that these water resources become inputs on the farm. Maintaining healthy drinking water can reduce the chance for illness, and associated costs, from contaminated water.

- **Regulatory environment and funding.** Currently the EPA requires that farms with large 'concentrated animal feeding operations' (CAFO) obtain a permit for operation. However, in order to get a permit, a farmer must first develop and implement a comprehensive nutrient management plan. In addition, medium size farms (200 to 699 milking cows) in Vermont must file a general permit to operate and develop a nutrient management plan that meets the NRCS 590 standard. As this and other water quality legislation becomes more stringent, dairy farms will increasingly need to demonstrate nutrient management best practices.

ASSESSMENT QUESTIONS

For all questions, please choose the categories that best identify your current management practices. Use the Summary sheet on the last page of this module to evaluate overall performance.

- **NUTRIENT MANAGEMENT & RECORD KEEPING**:
  1. No nutrient management plan exists for the farm.
  2. Nutrient management plan is based on some soil testing and recommendations of the University of Vermont or another credible source. Recommended nutrient application rates are exceeded by 5-25% as 'insurance' for a good yield level.
  3. In addition to #2, the plan is based on soil tests ever 1-3 years and recommended application rates not exceeded by more than 10%. Detailed nutrient records are kept (soil test results, crop yields, nutrient application rates and timing, etc.).
  4. In addition to #3, recommended application rates are never exceeded. Additionally, detailed records are used to guide and improve the nutrient management plan on an annual basis.

Record keeping can help farmers further understand, monitor, and therefore improve, farm performance. It also demonstrates good management and can provide valuable data if management practices are ever challenged. While a bit of effort needs to be invested up front, implementation and maintenance of a nutrient management and record-keeping plan will ultimately save both time (e.g. records are readily available when needed for taxes or other purposes) and money in the long term. A nutrient management plan, developed in conjunction with the UVM Extension service, consultant or other expert resource, covers multiple nutrient flows on farms, including use of manure, fertilizer, and feed and supplements. Some best practices associated with nutrient management plans are captured in the questions in this module.

- **MANURE APPLICATION RATE:**
  1. Application rates are unknown or manure is applied until all manure is used up (without regard to nutrient requirements of field or crop).
  2. Application rates are determined by crop-specific phosphorus needs (per UVM or other published standards) and realistic yield goals (goals are within 10% of 5-year average yield). To prevent over-application, some excess manure may be applied to neighboring fields or otherwise properly disposed of.

3. In addition to #2, application rates are loosely determined by soil nutrient need according to soil tests performed every 3-5 years. To prevent over-application, most excess manure is applied to neighboring fields or otherwise properly disposed of.

4. In addition to #3, rates are determined by strictly following application recommendations from soil tests conducted every 1-3 years and application reflects manure nutrient content, as determined by laboratory analysis. To prevent over-application, all excess manure is applied to neighboring fields or otherwise properly disposed of.

Manure is a valuable source of nitrogen, phosphorus and potassium for crop production but it is important that the use of manure on fields focuses on crop utilization of manure nutrients rather than manure waste disposal. Over-application of manure can result in build up of nutrients in the soil and increased potential that nutrients will be leached through the soil to groundwater or transported to surface waters via runoff. The amount of manure applied should therefore be closely matched to the needs of each field.

Any excess manure remaining after application should be applied to neighboring fields or otherwise properly disposed of. As a benchmark for the amount of land that will be needed for your farm, best practice requires .5 to 1.0 animal units (AU) per acre of cropland that is environmentally, economically, and agronomically suitable for the application of manure.[113] One AU is equivalent to 1,000 pounds so a 1,400-pound dairy cow would be 1.4 AU's.[114]

To more closely match manure application rates to soil and crop needs, the farmer should base application rates on the following:

- Soil Testing*:* Soil testing, conducted at least every 3 years, is the best way to determine soil nutrient content and other characteristics that affect crop uptake of nutrients. UVM offers soil test kits that provide information on soil pH, available phosphorus, aluminum (which affects plant uptake of phosphorus) and other nutrients, and soil fertility recommendations. At $9/sample, soil testing is a non-time-intensive, non-costly way to better understand and manage on-farm nutrients.
- Manure Nutrient Content: The percentage of nutrients in manure will vary, depending on such factors as type of cow, composition of feed, additions of other substances to manure, and collection and storage methods. Because of the wide potential variation in nutrient content, a manure nutrient analysis, which can be done for $30 at UVM, is highly recommended as the best means of determining exact nutrient content for precision crop nutrient applications. If such an analysis is not possible, using published averages for manure nutrient levels is the next best alternative.
- Type of Crop and Crop Yield: Different crops and yield levels will result in varying crop nutrient needs. Manure use should be based on nutrient need of the crop being grown, together with realistic yield goals (within 10% of average yields from the last 5 years). Ideally, nutrient content should be matched with crop need and soil nutrient content per the results of soil testing. However, using general published standards is the next best alternative.

- **COMMERCIAL FERTILIZER APPLICATION RATE:**
  1. Application is based on historical practice; specific application rate is unknown.
  2. Rates are determined from crop-uptake values (per UVM Nutrient Recommendations for Field Crops) based on realistic yield goals (goals are within 10% of 5-year average yield).
  3. In addition to #2, application rates are loosely determined from soil tests performed every 3-5 years and manure nutrient credits and legume nitrogen credits (per UVM Nutrient Recommendations for Field Crops-).
  4. In addition to #3 rates are determined by strictly following application recommendations from soil tests and by annual Pre-Sidedress Nitrate Tests. Every effort is made to use only on-farm nutrient sources (manure, compost, cover crops, etc.).

Given that manure is an excellent and abundant source of crop nutrients, every effort should be made to effectively utilize manure (or other on-farm, organic nutrient sources) to satisfy crop nutrient need. However, and when inorganic commercial fertilizer is needed to supplement manure nutrients, precisely matching it to crop need will minimize fertilizer costs and nutrient build-up in soils.

As discussed in the "Manure Application Rate" section, soil testing and closely following corresponding nutrient recommendations is a best management practice. These nutrient recommendations should take into account crop type and yield (as discussed above) as well as the following:

- Manure and Legume Nutrient Credits: Fertilizer rates should be adjusted for nutrients provided by manure, both present and past applications, and by legume crops such as alfalfa, clover or soybeans. A percentage of nitrogen from manure applications remains in the soil in the years following application and legume crops also add nitrogen to the soil. This amount of nitrogen must be taken into account and fertilizer application rates need to be adjusted accordingly so as not to provide more nutrients than necessary for the soil. A soil test is the preferred and most accurate means of assessing soil nutrient content and corresponding need. In the absence of that, estimates for manure and legume nitrogen credits can be found in the UVM Nutrient Recommendations for Field Crops .
- Pre-Sidedress Nitrate Test (PSNT): The PSNT, a soil sample taken when corn plants are 8-12 inches tall, is a way to accurately understand precise nitrogen needs of the crops and to adjust nitrogen fertilizer levels for specific field conditions. The PSNT should be done on an annual basis and, at a cost of $6/sample, is not a costly investment toward proper fertilizer application levels.

- **MANURE & PHOSPHORUS FERTILIZER APPLICATION TIMING & TECHNIQUES:**
  1. Application is performed without regard to weather or proximity to on-farm water sources. Manure and phosphorus fertilizer is not incorporated into soil.

2. Some effort is made to avoid application near water sources or prior to heavy rains (that could result in manure runoff). When growing annual crops, manure and phosphorus fertilizer is incorporated after 7 days.
3. Nutrients are never applied if heavy rain is expected and are not applied to frozen soils; buffer strips separate fields and nearby water sources. When growing annual crops, manure and phosphorus fertilizer is incorporated within 4 to 7 days.
4. Nutrients are never applied if heavy rain is expected and are not applied to frozen soils; buffer strips separate fields and nearby water sources and manure not applied to edge of field. When growing annual crops manure and phosphorus fertilizer is incorporated within 1 to 3 days.

Every effort should be made to prevent manure ponding and runoff to surface water, adjacent property, or drainage ditches. It is therefore very important to incorporate manure soon after application to prevent runoff, particularly on sloped land, and to avoid applying manure if heavy rain is expected, since the rain may simply wash the manure off the field if it is sitting on the surface of the soil. Furthermore, avoiding application close to water sources and using buffer strips between fields and water sources can prevent manure and runoff from reaching the water.

Quickly incorporating manure is also valuable to making sure that it can 'do its job,' since ammonium nitrogen can evaporate out of manure if it is left on the surface. It has been found that 70% of nitrogen is retained if manure is incorporated within one day. Only 40% remains if incorporated in 2 to 3 days and only 20% of nitrogen is left in manure if it is incorporated in 4 to 7 days.[115] Manure should never be applied to frozen soils because it cannot be easily incorporated, leading to higher runoff potential and nutrient loss. An effort should be made to spread manure earlier in the season (i.e. well before the December 15 manure spreading ban) to ensure that application to frozen soils is avoided.

- **NITROGEN FERTILIZER APPLICATION TIMING & TECHNIQUES:**

1. Broadcast applications are made without consideration to weather. Timing is not planned to optimize crop utilization of nutrients.
2. Application is based in part on some precision application techniques (sidedress or band applications) and/or proper timing to optimize crop utilization of nutrients (multiple delayed or split applications with starter fertilizer, if appropriate). An effort is made to not apply fertilizer prior to heavy rain.
3. Per #2, application strategy relies almost exclusively on precision application techniques and proper timing to optimize crop utilization of nutrients. Fertilizer is never applied prior to heavy rain.

Timing fertilizer applications to maximize crop uptake and utilizing precision application methods are other ways of ensuring the most efficient use of commercial inorganic fertilizer. The use of starter fertilizer and split applications of fertilizer should be matched to soil and climate characteristics as well as to PSNT results to maximize their benefits.

- **FERTILIZER & MANURE APPLICATION EQUIPMENT:**
  1. Application equipment has never been calibrated and application rates unmonitored. No effort is made to prevent spillage.
  2. Application equipment is calibrated periodically and application rates are monitored somewhat. Spillage is controlled and minimized. Spills, if any, are cleaned up promptly.
  3. Application equipment is adjusted and calibrated at least once a year and application rates monitored closely. Spillage is minimized and spills, if any, are cleaned up promptly.

Efforts to match nutrient application amounts to soil and crop need would be wasted if the nutrient application equipment is not calibrated or otherwise cannot be relied on to provide accurate information on nutrient application rates (e.g. due to spills or leaks). As such, best management practice calls for regular calibration of the equipment, close monitoring of application rates, and avoidance of any spillage or leaks.

- **USE OF PHOSPHORUS SUPPLEMENTS:**
  1. Dietary phosphorus is not closely monitored, or is maximized to guarantee production levels.
  2. Dietary phosphorus levels are monitored but exceed National Research Council (NRC) 2001 guideline levels.
  3. Diets are strictly regulated and monitored to ensure that cows are receiving no more than the NRC recommended amount of dietary phosphorus.

Numerous studies have found that closely following National Research Council 2001[116] recommendations for dietary phosphorus can reduce current phosphorus levels for dairy cows (which frequently exceed required amounts) without affecting production levels. The result is dramatically reduced phosphorus levels in manure, which can allow for better matching of manure nutrients to soil and crop need. **Important:** Any phosphorus reduction strategy must result from a collaborative effort between farmers, feed and fertilizer consultants, veterinarians and manure haulers.

LINKAGES TO OTHER MODULES

Nutrient issues are very closely tied to Water Management, Soil Health and, to a lesser extent, Animal Husbandry. The table below identifies where you can find more information on some of the topics mentioned in this module.

NUTRIENT MANAGEMENT TOPIC	OTHER MODULE(S)
Manure Storage	Water Management
Fertilizer Storage	Water Management
Dietary Phosphorus	Animal Husbandry
Soil Testing	Soil Health

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following programs.

- **University of Vermont Extension Program** provides laboratory testing, nutrient recommendations for field crops in Vermont and other services. Information can be accessed on the web at http://pss.uvm.edu/vtcrops/?Page=nutrientmanure.html. Soil test information is available at http://pss.uvm.edu/ag_testing/?Page=soils.html.

- **Miner Institute** (http://whminer.serverbox.net/) does research and education on dairy farm and environmental conservation best practices. They published "Feeding Strategies to Reduce Phosphorus Inputs from Dairy Sources," which provides information on better utilizing dietary phosphorus. More information is available on the internet or by calling Kurt Cotanch at the Miner Institute at 518-846-7121, extension #123.

- **Livestock and Poultry Environmental Stewardship (LPES) Curriculum** provides environmental best management practice recommendations for dairy farms (http://www.lpes.org/les_plans.html). They also provide information on the new Concentrated Animal Feeding Operations (CAFO) regulations and links to funding and additional technical resources (http://www.lpes.org/CAFO.html). You can also call 1-800-562-3618 for more information.

    - The **USDA Natural Resource Conservation Service (NRCS)** offers nutrient management information and tools at http://www.nrcs.usda.gov/technical/ECS/nutrient/. The program also provides funding and technical assistance for conservation efforts through Farm Bill 2002 (http://www.nrcs.usda.gov/programs/farmbill/2002/) and its affiliate programs, such as EQIP (http://www.nrcs.usda.gov/programs/eqip/). The **Vermont NRCS** also manages Farm*A*Syst, a program devoted to national and state-level improvements to ground water that provides comprehensive evaluation and best management sheets specifically for dairy farmers in Vermont. More information can be found at http://www.vt.nrcs.usda.gov/technical/FarmASyst/. Vermont NRCS State Office: 802-951-6796.

- The **Vermont Agency of Agriculture, Food and Markets** provides a clearinghouse of information on controlling non-point source pollution from dairy farms, including accepted agricultural practices (AAPs), best management practices (BMPs) and technical and financial assistance for projects.
  See http://www.vermontagriculture.com/pidnonpointsource.htm for more information. You can also call the Vermont Natural Resources Conservation Districts
    - Windham, Bennington, Rutland, Windsor, Counties: 802-257-5621
    - Orleans, Essex, Caledonia, Orange, Washington Counties: 802-229-2720
    - Addison, Chittenden, Lamoille, Franklin, & Grand Isle Counties: 802-388-6746

SUMMARY OF RESULTS FOR NUTRIENT MANAGEMENT

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that apply questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

Once all responses have been completed, add up the answers and record the total.

QUESTION	ANSWER/SCORE
1. Nutrient Management & Record Keeping	
2. Manure Application Rate	
3. Commercial Fertilizer Application Rate	
4. Manure & Phosphorus Fertilizer Application Timing & Techniques	
5. Nitrogen Fertilizer Application Timing & Techniques	
6. Fertilizer & Manure Application Equipment	
7. Use of Phosphorus Supplements	
Total Score (Out of Possible 25)	

Interpretation: The next step in understanding your farm's performance in the category of Nutrient Management is to compare your results to best practices. Below is a table that ranks your performance from overall best practice (green) to general need for improvement (red). Compare the number of points you received for your practices compared to optimal practices.

	Point Range	**Interpretation**
Green	21 – 25	Nutrient Management best practices are currently being employed on this farm.
Yellow	16 – 20	Farm is using some good practices regarding Nutrient Management. However there are some key areas that should be improved upon.
Red	7 – 15	Nutrient Management should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

ORGANIC EDUCATIONAL MODULE

DESCRIPTION

Organic farms are those certified under the USDA National Organic Program. The USDA National Organic Program is defined in the United States Federal code and is the only legally recognized standard for organic products in the United States (although programs from other countries may be granted USDA status). The National Organic Program requires that farmers meet certain criteria with regard to planning, producing, handling, labeling, and record keeping for plant and animal products. In general, these standards require a 'natural' approach to farming in which ecosystem processes drive growth as opposed to 'man-made' inputs such as synthetic fertilizers, pesticides, and other chemicals. Conversion of a herd from traditional to organic takes at least one year. Conversion of a field takes at least 3 years.

Because only an accredited organization can certify a farm as organic under the requirements of the USDA National Organic Program, this module provides a summary of the regulations rather than certification questions. To obtain an application form or further information on certification, contact the Northeast Organic Farming Association of Vermont (NOFA) (see www.nofavt.org).

INCENTIVES FOR CHANGE

- **Benefits to the farmer.** Currently, less than 2% of the U.S. food supply is grown using organic methods.[117] However, the market is growing approximately 20% per year,[118] and is expected to continue growing at a high rate into the future. Therefore, the organic milk market provides a unique opportunity for farmers to differentiate their products within the milk market and sell them at a premium. Current organic milk prices are almost $20 per hundred pounds compared to $11 to $14 for conventional milk.[119] Moreover, there is little difference between traditional and organic yields. Research shows that organic harvests are dependent upon the type of feed given to cows, rather than upon the type of farming system used.[120] Yields may also vary depending upon the amount of grazed forage compared to high-concentrate feed.[121]

  While the price paid to farmers per hundredweight is higher than conventional milk prices, inputs such as feed and seed are also more expensive, so this method may not necessarily be more profitable than non-organic production. Given this, and the fact that demand for organic milk may vary by season or location, it is recommended that farmers ensure adequate demand before undertaking conversion to organic. With current trends in fluctuating milk prices, however, this method does guarantee a higher price per hundredweight.

- **Environmental benefits.** To be certified, the USDA National Organic Program requires that farms take action to produce their goods in an environmentally sustainable way. This Program addresses the following issues: water quality, soil health, nutrient balances, erosion, biodiversity, and Animal Husbandry practices. Many of the requirements are specific to cropping practices, but also affect livestock production in that only organic feed may be fed to an organic herd.

Summary of USDA National Organic Program Regulations

The following metrics are taken from the USDA National Organic Program regulations and are divided into three categories: management, livestock, and cropping. It is important to note that some of the criteria laid out under the regulations are absolute, leaving no room for interpretation by the certifying official (such as no use of hormones). Other criteria lack strict definitions for compliance (such as whether or not tillage practices minimize soil erosion), leaving the certifying official to evaluate performance in each category.

- **Management**[122]

  Organic production and handling system plan. A farmer must provide a management plan that includes a description of the practices and procedures to be used in raising organic crops and livestock; a list of chemicals and other inputs to be used; a description of monitoring practices; and a description of a recordkeeping system.

  Separate organic and non-organic handling systems. The farmer must implement measures necessary to prevent commingling of organic and non-organic products and protect products from prohibited substances. He or she must not package goods in containers that have a synthetic fungicide preservative or fumigant or use or reuse any container that could contaminate the integrity of an organic product.

  Product labeling. Only products with a certain amount of organic content may be marketed as ‘organic.’ Products sold as ‘100% organic’ must contain by weight or fluid volume 100% organically produced ingredients (excluding water and salt). Products sold as ‘organic’ must contain at least 95% organically produced products (excluding water and salt). Both 100% and 95% organic products may be labeled with the USDA organic seal. Products sold as ‘made with organic ingredients or food group(s)’ must contain at least 70% organically produced products (excluding water and salt). These products may not use the USDA seal. Products with less than 70% organically produced ingredients may identify each ingredient that is organic with the word ‘organic’ if the percentage of organic contents is shown on the information panel. These products may also not use the USDA seal.

  Organic handling requirements. Mechanical or biological methods may be used to process organic products for the purpose of retarding spoilage or preparing goods for market.

  Pest management in buildings and facilities. The farmer must use practices to prevent pests, including, but not limited to: removal of pest habitat, food sources, and breeding areas; preventing pest from accessing facilities; and management of temperature, light, humidity, and other factors. Pests may be controlled through: mechanical or physical controls, lures and repellents allowed under the rule, or methods not allowed under the rule if the handler and certifying agent agree on the method and the handler updates the management plan accordingly.

- **Livestock**[123]

- **Origin of livestock.** Organic milk or milk products must be from animals that have been under organic management for at least one year. If a grower wants to convert an entire herd, he or she must provide a minimum of 80% organic feed for 9 months, followed by three months of 100% organic feed. In addition, all other requirements must be met. Moreover, cows must be managed under organic requirements for at least the last third of gestation in order for newborn calves to be considered organic. The heifer that gave birth however will not be considered organic and must be removed from the farm or converted separately. Cows removed from an organic operation may not be sold as organic. All management must be continuous. Records must be maintained to identify organically managed animals.
- **Livestock feed.** Farmers must provide cows organic feed, including pasture and forage, and may provide non-synthetic or synthetic feed additives and supplements allowed under the rule. The farmer must not use animal drugs (including hormones) to promote growth or provide feed supplements and additives above amounts needed for nutrition and health maintenance. A farmer can not use plastic pellets for roughage; must not feed cows formulas containing urea, manure, or mammalian or poultry slaughter by-products; or use additives or supplements in violation of the Federal Food, Drug, and Cosmetic Act.
- **Use of drugs, vaccinations, hormones.** Milk or milk products may not be sold as organic if biologics have been administered within 30 days. Farmers may not administer any drugs other than vaccinations in the absence of illness, use growth hormones or recombinant bovine growth hormone, administer synthetic parasiticides on a routine basis, administer parasiticides to slaughter stock, administer drugs in violation of the Federal Food, Drug, and Cosmetic Act, or withhold medical treatment from a sick animal in an effort to preserve its organic status. All appropriate medications must be used to restore a sick animal to health. Cows treated with prohibited substances may not be represented as organic.
- **Livestock health care practice standard.** The farmer must provide and maintain health care practices. He or she must: select species and types of livestock with regard to suitability for site-specific conditions; provide a feed ration sufficient to meet nutritional requirements; establish appropriate housing, pasture conditions, and sanitation practices; provide conditions which allow for exercise, freedom of movement, and reduction of stress; perform physical alterations to minimize pain and stress; and administer vaccines and biologics if necessary.
- **Livestock living conditions.** The farmer will provide living conditions that accommodate the health and natural behavior of animals including access to outdoors, shade, shelter, exercise areas, fresh air, and direct sunlight, access to pasture for ruminants, and clean dry bedding. The farmer must provide shelter designed for natural maintenance, comfort behaviors, and the opportunity to exercise. Any shelter must also be designed for the appropriate temperature level, air circulation, and low potential for injury. The farmer may provide temporary confinement due to inclement weather, animals' stage of production, conditions where health and safety may be jeopardized, or to avoid risk to soil or water quality. The farmer must manage manure in a way that

optimizes recycling of nutrients and does not contribute to contamination of crops, soil or water.

- **CROPPING**[124]
  - **Land requirements.** Any parcel of land must have been managed according to the soil fertility and crop nutrient practice standard (see below) and have had no prohibited substances applied to it for at least three years preceding harvest of any organic crops.
  - **Soil fertility and crop nutrient management practice standard.** The farmer must implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion; manage crop nutrients and soil fertility through crop rotations, cover crops, and the application of plant and animal materials; and manage plant and animal material to maintain or improve soil organic matter content. Specific direction is included for use of raw animal matter, composted plant and animal materials, and uncomposted plant materials. In addition, methods for managing crop nutrients through other means are provided.
  - **Crop pest, weed, and disease management practices standard.** The farmer must use management practices to prevent crop pests, weeds, and diseases through crop rotation, sanitation measures, and cultural practices such as selecting plant varieties that are resistant to pests, weeds, and diseases. When natural methods cannot control pests, weeds, and diseases, an allowed synthetic substance may be used as long as it is documented in the organic plan.
  - **Crop rotation practice standard.** The farmer must implement a crop rotation including, but not limited to sod, cover crops, green manure crops, and catch crops to maintain or improve soil organic matter content, provide for pest management, manage nutrients, and provide erosion control.

LINKAGES TO OTHER MODULES

While this is the only module that focuses directly on organic production, it should be noted that organic practices can positively impact other sustainable agriculture indicators such as Animal Husbandry, Soil Health, Water Management, Nutrient Management, and Pest Management as described below.

ORGANIC TOPIC	OTHER MODULE(S)
Livestock Feed	Nutrient Management
Livestock Health Care Practice Standard	Animal Husbandry
Livestock Living Conditions	Animal Husbandry
Soil Fertility and Crop Nutrient Management Practice Standard	Soil Health
Soil Fertility and Crop Nutrient Management Practice Standard	Water Management
Soil Fertility and Crop Nutrient Management	Nutrient Management

Practice Standard	
Crop Pest, Weed, and Disease Management Practices Standard	Pest Management
Crop Rotation Practice Standard	Nutrient Management

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following programs or sources.

- **Northeast Organic Farming Association of Vermont.** http://www.nofavt.org/index.cfm. This non-profit association of farmers, gardeners, and consumers works to organic farming in Vermont. It is also the only accredited certifying organization in Vermont.

- **Appropriate Technology Transfer for Rural Areas (ATTRA).** "Organic Farming Source List." http://attra.ncat.org/organic.html#list. ATTRA specializes in developing sustainable agricultural information and tools. This page provides a number of documents focused on organic farming including: organic fruits, vegetables, flowers, herbs, field crops and livestock. It also has documents focusing on organic practices for pests, soil and fertilizer health, and marketing.

- **Appropriate Technology Transfer for Rural Areas (ATTRA).** "An Organic and Sustainable Practices Workbook and Resource Guide for Livestock Systems, April 2002." http://attra.ncat.org/attra-pub/PDF/livestockworkbook.pdf. ATTRA specializes in developing sustainable agricultural information and tools. This workbook explains the range of practices and materials allowed under the USDA National Organic Program regulations. It is a great tool for helping farmers contemplating conversion to organic production.

- **USDA.** "The National Organic Program" homepage. http://www.ams.usda.gov/nop/indexIE.htm. This USDA site provides the full regulation text, questions and answers, a list of certifying agents, and other information on the National Organic Program.

PEST MANAGEMENT EDUCATIONAL MODULE

DESCRIPTION

Since its introduction to agriculture in the 1940's,[125] chemical pesticides have been the dominant approach to controlling and eliminating pests, resulting in more consistent crop yields as well as a reduction in labor needed to manage the crops. Pesticides include herbicides, insecticides, fungicides, rodenticides, and plant growth regulators. While pesticide use has increased, traditional pest management methods, such as crop rotation and growing a variety of crops, have been phased out. However, there is growing concern regarding the use of pesticides as they "…can cause harm to humans, animals, or the environment because they are designed to kill or otherwise adversely affect living organisms."[126]

These concerns lead to an alternative approach, called Integrated Pest Management (IPM). The California Healthy Schools Act of 2000 defines IPM as "…a pest management strategy that focuses on long-term prevention or suppression of pest problems through a combination of techniques such as monitoring for pest presence and establishing treatment threshold levels, using non-chemical practices to make the habitat less conducive to pest development, improving sanitation, and employing mechanical and physical controls. Pesticides that pose the least possible hazard and are effective…are used only after careful monitoring indicates they are needed according to pre-established guidelines and treatment thresholds.[127] Elements of IPM are integrated into the Assessment Questions below.

INCENTIVES FOR CHANGE

- **Human benefits.** From a health perspective, there are diseases related to significant exposure of pesticides as well as afflictions related to minimal exposure of pesticides, but over longer periods of time. Children are especially at risk. There are "increasing amounts of data that suggest links between pesticide exposure and cancers in children"[128] as well as Parkinson's disease.[129] In addition to cancers, other suspected affects of chronic exposure, even at low levels, include damage to immune systems and the nervous system. Those working and living in close proximity to treated fields may be at significant risk, depending on factors such as the pesticide type, weather conditions during application, and frequency of application.

- **Environmental benefits.** In addition to concerns regarding the elimination of the natural predators of the pests, environmental concerns include possible contamination of ground and surface water. This could then affect human health, marine life and many other species that rely upon these water sources.

- **Cost savings.** With repeated pesticide use, the effectiveness on pests decreases. From 1945 to 1989, pesticide use in the US increased 10 times, but total crop loss from pests almost doubled from 7 to 13%.[130] The decrease in effectiveness occurs because the target pest builds up resistance and/or because competitors or predators of the target pest are also eliminated by the pesticide.[131] Moving towards IPM provides cost benefits by taking advantage of nature's own system, versus purchasing chemicals.

Assessment Questions

For all questions, please choose the categories that best identify your current management practices. Use the Summary sheet on the last page of this module to evaluate overall performance.

- **Pest Identification**[132]

  1. Farmer has not been trained to identify pests OR does not seek advice from a professional consultant when managing pests.
  2. Farmer knows key pest species of crops and has been trained in pest identification, but does not routinely use scouting information to manage pests.
  3. Farmer knows key pest species of crops, has been trained in pest identification, OR employs certified consultant.
  4. Farmer and consultant (if hired) understand key pest life cycle factors and exploit "weak links" for effective management. Pest identification and scouting information are always used to manage pests and beneficial organisms.

To maximize pesticide efficiency, it is best to determine what the target pest is. Once correctly identified by the farmer or a specialist, it is better to apply the pesticide specific to that pest, but only when there is evidence (through scouting) that the pest is causing problems. The best practice in terms of *when* to apply the pesticide includes an understanding of when the pest is most susceptible based on the optimal timeframe (day/night, weather conditions, etc.). By combining all these practices, the farmer will require less pesticide, incur lower costs, and create fewer human and environmental impacts.

- **Pesticide Selection**[133]

  1. Only pesticides registered in the state as 'approved' for the target pests and affected crop are used. Pesticide mixtures prohibited by the label are not used.
  2. In addition to #1, all pesticides at risk of pest resistance development are rotated with other pesticides of a different chemical class, starting with the first year of use. Pesticides at high risk of resistance development are used sparingly.
  3. In addition to #2, pesticides labeled "Danger" are avoided. The timing of applications and selection of pesticide materials correspond to scouting records.
  4. When a control measure is needed, every effort is made to use beneficial organisms or cultural controls, using reduced toxicity pesticides (labeled "Caution") as a last resort.

When determining which pesticide to use, consideration should be given to the effectiveness of the pesticide. Factors that can decrease the effectiveness of the pesticide include: (1) built-up resistance by pests and (2) accidental elimination of benign, natural competitors or predators of the pest. To minimize the development of resistance by pest to pesticides, farmers should rotate the type of pesticide that is used and understand which types of pesticides the pest is able to more readily resist. Another concern addressed here, is the level of toxicity with regard to human health. Using pesticides labeled “Danger” and “Caution” should be avoided whenever possible.

- **TIMING OF PESTICIDE APPLICATION**[134]
  1. Pesticide application is based only on calendar date or stage of crop development.
  2. Pesticide application is made at first sign of pests.
  3. Pesticide application is based on pest population levels determined by scouting, but treatment threshold is not used.
  4. Pesticide applications are made only when pests reach a predetermined treatment threshold. “Weak link” of pest’s life cycle is targeted for pesticide applications.

Another way to decrease the amount of pesticides used while reducing costs and achieving the same outcome is to understand how to determine when pesticides should be applied. The easiest and least efficient method is to apply pesticide annually at certain time periods. In contrast a best practice is to plan ahead of time what level of pest presence will prompt you into action. When this level is achieved, the timing of the application is aligned with when the pest is most susceptible. This practice allows for optimal pesticide efficiency, which translates into cost savings and minimal threat to humans and the environment.

- **WEATHER CONDITIONS**[135]
  1. Weather forecasts are not considered when planning to spray. Spraying occurs in weather conditions contrary to the pesticide bottle label, such as windy days or imminent rain.
  2. Weather forecasts are considered when planning to spray. Pesticide application is made during rain-free periods and at low wind speeds.
  3. Weather forecasts are used to plan pesticide applications. No spraying is done when wind would move it off target. Applications are made during label-required rain-free periods.

What happens to pesticides post-application is of great importance. There is significant concern regarding the entry of these chemicals into the water system, which can happen if there is no or minimal consideration given to the rain forecast. Wind can also carry the pesticide to non-target areas, such as the barn area or farmer’s house. Inadvertent exposure to these chemicals should be avoided whenever possible. By considering the weather, pesticide application can be more concise and efficient.

- **RECORD KEEPING**[136]
  1. All legal requirements for pesticide record keeping are met, including date, field identification, target pest, pesticide name and EPA number, formulation, rate and number of acres treated.
  2. Pesticide record keeping includes regular weekly pest scouting records.

3. The timing of applications and the selection of pesticide materials correspond to scouting records.

4. Application records include reference to decisions about the materials selected based on pesticide toxicity rankings. Pesticide records are tabulated annually to indicate progress in reducing overall use of high toxicity pesticides.

Keeping accurate and up to date records is important for regulations but also can aid in better understanding of your current pesticide management practices. Once a baseline is established, opportunities to decrease pesticide usage or increase its efficiency can be identified.

SPECIFIC MANAGEMENT PRACTICES TO CONTROL FLIES (Please check all that apply)

- ☐ Pesticide powder/spray
- ☐ Capture flies by using fly strips
- ☐ Eliminate wet seepage areas
- ☐ Handle and store manure properly
- ☐ Maximize sanitation in and around structures
- ☐ Use biological controls (such as fly parasites)

SPECIFIC MANAGEMENT PRACTICES TO CONTROL WEEDS (Please check all that apply)

- ☐ Conduct weed scouting
- ☐ Prepare and update weed maps twice per season
- ☐ Rank weeds in order of abundance or importance
- ☐ Plan and manage ground cover or soil quality to prevent weeds and weed seed immigration
- ☐ Manipulates weeds by rotating various crops.

One aspect of IPM is to modify the habitat so it is less conducive to pest development, improves sanitation, and employs mechanical and physical controls.[137] Such management practices for controlling flies and weeds are identified in the above questions. Some practices are less time and/or resource intensive than others and are more applicable and/or easier to implement, but they all work to minimize use of pesticides. As a farmer who switched to IPM as part of a research project commented, "You have to change with the times. That's why I got involved with the IPM project," explains Iverson. "You have to be able to adapt to survive in farming these days, whether it's portable computers or the new soft chemicals. They're here to stay."[138]

LINKAGES TO OTHER MODULES

Pest management issues are tied to nutrients, biodiversity and water management. The table below identifies where you can find more information on some of the topics mentioned in this module.

PEST MANAGEMENT TOPIC	OTHER MODULE(S)
Crop Rotation	Soil Health
GMOs Competitors or Predators of Target Pest	Biodiversity

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following programs.

- **University of Vermont Extension Program** is conducting research on Integrated Pest Management. Information on the program's current efforts can be accessed on the web at http://pss.uvm.edu/ipm/.

- **Farm*A*Syst**, managed through the Vermont Natural Resources Conservation Council, is devoted to national and state-level improvements to pest management and provides comprehensive evaluation and best management sheets specifically for dairy farmers in Vermont. More information can be found at their web-site, http://www.vt.nrcs.usda.gov/technical/FarmASyst/**.**

- **The Food Alliance.** http://www.thefoodalliance.org/. This organization certifies producers, which use socially and environmentally responsible farming practices. The certification process includes sections on natural area management, watershed management, crop management, pest management, pastureland management, and animal welfare. Details on pest management are included under pesticide applications and record keeping.

- **Appropriate Technology Transfer for Rural Areas** (ATTRA) "Sustainable Agriculture: An Introduction." http://attra.ncat.org. ATTRA specializes in developing sustainable agricultural information and tools. For a summary of the practices they advocate regarding pest management, see "Sustainable Agriculture: An Introduction" at http://attra.ncat.org/attra-pub/PDF/sustagintro.pdf. Phone: 1-800-346-9140.

Summary Results for Pest Management

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that apply questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

Question	Answer/Score
1. Pest Identification	
2. Pesticide Selection	
3. Timing of Pesticide Application	
4. Weather Conditions	
5. Record Keeping	
6. Specific Management Practices: Flies (Add 1 for each box checked)	
7. Specific Management Practices: Weeds (Add 1 for each box checked)	
Total Score (Out of Possible 30)	

Interpretation: The next step in understanding your farm's performance in the category of Pest Management is to compare your results to best practices. Below is a table that ranks your performance from best practice (green) to practices that require improvement (red). Compare the number of points you received for your practices to optimal practices.

	Point Range	Interpretation
Green	26 – 30	Best practices regarding Pest Management are currently being employed on this farm.
Yellow	18 - 25	Farm is using some good practices regarding Pest Management, however there are some key areas that should be improved upon.
Red	5 - 17	Pest Management practices should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

Soil Health Educational Module

Description

Soil health is based on a variety of characteristics, including organic matter, salinity, structure and compaction, available nutrients, pH, water holding capacity and erosion levels. Together, these characteristics allow soil to serve a variety of functions: supporting the growth of crops (and therefore animals), regulating the distribution of rain and irrigation water and providing filtration to improve water as it infiltrates through soils.

Under current production methods, soil health and its corresponding contribution to farm production is under threat by increasing levels of soil degradation and erosion. The 1999 National Resources Inventory of the USDA reports that 1,700 megatonnes (million metric tonnes) of soil eroded from U.S. land in 1997.[139] This is enough to fill a fully loaded freight car train that would encircle the planet seven times.[140] Also, soil organic matter in some areas of North America, has declined 30-60% since the start of cultivation.[141] These effects make farmers' jobs increasingly difficult, as it becomes necessary to improve degraded soil quality with cost and time intensive inputs. Soil erosion is particularly problematic since its effects are irreversible.

Healthy soils are not only important to farm production, but also to overall environmental health. When soil is eroded via runoff, sediments, in addition to being a water pollution source, can carry nutrients or pesticide residues that further pollute surface waters. Soil that is compacted worsens this problem in that impacted soils cannot absorb as much water, increasing the amount of runoff. Unhealthy soil also contributes to particulate matter air pollution when loose topsoil is transported off of the farm via wind.

This module focuses on best management practices to maximize soil quality and health in order to maximize production and minimize erosion and pollution to water or air. Recommended areas of management include monitoring overall quality, minimizing erosion, maximizing organic content and preventing soil compaction.

INCENTIVES FOR CHANGE

- **Regulations:** The most recent 2002 Farm Bill includes an amendment to the Food Security Act of 1985 requiring that conservation systems must be implemented for agricultural operations on federally-designated "highly erodible land" (HEL). Conservation systems must protect land from excessive soil erosion and non-compliance can result in a producer becoming ineligible for numerous USDA benefits. In 1997, Vermont had approximately 125,000 acres of HEL. Conservation efforts undertaken now can mean assured compliance with this regulation and can safeguard a farmer's operations in the future. Technical and financial assistance is often available for farmers to implement both voluntary and compliance-driven conservation initiatives. See the "Further Information" section for details.

- **Cost Savings:** Maintaining healthy soils encourages maximum yields, meaning that farmers can maximize the amount of feed that they grow on the farm and correspondingly reduce costs of purchased feed. Healthy soils can also support crop growth with fewer inputs of commercial fertilizers and pesticides, thereby decreasing costs for these inputs, saving farmers time on their application and providing more efficiently produced crop yields.

Benefits received now will be compounded in the future as soil health becomes increasingly better and increasingly self-sustaining.

- **Governmental Cost Sharing:** The 2002 Farm Bill re-authorized funding to help farmers adopt conservation strategies directed at improving soil quality, water quality, air quality and wildlife habitat. Through this program, farmers can be paid to implement new practices that will benefit their operations as well as the environment. For example, soil quality improvement practices can reduce impact to the environment and improve farmers' yields, thus improving revenues and lowering costs overall. Cost sharing is generally up to 75%, though certain farmers may be eligible for 90%, and incentive payments can last up to three years to promote continued use and long-term adoption of management strategies.

- Assessment Questions

For all questions, please choose the categories that best identify your current management practices. Use the Summary sheet on the last page of this module to evaluate overall performance.

➢ **SOIL ORGANIC MATTER**

1. Soil organic matter is not monitored and inorganic fertilizers are used to provide a large portion of crop nutrients.
2. Some effort is made to increase soil organic matter through a) restricted tillage practices, b) cover crops, c) use of least oxidizing inorganic fertilizers or precision fertilizer applications, d) crop rotations, or e) use of manures or composts on fields.
3. A strong effort is made to maximize and maintain soil organic matter. Soil is tested for organic content and two practices from #2 are used as appropriate to soil need.
4. In addition to #3, the use of inorganic fertilizer is completely or almost completely eliminated.

The elements of soil, including plant roots, that were once alive as well as the living organisms are termed 'soil organic matter.' Organic matter is essential to soil health and productivity due to the myriad of services and benefits it provides. Examples include stabilizing and holding the soil together; improving the soil's ability to store and transmit air, water and nutrients to crops; helping maintain a balanced population of soil organisms; and helping to prevent soil compaction. The net benefits are more productive crop harvests with fewer inputs, reduced runoff, and minimized soil erosion.

Cover crops contribute to soil organic content by increasing the plant material that is left on the soil and by preventing erosion of topsoil that is rich in organic material. Tillage and overuse of inorganic fertilizers, particularly nitrogen, instead of using organic materials to provide fertility, accelerates the rate of decomposition of organic material in the soil, thereby causing loss of this material at a faster rate. These practices should therefore be minimized. Manures, which increase organic matter in the soil, should be used to supply soil with needed nutrients.

- **USE OF COVER CROPS AND VEGETATIVE AREAS**

  1. No effort is made to vegetate areas of bare soil on the farm; cover crops are never used.
  2. Some effort is made to vegetate areas of bare soil on the farm. Soil is covered some of the time/in some areas by vegetative plantings, buffer strips, pasture, other perennial crops and seasonal crops. Cover crops are sometimes used.
  3. Bare soil on the farm is kept to a minimum via vegetative plantings, buffer strips, pasture, other perennial crops and seasonal crops. Cover crops are used every year to maximize soil coverage and soil benefits.
  4. In addition to #3, the cover crop type and timing are strategically chosen, based on farm characteristics such as soil type and traditional crop grown, to maximize benefits to soil.

Plantings such as cover or perennial crops, grass, and hay hold soil in place, prevent compaction of soil, improve tilth,[1] and curb runoff and nutrient loss. Plant cover is also beneficial in that it increases organic matter and biological activity in the soil, which is beneficial to soil quality and plant growth. When cover crops are legumes such as alfalfa, clover or soybeans, they provide an added benefit of fixing nitrogen into the soil for use by future crops. Cover crops provide the additional benefit that yields can be sold or used as feed for cows. It is important to manage any plantings well by maintaining appropriate practices with respect to nutrient application and pesticide use.

- **CROP ROTATION**

  1. Crops are not rotated and most fields have corn or other high intensity row crops.
  2. Crops are rotated every four or more years and rotation tends to include high intensity row crops and with small grain (oats, wheat, etc.) crops.
  3. Crops are rotated at least once every three years and rotation includes row crops and grass or legume forage crops. Some effort is made to utilize crop rotation to optimize nutrient and pest management.

[1] Tilth is defined as soil's suitability to support plant or root growth by means of proper pore spaces for air and water filtration and movement and ability to hold adequate amounts of water and nutrients

4. Crops are rotated at least once every three years and grass or legume forage crops are grown more often than row crops. Crop rotations are specifically planned to optimize nutrient and pest control.

Crop rotation leads to greater quantity and diversity of soil organic material, improves nutrient availability, and can help control pests. Including legume crops in the rotation will provide the needed diversity while also fixing nitrogen in the soil. Other crops can also help prevent nutrient leaching. The Michigan State University Agriculture Experiment Station found that, with regard to nutrient leaching, wheat never loses more than 20 pounds of nitrogen per acre per year, as compared to continuous corn, which leaches up to 100 pounds.[142] Various rotations may reduce nitrogen leaching 30-50% as compared to growing continuous corn.[143] Crop rotation is beneficial economically, in that it can improve amount and diversity of yields and reduces the need for costly commercial fertilizers and pest-control chemicals.

- **TILLAGE PRACTICES**

1. Tillage practices are undertaken without consideration of impacts to soil.
2. An effort is made to minimize/alter tillage use to benefit soil quality. Conservation tillage is used to maintain crop residue on soil; tillage is never done on wet soil; tillage is restricted to specific portion of fields (strip tillage); or tillage is avoided completely.
3. Tillage is strictly restricted as per one or more methods in #2, and resulting soil quality is monitored.
4. Perennial crops or crop rotation system is used, allowing for a no-till farming operation.

Adjusting tillage practices is beneficial for reducing soil compaction, minimizing erosion and improving organic matter content, all of which are environmentally and economically beneficial to the farmer. Soil compaction can restrict plant roots (reducing uptake of water and nutrients), affect moisture and soil temperatures (affecting organic matter and nutrient release), and decrease infiltration of water, which increases the levels of runoff and erosion.

Tillage should never be done on wet soil, as it is particularly susceptible to compaction versus dry soil. Conservation tillage leaves at least 30% of the soil surface covered by crop residues after planting, thereby protecting it from erosion and contributing to the organic matter and beneficial biological activity in the soil. Additionally, no-till or strip-tillage[2] practices minimize the area being tilled, thus minimizing soil compaction and removal of plant residues. Restrictive tillage practices can also result in cost savings by reducing the amount of fuel needed to run the equipment or eliminating the need to own and maintain the equipment.

- **SOIL CONSERVATION/EROSION PREVENTION**
  1. No consideration is given to the problem or prevention of soil erosion. Erosion rates are unknown.
  2. An effort has been made to evaluate soil erosion, per the following evidence: presence of channels/gullies on fields, soil deposits at field margins or base of sloping areas, surface-crusted areas, exposure of lighter colored subsoil, and/or bare soil and loss of soil around plant roots.
  3. In addition to #2, at least one step has been taken to minimize erosion, such as utilizing diversion ditches, maintaining vegetated buffer strips around bodies of water, using conservation tillage or creating windbreaks.
  4. In addition to at least two actions from #3, at least one other action is taken: no-till or strip-till methods, mulches are used, manure or composts incorporated into fields, perennial crops are used on farm.

Soil erosion is the physical removal of surface soil material. Erosion can negatively impact crop production by contributing to the breakdown of soil structure and resulting in the loss of the uppermost soil layer. This top layer of soil has the highest levels of organic matter and biological activity, both of which are important for plant growth and overall soil health. It is very important to minimize erosion on the farm even if signs are not obvious that erosion is occurring. The loss of just 1/32 of an inch of topsoil, very difficult to notice on a farm, can equal a loss of 5 tons of soil per acre.[144]

Soil loss can be mitigated in several ways:

- Diversion ditches or windbreaks reduce soil loss by diverting excess water or wind from reaching vulnerable soils.
- Vegetated buffer strips can 'catch' runoff from fields, including soil, sediments, and nutrients, to help prevent water pollution and soil loss from farms.

---

[2] Strip-tillage is defined as less than full-width tillage of varying intensity that is conducted parallel to the row direction. Generally no more than one-fourth of the plow layer is disturbed by this practice.

- o Adjusting tillage practices can help by leaving more crop residues on the soil, contributing to soil organic matter content and decreasing soil compaction and removal of plant residues, all of which minimize soil erosion.
- o Mulches and manure or composts cover the soil and increase organic matter content, protecting soil from erosion and improving its quality. Perennial crops provide compound benefits by covering the soil and holding it in place with their roots.

➢ **SOIL QUALITY MONITORING**

1. Soil quality on farm is not monitored.
2. Soil quality (including nutrient levels, salinity, and pH) is measured via soil tests every 5+ years but test results don't necessarily guide farm practices.
3. Soil quality is measured via soil tests every 3 years and test results and corresponding university recommendations guide farm practices.
4. In addition to #3, soil quality is measured via soil tests every 1-3 years and farm practices strictly follow corresponding UVM recommendations, including annual assessment of compaction, runoff, earthworms, and root health.

Regular soil testing (done at least once every 3 years) is the best way to ensure that soil remains healthy and productive, maximizing benefits to your farm. UVM and other experts offers soil test kits, analysis services and corresponding management recommendations that provide information such as soil pH, organic matter, available phosphorus and other nutrient levels, and fertility recommendations. At UVM, a basic soil test costs $9/sample and additional tests can be run for nominal fees (e.g. tests for organic matter cost an additional $3).

It is important to not only do the tests, but also to follow recommendations associated with the results. Results of these tests may include recommendations for nutrient application rates or improve soil characteristics such as pH or organic matter content. Maintaining high soil quality is increasingly beneficial over time as the soil is able to do the job that it is intended with fewer inputs (including time and money) from the farmer. If done every 1 to 3 years, soil testing is a non-time-intensive, inexpensive way to better understand and manage soil quality.

LINKAGES TO OTHER MODULES

Soil Health issues are closely tied to Biodiversity and Nutrient Management. The table below identifies where you can find more information on some of the topics mentioned in this module.

SOIL HEALTH TOPIC	OTHER MODULE(S)
Use of Inorganic Fertilizers	Nutrient Management
Soil Testing	Nutrient Management
Manure Use on Fields	Nutrient Management

Cover Crops	Biodiversity
Buffer Strips	Biodiversity

FURTHER INFORMATION

Additional details and information on the above can be obtained through the following programs.

- The **USDA Natural Resources Conservation Service** provides information on soil quality, offers tools for assessing soil quality and recommends best practices for improving soil quality. Information can be found at http://soils.usda.gov/sqi/soil_quality/what_is/index.html.

- NRCS also operates a **Conservation Reserve Program (CRP)**, which provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. See http://www.vt.nrcs.usda.gov/programs/CRP/and http://www.fsa.usda.gov/dafp/cepd/crp.htm for more information.

- The **Environmental Quality Incentives Program** (EQIP), also run by the NRCS, was re-authorized by the 2002 Farm Bill to provide cost sharing up to 75% for farmers to implement conservation practices that address soil, water, air, wildlife and other natural resource concerns. Incentive payments may last up to 3 years to encourage farmers to continue utilizing new management practices. See http://www.nrcs.usda.gov/programs/eqip/ for more information.

- Center for Sustainable Agriculture, University of Vermont. http://uvm.edu/sustainableagriculture.

- **Vermont NRCS** has twelve regional field offices that can provide more assistance and information on all of the above. Contact the District Conservationist at Vermont NRCS State Office: 802-951-6796.

- The **Vermont Agency of Agriculture, Food and Markets** provides a clearinghouse of information on controlling non-point source pollution and runoff from dairy farms, including accepted agricultural practices (AAPs), best management practices (BMPs) and technical and financial assistance for projects. See http://www.vermontagriculture.com/pidnonpointsource.htm for more information. You can also call the Vermont Natural Resources Conservation Districts
    - Windham, Bennington, Rutland, Windsor, Counties: 802-257-5621
    - Orleans, Essex, Caledonia, Orange, Washington Counties: 802-229-2720
    - Addison, Chittenden, Lamoille, Franklin, & Grand Isle Counties: 802-388-6746

SUMMARY OF RESULTS FOR SOIL HEALTH

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that apply questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

QUESTION		ANSWER/SCORE
1.	Soil Organic Matter	
2.	Use of Cover Crops and Vegetative Areas	
3.	Crop Rotation	
4.	Tillage Practices	
5.	Soil Conservation/Erosion Prevention	
6.	Soil Quality Monitoring	
Total Score (Out of Possible 24)		

Interpretation: The next step in understanding your farm's performance in the category of Soil Health is to compare your results to best practices. Below is a table that ranks your performance from best practice (green) to practices that require improvement (red). Compare the number of points you received for your practices compared to optimal practices.

	Point Range	**Interpretation**
Green	21 - 24	Soil Health best practices are currently being employed on this farm.
Yellow	15 - 20	Farm is using some good practices regarding Soil Health. However there are some key areas that should be improved upon.
Red	6 - 14	Soil Health practices should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

<u>WATER MANAGEMENT EDUCATIONAL MODULE</u>

<u>DESCRIPTION</u>

The availability of clean, high quality water is essential to life. Prevention of water pollution is critical to maintain ground water that is safe for drinking. Surface waters must also be protected to maintain healthy aquatic ecosystems, provide industrial and municipal water supplies, and support recreational enjoyment. In Vermont, Lake Champlain, a critical water resource, is experiencing a serious decline in water quality, in part due to sediment and nutrients from agricultural runoff. Many drinking water wells have been found to have nitrate-nitrogen levels exceeding the Vermont public health standard (caused by nitrogen leaching through soil).[cxlv] Nitrate contamination can make drinking water unsafe for infants or young livestock and fecal bacteria in drinking water (from manure) can cause infectious diseases such as dysentery, typhoid and hepatitis.[cxlvi] While Vermont dairy farms are certainly not the only source of this pollution, contributions from these sources can be significant and participation from the dairy farmer community is therefore essential to correcting this water quality problem.

Though Vermont does not have a shortage of water, the availability of potable water is increasingly becoming a concern. A drought in Frederick County, MD, in the summer of 2004, illustrates that “while water may be abundant in many areas, it is not limitless, and even our nation’s most water-rich regions can run dry.”[cxlvii] While irrigation is a significant user of water, it is important to note that livestock are as well. Even in Vermont, sources say the “Demand for ground water from the bedrock aquifer is continuously increasing as new sources of surface water decrease and the cost of surface-water treatment increases.”[cxlviii]

This module will focus on best management practices dairy farmers can use to minimize and prevent water pollution and, to a lesser extent, to promote appropriate water use. General areas to be covered include preventing pollution from livestock yards, storage areas and milkhouse waste, general land management strategies and management of water use.

<u>INCENTIVES FOR CHANGE</u>

- **Regulations.** As water pollution becomes an ever-larger issue throughout the U.S., legislation supporting the Clean Water Act is becoming increasingly broad reaching and stringent. In 2002, the EPA approved a new regulation requiring that certain “concentrated animal feeding operations” implement best management practices to improve water quality in order to gain a permit to operate. In Vermont, there are many programs to address water quality issues of, and dairy farmers may find themselves subject to increasing pressure and/or regulations to take steps to improve water quality. Local Vermont programs to protect overall water quality include the State’s Accepted Agricultural Practices (AAPs).

- **Governmental cost sharing.** USDA and state-level programs provide support in the form of cost sharing, technical assistance and economic incentives to implement agricultural NPS pollution management practices. Recently, on a nationwide basis, 40% of section 319 Clean Water Act grants were used to control agricultural NPS pollution.[cxlix] The National Environmental Quality Incentives Program (EQIP) authorizes the Secretary of US Dept. of

Agriculture to provide cost-sharing incentives up to $450,000 per farmer to implement management practices that will protect water quality.[cl]

- **Cost Savings:** Conserving and reusing water can have economical benefits. While current prices for water are reasonable, as water shortages become more common, frequent occurrences, water costs will increase. Therefore, the more water that can be collected, conserved, and reused, the more flexibility the farmer has regarding water demand.

- **Improved On-farm Water Quality:** Minimizing impact on surface and ground water is beneficial to the extent that these water resources become inputs on the farm. Maintaining healthy drinking water can reduce the chance for illness, and associated costs, from contaminated water.

ASSESSMENT QUESTIONS

For all questions, please choose the categories that best identify your current management practices. Use the Summary sheet on the last page of this module to evaluate overall performance.

➢ LIVESTOCK YARD MANAGEMENT

1. Livestock yard is unroofed and on course-textured (sands, sandy loam) soil less than 100 feet from waterways and streams. Yard is rarely cleaned and runoff water is uncontrolled.
2. Livestock yard is open or partially roofed on medium- or fine-textured soils (loam, silt loam, clay loams, clay) greater than 100 feet from waterways and streams. Yard is cleaned once a month and some effort is made to collect runoff water or divert to manure storage area.
3. Livestock yard is open or partially roofed on concrete or medium- or fine-textured soils greater than 100 feet from waterways and streams. Yard is cleaned once per week and has protective barriers to prevent runoff. An effort is made to prevent water from entering/flooding yard and any runoff is collected or diverted to manure storage area.
4. Livestock yard is open or partially roofed on concrete greater than 100 feet from waterways and streams. Yard is cleaned at least once per day and water is diverted so that flooding or runoff from yard never occurs.

Livestock yards (barnyards, holding areas and feedlots) are concentrated areas of livestock wastes and are therefore vital to protection of water quality. These yards, especially when on permeable soils or near on-farm water sources, can cause nitrate and bacteria contamination in ground or surface water. To minimize the possibility of contaminants leaching to groundwater or running off to surface water, such yards should be located on concrete or fine- to medium textured soils over 100 feet from water sources such as wells, surface water, adjacent property, drainage ditches, or other areas that could result in the runoff reaching water sources. The best means to achieve this is to prevent flooding in livestock yards by diverting rain and/or floodwaters from the area. Having a roof over the yard, and effective use of rain gutters, or otherwise diverting water from yard is the best way to prevent runoff. This is especially important if yards are on a slope. If it is impossible to prevent runoff completely, other practices, such as keeping the yard clean, diverting runoff to manure storage areas or collecting and re-using runoff (e.g. as nutrients on fields), can minimize potential pollution to water sources.

- **MANURE STORAGE SYSTEM**

  1. Storage structures allow for contact of stored material with porous/non-clay soils (because of leakage/cracks or overflow) and are subject to flooding. Storage structures are located without regard to proximity to waterways and streams.
  2. Storage structures are lined with clay or cement, though some leakage may occur due to cracks or overflow. Some effort is made to divert water from site and proximity of storage structures to bodies of water is considered in their placement.
  3. Storage structures are lined with clay or cement, are of sufficient capacity to hold all materials for 180 days, and cracks/leaking are minimized. Some effort is made to divert groundwater from site and proximity of storage structures.
  4. Storage structures are lined with clay or cement, are of sufficient capacity to hold all materials for 180 days, and are maintained to allow for no leakage. Water is prevented from entering/flooding storage area. Storage structures are all located downslope from farm buildings and at a maximum distance from bodies of water that may be effective

- **FERTILIZER STORAGE SYSTEM**

  1. Storage structures allow for contact of stored material with porous/non-clay soils (because of leakage/cracks) and are subject to flooding. Storage structures are located without regard to proximity to waterways and streams.
  2. Storage structures are lined with clay or cement, though some leakage may occur due to cracks. Some effort is made to divert water from site and proximity of storage structures to bodies of water is considered in their placement.
  3. Storage structures are lined with clay or cement, are of sufficient capacity to hold all materials, and cracks/leaking are minimized. Some effort is made to divert clean water from site and proximity of storage structures to bodies of water is considered in their placement.
  4. Storage structures are lined with clay or cement, are of sufficient capacity to hold all materials, and are maintained to allow for no leakage. Water is prevented from entering/flooding storage area. Storage structures are all located downslope and at a maximum distance from bodies of water.

- **SILAGE STORAGE SYSTEM**

  1. Storage structures allow for contact of stored material with porous/non-clay soils (because of leakage/cracks) and are subject to flooding. Storage structures are located without regard to proximity to waterways and streams.

2. Storage structures are lined with clay or cement, though some leakage may occur due to cracks. Some effort is made to divert water from site and proximity of storage structures to bodies of water is considered in their placement.
3. Storage structures are lined with clay or cement, are of sufficient capacity to hold all materials, and cracks/leaking are minimized. Some effort is made to divert water from site and proximity of storage structures to bodies of water is considered in their placement.
4. Storage structures are lined with clay or cement, are of sufficient capacity to hold all materials, and are maintained to allow for no leakage. Water is prevented from entering/flooding storage area. Storage structures are all located downslope and at a maximum distance from bodies of water.

Storage areas for manure, fertilizer and silage can be potential sources of water pollution if not managed properly. It has been found that silage leachate and cow manure have 140 and 200 times the oxygen depleting potential of *untreated* municipal sewage, which can lead to eutrophication in water bodies.[cli] Silage leachate is also highly acidic and leachate from 300 tons of high-moisture silage has been compared to the daily sewage generated by a city of 80,000 people.[clii] The best way to prevent such pollution is to ensure that storage systems are well-maintained (allowing for no leakage of stored material), are of adequate size (to avoid spillage due to overflows), are not subject to water infiltration or runoff, and do not allow for contact of stored material with porous or course-textured soils. Runoff prevention can be achieved by using closed or covered storage and by ensuring that diversion ditches or other techniques are used to prevent moving clean water from coming into contact with the stored material. If it is impossible to prevent runoff completely, other practices, such as collecting and re-using runoff as fertilizer, can minimize potential pollution to water sources. Finally, locating these storage systems an adequate distance (preferably at least 100 feet) from wells, surface water, adjacent property, drainage ditches, or other areas that could result in runoff reaching water sources, can prevent or minimize water pollution.

Protection of farm inputs such as silage and fertilizer can also improve efficiency and cost-effectiveness on farms. For example, preventing water from coming into contact with silage can help to maintain the freshness and quality of the silage, thereby minimizing additional feed costs. Preventing impact to fertilizers can also ensure that these materials remain useful for their intended life.

- **MILKHOUSE WASTE**

1. All waste is poured down a drain that leads to the farms leachfield system, or indirectly into an open field drainage ditch. or is sent to a leach field, usually also washing down feed and manure.
2. Most waste is diverted to the manure storage area, though some goes to the municipal drainage system or is sent to a leach field. No effort is made to remove excess feed and manure from the parlor prior to wash down.

3. All waste is diverted to the manure storage area, though the first rinse is sometimes used as fertilizer. Some effort is made to remove excess feed and manure from the parlor prior to wash down.
4. All waste is diverted to the manure storage area. Any field application of first rinse is matched to field nutrient needs. Most manure and excess feed is removed from the parlor prior to wash down.

Water used to clean the milkhouse and milkhouse equipment contains high levels of organic matter, nutrients, chemicals and microorganisms, which can contaminate water with ammonia, nitrate, phosphorus, detergents and disease-causing organisms if not disposed of properly.[cliii] Milkhouse wastewater is made nutrient-rich by virtue of having cleaners and high amounts of milk residues or being washed down the drain with manure and feed. This nutrient-rich water can lead to pollution if it is untreated before it reaches water bodies. To minimize this potential impact to water, wastewater should be diverted to manure storage areas. Nutrient-rich first rinse water can also be re-used by applying it directly to fields as fertilizer. When applying first rinse to fields, care should be taken to match field nutrient needs with nutrient content of first rinse. Cleaning the parlor of feed and excess manure prior to wash down will minimize the amount of this material that enters water and can minimize the volume of water needed for cleaning.

- **PROTECTING ON-FARM WATER SOURCES**

1. There is no effort made to protect on-farm bodies of water (lakes, ponds, streams, creeks).
2. Some 'buffer areas' (uncultivated land with some natural vegetation) are utilized to absorb farm runoff water and protect some water sources.
3. Buffer areas are utilized along edges of all water sources and an effort is made to maximize vegetation in these areas in order to maximize absorption of runoff water. Cows are generally prevented from entering the water.
4. Buffer areas with maximum vegetation are utilized along edges of all water bodies sources and the width of buffer strips is increased if water is at the bottom of a downslope. Cows are prevented from entering the water at any time.

Buffer areas are natural, uncultivated areas on the farm that are covered with vegetation (either planted or naturally occurring). Maintenance of these areas around water sources on the farm serves to further protect these water sources from pollution due to runoff. The protection comes from the fact that the buffer areas can potentially halt the flow of runoff water or absorb it before it reaches surface waters. Buffer areas should be as wide as possible in order to maximize the benefits they provide. When they are at the bottom of a slope (i.e. protecting water at the base of a slope), it is especially important that they be as wide and densely vegetated as possible.

It is important to note that buffer areas should be **untreated** by chemicals or nutrients and instead developed and managed in a way that they do not need additional inputs to flourish. In this way buffer areas can benefit from the addition of nutrients to their soils via the absorption of runoff waters from upslope contributing areas. Buffer areas also have the additional benefit of adding to the biodiversity (variance of flora and fauna) on a farm.

In addition to vegetated and undisturbed buffer strips, preventing cows from entering water is vital to maintaining surface water quality. Cows can be harmful to water quality to the extent that they urinate or excrete manure into the water or track these and other substances, such as bedding or feed, into water via their legs or hooves. In addition the trampling and degradation of the streambed leads to further water quality issues. Cows should not come into contact with water sources at any time.

- **WATER USE PLAN**[cliv]
  1. Water use on the farm is not monitored or planned.
  2. Water use on the farm is monitored and reported to users with suggestions for decreasing use.
  3. In addition to #2, water use on the farm is budgeted and includes action steps to improve water use efficiency by minimizing runoff, water loss, and erosion and pest problems. Areas monitored include wash down and milking equipment clean up, drinking, cooling and irrigation.
  4. In addition to #3, imported water use on the farm is minimized by recycling, conserving, and/or collecting water and/or using low demand systems. Water use is further minimized by planting water-conserving varieties and/or ground covers.

While there appears to be plenty of water available for a reasonable to cheap price, it is important to start thinking about a water use plan. As more and more water shortages are realized, water costs are expected to increase. If the market is used to dictate price, this competition, is expected to have significant impacts on agriculture.[clv] Once a baseline is established, then proactive steps can be taken in a methodical manner.

- **WATER USE MANAGEMENT STRATEGIES** (Please check all that apply)
  - ☐ I recycle water on the farm, such as using wastewater to flush feeding areas and free-stall barns (ensuring that resulting water flow is directed to the manure storage area).
  - ☐ I use grass-based and/or seasonal dairying to reduce the need to wash off manure from high use areas.
  - ☐ I use a housing system that keeps cows clean which reduces the need to wash cows before milking.
  - ☐ I use water to cool milk by passing it through the cooler plate, while simultaneously using that heated water for the cows to drink.

Using certain management strategies can decrease water use. There are strategies regarding irrigation as well as reuse and recycling water from different activities. While recognizing that irrigation is not a top concern in Vermont, it is worth noting that corn is one of the top six crops in the US that requires 70% of the irrigation.[clvi] More applicable to Vermont are the management strategies that focus on either reducing the need for water (via type of dairying or housing system) or by reusing wastewater.

Linkages to Other Modules

Water quality issues are tied to Nutrient Management, Soil Health, Biodiversity and Animal Husbandry. The table below identifies where you can find more information on some of the topics mentioned in this module.

WATER MANAGEMENT TOPIC	OTHER MODULE(S)
Buffer Areas	Soil Health & Biodiversity
Field Nutrient Applications	Nutrient Management

Further Information

Additional details and information on the above can be obtained through the following programs.

- **Livestock and Poultry Environmental Stewardship (LPES) Curriculum** provides environmental best management practice recommendations for dairy farms (http://www.lpes.org/les_plans.html). They also provide information on the new Concentrated Animal Feeding Operations (CAFO) regulations and links to funding and additional technical resources (http://www.lpes.org/CAFO.html). Call 1-800-562-3618 for more information.

    - The **USDA Natural Resource Conservation Service (NRCS)** offers nutrient management information and tools at http://www.nrcs.usda.gov/technical/ECS/nutrient/. The program also provides funding and technical assistance for conservation efforts through Farm Bill 2002 (http://www.nrcs.usda.gov/programs/farmbill/2002/) and its affiliate programs, such as EQIP (http://www.nrcs.usda.gov/programs/eqip/). The **Vermont NRCS** also manages Farm*A*Syst, a program devoted to national and state-level improvements to ground water that provides comprehensive evaluation and best management sheets specifically for dairy farmers in Vermont. More information can be found at http://www.vt.nrcs.usda.gov/technical/FarmASyst/.
    - Vermont NRCS State Office: 802-951-6796.

- The **Vermont Department of Environmental Conservation Water Quality Division** provides a newsletter pertaining to water quality as well as information on best management practices, grants and educational opportunities. See http://www.vtwaterquality.org/ for more information or contact the Water Quality Division at 802-241-3770 or 802-241-3777.

- University of Vermont Extension, Water Quality Initiative. www.uvm.edu/extension.802-656-5459.

- The **Vermont Agency of Agriculture, Food and Markets** provides a clearinghouse of information on controlling non-point source pollution from dairy farms, including accepted agricultural practices (AAPs), best management practices (BMPs) and technical and financial assistance for projects. See http://www.vermontagriculture.com/pidnonpointsource.htm for more information. You can also call the Vermont Natural Resources Conservation Districts
  - Windham, Bennington, Rutland, Windsor, Counties: 802-257-5621
  - Orleans, Essex, Caledonia, Orange, Washington Counties: 802-229-2720
  - Addison, Chittenden, Lamoille, Franklin, & Grand Isle Counties: 802-388-6746

SUMMARY OF RESULTS FOR WATER MANAGEMENT

Instructions: In the table below, please record the score for the answer you selected for each question. For multiple-choice questions, the response number serves as your score for that category (i.e. choice # 2 is worth 2 points). For "check all that apply questions," please see scoring criteria for each question in the chart below. Once all responses have been completed, add up the answers and record the total.

QUESTION	ANSWER/SCORE
1. Livestock Yard Management	
2. Manure Storage System	
3. Fertilizer Storage System (If no fertilizer is stored on property, give yourself 4 points)	
4. Silage Storage System	
5. Milkhouse Waste	
6. Protecting On-Farm Water Sources	
7. Water Use Plan	
8. Water Use Management Strategies (Add 1 for each box checked)	
Total Score (Out of Possible 32)	

Interpretation: The next step in understanding your farm's performance in the category of Water Management is to compare your results to best practices. Below is a table that ranks your performance from best practice (green) to practices that require improvement (red). Compare the number of points you received for your practices compared to optimal practices.

	Point Range	**Interpretation**
Green	27 - 32	Best practices regarding Water Management are currently being employed on this farm.
Yellow	20 - 26	Farm is using some good practices regarding Water Management, however there are some key areas that should be improved upon.
Red	7 - 20	Water Management should be carefully evaluated and a strong effort should be made to adopt improved practices in several areas.

For additional information, please contact:

Andrea Asch
Manager of Natural Resources Use
Ben & Jerry's Homemade, Inc.
30 Community Dr.
So. Burlington, VT 05403-6828
(802) 846-1500
andrea@benjerry.com

Allen Matthews
UVM Center for Sustainable Agriculture
63 Carrigan Dr.
Burlington, Vermont 05405
802-656-0037
allen. matthews@uvm.edu

Diane Bothfeld
St. Albans Cooperative Creamery
140 Federal St.
St. Albans, Vermont 05478
802-524-6581
diane_bothfeld@stalbanscooperative.com

Special Thanks
University of Michigan
Center for Sustainable Systems
Mindy Murch
Carey Bylin
Ruchi Misra
Wendy Rigterink

[1] American Veterinary Medical Association Policy on Animal Welfare and Animal Rights. Animal Welfare Guidelines, Heifer International.

[2] International Livestock Research Institute. <http://www.cgiar.org/ilri/dbtw-wpd/fulldocs/smhdairy/22egan-02.htm>. 8 July 2003.

[3] Wells, Ann. Personal Interview. 30 July 2003.

[4] "Report on the Welfare of Dairy Cattle by Farm Animal Welfare Council (UK)." Sept. 2003. <http://www.fawc.org.uk/reports/dairycow/dcowr079.htm>. 12 Oct. 2003.

[5] Broom, Donald M., "Effects of Dairy Cattle Breeding and Production Methods on Animal Welfare." University of Cambridge, Department of Clinical Veterinary Medicine. <http://www.nal.usda.gov/awic/pubs/dairy/effects.htm>. 8 July 2003.

[6] Question adapted from The Food Alliance. Dairy Inspection Tool for the Pacific Northwest. 2002.

[7] Rice, Duane N. and Grant, Rick. "Dairy Cow Health and Metabolic Disease Relative to Nutritional Factors." Institute of Agriculture and Natural Resources, Cooperative Extension, University of Nebraska-Lincoln. July 1996. <www.ianr.unl.edu/pubs/animaldisease/g1032.htm#nutritionally>. September 2003.

[8] Question adapted from The Food Alliance. Dairy Inspection Tool for the Pacific Northwest. 2002.

[9] Ibid.

[10] Appropriate Technology Transfer for Rural Areas. Dairy Farm Sustainability Check sheet. March 2001. <http://attra.ncat.org/attra-pub/PDF/dairychecksheet.pdf>. 10 June 2003.

[11] Question adapted from The Food Alliance. Dairy Inspection Tool for the Pacific Northwest. 2002.

[12] "Report on the Welfare of Dairy Cattle by Farm Animal Welfare Council (UK)." Sept. 2003. <http://www.fawc.org.uk/reports/dairycow/dcowr079.htm>. 12 Oct. 2003.

[13] Question adapted from The Food Alliance. Dairy Inspection Tool for the Pacific Northwest. 2002.

[14] Ibid.

[15] Question adapted from The Food Alliance. Dairy Inspection Tool for the Pacific Northwest. 2002.

[16] Leadley, Sam and Sojda, Pam, "Calving Ease." March 2001. <http://www.calfnotes.com/pdffiles/CNCE0301.pdf>. 1 Dec. 2003.

[17] Vandermeer, J., Perfecto, I. *Breakfast of biodiversity*. 1995.

[18] *World Wildlife Fund.* "Endangered Species." 31 Oct. 2003 <http://www.worldwildlife.org/species/species.cfm>.

[19] US Fish and Wildlife Service. "Summary of Listed Species and Recovery Plans as of 9/1/2003." *Threatened and Endangered Species System* 7 Dec. 2003 http://ecos.fws.gov/tess_public/html/boxscore.html>.

[20] *Natureserve.org.* "Biodiversity Insights > U.S. Species at Risk: A State-by-State View." 15 Nov. 2003 <http://www.natureserve.org/conservation/usSpeciesatRisk.jsp#>.

[21] Ibid.

[22] Ibid.

[23] *Fish and Wildlife Service.* "Threatened and Endangered Species System." 15 Nov. 2003 <http://ecos.fws.gov/tess_public/TESSWebpageUsaLists?state=VT>.

[24] Ferguson, Mark. Vermont Nongame and Natural Heritage Program. Personal Interview. 13 Nov. 2003.

[25] Auman-Bauer, Kristie, 'Bt Corn and Monarch butterflies.' *PA IPM News.* Winter 2001. 16 Nov. 2003 <http://biotech.cas.psu.edu/articles/bt_corn_monarch.htm>.

[26] Ibid.

[27] Altieri, Miguel. "The ecological role of biodiversity in agroecosystems." *Agriculture, Ecosystems and Environment 74* (1999) 19-31.

[28] Ibid.

[29] Ibid.

[30] Ibid.

[31] Ellsworth, David. Assistant Professor of Plant Ecophysiology, SNRE, U Mich. Lecture 20 Nov. 2003.

[32] *Oregon State University website.* "Diminished Crop Diversity." 26 Aug. 2003 <http://oregonstate.edu/instruction/bi301/cropdiv.htm>.

[33] Question from The Food Alliance. “Dairy Inspection Tool for the Pacific Northwest.” *The Food Alliance*, 2002.

[34] Question adapted from The Food Alliance. “Dairy Inspection Tool for the Pacific Northwest.” *The Food Alliance*, 2002.

[35] Wells, Anne and Morrow, Ron. *Dairy Farm Sustainability Checksheet.* ATTRA, March, 2001.

[36] Personal Communication, Mark Ferguson, Vermont Nongame and Natural Heritage Program, 13 Nov. 2003.

[37] Question adapted from The Food Alliance. “Dairy Inspection Tool for the Pacific Northwest.” *The Food Alliance*, 2002.

[38] Ibid.

[39] Ibid.

[40] *European Commission*, “Genetically Modified Organisms.” 14 Aug. 2002 <http://europa.eu.int/comm/food/fs/gmo/gmo_index_en.html>.

[41] European Union Directive 2001/18/EC, Directive 90/220/EEC.

[42] “Question and Answers on the regulation of GMOs in the EU.” *Memo 02/160 Revised*. 1 July 2003. 3 Sept. 2003 <http://europa.eu.int/comm/dgs/health_consumer/library/press/press298_en.pdf>..

[43] Dorey, Emma. “GMO Backlash Hits US.” *Nature.* 4 Sept. 2003 <http://www.nature.com/cgi-taf/DynaPage.taf?file=/nbt/journal/v17/n10/full/nbt1099_941a.html>.

[44] Mace, David. “Vermont Biotech Legislation Follows National Trends.” *The Barre Montpelier Times Argus* June 11, 2003. 2 Nov. 2003 < http://timesargus.nybor.com/Regional_News/Story/66935.html >.

[45] Vogt, Donna and Parish, Mickey. “Food Biotechnology in the United States: Science, Regulation, and Issues.” *Department of State website* 3 Sept. 2003 <http://fpc.state.gov/6176.htm>.

[46] Spinelli, Mike. Ben & Jerry’s Homemade. Personal Interview 4 Sept. 2003.

[47] *Humane Farming Association.* "Milk Machines – Dangers in the Dairy Industry." 4 Sept. 2003 <http://www.hfa.org/campaigns/dairy.html>.

[48] Ibid.

[49] Heller, Martin C., Keoleian, Gregory A. "Assessing the sustainability of the US food system: a life cycle perspective." *Agricultural Systems*, 76, 2003, 1007-1041.

[50] Food Alliance; *Certification Standards for the Food Alliance Certified Label;* February 19, 2003.

[51] Heller, Martin C., Keoleian, Gregory A. "Assessing the sustainability of the US food system: a life cycle perspective." *Agricultural Systems*, 76, 2003, 1007-1041.

[52]***Jeffrey F. Keown. Extension Dairy Specialist.*** Managing Dairy labor, Cooperative Extension , Institute of Agriculture and Natural Resources , University of Nebraska-Lincoln; April 1996 http://www.ianr.unl.edu/pubs/dairy/g1064.htm#WAGES

[53] Heller, Martin C., Keoleian, Gregory A. "Assessing the sustainability of the US food system: a life cycle perspective." *Agricultural Systems*, 76, 2003, 1007-1041.

[54] Pelsue, Neil, and Woodruff, Katie. "Agriculture, Food, and Community in Vermont." The University of Vermont Extension. July, 1996. 7 Dec. 2003<http://www.uvm.edu/extension/publications/factsheets/agfs2/>.

[55] Heller, Martin C., Keoleian, Gregory A. "Assessing the sustainability of the US food system: a life cycle perspective." *Agricultural Systems*, 76, 2003, 1007-1041.

[56] Stonyfield Farms. *"Have a Cow" Program. <* http://www.stonyfield.com/fungames/HaveACow/>

[57] Heller, Martin C., Keoleian, Gregory A. "Assessing the sustainability of the US food system: a life cycle perspective." *Agricultural Systems*, 76, 2003, 1007-1041.

[58] Ibid.

[59] Child Labor Coalition; Child Labor in the U.S.: *"An Overview of Federal Child Labor Laws;"* http://www.fieldsofhope.org/world/index.asp?country=United+States+Of+America.

[60] Ibid.

[61] ***Jeffrey F. Keown. Extension Dairy Specialist.*** Managing Dairy labor, Cooperative Extension , Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln; April 1996, http://www.ianr.unl.edu/pubs/dairy/g1064.htm#WAGES

[62] Department of Labor & Industry, Vermont. *"Wage and Hour Program";* <www.state.vt.us/labind/>

[63] ***Jeffrey F. Keown. Extension Dairy Specialist.*** Managing Dairy labor, Cooperative Extension , Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln; April 1996, http://www.ianr.unl.edu/pubs/dairy/g1064.htm#WAGES

[64] http://www.cpast.org/Articles/fetch.adp?topicnum=12. Corporation for Public Access to Science and Technology. Non Profit based in St. Louis, MO that publishes scientific and technical information on the web for a general audience.

[65] Ludington, David and Eric L. Johnson. *Dairy Farm Energy Audit Summary Report*. Prepared for New York State Energy Research and Development Authority. July 2003.

[66] Ibid.

[67] Heller, Martin and Gregory A. Keoleian. "Assessing the Sustainability of the U.S. Food System: A life Cycle Perspective. Center for Sustainable Systems, School of Natural Resources and Environment, University of Michigan. ScienceDirect. May 14, 2002

[68] Texas Renewable Energy Industries Association; *Definition of Renewable Energy.* <http://www.treia.org/redefinition.htm>.

[69] National Biodiesel Board; *What is Biodiesel.* December 2003. <www.biodiesel.org/resources/faqs/default.shtm>.

[70] Ibid.

[71] Australian Greenhouse Office; Greenhouse Emissions from Dairy Farms. 10 Oct. 2003. <http://www.greenhouse.gov.au/agriculture/factsheets/fs_dairy.html>.

[72] Vermont Department of Energy, *Vermont Electricity Rates, 2000.* <http://www.eere.energy.gov/state_energy/states_currates.cfm?state=VT>.

[73] Efficiency Vermont. *Dairy Farms: Top Energy Saving Methods.* <www.efficiencyvermont.com/index.cfm?L1=84&L2=165&L3=278&sub=bus>

[74] Appropriate Technology Transfer of Rural Agriculture; Dairy Farm Sustainability Check List; www.attra.ncat.org. March 2001.

[75] Ludington, David and Eric L. Johnson. *Dairy Farm Energy Audit Summary Report*. Prepared for New York State Energy Research and Development Authority. July 2003.

[76] Visit to the St. Albans Cooperative Creamery; 8 Nov.. 2003.

[77] EnSave Energy Performance; 10 Nov. 2003, <http://www.ensave.com>.

[78] Ibid.

[79] Ludington, David and Eric L. Johnson. *Dairy Farm Energy Audit Summary Report*. Prepared for New York State Energy Research and Development Authority. July 2003.

[80] Ibid.

[81] Wisconsin Public Service Corporation; Methane *Gas Recovery: Is it Right for Your Farm?* < http://www.wisconsinpublicservice.com/farm/gasrecovery.asp >

[82] Ibid.

[83] Forward, Jeffrey. *Vermont Methane Project Quarterly Report*. January 2001. <http://www.state.vt.us/psd/ee/4th2000.pdf>; January 2001

[84]University of Vermont Environmental Council; "What is Biodiesel." <http://esf.uvm.edu/envcncl/referlibrary/biodiesel.html>; July 13 2001.

[85] Kohl, David. "RE: Research on Sustainability of Dairy Farming for Ben and Jerry's Ice Cream." E-mail to Mindy Murch. 7 July 2003.

[86] This question is based on ratios described in (1) Farm Financial Standards Council. *Financial Guidelines for Agricultural Producers. Revised*, December 1997; and (2) Kohl, David. *Summary of Key Ratios and Benchmarks*. Not dated.

[87] Ibid.

[88] Ibid.

[89] Kohl, David. *Summary of Key Ratios and Benchmarks.* Not dated.

[90] This question based on ratios described by (1) Farm Financial Standards Council. *Financial Guidelines for Agricultural Producers. Revised*, December 1997 and (2) Kohl, David. *Summary of Key Ratios and Benchmarks*. Not dated.

[91] Doehring, *Todd A. Analyzing the Profitability of Your Operation,* AEC, 2001. 19 Nov. 2003 <http://www.centrec.com/resources/Articles/FinAnalysisFarmRanches/Profitability.pdf>.

[92] Kohl, David. *Summary of Key Ratios and Benchmarks*. Not dated.

[93] Ibid.

[94] This question is based on ratios described in (1) Farm Financial Standards Council. *Financial Guidelines for Agricultural Producers. Revised*, December 1997; and (2) Kohl, David. *Summary of Key Ratios and Benchmarks*. Not dated.

[95] Kohl, David. *Summary of Key Ratios and Benchmarks*. Not dated.

[96] This question is based on ratios described in (1) Farm Financial Standards Council. *Financial Guidelines for Agricultural Producers. Revised*, December 1997; and (2) Kohl, David. *Summary of Key Ratios and Benchmarks*. Not dated.

[97] Doehring, Todd A. *Analyzing the Efficiency of Your Operation*, AEC, 2001. 19 Nov. 2003 <http://www.centrec.com/resources/Articles/FinAnalysisFarmRanches/Efficiency.pdf>.

[98] Kohl, David. *Summary of Key Ratios and Benchmarks*. Not dated.

[99] Ibid.

[100] Weersink, A., et al. "Multiple Job Holdings Among Dairy Farm Families in New York and Ontario." *Agricultural Economics 18.* 1998.

[101] Ibid.

[102] Kroma, Margaret M. and Cornelia Butler Flora. 2001. "An Assessment of SARE-funded Farmer Research on Sustainable Agriculture in the North Central U.S." ***American Journal of Alternative Agriculture.*** 16 (2): 73-80. 7 Dec. 2003 <http://www.ag.iastate.edu/centers/rdev/pubs/flora/asses-sare.htm>.

[103] Wells, Anne and Morrow, Ron. "Dairy Farm Sustainability Checksheet." *ATTRA*, March, 2001.

[104] Ibid.

[105] Ibid.

[106] Pelsue, Neil, and Woodruff, Katie. “Agriculture, Food, and Community in Vermont.” The University of Vermont Extension. July, 1996. 7 Dec. 2003<http://www.uvm.edu/extension/publications/factsheets/agfs2/>.

[107] Ibid.

[108] Weber, Greg. “Vermont Dairy Farm Sustainability Project, Inc. (VDFSP) DRAFT Summary.” Provided by Greg Weber, formerly of VDFSP, via e-mail in June 2003.

[109] Klausner. 1993. Quoted in Weber, Greg. “Vermont Dairy Farm Sustainability Project, Inc. (VDFSP) DRAFT Summary.” Provided by Greg Weber, formerly of VDFSP, via e-mail in June 2003.

[110] *Vermont NRCS Farm*A*Syst.* “Worksheet #3: Assessing the Risk of Groundwater Contamination from Fertilizer Storage and Handling.” May 1998. Vermont Natural Resources Conservation Service (NRCS). 2003. 23 Nov. 2003. <ftp://ftp-fc.sc.egov.usda.gov/VT/Technical/FarmASyst/Worksheet3-Fertilizer_Storage&Handling.pdf>.

[111] Jokela, Bill. “UVM Missiquoi Water Quality Factsheets: Dairy Farmers Save Dollars and Nutrients by Participating in HUA Crop Management Service.” University of Vermont, Department of Plant and Soil Sciences. 15 Nov. 2002. 8 Dec. 2003. <http://pss.uvm.edu/vtcrops/LMWQ/Lmwq5.pdf>.

[112] *Vermont Dairy Farm Sustainability Project, Inc.* 2002 update. 8 Dec. 2003. <http://www.sare.org/reporting/report_viewer.asp?pn=LNE01-151&ry=2002&rf=0>.

[113] *Vermont NRCS Farm*A*Syst.* “Worksheet #13: Assessing the Risk of Groundwater Contamination from Nutrient Management.” October 1997. Vermont Natural Resources Conservation Service (NRCS). 2003. 23 Nov. 2003. < ftp://ftp-fc.sc.egov.usda.gov/VT/Technical/FarmASyst/Worksheet13-Nutrient_Management_Practices.pdf>.

[114] Ibid.

[115] Michigan Department of Agriculture “Generally Accepted Agriculture and Management Practices for Nutrient Utilization.” February 2002. Supplied via mail from Dr. Lee Jacobs, Department of Crop & Soil Sciences, Michigan State University.

[116] The National Academies Press. "Nutrient Requirements of Dairy Cattle: Seventh Revised Edition, 2001." 2003. 22 Nov. 2003. <http://books.nap.edu/catalog/9825.html>.

[117] Dimitri, Carolyn, and Greene, Catherine. *Recent Growth Patterns in the U.S. Organic Foods Market*. USDA Economic Research Service. Washington, DC, 2002. 30 Nov. 2003 <http://www.ers.usda.gov/publications/aib777/>

[118] Ibid

[119] Smallheer, Susan. "Organic milk called a cure for Vt. Dairies." *The Barre Montpelier Times Angus on the Web.* 6 July 2003. 7 Aug. 2003 <http://www.timesargus.com/Story/66645.html>.

[120] *Research-station of Öjebyn.* Swedish University of Agricultural Sciences. 22 Nov. 2003 <http://www.njv.slu.se/sections/animal/organic.cfm>.

[121] Cederberg, Christel and Berit, Mattsson. "Life cycle assessment of milk production – a comparison of conventional and organic farming." *Journal of Cleaner Production, Vol. 8* (2000).

[122] Adapted from USDA National Organic Program. "Regulatory Text Only." *National Organic Program 7 CFR 205.* 22 Nov. 2003 <www.ams.usda.gov/nop/NOP/standards/FullRegTextOnly.html>.

[123] Ibid.

[124] Ibid.

[125] Heller, Martin C., Keoleian, Gregory A. "Assessing the sustainability of the US food system: a life cycle perspective." Center for Sustainable Systems Agricultural Systems. 6 Dec. 2000. <http://css.snre.umich.edu/css_doc/CSS00-04.pdf>. March 2003.

[126] US EPA. "About Pesticides" 18 June 2003. <http://www.epa.gov/pesticides/about/index.htm>. 1 Nov. 2003.

[127] State of California. "Definition of IPM (Integrated Pest Management)." 2003. <http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/overview/definition_ipm.cfm?crumbs_list=1,19>. 1 Nov. 2003.

[128] Pesticide Use in the US. Oregon State. Oct. 2003. <http://oregonstate.edu/instruction/bi301/pesttren.hm>. 1 Nov. 2003.

[129] Ibid.

[130] Heller, Martin C., Keoleian, Gregory A. "Assessing the sustainability of the US food system: a life cycle perspective." Center for Sustainable Systems Agricultural Systems. 6 Dec. 2000. <http://css.snre.umich.edu/css_doc/CSS00-04.pdf>. March 2003.

[131] Central Coast Vegetable Integrated Pest Management Project, University of California Cooperative Extension. <http://ccvipmp.ucdavis.edu/media5-salinas.ipm.final.html>. 18 Oct. 2003.

[132] Question from Farm*A*Syst. Pesticide Storage and Handling.

[133] Question adapted from The Food Alliance. Dairy Inspection Tool for the Pacific Northwest. 2002.

[134] Question from Farm*A*Syst. Pesticide Storage and Handling.

[135] Ibid.

[136] Question adapted from The Food Alliance. Dairy Inspection Tool for the Pacific Northwest. 2002.

[137] State of California. "Definition of IPM (Integrated Pest Management)." 2003. <http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/overview/definition_ipm.cfm?crumbs_list=1,19>. 1 Nov. 2003.

[138] Central Coast Vegetable Integrated Pest Management Project, University of California Cooperative Extension. <http://ccvipmp.ucdavis.edu/media6-media-quotes.html>. 18 Oct. 2003.

[139] Heller, Martin C., Keoleian, Gregory A. "Assessing the sustainability of the US food system: a life cycle perspective." *Agricultural Systems*, 76, 2003, 1007-1041.

[140] Ibid.

[141] *USDA Agricultural Research Service Website*. National Programs Soil Resource Management "Component II: Nutrient Management." 25 Oct. 2003 <http://www.nps.ars.usda.gov/programs/programs.htm?npnumber=202&docid=349>.

[142] Magdevski, Sonja. “Cropping Systems Can Benefit the Soil.” *Futures: Sustainable Agriculture*. Fall/Winter 2000/Spring/Summer 2001, Vol. 18, No. 3/vol.19, nos. 1,2,3. *Michigan State University Agricultural Experiment Station Website*. 25 Nov. 2003. 3 Dec. 2003. < http://www.maes.msu.edu/Futures/fall_winter2001.pdf>.

[143] Ibid.

[144] “Soil Quality Resource Concerns: Soil Erosion” USDA NRCS Soil Quality Information Sheet. *USDA Natural Resources Conservation Service Website.* Soil Quality Information Sheet. “Soil Quality Resource Concerns: Soil Erosion” April 1996. 19 Nov. 2003. < http://soils.usda.gov/sqi/files/sq_two_1.pdf>.

[cxlv] *Vermont NRCS Farm*A*Syst.* “Worksheet #3: Assessing the Risk of Groundwater Contamination from Fertilizer Storage and Handling.” May 1998. Vermont Natural Resources Conservation Service (NRCS). 2003. 23 Nov. 2003. <ftp://ftp-fc.sc.egov.usda.gov/VT/Technical/FarmASyst/Worksheet3-Fertilizer_Storage&Handling.pdf>.

[cxlvi] *Vermont NRCS Farm*A*Syst.* “Worksheet #8: Assessing the Risk of Groundwater Contamination from Barn Yard Management.” May 1998. Vermont Natural Resources Conservation Service (NRCS). 2003. 23 Nov. 2003. < ftp://ftp-fc.sc.egov.usda.gov/VT/Technical/FarmASyst/Worksheet8_Barnyard_Management.pdf>.

[cxlvii] U.S. Water Scarcity Problems Highlighted At Congressional Hearing. 8 May 2003. 19 Nov. 2003. <http://www.house.gov/transportation/press/press2003/release97.html>.

[cxlviii] USGS Homepage. “Water Resources of New Hampshire and Vermont, New Hampshire Bedrock Aquifer Assessment.” 31 May 2000. 10 Oct. 2003. <http://nh.water.usgs.gov/CurrentProjects/bedrock.htm>.

[cxlix] *US EPA Website*. 3 Dec 2003. Non-Point Source Pointers (Factsheets) “Pointer #6 EPA841-F-96-004F: Managing Nonpoint Source Pollution from Agriculture” 23 Nov. 2003. <http://www.epa.gov/OWOW/NPS/facts/point6.htm>.

[cl] NRCS National Environmental Policy Act (NEPA) Documents. “Environmental Quality Incentives Program (EQIP): Risk Assessment for the EQIP Program.” December 10, 2002. USDA Natural Resources Conservation Service. 23 Nov. 2003. <http://www.nrcs.usda.gov/programs/Env_Assess/EQIP/EQIP_RA_121002.pdf >.

[cli] *Region 5 Water, Water Quality Impacts Website*. US EPA. 4 Sept. 2003. 19 Nov. 2003. <http://www.epa.gov/r5water/npdestek/npdcafowaterqualityimpacts.htm>.

[clii] *Vermont NRCS Farm*A*Syst.* "Worksheet #9: Assessing the Risk of Groundwater Contamination from Silage Storage." Sept. 1997. Vermont Natural Resources Conservation Service (NRCS). 2003. 23 Nov. 2003. < ftp://ftp-fc.sc.egov.usda.gov/VT/Technical/FarmASyst/Worksheet9-Silage_%20Storage.pdf>.

[cliii] *Vermont NRCS Farm*A*Syst.* "Worksheet #10: Assessing the Risk of Groundwater Contamination from Milkhouse Wastewater Treatment." Dec. 1997. Vermont Natural Resources Conservation Service (NRCS). 2003. 23 Nov. 2003. < ftp://ftp-fc.sc.egov.usda.gov/VT/Technical/FarmASyst/Worksheet10-Milkhouse_Wastewater_Treatment.pdf>.

[cliv] Question adapted from The Food Alliance. Dairy Inspection Tool for the Pacific Northwest. 2002.

[clv] *USDA Agricultural Research Service Website*. National Programs Water Quality & Management "Program Summary: Program Direction." 6 June 2003. <http://www.ars.usda.gov/research/programs/programs.htm?NP_CODE=201>.

[clvi] Ibid.