LONG-RUN IMPLICATIONS OF A FOREST-BASED CARBON SEQUESTRATION POLICY ON THE UNITED STATES ECONOMY: A COMPUTABLE GENERAL EQUILIBRIUM (CGE) MODELING APPROACH

A Dissertation

by

JUAN JOSE MONGE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2012

Major Subject: Agricultural Economics

LONG-RUN IMPLICATIONS OF A FOREST-BASED CARBON SEQUESTRATION POLICY ON THE UNITED STATES ECONOMY: A COMPUTABLE GENERAL EQUILIBRIUM (CGE) MODELING APPROACH

A Dissertation

by

JUAN JOSE MONGE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Approved by:

Co-Chairs of Committee,	Henry L. Bryant
	James W. Richardson
Committee Members,	Joe L. Outlaw
	Jianbang Gan
Head of Department,	John P. Nichols

August 2012

Major Subject: Agricultural Economics

ABSTRACT

Long-run Implications of a Forest-based Carbon Sequestration Policy on the United States Economy: A Computable General Equilibrium (CGE) Modeling Approach. (August 2012)

Juan Jose Monge, B.Sc.; M.Sc., University of Arkansas

Co-Chairs of Advisory Committee: Dr. Henry L. Bryant
Dr. James W. Richardson

The economic impacts of a government-funded, forest-based sequestration program were analyzed under two different payment schemes. The impacts were obtained by developing a regional, static CGE model built to accomodate a modified IMPLAN SAM for a determined region in the United States for 2008. The IMPLAN SAM was modified to accommodate the more conventional factors of production (labor, capital and land) and to account for land heterogeneity using the Major Land Resource Areas (MLRA). The regional aggregation considered included the Southern, Northeastern, Southwestern and Midwestern regions. The two policy scenarios considered consisted of two CO_2-offset payment schemes: 1) the government compensates the generation of CO_2-offsets only by the land converted to a carbon graveyard and 2) the government additionally compensates the CO_2 offsets generated as a by-product by the existing commercial logging activity. By doing an analysis of the model with different budget magnitudes under the two scenarios, two different CO_2-offset supply schedules were obtained with their respective CO_2-offset price and quantity sets.

For a budget allocation of $6.9 billion, approximately 1 billion metric tons of CO_2 offsets (15% of U.S. 2008 total GHG emissions) were produced in the first scenario versus 0.8 billion metric tons (11% of U.S. 2008 GHG net emissions) in the second one. Fifty million acres were diverted out of agriculture and commercial forestry

land to the carbon graveyard mainly in the Northern, Western and Central Great Plains in the first scenario. Twenty two million acres were diverted out of agricultural land to the carbon graveyard and commercial logging mainly in the Northern and Western Great Plains; and the Eastern and Western boundaries of the Appalachian mountains in the second scenario.

Both scenarios resulted in higher land and agricultural commodity prices, lower consumption of agricultural commodities by households, lower agricultural exports and higher imports. The payment structure of the second scenario benefited the commercial logging industry, increasing its production and exports, and decreasing its imports. The non-agricultural sectors mostly impacted by the two policy scenarios were the manufacturing, construction and government employment sectors.

DEDICATION

I would like to dedicate this dissertation to God, first of all, my family, my wife and especially my mother. Gracias madre por estar siempre conmigo. Gracias por ser un ejemplo incondicional de perseverancia y disciplina. Si no fuera por tu entrega y amor como madre nunca hubiera llegado a alcanzar lo que hasta el momento he logrado.

ACKNOWLEDGMENTS

Special thanks to my committee members, especially Dr. Bryant for his endless help. I would have never undertaken a project of such magnitude and relevance if it had not been because of him. I'm grateful to Dr. Richardson for believing in me from the beginning and for guiding me through the program. Special thanks also go to Dr. Outlaw and Dr. Gan for helping me with the revisions of this document.

I would like to thank my family, specially my mother, sister and wife for emotionally supporting and understanding me through this critical period of my life. My friends Mariano and Raul for supporting me in the good and the bad moments. Special thanks to my aunts Silvia and Vilma for playing the roles of my second mothers throughout my childhood and youth. Gracias por ser mis segundas madres y por guiarme en este camino laborioso pero lleno de felicidad. I'm also grateful to my dad for guiding me in life.

I would like to thank the staff at the Agricultural and Food Policy Center (AFPC). Specially to Rob and Kurt for helping me with the technical and computational work involved in this study.

TABLE OF CONTENTS

Page

Page

LIST OF TABLES

TABLE Page

TABLE Page

TABLE Page

TABLE Page

TABLE Page

TABLE Page

LIST OF FIGURES

FIGURE Page

FIGURE Page

FIGURE Page

1. INTRODUCTION

1.1 Background

1.1.1 Global climate change

In the last two centuries, starting with the industrial revolution, societies around the world experienced a great deal of progress. The introduction of steam power, large scale production of chemicals, the mechanization of agriculture, the development of new petroleum distillation methods, electricity generation and distribution, the invention of the internal combustion engine and the development of the automotive industry are some of the major turning points that contributed to the greatest economic and societal leap in the history of human kind. However, as economists like to put it “there is no such thing as a free lunch.” An inevitable byproduct of the standardization of the previously mentioned discoveries in every day activities is the unprecedented amount of greenhouse gases (GHG) released and concentrated into the atmosphere and the resulting climate-retaled damage (i.e. global warming). The trend at which fossil-fuel emissions have been increasing is shown in figure 1.1 (Boden, Marland, and Andres 2012).

The United States is one of the nations that has greatly benefited from the progress experienced, and the wealthiest nation in the world, accounting for approximately a quarter of the global GHG emissions, or 6.8 billion metric tons in 2010. CO_2 is the most significant GHG produced by human activities, mainly the combustion of fossil fuels, accounting for 83% of total United States GHG emissions. However, land use, land-use change, and forestry acted as a net sink reducing total GHG emissions by approximately 1 billion metric tons to a net total of 5.8 billion metric tons in 2010 as shown in figure 1.2 (EPA 2012).

This dissertation follows the style of the *American Journal of Agricultural Economics*.

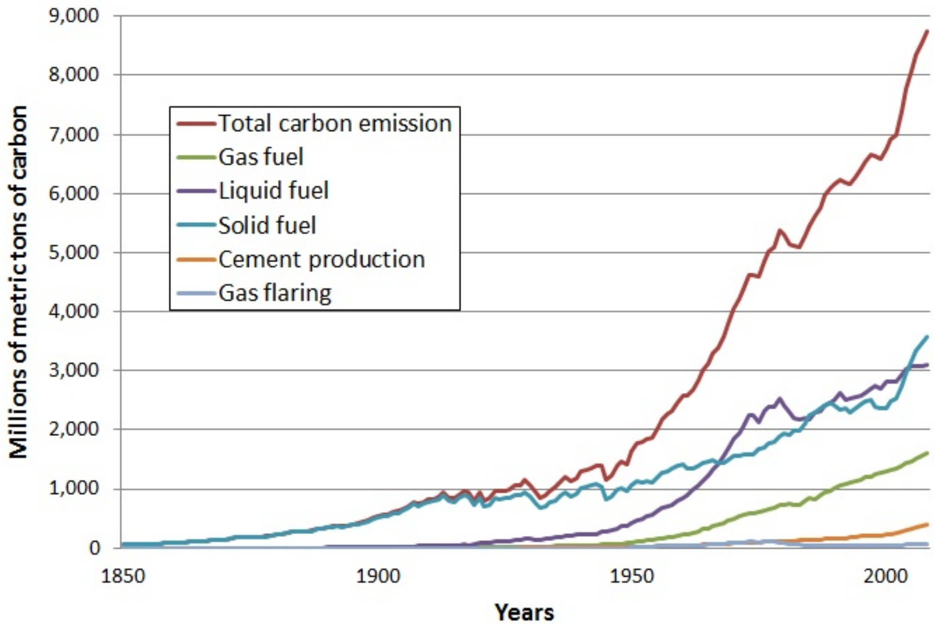


Figure 1.1. Global fossil-fuel carbon emissions

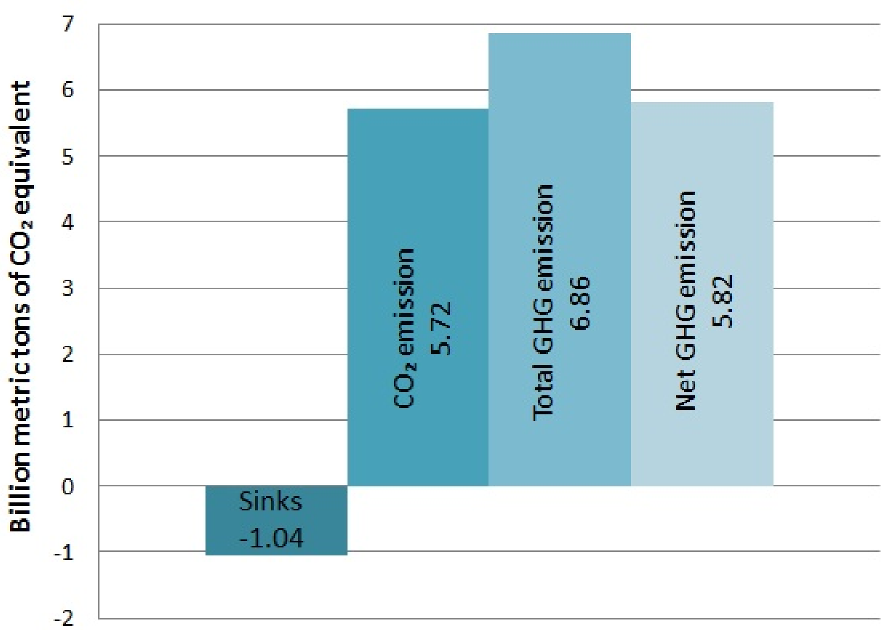


Figure 1.2. Greenhouse gas emissions in the U.S., 2010

1.1.2 Biological carbon sequestration

According to CBO (2007), the two main current alternatives to sequester carbon are: biological sequestration and CO_2 capture and storage (CCS). Hence, it is important to differentiate among the two alternatives in this document. Biological sequestration includes activities in the agriculture and forestry sectors that encourage the absorption of CO_2 from the atmosphere into the vegetation and soil. The carbon in the vegetation and soil is mainly quantified in terms of carbon mass, not CO_2. However, the carbon released into the atmospere is mainly in the form of CO_2. The conversion rule is that one metric ton of carbon is equivalent to 3.67 metric tons of CO_2.

According to Stavins and Richards (2005), paying no serious attention to carbon sequestration alternatives would lead to "incorrect and overly pessimistic conclusions about the cost and feasibility of addressing global climate change." The role of the agriculture and forestry sectors as net carbon sinks has made policymakers become aware of the great potential offered by these sectors to contribute to the national, and global, effort to curb GHG emissions. Among the options to mitigate the risk of global climate change, two are of great importance: 1) carbon source reduction programs and 2) carbon sink enhancement programs. If the country implemented a national program, the economic impact exerted by the first option to the private sector would require a great deal of investment in the development of new technologies, which translates into time and capital. In contrast, Richards et al. (1993) concluded that "trees could reduce the overall cost of stabilizing U.S. carbon emissions by as much as 80%" compared to a policy that only addressed the reduction of fossil-fuel emissions.

The most recent and ambitious attempt to address climate change in the country was the House Resolution (H.R.) 2454 in the 111th Congress and included, in section

503 (b), the following activities in the agriculture and forestry sectors as eligible domestic offset practices: [1]

1. agricultural, grassland, and rangeland sequestration and management practices;
2. changes in carbon stocks attributed to land use change and forestry activities; and
3. manure management and disposal.

1.1.3 Forest-based carbon sequestration

To decide what alternatives to include in a hypothetical domestic portfolio of compliance activities, the cost and price of the different sequestration options would be a major inclusion criterion for policymakers. Among the most promising biological sequestration alternatives to date, forest-based carbon sequestration has proven to be a relatively inexpensive means of addressing climate change. The H.R. 2454, section 503 (b) (2), included the following forestry activities as eligible domestic offset practices:

1. afforestation or reforestation of acreage that is not forested;
2. forest management resulting in an increase in forest carbon stores including but not limited to harvested wood products;
3. management of peatland or wetland;
4. conservation of grassland and forested land;

[1] The H.R. 2454, also known as the American Clean Energy and Security Act of 2009, was an energy bill that sought to reduce global warming pollution among other objectives. The bill passed in the House of Representatives on June 26, 2009. However, it did not pass in the Senate and was placed on the legislative calendar under General Orders. Calendar No. 97. The H.R. 2454, section 722 (d) (1) (A), allowed covered entities to collectively use offset credits to demonstrate compliance for up to a maximum of 2 billion tons of GHG emissions annually.

5. improved forest management, including accounting for carbon stored in wood products;
6. reduced deforestation or avoided forest conversion;
7. urban tree-planting and maintenance;
8. agroforestry; and
9. adaptation of plant traits or new technologies that increase sequestration by forests.

1.1.4 Afforestation

According to EPA (2008; 2005); Lewandrowski et al. (2004) and Johnson, Ramseur, and Gorte (2010), afforestation is the sequestration alternative that would, potentially, contribute the most towards the generation of domestic carbon offsets from the agriculture and forestry sectors. Afforestation consists on planting trees on land previously used for other purposes. Afforestation is the alternative with the highest per-acre and total potential carbon sequestration for land used either for cropland or pastureland (Lewandrowski et al. 2004). According to Birdsey (1992), the estimated per-acre sequestration rates for forest coming from cropland and pastureland are 0.79 - 1.72 and 0.73 - 2.09 metric tons per acre, respectively.

The potential generation of domestic carbon offsets from land-use change to afforestation depends on hypothetical carbon offset prices,[2] tree-establishment costs, land rents for alternative uses, competing prices of agricultural products, carbon sequestration rates for different geographical regions and tree species, and the effect of key analytical parameters such as discount rates. Hence, to analyze the potential

[2]The offset price is the marginal cost of abatement for uncovered sectors and entities. When the limit on offset usage is non-binding, the offset price is equal to the allowance price. The allowance price is equal to the marginal cost of abatement for covered sectors and entities.

contribution from afforestation, an analytical approach is needed that accounts for all these factors.

The literature cites several approaches to analyze such an encompassing issue. Among the most cited ones are:

1. Bottom-up engineering studies,
2. Sectoral models, and
3. Econometric studies.

Each of these models will be treated in more detail in the literature review section of this document, covering their strengths, weaknesses and conclusions.

1.1.5 Computable General Equilibrium (CGE) models

One appropriate approach to account for different agents in society (e.g. households categorized by annual income and different state and federal government divisions) and their interactions with the different sectors in the economy is the Computable General Equilibrium (CGE) modeling approach. CGE modeling would help explain, identify and structure the intricate relationships between all of the factors affecting potential generation of carbon offsets from afforestation and their impacts on society and the economy. However, very few CGE models have considered afforestation. Even fewer, if not any, have considered the effect of afforestation on land-use change in different regions in the nation. Hence, the literature lacks a CGE model that analyzes the impact of afforestation program magnitudes on land-use change for different geographically associated regions in the United States.

1.2 Objective

The main objective of the current dissertation is to analyze the impact of different government budget allocations devoted to forest-generated carbon offsets on land-use change in different Major Land Resource Areas (MLRA), land rents, and the production and prices of related commodities using a CGE framework.

To achieve the main objective the following secondary objectives were accomplished:

1. Develop and modify a regional Social Accounting Matrix (SAM) from the Impact Analysis for Planning (IMPLAN) Version 3.0, reflecting economic activity for 2008 for different regional aggregations in the country at the state level (MIG 1997).[3]

    (a) Balance the IMPLAN SAM using the Cross Entropy (CE) SAM-balancing technique.

    (b) Modify certain IMPLAN value-added accounts to acommodate the more common capital and labor production factor accounts.

    (c) Modify the allocation of Indirect Business Taxes (IBT) to the appropriate producing activities.

2. Modify the regional IMPLAN SAM to accomodate land as a production factor for different MLRAs.

    (a) Obtain and estimate per-acre land rents for different land-use categories within the agricultural and forestry sectors for different MLRAs.

    (b) Include land rent payments into any regionally aggregated IMPLAN SAM.

3. Develop a static IMPLAN SAM-based regional CGE model with special emphasis on the market for agricultural land in any arbitrary state-level aggregation in the U.S.

    (a) Develop and calibrate the CGE model using the General Algebraic Modeling System (GAMS).

[3]Note that only the IMPLAN data have been used; neither the IMPLAN model nor linear activity modeling have been used at all.

4. Include the afforestation component into the SAM-based regional CGE model.

   (a) Obtain per-acre sequestration rates and establishment costs for different regions and tree species.

   (b) Include the afforestation component into the CGE model as a latent activity reflecting the "carbon graveyard" practice.[4]

   (c) Modify the model to accomodate carbon offset demand from the federal government.

   (d) Include the sequestration generated by the commercial logging activity as a co-product.

[4]Carbon graveyard is the practice of leaving tree stands permanently without being harvested to avoid further release of carbon.

2. LITERATURE REVIEW

For over twenty years, the literature on carbon sequestration methodologies has claimed that it is possible to considerably counteract global GHG emissions by increasing forested areas around the world. Starting from Sedjo and Solomon (1989), there are dozens of carbon sequestration cost studies focusing on the entire globe, geographic regions, nations, national sub-regions, etc. Sedjo et al. (1995); van Kooten et al. (2004); Richards and Stokes (2004); Stavins and Richards (2005) offer a comprehensive review of studies for different regional aggregations. van Kooten et al. (2004); Richards and Stokes (2004); Stavins and Richards (2005) modified the costs and potential total carbon sequestration of some of the most important studies cited, if not all, to compare among them and give a unified conclusion. van Kooten et al. (2004); Stavins and Richards (2005) went even further and performed a meta-analysis of all the studies cited.[1] All of these comparisons were undertaken with the objective of assessing the relative importance of the various factors affecting the estimation of carbon sequestration costs such as:

- the treatment of carbon accounting;
- the estimation of land costs (i.e. opportunity costs);
- the choice of rates of return;
- the consideration of leakage, additionality and permanence; and
- the interpretation of the different cost curves (e.g. marginal and average costs).

However, to circumbscribe the type and scope of studies included and to provide a greater insight into the regional costs of carbon sequestration, this literature review focuses only on studies performed in the U.S.; mainly on the ones that used sector optimization or CGE modelling.

[1] van Kooten et al. (2004) included studies from all over the world and Stavins and Richards (2005) only from the U.S.

The review starts by describing the three main approaches used to date to estimate carbon sequestration costs and listing their strenghts and weaknesses. The discussion then focuses on the existing alternatives among optimization models in the literature, mainly on CGE models.

2.1 Forest-based carbon sequestration studies

According to Richards and Stokes (2004); Stavins and Richards (2005), based on the modeling of land costs, the three general categories of studies dealing with the estimation of forest-based carbon sequestration costs are:

- bottom-up engineering cost studies,
- econometric studies, and
- sectoral optimization studies.

2.1.1 Bottom-up engineering studies

Bottom-up engineering cost studies were among the first studies to consider the estimation of land costs as a major part of a forest-based sequestration program. They are also the first type of study that used the different accounting and reporting methods for carbon sequestration costs, Moulton and Richards (1990) and Richards et al. (1993) were the first to use the levelized and discounting costs approaches, respectively.[2] Moulton and Richards (1990) and the New York State Energy Office (1991) employed observed prices from agricultural land rental markets and Richards, Moulton, and Birdsey (1993) from agricultural land purchase markets.

According to Richards and Stokes (2004), engineering cost studies have the advantage of being fairly simple and transparent to interpret. This reason makes them

[2]For a more thorough treatment of the different accounting and reporting methods for carbon sequestration costs see Richards and Stokes (2004); Stavins and Richards (2005).

Table 2.1. Normalized Sequestration Costs from Previous Bottom-Up Engineering Studies

Authors	Scope	Potential normalized quantity	Range of normalized costs
		million MT of CO_2/year	\$/MT of CO_2
Moulton and Richards (1990)	National	2,693	2 - 17
Dudek and Leblanc (1990)	National	126	18
New York State (1991)	New York	250	2 - 16
Adams et al. (1993)	National	2,331	7 - 21
Richards, Moulton and Birdsey (1993)	National	1,492	3 - 24
Parks and Hardie (1995)	National	400	1 - 11
Alig et al. (1997)	National	146	8
Richards (1997)	National	1,648	3 - 43

good sources to obtain regional cost information. There is a relatively narrow range of sequestration cost estimates among this type of studies, claiming that considerable amounts of carbon could be sequestered for less than \$50/ton of carbon. Parks and Hardie (1995) is the only exception, using a least-cost engineering approach, they claim that the higher cost range is about \$90/ton of carbon. According to Richards and Stokes (2004), this difference in costs can be attributed to the fact that Parks and Hardie (1995) considered much less land availability than other engineering studies.

As previously noted, Stavins and Richards (2005) performed a meta-analysis of the sequestration studies published to date. Sequestration costs from different studies were normalized and reported on a carbon short-ton basis. To compare to other more recent studies, the estimates from Stavins and Richards (2005) were converted to a CO_2 metric-ton (MT) basis as listed in table 2.1.

Engineering studies have used several approaches to account for the opportunity cost of land or increasing marginal costs of diverting land from agricultural purposes to forest. Richards, Moulton, and Birdsey (1993); Richards (1997) used an exogenously determined elasticity of demand for agricultural land. Adams et al. (1993) used a consumer surplus loss specification to reflect incresing food prices due to a decreasing availability of agricultural land. Parks and Hardie (1995) accounted for lost economic rents due to the movement of land out of agricultural production to forests.

However, as cost estimation techniques have become more sophisticated (explicitly including more factors affecting sequestration costs), engineering studies present some shortcomings. Due to the difficulty of estimating land costs, some studies assumed a costless availability of land due to its public ownership status (New York State Energy Office 1991). These studies do not consider landowners' behavioral responses or the responses of other economic actors. Hence, they treat land conversion unidirectionally and irreversibly, giving landowners no flexibility for future land use directions. In other words, once land has been converted into forest, it cannot be converted back to agricultural land. This fact limits engineering models in considering the leakage phenomenon.[3]

Due to the lack of general equilibrium effects, engineering studies do not consider related market adjustments and may overstate the first order effects of carbon sequestration programs (Richards and Stokes 2004). They do not consider "decision-making inertia" and ignore the lagged effect of some economic incentives. They also do not consider private market benefits or costs related to alternative uses of land (Stavins and Richards 2005).

2.1.2 Econometric studies

This group of studies tries to circumvent some of the shortcomings presented by the engineering studies. All the econometric studies are based on the revealed-

[3]Leakage is the phenomenon experienced when a sequestration program induces an increment in agricultural land markets, thereby leading landowners to convert unregulated forestland to agricultural land. Leakage offsets and decreases the efficiency of a sequestration program.

preferences premise, which consists on identifying statistically significant relationships between actual land-use choices (i.e. landowners' responses) and changes in timber and agricultural product prices. Once the relevant relationships have been identified a response or supply function is statistically estimated and, with it, it is possible to simulate the effect of a hypothetical economic shock (e.g. a carbon sequestration program subsidized by the government) on landowners' land-use decisions. The sequestration costs, from previous studies, listed and normalized in Stavins and Richards (2005) where converted to a CO_2 metric-ton (MT) basis as listed in table 2.2.

Table 2.2. Normalized Sequestration Costs from Previous Econometric Studies

Authors	Scope	Potential normalized quantity	Range of normalized costs
		million MT of CO_2/year	\$/MT of CO_2
Stavins (1999)	Delta States	2,404	0 - 245
Plantinga, Maudlin and Miller (1999)	ME, SC, WI	256	0 - 79
Lubowski, Plantinga and Stavins (2003)	National	5,660	2 - 83

The advantage of econometric analysis over engineering studies is that with the former it is not necessary to understand and model the details of landowners' decision processes. Rather, econometric analysis depend on observable data to reveal and estimate the opportunity cost of converting land from alternative uses (e.g. agriculture or urban areas) to forestry. The "decision-making inertia" or lagged effects of some economic incentives are considered by these studies through lagged independent variables. Agricultural subsidies are intrinsically reflected and capitalized into land values; hence, the opportunity cost of switching land from agricultural uses to forestry is more accurately determined (Stavins and Richards 2005).

The regional focus of these studies goes from the national level (Stavins 1999; Lubowski, Plantinga, and Stavins 2006), to the Delta states (Stavins 1999; Newell and Stavins 2000), to Wisconsin, South Carolina and Maine (Plantinga, Mauldin, and Miller 1999; Plantinga and Mauldin 2001). According to Richards and Stokes (2004), Stavins (1999) is probably the most comprehensive, transparent and comparable of all econometric studies. It accounted for timber harvesting by allowing carbon stored in wood products. It also covered leakage by allowing land conversion in both directions depending on the respective land returns. The method of discounting and annualizing of carbon flows used in the study provides great comparability among studies. By reporting both marginal and average costs, it also provides comparability among both concepts. However, the meta-analysis by Stavins and Richards (2005) uses Lubowski, Plantinga, and Stavins (2006) as the reference study to be compared to the rest since it was the most recent study at that time.

2.1.3 Sector optimization studies

This group comprises two main sector optimization approaches: 1) partial equilibrium (PE) and 2) CGE models. Most of the studies dealing with forest-based carbon sequestration in the U.S. use the models from the first group. Studies using models in the second group are mainly focused in analyzing a vast variety of GHG reduction policies that cover not only the agriculture and forestry sectors but all GHG-emitting sectors. This subsection focuses only on the models from the first group. Section 2.2 will briefly list and describe existing global and regional CGE models that have included a GHG component.

According to Richards and Stokes (2004); Stavins and Richards (2005); Johnson, Ramseur, and Gorte (2010), the two most commonly used models in carbon sequestration studies are:

Table 2.3. Normalized Sequestration Costs from Previous Sector Optimization Studies

Source	\$3 - \$5	\$13 - \$15	\$30 - \$34
	Million MT of CO_2/year		
USDA study	0 - 31	105 - 264	224 - 498
EPA study	12	228	806

1. the Forest and Agriculture Sector Optimization Model with Greenhouse Gases (FASOMGHG) used in Adams et al. (1999); Alig et al. (1997); Alig, Adams, and McCarl (1998); and EPA (2005); and

2. the U.S. Mathematical Programming Regional Agriculture Sector Model (USMP) used in Lewandrowski et al. (2004).[4]

Both are multi-period, price endogenous, spatial and PE models that seek to maximize the sum of consumer and producer surplus across all commodity markets subject to policy constraints. Both also account for land conversion between different crop, livestock and forestry management practices. FASOMGHG includes afforestation, forest management, different tillage practices, livestock management, and feedstock production for biofuels; and simulates changes over a 100-year period. USMP includes afforestation of cropland and pastures, shifting cropland to permanent grasses, and different tillage practices; and simulates changes over a 15-year carbon storage program. As listed in table 2.3, Johnson, Ramseur, and Gorte (2010) normalized and reported the sequestration costs from two reports by EPA and USDA based on FASOMGHG and USMP, respetively.

The great advantage of this type of models is that they can easily include leakage in their specifications since landowner decisions are endogenous (Alig et al. 1997; Adams et al. 1999). Opportunity costs of land are estimated as a component of both

[4]FASOMGHG is a modification of the original and widely-used FASOM. The USMP model is currenlty known as the Regional Environmental and Agriculutural Programming Model (REAP).

optimization models. The studies based on FASOM used econometrics specifications to estimate consumer demand and measure the marginal cost from withdrawing land from agricutural production.

Richards and Stokes (2004) raised the concern that the sequestration costs from Alig et al. (1997) are substantially higher than the estimated costs from the engineering studies. Richards and Stokes (2004) stated that, in the fixed-increment scenario in Alig et al. (1997), the higher costs are a result of the artificially-imposed constraint, rather than the more accepted cost-minimizing strategy.

According to Johnson, Ramseur, and Gorte (2010), among the studies that use FASOMGHG and USMP, EPA (2005) and Lewandrowski et al. (2004) are two of the most cited reports and were criticized by prominent researchers on the grounds of being outdated and not including recent policy changes. Among the policy changes not included in these two studies are the Renewable Fuel Standard (RFS) and the increased federal support for farm-based bioenergy production. Furthermore, the models were developed following a period of declining agricultural prices, stable net farm income, and a reduction in agricultural land. EPA (2005) was also questioned about the validity of estimates of the carbon offset potential of carbon offsets projects. However, in March 2009, EPA announced it had updated the underlying model and its estimates of the carbon offset potential from the agriculture and forestry sectors.

2.2 Optimization models

As noted in section §1.1.5, to analyze the impact of a government-funded afforestation-based carbon sequestration program on different input and output markets it is necessary to use an approach that considers the economic interlinkages between different sectors in any regional aggregation or the nation. The literature on such models is large and according to it the best models that apply to this study are input-output (IO), partial equilibrium (PE) and computable general equilibrium (CGE) models.

2.2.1 Alternative models

IO models are mainly based on economic IO tables and take into account the economic linkages between sectors and regions needed for this study. However, to model the substitutability between inputs (consumption and production), IO models rely on a fixed elasticity of substitution (viz., $\sigma = 0$). In addition, due to its non-parametric nature, IO models also rely on a fixed input-output ratio or Leontief production structure. Hence, by using IO models it is difficult to model response to future changes in relative prices, to improvements in production technology or other structural economic changes. All these aspects were central to this study; hence, a more flexible approach was needed.

Besides IO models, the second class of models applied in regional studies are PE models. PE models concentrate on specific sectors of an economy taking the other sectors as exogenous variables to the model. As noted in 2.1.3, models such as FASOMGHG and USMP have been extensively used to model carbon sequestration programs in the agriculture and forestry sectors. The main utility of these models is the detailed disaggregation of the sectors under scrutiny, which facilitates a policy-impact analysis. However, besides the importance of direct policy impacts, considering the impacts and feedbacks from other sectors, institutions and markets to the relevant sectors can be of great importance. For example, most of the agricultural PE models represent the land factor of production through reduced-form supply, yield and area response equations and do not consider its demand side (Kretschmer and Peterson 2010). In other words, PE models do not consider the market for the land factor and, as a result, ignore the substitutability aspect of land use, which is of great importance to this study. Hence, the approach that circumvents IO models' fixed-substitutability limitation and PE models' scope limitation is the CGE modeling approach.

2.2.2 CGE models and climate change

A CGE model is essentially a set of equations that explains the optimizing behavior of the different actors in an economy through first order conditions. If PE models maximize the sum of consumer and producer surplus, CGE models solve a set of first-order conditions derived from utility and profit optimization theory. The inputs and outputs of the production and utility functions to be maximized are reflected by the production and consumption values recorded in the Social Accounting Matrix (SAM) in a specific year. All of these transactions reflected in the SAM in a specific year are assumed to be in equilibrium.

The SAM is a record-keeping framework of the payments between economic actors in a specific economic region and its regional context (i.e. trade). The economic actors included in any generic SAM are: activities, commodities, institutions, produciton factors and trade. An activity represents an aggregated firm in any specific sector in the economy that consumes and produces commodities as inputs and outputs, respectively. The institutions are the households, enterprises and the government. The production factors are capital, labor and, in the case of agriculture and forestry, land. Each of these institutions receives payments for offering factors of production (households) and for offering commodities and services (enterprises). The government is modeled as a passive institution that collects taxes, receives transfers and distributes these back into the economy.

In the literature regarding climate change, CGE models are used to analyze a wide variety of GHG reduction policies that cover not only the agriculture and forestry sectors but all GHG-emitting sectors. Among the most important CGE models used in climate change that have focused on the U.S. there are:

EPPA: The Emissions Predictions and Policy Analysis (EPPA) model is a multi-region, multi-sector dynamic CGE model of the world economy developed by the Massachusetts Institute of Technology. It has been widely used to generate projections of global development and the GHG emissions produced as a by-product. It has also been used in studies to analyze the impact of GHG-related policies and the distribution of the cost of implementation among nations. It is based on data developed by GTAP at Purdue University. GHG-emission parameters are added to the dataset along with taxes and rates of technological, economical and population growth. The GHG emissions sources included in the model are the combustion of carbon-based fuels, industrial processes, waste handling, and agricultural activities. There are two different versions of the model: 1) the recursive dynamic (myopic) and 2) dynamic (forward-looking) versions. The first and the second versions are documented in Paltsev et al. (2005) and Babiker et al. (2008), respectively.

GTAP: The Global Trade Analysis Project (GTAP) model is a multi-region, multi-sector CGE model of the world economy developed by Purdue University. The model works on the premises of perfect competition, constant returns to scale, non-homothetic CDE functional form for private households preferences, explicit treatment of international trade and transport margins, a global banking sector and the treatment of bilateral trade under the Armington assumption. The model has been mainly used in studies related to international trade policy. However, the basic dataset has been extended to include a more detailed disaggregation of the energy sector (GTAP-E), the biofuel industry (GTAP-BIO) and land into different agro-ecological zones (GTAP-AEZ). The model has been used to analyze policies related to climate change and its effects on international trade and land-use change. The model is documented in Hertel (1997).

ADAGE: The Applied Dynamic Analysis of the Global Economy (ADAGE) model developed by the Research Triangle Institute (RTI) is a dynamic CGE model with the ability to analyze climate change mitigation policies at different geographic scales: globally, nationally, regionally and at the state level in the U.S. The model is divided into different modules depending on the regional scope desired. These modules use datasets from different sources such as IMPLAN at the regional level and GTAP at the global level. The model's theoretical structure is the same for the different modules. The model has been documented in Ross (2008).

IGEM: The Intertemporal General Equilibrium Model (IGEM) of the U.S. is a multi-sector, dynamic model with perfect foresight. The parameters used in the model are estimated econometrically using time series spanning 50 years. The econometric approach offers an advantage over SAM-based CGEs in the sense that it does not impose restrictions on the parameters describing technology and preferences. On the contrary, using historical data, the model derives responses of producers and consumers to changes in energy, environmental, trade and tax policies. The models documentation can be found in Goettle et al. (2012).

3. SOCIAL ACCOUNTING MATRIX (SAM)

3.1 IMPLAN SAM

A method has been developed for rapidly constructing a SAM for regions consisting of subsets of U.S. states (including the possibility of all states). By developing a method for constructing a SAM, rather than a single SAM, we can rapidly implement an aggregation scheme appropriate for a particular analysis. For example, a SAM corresponding to a particular subset of U.S. states can be rapidly generated.

SAMs employ, as a primary source, data from the Impact Analysis for Planning (IMPLAN) Version 3.0, reflecting economic activity for 2008. The IMPLAN dataset contains information for 440 activity sectors at the national, state and county level. Any generic SAM reflects transactions among sectors of the economy as well as non-market transactions such as transfers to and from the government. The basic structure of an IMPLAN SAM is shown in figure 3.1. For a more detailed structure and the contents of every cell (transaction) please refer to MIG (1998) or figure A.2 in the appendix with its respective definitions in table A.3.

Any basic IMPLAN SAM contains the following institutional entities:

- Households (categories based on annual income of thousands of U.S. dollars):
  - less than 10,
  - between 10 and 15,
  - between 15 and 25,
  - between 25 and 35,
  - between 35 and 50,
  - between 50 and 75,
  - between 75 and 100,
  - between 100 and 150, and

    - more than 150.

- Government:
    - federal
        * defense,
        * non-defense,
        * investment,
    - state and local
        * education,
        * non-education,
        * investment.
- Enterprises (representative account)
- Investment
- Inventory
- Trade:
    - Rest of the U.S. (for regional aggregations)
    - Rest of the World (for regional and national aggregation).

3.1.1 Aggregation of activities and regions

There are two types of aggregation for this study that were performed by IMPLAN:

Activity and commodity aggregation: since some of the 440 activities and commodities share common aspects,[1] these were aggregated into 32 representative

[1] Such as technology, inputs, outputs, regional location, etc.

		Activities	Commodities	Factors	Institutions	Trade		TOTAL
						Rest of World	Rest of US	
Activities			Domestic Commodity Output			Commodity Exports	Commodity Exports	Incomes
Commodities		Domestic Intermediate Commodity Inputs			Domestic Institutional Commodity Consumption			
Factors		Value-added						
Institutions			Domestic Institutional Commodity Production	Factor Income to Institutions	Institutional Transfers	Institutional Commodity Exports and Transfers	Institutional Commodity Exports and Transfers	
Trade	Rest of World	Commodity Imports		Factor Imports and Transfers	Institutional Commodity Imports and Transfers	Trans-shipments		Imports
	Rest of US	Commodity Imports		Factor Imports and Transfers	Institutional Commodity Imports and Transfers			
TOTAL		Expenditures				Exports		

Figure 3.1. Basic structure of an IMPLAM SAM

activities and commodities as shown in table A.2. Following the main objective of this study, to analyze land use change, all the activities and commodities related to agriculture and forestry were left at their original IMPLAN disaggregation levels.[2] The crops included in the oilseed, grain, and all other crop farming are listed in table A.4 in the appendix.[3]

$$implan \supseteq \begin{cases} a \\ c \end{cases}, \tag{3.1}$$

where a and c are the sets of the 32 aggregated activities and commodities, respectively; and *implan* is the set of the 440 activities and commodities.

Regional aggregation: the state-level aggregation on which this study is based upon is presented in figure 3.2. The principal selection criteria was the potential to convert great agricultural land extensions to afforestation based on existing forest-type patterns. The Southern, Northeastern, Southwestern and Midwestern regions of the U.S. offer the greatest potential for afforestation due to their vast and continuous extensions of crop and pastureland. The Western region (Pacific and Mountains) was left out due to the predominant presence of high-value crops (fruits and vegetables), existing private and public forest areas and desertic regions.

$$region \subseteq states, \tag{3.2}$$

where *region* is a set representing the regional aggregation and *states* is a set containing the 48 states included in the contiguous U.S.

Once the activity and regional aggregations have been determined, IMPLAN automatically exports 26 files with the ”dat” extension. Refer to MIG (1998) for a detailed description of each of the 26 files. The core of these 26 files represent

[2]Only the “other agriculture” sector was composed of many other IMPLAN sectors such as vegetable and melon (IMPLAN code 3); fruit (4); tree nut (5); greenhouse, nursery, and floriculture (6); poultry and egg (13); animal production, except cattle poultry and eggs (14); forest nurseries, forest products, and timber tracts (15); fishing (17); hunting and trapping (18); and support activities for agriculture and forestry (19).

[3]For a more detailed list of the IMPLAN sectors, visit: http://implan.com

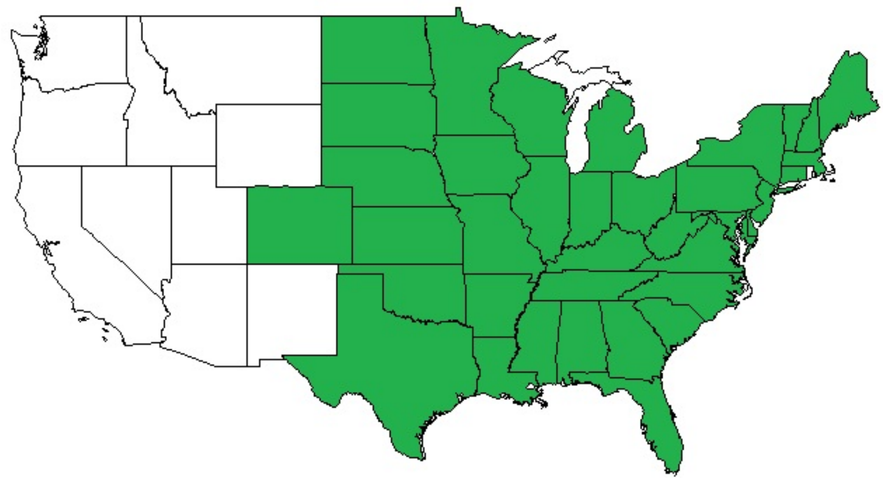


Figure 3.2. Regional aggregation (in green color) considered for the analysis of the impacts of a forest-based carbon sequestration program on land-use change

the submatrices included in figure 3.1 (i.e. a basic SAM). A basic IMPLAN SAM includes two aggregated accounts for foreign and domestic trade, respectively. The rest of the files are complementary and contain more dissagregated information on employment, foreign and domestic trade.[4]

Complying with CGE-modeling conventions, the General Algebraic Modeling System (GAMS) was used to include the trade information from the "satellite submatrices" into the basic SAM.[5]

3.1.2 IMPLAN SAM trade adjustments

The satellite submatrices obtained from IMPLAN represent trade as transacions between activities, institutions and commodities from and to outside regions (rest of

[4]These complementary files will be called "satellite submatrices."

[5]The GAMS code to build a basic SAM and to include the trade information from the satellite submatrices was obtained from Washington State University's School of Economic Sciences website for Regional CGE Models (Holland, Stodick, and Devadoss 2010). Three files were used: aggreg.gms, check.gms and map.gms. The three files were modified and compressed into a single GAMS program that produces a SAM.gdx file for any sectorial and regional aggregation from IMPLAN.

the US and the world). However, following CGE modeling conventions, trade needs to be represented in the SAM as transactions between commodities and outside regions. Hence, the transactions obtained from the IMPLAN satellite submatrices were added to their respective activity and institutional consumption and production submatrices.

Considering that a is a set that includes the IMPLAN aggregated activities; c is a set including the commodities produced by the aggregated activities; va is a set including IMPLAN's value-added accounts; $inst$ is a set representing households, governments, enterprises, investment and inventory; $sectors$ is a macro set that includes a, c, va and $inst$; $destin$ and $source$ are sets representing trade to and from outside regions, respectively; sam represents the transactions in the basic SAM and SAM in the modified SAM; $imports$ and $exports$ represent trade transactions from the satellite submatrices; $trade$ represents commodity trade transactions by activities; $trade\&transf$ represents an aggregated value including commodity trade and transfers by institutions and outside regions; $va\,trade$ represents value-added factor imports and is not changed in the modified SAM; $TRADE$ and $TRANSFERS$ represent the modified commodity trade and institutional transfers to and from the outside regions, respectively (see figure 3.3 and figure 3.4). Then, for exports:

$$SAM_{a,c} = sam_{a,c} + \sum_{destin} exports_{a,c,destin}, \tag{3.3}$$

$$SAM_{inst,c} = sam_{inst,c} + \sum_{destin} exports_{inst,c,destin}, \tag{3.4}$$

$$TRADE_{c,destin} = \sum_{sector} exports_{sector,c,destin}, \tag{3.5}$$

$$TRANSFERS_{inst,destin} = trade\&transf_{inst,destin} - \sum_{c} exports_{inst,c,destin}. \tag{3.6}$$

And for imports:

$$SAM_{c,a} = sam_{c,a} + \sum_{source} imports_{c,a,source}, \tag{3.7}$$

$$SAM_{c,inst} = sam_{c,inst} + \sum_{source} imports_{c,inst,source}, \tag{3.8}$$

$$TRADE_{source,c} = \sum_{sector} imports_{c,sector,source}, \tag{3.9}$$

$$TRANSFERS_{source,inst} = trade\&transf_{source,inst} - \sum_{c} imports_{c,inst,source}. \tag{3.10}$$

As shown in equations (3.3) and (3.7), the trade transactions in the satellite submatrices are added to the activity production and consumption submatrices, respectively. Hence, the transactions in these submatrices are a composite of domestic and foreign commodities. The same is done for the institutional production and consumption submatrices and shown in equations (3.4) and (3.8), respectively. Then, commodity exports and imports accross sectors in the satellite submatrices are allocated to the commodity accounts as shown in equations (3.5) and (3.9), respectively. This specification follows previous CGE-modeling conventions. And finally, the residual transactions are allocated as institutional transfers coming from and going to outside regions as shown in equations (3.6) and (3.10), respectively.[6]

3.1.3 IMPLAN SAM institutional transfers adjustments

Any regional IMPLAN SAM reflected negative transfers from low-income households to the government and from the government to high-income households. The former could be modeled as subsidies on household income taxes in the CGE. However, to obtain a SAM with positive transfers and for SAM-balancing purposes,

[6]Since some residual transfers from domestic institutions to outside regions were negative, they were subtracted from their counterparts (transfers from outside regions to domestic institutions) to obtain a SAM with only positive transfers with outside regions.

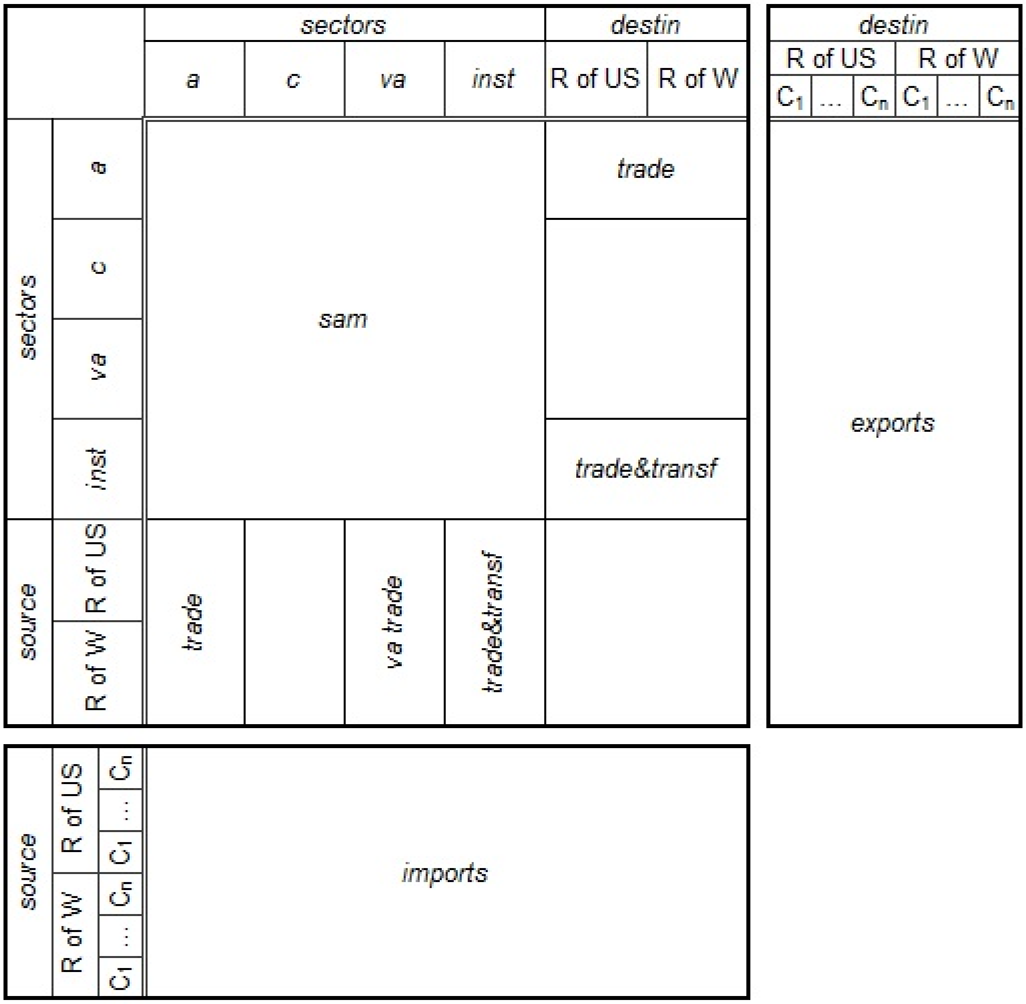


Figure 3.3. Basic IMPLAN SAM trade adjustment with satellite submatrices

these were subtracted from their counterpart transactions. Hence, the final SAM reflected positive transfers from the government to low-income households and from high-income households to the government.

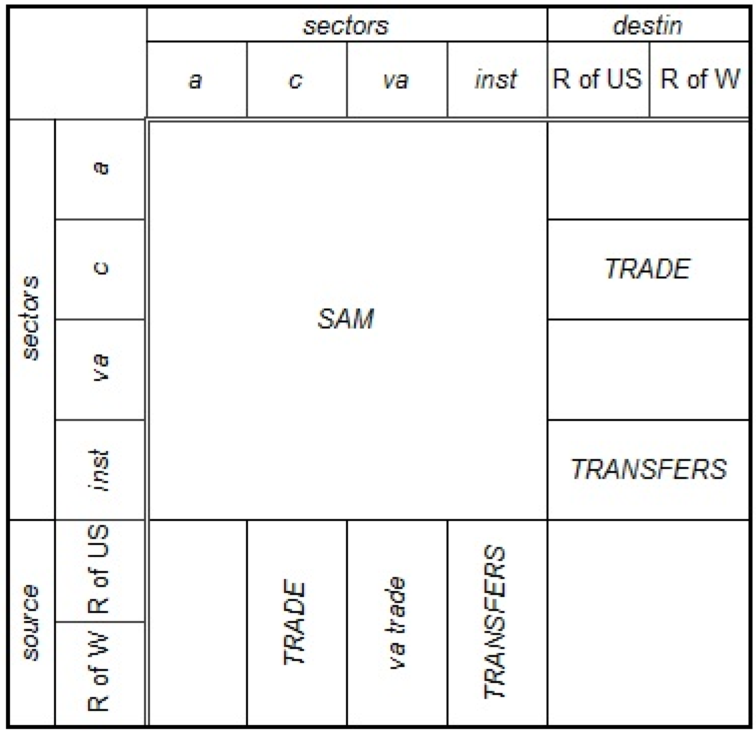


Figure 3.4. Complete trade structure including information from satellite submatrices obtained from an IMPLAN SAM

3.2 Balancing the IMPLAN SAM

By convention, a balanced SAM is a square matrix where row totals (or total receipts by account) should equal column totals (or total payments by account). According to Pyatt (1988), T is a square matrix of SAM transactions where $t_{i,j}$ is a payment from column account j to row account i, then:

$$T = [t_{i,j}]\,, \tag{3.11}$$

$$y_i = \sum_j t_{i,j} = \sum_j t_{j,i}. \tag{3.12}$$

Equations (3.11) and (3.12) show that for an adequately balanced SAM, column and row totals (y_i) should be equal. In other words, the difference should be zero.

Any basic IMPLAN SAM following any regional and sectorial aggregation, fulfilled all of these requirements to a certain degree. The differences between row and column totals were close enough to zero to appropriately represent the transaction flows in a deteremined regional economy. However, for CGE-modeling purposes, more specifically for the calibration stage, the difference between row and column totals had to be more accurately refined. Hence, the cross entropy (CE) SAM estimation technique shown in Fofana, Lemelin, and Cockburn (2005) and Robinson, Cattaneo, and El-Said (2000) was used to balance the basic regional IMPLAN SAM. The GAMS code containing the CE-balancing program was obtained from Robinson and El-Said (2000) and slightly modified to conform to the structure of a mixed complementarity problem (MCP) and be solved by the PATH solver.

The CE technique estimates a matrix of coefficients ($A_{i,j}$) from the SAM transactions and column totals:

$$A_{i,j} = \frac{t_{i,j}}{y_j}. \tag{3.13}$$

Assuming that the coefficients obtained from the modified IMPLAN SAM form a prior of equation (3.13), namely $\overline{A}$, and that the column totals (y^*) have been exactly specified and estimated, the objective function to be minimized reflects the CE distance between two coefficient matrices, the prior ($\overline{A}$) and the one to be estimated (A):

$$min_{\{A\}} I = [\sum_i \sum_j A_{i,j} \ln A_{i,j} - \sum_i \sum_j A_{i,j} \ln \overline{A_{i,j}}], \tag{3.14}$$

subject to:

$$\sum_j A_{i,j} y^* = y_i^*, \tag{3.15}$$

$$\sum_j A_{j,i} = 1 \text{ and } 0 \leq A_{j,i} \leq 1. \tag{3.16}$$

The final balanced basic IMPLAN SAM was then modified to include capital, labor, land and a correct estimation of indirect business taxes as will be explained in section §3.3, section §3.4 and section §3.5, respectively.

3.3 Factor decomposition

A difficulty experienced in the construction of the SAM was the decomposition of labor and capital from the somewhat vague value-added categories obtained from IMPLAN. The IMPLAN value-added categories are:

- employee compensation,
- other property income,
- proprietary income and
- indirect business taxes.

In Koh (1991), employee compensation, proprietary income and other property income were considered the equivalents of labor, capital and land returns, respectively. However, according to Marcouiller, Schreiner, and Lewis (1993) and Vargas et al. (2010), this decomposition method underestimates capital returns and overestimates labor returns since proprietary income is defined as income from self employment. In other words, proprietary income includes a share of both capital and labor returns.

For this study and as depicted in figure 3.5, employee compensation and other property income were considered part of labor and capital returns, respectively. A methodology was developed to partition proprietary income into labor and capital returns. Land, as explained in more detail in 3.5.6, was treated differently since IMPLAN reports payments to land as the intermediate use of a real estate commodity by different activities (Olson 2011a). Hence, land rents were a composition of this real estate commmodity demand and a share of the modified capital account as will be explained later and as depicted in figure 3.5.

3.3.1 Division of proprietary income into labor and capital returns

Kravis (1959); Christensen (1971); Hanson and Robinson (1991); and Gollin (2002) present and analyze a number of approaches to separate capital and labor

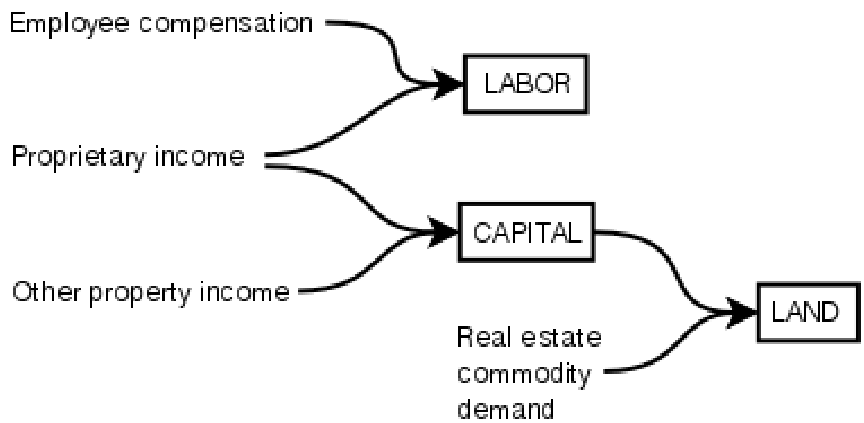


Figure 3.5. IMPLAN factors decomposition into the more intuitive accounts of factors of production

returns from proprietary income. It is in Christensen (1971) that by using the "competitive wage" approach, the author concluded that under an appropriate set of assumptions the rate of return on noncorporate capital and on corporate capital are the same. Under these premises, the "competitive wage" approach was used in this study. The basic division is achieved by imputing the average annual wage for employees as a proxy for a competitive wage to self-employed workers (or proprietors), and allocating the residual proprietary income to capital. The basic formulation is the following:

$$PROPINC_{implan} = LABINC_{implan} + CAPINC_{implan}, \tag{3.17}$$

$$WAGE_{implan} = \frac{COMP_{implan}}{WS_{implan}}, \tag{3.18}$$

$$LABINC_{implan} = (WAGE_{implan}) * (PROP_{implan}), \tag{3.19}$$

$$\%LABINC_{implan} = \frac{LABINC_{implan}}{PROPINC_{implan}}, \tag{3.20}$$

$$\%CAPINC_{implan} = 1 - \%LABINC_{implan}, \tag{3.21}$$

where *implan* is a set containing all 440 IMPLAN activities, $PROPINC$ represents proprietary income, $LABINC$ is proprietary labor income, $CAPINC$ is proprietary capital income, $WAGE$ is the average annual wage for employees, $COMP$ is employee compensation, WS is the number of wage and salary employees, $PROP$ is the number of proprietors and will be explained in more detail in the next subsection, $\%LABINC$ and $\%CAPINC$ are the labor and capital shares of proprietary income, respectively. [7] As shown in equation (3.18), the average annual wage for employees is obtained by dividing employee compensation by the number of employees working in the regional activity. Employee compensation was obtained from the IMPLAN matrices. However, the numbers of proprietors and employees were more difficult to estimate and additional external (to IMPLAN) datasets were needed as explained below.

3.3.2 Number of employees and proprietors

IMPLAN's employment figures include wage and salary employees, and proprietors. IMPLAN uses three different public datasets to obtain employment estimates:

1. Quarterly Census of Employment and Wages (QCEW), which is part of the Bureau of Labor Statistics (BLS);
2. County Business Patterns (CBP) run by the U.S. Department of Census; and
3. Regional Economic Information System (REIS), which is part of the Bureau of Economic Analysis (BEA).

However, there is no direct way to obtain the number of employees and proprietors from IMPLAN (Thordvalson 2011). Hence, shares for proprietors and employees were estimated out of IMPLAN's employment figures for each state and activity using BEA (2011) and BLS (2011).

[7] Instead of using absolute values, shares were used to account for possible negative proprietary income values coming from the IMPLAN matrix.

REIS is the most complete dataset since it reports total employment and wage and salary employees for each state and activity. The reports are the following:

- SA25 for total employment and
- SA27 for wage and salary employees.

The number of proprietors can be obtained by subtracting SA27 from SA25. The problem is that REIS reports at the three-digit North American Activity Classification System (NAICS) level. For this study, a finer disaggregation of the agricultural activities was needed (i.e. five- and six-digit NAICS levels). Hence, the IMPLAN employment figures were used to disaggregate the total employment (SA25) report from REIS to the finest IMPLAN activity disaggregation. The QCEW wage and salary employee figures were used to disaggregate the wage and salary employees (SA27) report from REIS to the finest possible disaggregation obtained from QCEW (five- and six-digit NAICS). The disaggregated figures are simple percentages estimated using the totals from each dataset (IMPLAN and QCEW):

$$\%QCEW\_WS_{state,implan} = \frac{QCEW\_WS_{state,implan}}{\sum_{implan} QCEW\_WS_{state,implan}}, \tag{3.22}$$

$$\%IMPLAN\_EMP_{state,implan} = \frac{IMPLAN\_EMP_{state,implan}}{\sum_{implan} IMPLAN\_EMP_{state,implan}}, \tag{3.23}$$

where $state$ is a set including all the states in the U.S., $implan$ is a set that includes the IMPLAN activities included within the three-digit NAICS aggregation reported in REIS, $QCEW\_WS$ represents the number of wage and salary employees obtained in QCEW and $IMPLAN\_EMP$ represents total employment (including wage and salary employees and proprietors) obtained in IMPLAN.

However, the three-digit NAICS totals from REIS were used as control totals to be consistent:

$$REIS\_WS_{state,implan} = \%QCEW\_WS_{state,implan} * REIS\_WS_{state,reis}, \tag{3.24}$$

$$REIS\_EMP_{state,implan} = \%IMPLAN\_EMP_{state,implan} * REIS\_EMP_{state,reis}, \tag{3.25}$$

$$REIS\_PROP_{state,implan} = REIS\_EMP_{state,implan} - REIS\_WS_{state,implan,} \tag{3.26}$$

where $reis$ is a set that includes the three-digit NAICS aggregated activities reported in REIS, $REIS\_WS$ represents the wage and salary employees, $REIS\_PROP$ the number of proprietors, and $REIS\_EMP$ total employment.

With the number of proprietors and employees per activity per state, to be consistent with IMPLAN's total employment data, shares were obtained for proprietors and employees for the 440 IMPLAN activities and 48 states:[8]

$$\%REIS\_PROP_{state,implan} = \frac{REIS\_PROP_{state,implan}}{REIS\_EMP_{state,implan}}, \tag{3.27}$$

$$\%REIS\_WS_{state,implan} = \frac{REIS\_WS_{state,implan}}{REIS\_EMP_{state,implan}}. \tag{3.28}$$

The final number of proprietors ($PROP$) and employees (WS) per IMPLAN activity ($implan$) per state ($state$) was obtained by multiplying the REIS shares by the total employment figures obtained from IMPLAN:

$$PROP_{state,implan} = \%REIS\_PROP_{state,implan} * IMPLAN\_EMP_{state,implan}, \tag{3.29}$$

$$WS_{state,implan} = \%REIS\_WS_{state,implan} * IMPLAN\_EMP_{state,implan}. \tag{3.30}$$

The previous procedure was followed for the IMPLAN agricultural activities. To obtain the number of proprietors ($PROP$) and employees (WS) for the rest of the aggregated activities, the following procedure was followed:

$$\%REIS\_PROP_{state,reis} = \frac{REIS\_PROP_{state,reis}}{REIS\_EMP_{state,reis}}, \tag{3.31}$$

[8] A GDX file was created containing the shares of employees and proprietors. This GDX file was then included into the extended IMPLAN SAM, process that will be explained later on.

$$\%REIS\_WS_{state,reis} = \frac{REIS\_WS_{state,reis}}{REIS\_EMP_{state,reis}}, \tag{3.32}$$

$$PROP_{state,implan} = \%REIS\_PROP_{state,reis} * IMPLAN\_EMP_{state,implan}, \tag{3.33}$$

$$WS_{state,implan} = \%REIS\_WS_{state,reis} * IMPLAN\_EMP_{state,implan}. \tag{3.34}$$

3.3.3 Adding capital and labor to the SAM

The shares of employees and proprietors had to be aggregated (regionally and by activity) since they were estimated per state and activity (for 440 IMPLAN activities) and the IMPLAN SAM was obtained for an arbitrary regional aggregation of states and activities.[9] The number of proprietors and employees for the regional aggregation were obtained as following:

$$PROP_{implan} = \sum_{region} PROP_{state,implan}, \tag{3.35}$$

$$WS_{implan} = \sum_{region} WS_{state,implan}, \tag{3.36}$$

where *region* is a subset of *state* including the states within the regional aggregation.

The regional number of proprietors and employees were aggregated for every aggregated activity in the following manner:

$$PROP_{a} = \sum_{a} PROP_{implan}, \tag{3.37}$$

$$WS_{a} = \sum_{a} WS_{implan}, \tag{3.38}$$

where a is a subset of *implan* including the aggregated activities.

Using the shares obtained from equations (3.37) and (3.38) and using the IMPLAN employment figures, the numbers of proprietors and employees were esti-

[9]A GAMS program was developed to include the GDX file containing the shares of employees and proprietors into the extended IMPLAN SAM.

mated, respectively. With these numbers, the estimation of equations (3.18), (3.19), (3.20) and (3.21) was straigforward.

The labor ($LABINC$) and capital ($CAPINC$) income figures obtained from proprietary income ($PROPINC$) are added to employee compensation ($COMP$) and other property income ($OPTI$) to create the more intuitive labor ($LABOR$) and capital ($CAPITAL$) accounts, respectively:

$$LABINC_a = \%LABINC_a * PROPINC_a, \tag{3.39}$$

$$CAPINC_a = \%CAPINC_a * PROPINC_a, \tag{3.40}$$

$$LABOR_a = LABINC_a + COMP_a, \tag{3.41}$$

$$CAPITAL_a = CAPINC_a + OPTI_a, \tag{3.42}$$

where $OPTI$ represents other property type income, $\%LABINC$ was estimated in equation (3.20) and $\%CAPINC$ was estimated equation (3.21).

The only exception to the previous formulation was the logging activity (Alogg). All proprietary income was assigned to the capital account. The reason for this was to accommodate the estimated forest land rents into the SAM using a share of the payments from the logging activity to the capital account as will be explained later in 3.5.6. Hence:

$$LABOR_{'Alogg'} = LABINC_{'Alogg'}, \tag{3.43}$$

$$CAPITAL_{'Alogg'} = PROPINC_{'Alogg'} + OPTI_{'Alogg'}, \tag{3.44}$$

where $'Alogg'$ is an element of a and represents the logging activity.

Following the SAM conventions, the two new row totals (capital and labor) needed their column counterparts. To include the two new columns into the SAM, two aspects needed consideration: the distribution of payments from the proprietary income column to the different accounts and the equality between row and column totals.

To achieve the first one, shares were estimated of the different payments from the proprietary income account ($PROPPMT$) as following:

$$\%PROPPMT_i = \frac{PROPPMT_i}{\sum_j PROPPMT_i}, \tag{3.45}$$

where i is the set of row accounts.

To achieve the second, the additional income added to the old employee compensation and other property income accounts is distributed among the receiving accounts (rows) using the shares estimated in equation (3.45). The additional income values are estimated as the difference between the row total of the new labor and capital accounts and the column total of the old employee compensation and other property income accounts, respectively:

$$DIFFLABOR = \sum_a LABOR_a - \sum_i COMPPMT_i, \tag{3.46}$$

$$DIFFCAPITAL = \sum_a CAPITAL_a - \sum_i OPTIPMT_i. \tag{3.47}$$

where $COMPPMT$ and $OPTIPMT$ are the payments from the employee compensation and other property income accounts to the i accounts. To maintain a consistent distribution of payments from the old proprietary income to the receiving accounts (rows), the differences were multiplied by the shares:

$$LABPMT_i = (\%PROPPMT_i * DIFFLABOR) + COMPPMT_i, \tag{3.48}$$

$$CAPPMT_i = (\%PROPPMT_i * DIFFCAPITAL) + OPTIPMT_i, \tag{3.49}$$

where $LABPMT$ and $CAPPMT$ are the payments from the new labor and capital accounts to the i row accounts. By following this procedure the row totals and the column totals of the new labor and capital accounts were set equal.

3.4 Indirect business taxes decomposition

The indirect business taxes (IBT) account, now termed "taxes on production and import less subsidies" by NIPA, is a combination of excise, sales and property taxes plus other non-tax charges such as fees, fines, licenses and permits. For the purposes of SAM and CGE modeling, the IBT account of any production activity includes:

- taxes paid on the sale of the activity's products,
- factor taxes charged on the production factors used,
- production taxes charged on the output produced and
- import duties charged on the imported commodities used as inputs.

All these categories are aggregated by IMPLAN into a single value for each production activity.

For CGE modeling purposes, this aggregation of the IBT account by activity poses a problem. When considering the Armington convention of imperfect substitutability between imports and domestic supply, import duties should be reflected in the SAM as payments from the commodity accounts to an import duty account (Armington 1969). Hence, import duties had to be estimated by commodity and disaggregated from the aggregate IBT payment by activity. Furthermore, since IMPLAN data are based on the input-output tables published by BEA, Dixon and Maureen (2001) and Giesecke (2009) have stated that IMPLAN data replicates the misallocation of sales taxes where these taxes are attributed to the activities collecting them and not to the activities producing the commodities on which the taxes are imposed. The collecting activities are the retail and wholesale trade activities.

Hence, sales taxes needed to be redistributed from the collecting activities to the appropriate producing activities.

The total import duties, wholesale and retail sales taxes used as controls were obtained from IMPLAN under the option “Industry detail SAM files - GAMS single file.” This GAMS file provides a SAM with detailed receipt transactions and categorizes them by transaction types. The payments from the IBT account to the different government entities show the totals for sales taxes, property taxes, trade duties, etc.

3.4.1 Import duties

According to Dixon and Maureen (2001), the IMPLAN SAM contains the total amount of import duties ($TOTIMPTAX$) within the wholesale trade activity payment to the IBT account ($WHOLEIBT$). The total amount of import duties was obtained from the GAMS file mentioned previously. $NWHOLEIBT$ represents the new wholesale trade payment to the IBT account after subtracting total import duties, then:

$$NWHOLEIBT = WHOLEIBT - TOTIMPTAX. \tag{3.50}$$

After the wholesale trade activity's column total had been altered, its row counterpart had to be modified as well. To account for this alteration, the value of the production of the wholesale trade commodity ($WHOLEPROD$) by its respective activity had to be modified:

$$NWHOLEPROD = WHOLEPROD - TOTIMPTAX, \tag{3.51}$$

where $NWHOLEPROD$ is the new value of the production of the wholesale trade commodity by its respective activity.

Following conventional SAM structures, this total amount of duties should be distributed and reflected as payments from the commodity accounts (columns) to an import tax account (row). To distribute this total amount of import duties to the different commodity accounts, shares were estimated using GTAP import duty rates (Dimaranan and McDougall 2002). An approximate mapping was estimated between GTAP and IMPLAN activities using the International Standard Industry Classification (ISIC) Rev. 3 and NAICS.[10]

Assuming that $TOTIMPTAX$ is the total import duties extracted from the GAMS single file, $IMPTAX$ represents the GTAP duty rates, $COMIMP$ the commodity imports from the rest of the world, $IMPTAXPAID$ the total import taxes paid by commodity (*comm*), $\%IMPTAX$ the percentage of total import duties paid by commodity and $IMPTAXSAM$ the import tax payment by commodity to the import tax account (row) in the SAM, then:

$$IMPTAXPAID_c = COMIMP_c * IMPTAX_c, \tag{3.52}$$

$$\%IMPTAX_c = \frac{IMPTAXPAID_c}{\sum_c IMPTAXPAID_c}, \tag{3.53}$$

$$IMPTAXSAM_c = \%IMPTAX_c * TOTIMPTAX. \tag{3.54}$$

Now that the total amount of duties has been distributed to the different commodities and allocated to the new import tax account, the column totals of the commodity accounts have been altered. To account for this alteration in its row counter-

[10]Correspondence tables between ISIC Rev.3 and NAICS can be found on the United Nations Statistics Division's website under Statistical Databases. The correspondence between GTAP and ISIC Rev. 3 can be found in GTAP's database manual. Correspondence between IMPLAN and NAICS can be found on IMPLAN's website.

parts, the production value of the taxed (import duty) commodities ($COMPROD$) by its respective activities had to be modified as follows:[11]

$$NCOMPROD_c = COMPROD_c - IMPTAXSAM_c, \tag{3.55}$$

where $NCOMPROD$ is the modified production value of a commodity by its respective activity.

Now that the row totals of the activity accounts have been altered, its column counterparts had to be modified. To account for this modification and using a one-to-one mapping from commodity to activity (a), the import duties paid by commodity in the SAM ($IMPTAXSAM$) were subtracted from the consumption of the wholesale trade commodity (row) by the activities being taxed ($WHOLE$):

$$NWHOLE_a = WHOLE_a - IMPTAXSAM_a, \tag{3.56}$$

where $NWHOLE$ is the modified usage value of the wholesale trade commodity.

As a result, the total import duties allocated to the wholesale trade activity were distributed and reflected as payments from the commodity accounts to a new import tax account.

As a final step, since $WHOLEIBT$ was modified to $NWHOLEIBT$, the row total of the IBT account was altered. Hence, its column counterpart needed to be modified. To achieve this, $TOTIMPTAX$ was subtracted from the payment of the IBT account to the federal government non-defense division. The new import tax account (column) payment to the federal government non-defense division is equal to $TOTIMPTAX$.

[11] For this, a one-to-one commodity-to-activity mapping had to be developed. Any IMPLAN SAM allows any specific activity to produce different commidities; hence, the production submatrix is not a diagonal matrix. However, to alter the production value of a taxed commodity, the modifications took place only diagonally.

3.4.2 Retail indirect business taxes

To correct BEA's misallocation of sales taxes to the retail activity, a portion of the payments from the retail activity (column) to the IBT account (row) needed to be subtracted and reallocated to the respective producing activities and institutions. According to Dixon and Maureen (2001), retail taxes paid by all the different producing activities and institutions accounted for approximately 28% of total sales taxes in 1992. The total amount of sales taxes ($TOTSALETAX$) in 2008 was obtained from the GAMS file mentioned previously. Assuming that the percentage of retail taxes does not change in 2008, the total amount of retail taxes ($TOTRETAILTAX$) was estimated as following:

$$TOTRETAILTAX = TOTSALETAX * 0.28. \tag{3.57}$$

The demand shares of the retail trade commodity ($\%RETAIL$) by different activities and institutions was used as a proxy to distribute $TOTRETAILTAX$ paid by activities (a) and institutions ($inst$):

$$TOTRETAIL = \sum_{a} RETAIL_a + \sum_{inst} RETAIL_{inst}, \tag{3.58}$$

$$\%RETAIL_a = RETAIL_a / TOTRETAIL, \tag{3.59}$$

$$\%RETAIL_{inst} = RETAIL_{inst} / TOTRETAIL, \tag{3.60}$$

where $RETAIL$ is the demand of the retail commodity by activity and institution and $TOTRETAIL$ is the total demand of the retail commodity.

An approximate and more accurate distribution of the misallocated sales taxes to their respective producing activities and institutions was achieved by multiplying the shares by $TOTRETAILTAX$:

$$RETAILTAX_a = \%RETAIL_a * TOTRETAILTAX, \tag{3.61}$$

$$RETAILTAX_{inst} = \%RETAIL_{inst} * TOTRETAILTAX, \tag{3.62}$$

where $RETAILTAX$ is the approximation of the sales taxes paid by activities and institutions that was misallocated and charged to the retail trade activity.

Subtracting TOTRETAILTAX from the IBT payments of the retail trade activity:

$$NRETAILIBT = RETAILIBT - TOTRETAILTAX, \tag{3.63}$$

where $NRETAILIBT$ and $IBTRETAILIBT$ are the the new and old IBT payments of the retail trade activity, respectively. Since the column sum of the retail trade activity was modified, its row counterpart needed modification as well. Hence, $TOTRETAILTAX$ was subtracted from the production value of the retail trade commodity by its respective activity:

$$NRETAILPROD = RETAILPROD - TOTRETAILTAX, \tag{3.64}$$

where $NRETAILPROD$ and $RETAILPROD$ are the new and the old production values of the retail trade commodity by its activity, respectively.

After the previous manipulation, the column sum of the retail trade commodity was modified; hence, its row counterpart needed modificiation. To achieve this, $RETAILTAX$ by activity and institution was subtracted from the demand of the retail commodity by activities and institutions ($RETAIL$) and added to the IBT payments of these activities and institutions:

$$NRETAIL_a = RETAIL_a - RETAILTAX_a, \tag{3.65}$$

$$NRETAIL_{inst} = RETAIL_{inst} - RETAILTAX_{inst}, \tag{3.66}$$

$$NIBT_a = IBT_a + RETAILTAX_a, \tag{3.67}$$

$$NIBT_{inst} = IBT_{inst} + RETAILTAX_{inst}, \tag{3.68}$$

where $NRETAIL$ represents the modified retail commodity demand and $NIBT$ the modified payments to the IBT account. The original IMPLAN SAM only reflected payments to the IBT account from activities, not from institutions. However, since sales taxes were appropriately reallocated from being paid by the retail trade activity to the producing entities (activities and institutions), the modified SAM reflects payments to the IBT account from institutions. Since IBT payments from activities include sales taxes among other taxes, the IBT payments from institutions are composed entirely of the reallocated sales taxes.

3.4.3 Wholesale indirect business taxes

According to Dixon and Maureen (2001), BEA's misallocation of sales taxes are also reflected in the wholesale trade activity; hence, they needed to be modified. The procedure followed was the same as with the retail sales taxes misallocation. However, the total amount of sales taxes misallocated to the wholesale trade activity ($TOTWHOLETAX$) was obtained by setting it equal to $NWHOLEIBT$ (previously estimated) representing the modified IBT payment from the wholesale trade activity. Hence, the reallocation was undertaken as following:

$$TOTWHOLETAX = NWHOLEIBT, \tag{3.69}$$

$$TOTWHOLE = \sum_{a} NWHOLE_a + \sum_{inst} NWHOLE_{inst}, \tag{3.70}$$

$$\%WHOLE_a = NWHOLE_a / TOTWHOLE, \tag{3.71}$$

$$\%WHOLE_{inst} = NWHOLE_{inst} / TOTWHOLE, \tag{3.72}$$

$$WHOLETAX_a = \%WHOLE_a * TOTWHOLETAX, \tag{3.73}$$

$$WHOLETAX_{inst} = \%WHOLE_{inst} * TOTWHOLETAX, \tag{3.74}$$

$$NNWHOLEIBT = NWHOLEIBT - TOTWHOLETAX, \tag{3.75}$$

$$NNWHOLEPROD = NWHOLEPROD - TOTWHOLETAX, \tag{3.76}$$

$$NNWHOLE_a = NWHOLE_a - WHOLETAX_a, \tag{3.77}$$

$$NNWHOLE_{inst} = NWHOLE_{inst} - WHOLETAX_{inst}, \tag{3.78}$$

$$NNIBT_a = NIBT_a - WHOLETAX_{a,} \tag{3.79}$$

$$NNIBT_{inst} = NIBT_{inst} - WHOLETAX_{inst}, \tag{3.80}$$

where $TOTWHOLE$ represents total wholesale trade commodity demand by activities and institutions, $NNWHOLE$ twice-modified wholesale trade commodity demand, $\%WHOLE$ demand shares of the wholesale trade commodity, $WHOLETAX$ the approximation of the sales taxes paid by activities and institutions that was misallocated and charged to the wholesale trade activity, $NNWHOLEIBT$ twice-modified IBT payment from the wholesale trade activity, $NNWHOLEPROD$ twice-modified production value of the wholesale trade commodity by its activity and $NNIBT$ twice-modified payments to the IBT account.

3.5 Land rent decomposition

Since the competition for the productive factor of land is the major component of this study, the estimation of land rents and their inclusion into a regional IMPLAN SAM was treated extensively in this study. As mentioned before in section §3.3, IMPLAN reports payments to land as an intermediate demand of a real estate commodity (i.e. IMPLAN sector 3360). Hence, land rents were included into the SAM as a composition of these payments coming from a group of agriculture-related IMPLAN activities (explained in 3.5.6) and the capital account.

As will be explained below, land rent payments were estimated for different land use categories from national and public databases sponsored by the U. S. Department of Agriculture (USDA). These land use categories were aggregated and matched with the agricultural IMPLAN activities. Besides the land use division, land was also categorized following an agronomic criteria into the Major Land Resource Areas (MLRA) classification system, explained in 3.5.5. Since there is no publicly available database containing the land rent payments from the different land use categories to the MLRAs, rent payments had to be estimated at the county level and each county was assigned to the predominant MLRA as will be explained in 3.5.5 on page 67. The final matrix with land rents looked like figure 3.6.

According to the USDA 2007 Census of Agriculture, the four major land use categories for agricultural land in the U.S. are cropland, pastureland, land enrolled in the Conservation Reserve Program (CRP) and forestland. Rents and acreage figures were obtained for each land use category. [12]

[12]Rents and acreage for cropland and pastureland were divided into a finer disaggregation set following the IMPLAN classification system for activities.

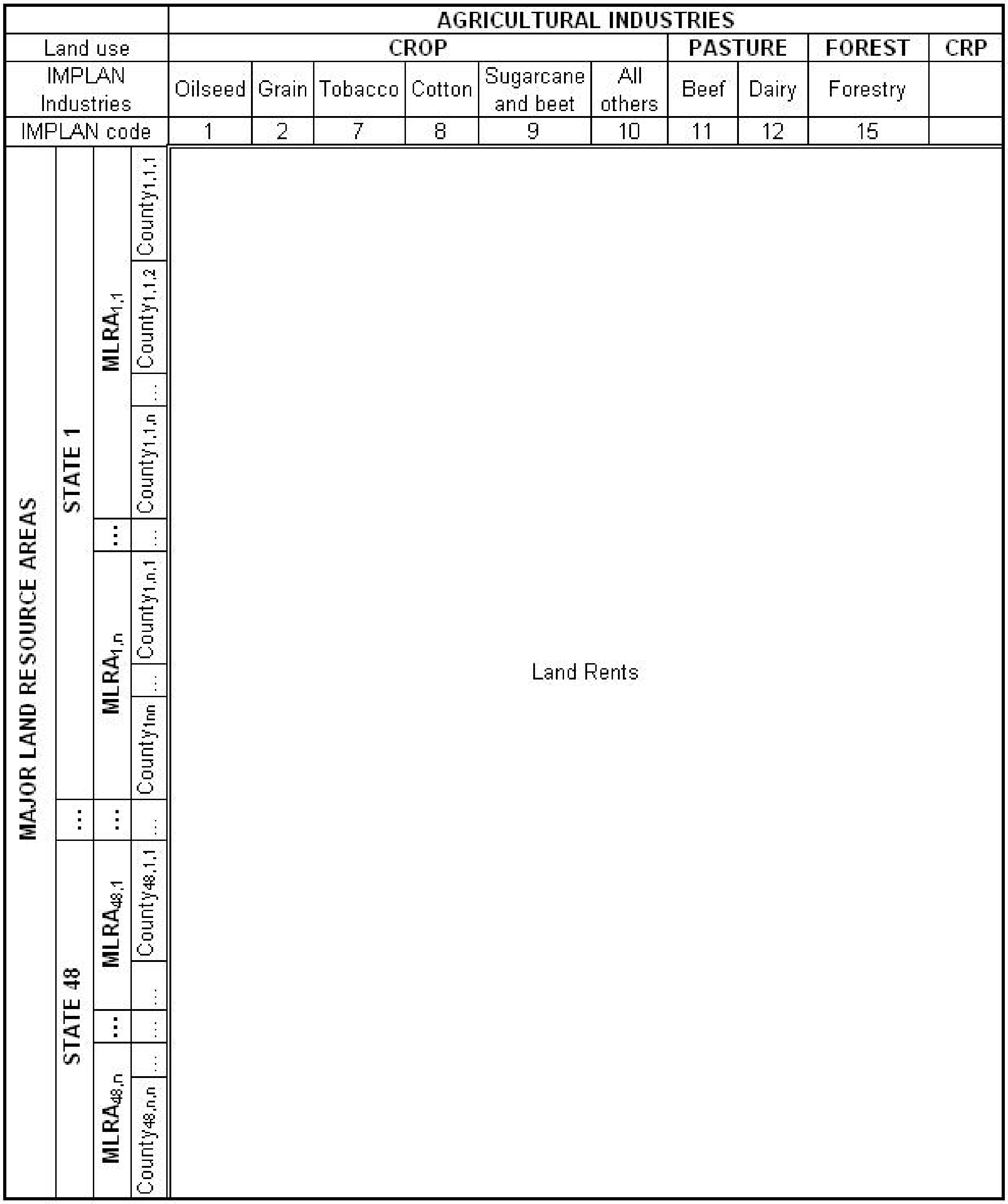


Figure 3.6. Land rent matrix obtained as the final result of assigning estimated land rents for different land-use types to the Major Land Resource Areas (MLRAS)

3.5.1 Cropland

Cropland acreage

Harvested acreage figures were obtained from the USDA National Agricultural Statistics Service (NASS) through Quick Stats (National Agricultural Statistics Service (NASS). 2011). The crops considered are listed in table A.4 in the appendix. Since county-level acreage figures were used for this study, table A.4 also shows the total acreage recorded at the county-level with their respective percentage of total national acreage.[13]

Harvested acreage was used instead of planted acreage since the rental rates are generated from the activity (or use) on a given parcel of land during the calendar year. Hence, by using harvested acreage the value of the land in production over the course of the entire year would be considered rather than just one season (i.e. double cropping).

Cropland rents

NASS provides cropland rent figures ($/ac) per county on Quick Stats (NASS 2011). These per-acre rent figures ($CROPRENT$) are provided for irrigated and non-irrigated cropland. To estimate a single cropland rental rate per county, a weighted average ($CROPRENTAVG$) was estimated using irrigated and non-irrigated cropland acreages ($CROPACRES$) as weights ($IRRWEIGHT$):

$$CROPRENTAVG_{county} = \sum_{irrig} CROPRENT_{county,irrig} * IRRWEIGHT_{county,irrig}, \tag{3.81}$$

[13]The majority of the acreage figures were obtained for 2008 and some for 2007. For some counties, acreage figures were not disclosed; hence, historical data was used to fill these gaps. Quick Stats provides acreage figures for the entire set of districts for 2008. County shares were estimated by district from the historical data and multiplied by the 2008 district-level totals. A VBA macro was created in MS Excel to fill these undisclosed figures.

$$IRRWEIGHT_{county,irrig} = \frac{CROPACRES_{county,irrig}}{\sum_{irrig} CROPACRES_{county,irrig}}, \quad (3.82)$$

where *irrig* is a set that includes irrigated and non-irrigated crop and *county* is a set of counties in the U.S.

3.5.2 Forest land

Forest land acreage

The Forest Inventory Data Online (FIDO) created by Forest Inventory and Analysis (FIA) National Program, part of the USDA Forest Service (FS), provides timber land acreage figures at the state level for four ownership categories: private, forest service, state and local government, and other federal (FS 2010).[14] By estimating the share of private timber land at the state level and implementing it to every county, acreage figures were obtained at the county level for private timber land ($FORACRES$).

Regional forest land net present value (NPV)

Sohngen et al. (2008) developed two different alternatives to estimate land rents per hectare per year. The first one represented a marginal hectare in a forest and was estimated from the rental function developed in Sohngen and Mendelsohn (1999, 2003); and Sohngen and Mendelsohn (2007). The second was obtained using a net

[14] According to FIA, forest land includes three subcategories: timber land, reserved forest land, and other forest land. Timber land is considered forest land that is producing or capable of producing more than 20 cubic feet per acre per year of wood. Timber land excludes reserved forest land. Hence, the type of forest land included in this study is privately-owned timber land. Since NRCS reports land use using the term forest land, the term forest and timber land will be used interchangeably in this document.

present value (NPV) specification and was estimated for an average hectare in a forest. The NPV formulation is the following:

$$NPV = \frac{\left(P^{QA}\right)\left(V_t^M\right)(1+r)^t - C}{\left(1-(1+r)^{-t}\right)}, \tag{3.83}$$

where P^{QA} is the quality-adjusted net stumpage price, "t" is the rotation age, V_t^M is the merchantable yield of the timber type at age "t", "r" is the discount rate (5%), and C is the regeneration cost. According to Sohngen et al. (2008), annual land rent figures ($FORRENT$) can be estimated using the following approximation :

$$FORRENT = r * NPV. \tag{3.84}$$

Sohngen et al. (2008) mentioned that the rental values estimated using the rental function would be higher than the ones derived with the NPV formulation. The rental rate for the average hectare in a forest was the variable needed for the model to be developed in this study; hence, the NPV specification was used. Sohngen (2010) provides the NPV values for 13 different timber types in the US in 2000 U.S. \$ per hectare. By using the conversion rate of 0.4047 hectares per acre, NPV values on a per-acre basis were obtained. These figures are shown in table 3.1 along with their respective major timber categories.

Sohngen (2010) divided the U.S. into five different regions:

1. South,
2. Northeast,
3. Great Lakes,
4. West, and
5. Pacific Northwest.

Table 3.1. Timber Production and Per-acre Net Present Value in 2008

Type	Description	Major category	Timber production (million m^3/yr)	Net Present Value ($/ac)
M1	Southern pine plantation	Softwood	70.49	738.59
M2	Southern natural pine	Softwood	56.51	492.39
M3	Southern upland hardwoods	Hardwood	77.74	151.92
M4	Southern bottomland hardwood	Hardwood	29.87	97.52
M5	Northeast softwood	Softwood	8.18	33.41
M6	Northeast Oack/Hickory	Hardwood	24.45	73.44
M7	Northeast Maple/Beech/Birch	Hardwood	19.27	24.05
M8	Great lakes softwood	Softwood	6.17	75.49
M9	Great lakes Oak/Hickory	Hardwood	8.28	15.40
M10	Great lakes Maple/Beech/Birch	Hardwood	23.90	27.59
M11	Western Pine	Softwood	30.22	27.86
M12	Western Hardwood	Hardwood	5.62	19.07
M13	Pacific Northwest Douglas-Fir	Softwood	59.30	285.57

Each region contains the states shown in table 3.2. They also aggregated the timber types into two major categories:

1. softwood and

2. hardwood.

Each of these two major categories includes different subcategories depending on the region in the U.S. as shown in table 3.3.

Since forest land acreage information at the county-level was presented by forest-type group, the two major timber categories and their respective subcategories were more finely disaggregated by forest-type groups. There are 32 forest-type groups that include different tree species. These 32 forest-type groups with their respective major categories and subcategories are listed in table 3.4.

Table 3.2. Timber Land Regions Considered for the Regionalization of Forest Land Rents

South	Northeast	Great Lakes	West	Pacific Northwest
Alabama	Connecticut	Illinois	Arizona	Oregon
Arkansas	Delaware	Indiana	California	Washington
Florida	Maine	Iowa	Colorado	
Georgia	Maryland	Michigan	Idaho	
Kentucky	Massachusetts	Minnesota	Iowa	
Louisiana	New Hampshire	Wisconsin	Kansas	
Mississippi	New Jersey		Missouri	
North Carolina	New York		Montana	
Oklahoma	Ohio		Nebraska	
South Carolina	Pennsylvania		Nevada	
Tennessee	Rhode Island		New Mexico	
Texas	Vermont		North Dakota	
Virginia	West Virginia		South Dakota	
			Utah	
			Wyoming	

Table 3.3. Timber Categories and Subcategories by Regions

	South	Northeast	Great Lakes	West	Pacific Northwest
Softwood	Pine plantation and natural pine	Softwood	Softwood	Pine	Douglas-Fir
Hardwood	Upland and bottomland	Oack/Hickory and Maple/Beech/ Birch	Oack/Hickory and Maple/Beech/ Birch	Hardwood	

Southern region

As shown in table 3.3, softwood in the Southern region was divided into two subcategories:

1. pine plantation and
2. natural pine.

Table 3.4. Forest-type Group Aggregation by Major Timber Category

Major timber category		Forest-type groups
Softwood		White / red / jack pine group (100)
		Spruce / fir group (120)
		Longleaf / slash pine group (140)
		Loblolly / shortleaf pine group (160)
		Other eastern softwoods group (170)
		Pinyon / juniper group (180)
		Douglas-fir group (200)
		Ponderosa Pine group (220)
		Western white pine group (240)
		Fir / spruce / mountain hemlock group (260)
		Lodgepole pine group (280)
		Hemlock / Sitka spruce group (300)
		Western larch group (320)
		Redwood Group (340)
		Other western softwoods group (360)
		California mixed conifer group (370)
		Exotic softwoods group (380)
		Other softwoods group (390)
Hardwood	Oak / Hickory	Oak / hickory group (500)
		Western oak group (920)
		Tanoak / laurel group (940)
		Tropical hardwoods group (980)
	Maple / Beech / Birch	Elm / ash / cottonwood group (700)
		Maple / beech / birch group (800)
		Aspen / birch group (900)
		Alder / maple group (910)
		Exotic hardwoods group (990)
	Other hardwoods	Other hardwoods group (960)
		Woodland hardwoods group (970)
Combined		Oak / pine group (400)
		Oak / gum / cypress group (600)

Since the county-level shares of planted and natural pines could not be found, the acreage of natural stand and regenerated pines obtained in FIDO were used to estimate a state-level weighted average of the NPV ($NPVSTAVG$) of the two subcategories ($southsoft$). The acreage of natural and regenerated softwood was obtained by summing the acreage of softwoods among the 32 forest-type groups as shown in the example for Alabama in table 3.5. The acreage and shares for the entire Southern region are listed in table 3.6. Hence, 13 different softwood NPV figures were estimated, one for each state in the South as shown in table 3.7:

$$NPVSTAVG_{south,'soft'} = \sum_{southsoft} NPV_{'south',southsoft} * SOFTWEIGHT_{south,southsoft}, \tag{3.85}$$

$$SOFTWEIGHT_{south,southsoft} = \frac{\sum_{type} SOFTACRES_{south,southsoft,type}}{\sum_{southsoft} \sum_{type} SOFTACRES_{south,southsoft,type}}, \tag{3.86}$$

where $woodreg$ is a set including the timber land regions developed by Sohngen (2010), $'south'$ is an element of $woodreg$, $'soft'$ is an element of the major category set $wood$, $south$ is a subset of $state$ containing the Southern states, $state$ is a set including all the states in the U.S. and $southsoft$ is a set that includes planted and natural softwoods.

Table 3.5. Acreage and Shares of Natural and Planted Softwood in Alabama in 2008

Forest-type group	Acres of stand origin		Total
	Natural	Planted	
White / red / jack pine group	3,026.00		3,026.00
Longleaf / slash pine group	767,974.00	359,737.00	1,127,711.00
Loblolly / shortleaf pine group	2,823,468.00	5,393,953.00	8,217,421.00
Other eastern softwoods group	51,595.00	12,717.00	64,312.00
Total	3,646,063.00	5,766,407.00	9,412,470.00
Shares	**0.39**	**0.61**	

Hence for the state of Alabama, included in the Southern timber land region, the shares of planted and natural pine stands are 0.61 and 0.39, respectively. The NPV estimates for the entire Southern region for planted and natural pine stands are

Table 3.6. Acreage and Shares of Natural and Planted Softwood in the Southern Timber Land Region

Southern states	Acreage		Shares	
	Natural	Planted	Natural	Planted
Alabama	3,646,063	5,766,407	0.39	0.61
Arkansas	3,003,105	2,644,050	0.53	0.47
Florida	2,727,343	4,534,693	0.38	0.62
Georgia	4,246,723	6,864,727	0.38	0.62
Kentucky	408,666	40,136	0.91	0.09
Louisiana	2,179,607	3,482,205	0.38	0.62
Mississippi	3,324,630	4,606,469	0.42	0.58
North Carolina	3,016,284	2,679,811	0.53	0.47
Oklahoma	511,708	585,072	0.47	0.53
South Carolina	2,880,016	3,052,570	0.49	0.51
Tennessee	689,774	495,381	0.58	0.42
Texas	2,643,974	2,519,509	0.51	0.49
Virginia	1,283,334	1,878,052	0.41	0.59

\$738.59 and \$492.39 per acre, respectively. Using these four estimates, a weighted NPV for softwood for the state of Alabama of \$643.22/ac was obtained:

$$SOFTWEIGHT_{'alabama','planted'} = 5,766,407/9,412,470 = 0.61, \tag{3.87}$$

$$SOFTWEIGHT_{'alabama','natural'} = 3,646,063/9,412,470 = 0.39, \tag{3.88}$$

$$NPVSTAVG_{'alabama','soft'} = (738.59 * 0.61) + (492.39 * 0.39) = 643.22. \tag{3.89}$$

Sohngen also divided the hardwood major category into two subcategories in the South:

1. upland species and
2. bottomland hardwood species.

Since there were no upland and bottomland share figures at the state or county level and no mapping existed between tree species and hardwood subcategories, a weighted average of the NPV for the entire Southern region ($NPVREGAVG$) was

Table 3.7. Net Present Value for Softwood in the Southern Region in 2008

Southern States	Regional NPV ($/ac)		Shares of pine		Weighted NPV for softwood ($/ac)
	Planted	Natural	Planted	Natural	
Alabama	738.59	492.39	0.61	0.39	643.22
Arkansas	738.59	492.39	0.47	0.53	607.67
Florida	738.59	492.39	0.62	0.38	646.13
Georgia	738.59	492.39	0.62	0.38	644.50
Kentucky	738.59	492.39	0.09	0.91	514.41
Louisiana	738.59	492.39	0.62	0.38	643.82
Mississippi	738.59	492.39	0.58	0.42	635.39
North Carolina	738.59	492.39	0.47	0.53	608.22
Oklahoma	738.59	492.39	0.53	0.47	623.73
South Carolina	738.59	492.39	0.51	0.49	619.07
Tennessee	738.59	492.39	0.42	0.58	595.30
Texas	738.59	492.39	0.49	0.51	612.53
Virginia	738.59	492.39	0.59	0.41	638.65

estimated using timber production figures ($PROD$) for every subcategory as weights ($HARDWEIGHT$). The timber production figures are shown in table 3.1 and were estimated by Sohngen (2010). Hence, one hardwood NPV figure was estimated for the entire Southern region.

$$NPVREGAVG_{'south','hard'} = \sum_{southard} NPV_{'south',southard} * HARDWEIGHT_{'south',southard}, \tag{3.90}$$

$$HARDWEIGHT_{'south',southard} = \frac{\sum PROD_{'south',southard}}{\sum_{southard} PROD_{'south',southard}}, \tag{3.91}$$

where $PROD$ is timber production in million cubic meters and $southard$ is a set that includes upland and bottomland hardwood species.

Hence, if the production figures of upland and bottomland hardwoods in the Southern region were 77.74 and 29.87 million cubic meters, the shares were 0.72 and 0.28, respectively. The NPV figures for upland and bottomland hardwoods are

\$152 and \$98 per acre, respectively. Then, the regional average is approximately \$138.43/ac:

$$HARDWEIGHT_{'south','upland'} = 77.74/107.61 = 0.72, \tag{3.92}$$

$$HARDWEIGHT_{'south','bottomland'} = 29.87/107.61, \tag{3.93}$$

$$NPVREGAVG_{'south','hard'} = (152 * 0.72) + (98 * 0.28) = 138.43. \tag{3.94}$$

Northeastern and Great Lakes regions

For the Northeastern and Great Lakes regions, there is only one subcategory for softwoods. However, Sohngen (2010) divided the hardwood major category into the:

1. Oak/Hickory subcategory and

2. Maple/Beech/Birch subcategory.

To match these two hardwood subcategories with the forest-type groups at the county level, the forest-type groups that shared similar characteristics were aggregated according to Sohngen's hardwood subcategories. The forest-type group aggregation is shown in table 3.4.

A simple average NPV between the Oak/Hickory and Maple/Beech/Birch subcategories was assigned to the woodland and other hardwoods forest-type groups.

Western and Pacific Northwestern regions

The Western region is simply divided into the two major timber categories. Hence, a county-level weighted average NPV was estimated using acreage figures for softwoods and hardwoods as weights. The Pacific Northwestern region only includes the softwood major category since this is the predominant timber type; however, Western hardwood NPV figures were used for the regions that included hardwood species.

Combined forest-type groups

The 2 forest-type groups that combine hardwood and softwood are the:

1. Oak/Pine group and
2. Oak/Gum/Cypress group.

Since the pine and cypress species are softwoods, the softwood shares of both of these groups were needed. The forest-type groups are a composition of tree-specie groups; hence, the latter are more disaggregated. Hence, the softwood share was estimated from the Oak/Pine and Oak/Gum/Cypress groups using tree-volume figures from the tree-species groupings.

The state-level net tree volume figures (in cubic feet) by tree-specie and forest-type groups were obtained from FIDO (FS 2010). From the tree-specie groups, the "exact" shares of softwood and hardwood were obtained at the state level and then applied to the state-level forest-type groups.

State-level estimates

The state-level NPV figures for hardwood, softwood, Oak/Pine, Oak/Gum/Cypress, Oak/Hickory, and Maple/Beech/Birch are listed in table A.5 in the appendix. These NPV figures were adjusted for inflation by considering a 1.05 percent change in the Producer Price Index from 2000 to 2008 for the forestry sector. As previously noted, the state-level weighted NPV averages had to be multiplied by an interest rate of 5% to obtain annualized forest land rent figures as listed in table A.6 in the appendix.

County-level estimates

To obtain the average annual forest land rents ($NPVCNTAVG$) at the county level, the state-level rents previously estimated were disaggregated. The procedure used by Lubowski (2002) was followed using acreage weights ($WOODWEIGHT$) to estimate weighted averages for every county as formulated in equation (3.95). The weights used to disaggregate the state-level rents were the county-level acreage figures ($WOODACRES$) for the different forest-type groups (*type*) in the U.S. as shown in equation (3.96). These figures were estimated by the USDA's FS and presented in FIDO (FS 2010).

$$FORRENTAVG_{county} = \sum_{wood} FORRENT_{state} * WOODWEIGHT_{county,wood}, \tag{3.95}$$

$$WOODWEIGHT_{county,wood} = \frac{\sum_{type} WOODACRES_{county,wood,type}}{\sum_{wood}\sum_{type} WOODACRES_{county,wood,type}}, \tag{3.96}$$

where *wood* is a set including softwood and hardwood species.

For example, Autauga county in Alabama has 158,917 acres of softwood; 84,929 acres of hardwood; 23,706 acres of Oak/Pine; and 24,648 acres of Oak/Gum/Cypress. The state-level, per-acre rent figures for Alabama are \$36.64 for sofwood, \$7.24 for hardwood, \$16.74 for Oak/Pine, \$8.92 for Oak/Gum/Cypress. Hence, the weighted average per-acre rent for Autauga county, Alabama is \$22.51/acre:

$$WOODWEIGHT_{'autauga','soft'} = 158,917/292,200 = 0.54, \tag{3.97}$$

$$WOODWEIGHT_{'autauga','hard'} = 84,929/292,200 = 0.29, \tag{3.98}$$

$$WOODWEIGHT_{'autauga','oak/pine'} = 23,706/292,200 = 0.08, \tag{3.99}$$

$$WOODWEIGHT_{'autauga','oak/gum/cypress'} = 24,648/292,200 = 0.08, \tag{3.100}$$

$$FORRENTAVG_{'autauga'} = (36.64 * 0.54) + (7.24 * 0.29) + (16.74 * 0.08) + (8.92 * 0.08) = 22.51. \tag{3.101}$$

The majority of the per-county acreage information obtained was from 2008. There were 7 states for which previous years were used and 3 for which future years were used.[15]

3.5.3 Pastureland

Pasture and rangeland acreage and rent figures were obtained from NASS's Quick Stats (NASS 2011). Acreage figures presented on Quick Stats were obtained from the 2007 Census of Agriculture. These include cropland and timber land pastured. County-level, per-acre rent figures ($PASTRENT$) were obtained from an annual survey performed in 2008.

To divide pastureland acreage demand among its main consumers, county- and state-level inventory figures (number of heads) were obtained from NASS's Quick Stats for: cattle (including calves), cattle on feed, beef cows, dairy cows, replacement dairy heifers, beef heifers, calves, bulls, steers, goats, sheep, horses, mules, alpacas, bison, deer, elks, and llamas. All these figures were obtained from the 2007 Census of Agriculture for the inventories recorded at the end of December.

Beef cattle

Besides consuming grain and other supplements, a great percentage of the beef cattle's diet is grazed pasture, making this activity the main consumer of pastureland.

[15] Previous years' figures were used for Florida (2007), Louisiana (2005), Mississippi (2006), North Carolina (2007), Nevada (2005), New Mexico (1999) and Wyoming (2000). Future years' estimates were used for California (2009), Oregon (2009) and Washington (2009).

To identify the average number of beef cattle heads per year using pastureland, the following formula was used:

$$\begin{aligned} PASTBEEF_{county} =& CAT_{county} - FEEDCAT_{county} \\ & - DAICOW_{county} - DAIHEIF_{county}, \end{aligned} \tag{3.102}$$

where $PASTBEEF$ represents pasture-grazing beef cattle, CAT represents overall cattle inventories (including calves), $FEEDCAT$ is beef cattle on feed, $DAICOW$ represents dairy cows and $DAIHEIF$ represents replacement dairy heifers. Hence, $PASTBEEF$ includes calves, steers, beef heifers, beef cows and bulls on pasture and neither on feed nor part of the dairy activity.

Since the inventory figures for replacement dairy heifers ($DAIHEF$) are not published at the county level, the state-level figures ($DAIHEFST$) were used to estimate a percentage of the dairy cow's state total and were applied to the county level:

$$DAIHEF_{county} = (DAICOW_{county}) \left(\frac{DAIHEFST_{state}}{DAICOWST_{state}} \right). \tag{3.103}$$

Dairy cattle

Dairy cattle's diet is also partially based on grazed pasture, mainly for dry cows and small dairy operations (MacDonald et al. 2007). Hence, a small percentage of the dairy activity depends on pastureland. To identify this percentage at the county level, dairy-cow inventory figures categorized by the operation size were obtained from Quick Stats from the 2007 Census of Agriculture (NASS 2011). For each operation size, a percentage of grazing dairy cattle was estimated using percentages published by the Wisconsin Agricultural Statistics Service and obtained through a survey performed in Wisconsin (Wisconsin Agricultural Statistics Service 2005).

These percentages are shown in table 3.8. Hence, the number of dairy cows on pasture is estimated like the following:

$$PASTDAI_{county} = \sum_{operation} DAICOW_{county,operation} * \%PASTDAI_{operation}, \quad (3.104)$$

where *operation* is a set that includes the different operation sizes shown in table 3.8, $PASTDAI$ represents grazing dairy, and $\%PASTDAI$ are the percentages obtained from the Wisconsin report and shown in table 3.8.

Table 3.8. Wisconsin Grazing Dairy Herd, 2009

Herd Size	Grazing Herds
1-29	31%
30-49	27%
50-99	11%
100-199	8%
200-499	1%
500+	0%

Pastureland demand (animal unit)

Since the livestock inventory distribution was different for every county, the animal-unit (AU) concept was used to obtain a representative distribution of the pastureland rents paid by each livestock activity in each county. The AU is "a convenient denominator for use in calculating relative grazing impact of different kinds and classes of domestic livestock and of common wildlife species" (NRCS 1997).[16] Hence, by multiplying the number of heads in the inventory by the AU, an approximate estimate of the pastureland demanded by each category was obtained. Table 3.9 shows the different AU equivalents for the livestock categories included in this study (NRCS 1997).

[16]The standard animal unit has been generally defined as one mature cow of approximately 1,000 pounds and a calf as old as 6 months.

Table 3.9. Animal Units Equivalents Guide

Categories	NRCS class	AU equiv.
Beef cattle		
Beef cow	Cow, dry	0.92
Bull	Bull, mature	1.35
Calf	Cattle, 1 year old	0.60
Heifer and steer	Cattle, 2 years old	0.80
Dairy cattle		
Dairy cow	Cow, with calf	1.00
Heifer and steer	Cattle, 2 years old	0.80
Sheep[a]		0.18
Goat[b]		0.13
Deer[c]		0.18
Horse		1.25
Elk		0.60
Bison		1.00
Alpaca[d]		0.10
Llama[e]		0.20

[a] Average of sheep (0.20) and lamb (0.15)
[b] Average of goat (0.15) and kid (0.10)
[c] Average of white-tailed (0.15) and mule (0.20)
[d] Same as a kid (0.10)
[e] Same as a sheep (0.20)

As listed in table 3.9, the beef and dairy cattle categories contained several sub-categories. Hence, a single AU had to be estimated for each, beef and dairy, cattle category. Since $PASTBEEF$ includes calves, steers, beef heifers, beef cows and bulls, a single animal-unit figure was estimated for the beef cattle category for every state. The same applied to $PASTDAI$ since it included dairy cows and replacement dairy heifers. Inventory figures for calves, steers, beef heifers, dairy heifers and bulls were only found at the state level in Quick Stats (NASS 2011).

Hence, a state-level weighted average AU figure (AU) was estimated for the beef cattle category using the inventory ($BEEFINVENT$) figures as ($BEEFWEIGHT$) weights:

$$AU_{state,'beef'} = \sum_{beefcateg} BEEFAU_{beefcateg} * BEEFWEIGHT_{state,beefcateg}, \quad (3.105)$$

$$BEEFWEIGHT_{state,beefcateg} = \frac{BEEFINVENT_{state,beefcateg}}{\sum_{beefcateg} BEEFINVENT_{state,beefcateg}}, \quad (3.106)$$

where $'beef'$ is an element of the set $livestock$ representing the beef cattle category, $livestock$ is a set including all the livestock categories that depend on pastureland, $beefcateg$ is a set including the AU subcategories included in the beef cattle category as presented in table 3.9, $BEEFAU$ represents the AU of the beef cattle's subcategories.

The same procedure was applied to dairy cattle. A state-level weighted average AU figure (AU) was estimated for the dairy cattle category using the inventory ($DAIRYINVENT$) figures as weights ($DAIRYWEIGHT$):

$$AU_{state,'dairy'} = \sum_{dairycateg} DAIRYAU_{dairycateg} * DAIRYWEIGHT_{state,dairycateg}, \quad (3.107)$$

$$DAIRYWEIGHT_{state,dairycateg} = \frac{DAIRYINVENT_{state,dairycateg}}{\sum_{dairycateg} DAIRYINVENT_{state,dairycateg}}, \quad (3.108)$$

where $'dairy'$ is an element of the set $livestock$ representing the dairy cattle category, $dairycateg$ is a set including the different AU subcategories included in the dairy cattle category as presented in table 3.9, $DAIRYAU$ represents the AU of the dairy cattle's subcategories.

As listed in table A.7 in the appendix, an AU estimate was assigned to every category that depends on pastureland ($livestock$), except for the beef and dairy categories, since each had an estimate for every state. The following formula was used to separate pastureland acreage for every category for every county:

$$\%ACRES_{county,livestock} = \frac{INVENT_{county,livestock} * AU_{state,livestock}}{\sum_{livestock} INVENT_{county,livestock} * AU_{state,livestock}}, \tag{3.109}$$

where *livestock* is a set that includes all the livestock activities that depend on pastureland, $\%ACRES$ represents the percentage of pastureland used by every category in every county, and $INVENT$ is the number of heads in inventory for every category where for the beef and dairy cattle categories:

$$INVENT_{county,'beef'} = PASTBEEF_{county}, \tag{3.110}$$

$$INVENT_{county,'dairy'} = PASTDAI_{county}. \tag{3.111}$$

The number of heads in inventory for each state is listed in table A.8 in the appendix.

With the previous equations, the pastureland acreage demand by category by county was obtained, as well as the rent per acre and total rent for every county:

$$PASTACRES_{county,livestock} = \%ACRES_{county,livestock} * TOTPASTACRES_{county}, \tag{3.112}$$

where $TOTPASTACRES$ represents total pastureland acreage per county and total pastureland demand by livestock category per county in acres is represented by $PASTACRES$.

For example, the pastureland acreage demanded by the beef and dairy cattle categories in Grant County, Wisconsin is the following:

$$\%ACRES_{'grant','beef'} = \left(\frac{79,371 * 0.74}{69,943}\right) = 0.84, \tag{3.113}$$

$$\%ACRES_{'grant','dairy'} = \left(\frac{4,456 * 0.93}{69,943}\right) = 0.06, \tag{3.114}$$

$$PASTACRES_{'grant','beef'} = 0.84 * 167,908 = 141,474, \tag{3.115}$$

$$PASTACRES_{'grant','dairy'} = 0.06 * 167,908 = 9,962. \tag{3.116}$$

3.5.4 Conservation Reserve Program (CRP)

CRP acreage and rent figures were obtained, at the county level, from the USDA's Farm Service Agency (FSA) website for 2008 (FSA 2011).

3.5.5 Major Land Resource Areas (MLRA)

Besides a detailed disaggregation of land uses across the U.S., a proper recognition of land heterogeneity plays a key role in the adequate allocation of land among competing uses. The USDA developed a classification of geographically associated land units called Major Land Resource Areas (MLRA). A complete list, description and location of each MLRA can be found in NRCS (2006). There are 278 MLRAs identified by Arabic numbers and a descriptive geographic name. The main criteria used by NRCS to categorize land into the different MLRAs are: physiographic, geological, climatic, water, soil, biological and land use characteristics.

The percentages of land covered by each MLRA at the county level were obtained by superimposing two maps (counties and MLRAs) based on Geographic Information System (GIS) data provided by NRCS (2011). Each county was assigned to the predominant MLRA:

$$l \cong county, \tag{3.117}$$

where l is the land set representing the different MLRAs. Table A.10 in the appendix lists all the MLRAs included in the regional aggregation used in this study. Using this mapping, the county-level land rents developed in subsections 3.5.1 through

3.5.4 were aggregated to obtain a matrix containing total land rents payments to each MLRA in each state in the following form:

$$CROPSTRENT_{state,l,crop} = CROPRENTAVG_{state,l} * CROPACRES_{state,l,crop}, \quad (3.118)$$

$$PASTSTRENT_{state,l,past} = PASTRENT_{state,l} * PASTACRES_{state,l,past}, \quad (3.119)$$

$$FORSTRENT_{state,l,logg} = FORRENTAVG_{state,l} * FORACRES_{state,l,logg}, \quad (3.120)$$

where *crop* is a set including the crops listed in table A.4 in the appendix, *past* is a set including only the beef and dairy cattle categories, *logg* is a set including only private commercial forests.

3.5.6 Adding land rents to the SAM

The final product of the procedure explained in section §3.5 is a matrix containing the land rents similar to figure 3.6.[17] To include these payments into the extended IMPLAN SAM, the real estate commodity demands and capital payments (when necessary) from each IMPLAN agricultural activity were distributed to each MLRA included in the regional aggregation (Olson 2011a).

Considering that *acrop*, *apast*, and *alogg* are subsets of *a* and the SAM equivalents of *crop*, *past*, and *logg*, respectively. Following the abbreviations of the aggregated activities used in this study and listed in table A.2, the *acrop* subset includes oilseeds (Aolsd), grains (Agran), tobacco (Atobc), cotton (Acott), sugarcane and sugar beet (Asugr), and all other crop farming (Aocrp). The *apast* subset includes cattle ranch-

[17] A GDX file was created containing all the estimated land rent payments. A GAMS program was created to include these payments into the extended IMPLAN SAM.

ing and farming (Acatt), and dairy cattle and milk production (Adair). The *alogg* subset includes only the logging activity (Alogg). Then:

$$acrop \equiv crop, \tag{3.121}$$

$$apast \equiv past, \tag{3.122}$$

$$alogg \equiv logg, \tag{3.123}$$

where the set *crop* was mapped into *acrop* following table A.4 in the appendix; the $'beef'$ and $'dairy'$ elements of the set *past* were mapped into Acatt and Adair of the set *apast*, respectively; and the set *logg* was mapped into Alogg.

The subset of a including activities that use land where afforestation could take place or where forest already exists is the *agr* set:[18]

$$agr = acrop \cup apast \cup alogg. \tag{3.124}$$

Hence, using the estimated rents from equations (3.118), (3.119), (3.120); the equivalences from (3.121), (3.122), (3.123); and the macroset from (3.124), rents were included in the SAM in the following manner:

$$\begin{aligned} STRENT_{state,l,agr} = & CROPSTRENT_{state,l,crop} \\ & \cup PASTSTRENT_{state,l,past} \\ & \cup FORSTRENT_{state,l,logg}, \end{aligned} \tag{3.125}$$

$$RENT_{l,agr} = \sum_{region} STRENT_{region,l,agr}, \tag{3.126}$$

[18]Following the criteria in Graham (1994), land in high-value agricultural crop production such as vegetable and melon (IMPLAN sector 3); fruit (4); tree nut (5); and greenhouse, nursery and floriculture (6) were excluded. The poultry sector (IMPLAN sector 13) was excluded due to its low pastureland demand. The sector for the rest of the animal production (IMPLAN sector 14) was also excluded since it includes animal families whose pastureland demand is negligible and, hence, no recorded demand figures existed.

$$TOTRENT_{agr} = \sum_{l} RENT_{l,agr}, \tag{3.127}$$

$$ACRES_{l,agr} = \sum_{region} STACRES_{region,l,agr}, \tag{3.128}$$

$$RENTACRE_{l,agr} = \frac{RENT_{l,agr}}{ACRES_{l,agr}}, \tag{3.129}$$

where *region* is a subset of *state* including the states for the regional analysis, $STRENT$ represents the estimated rent payments from the agricultural activities to the different MLRAs in different states, $RENT$ represents the aggregated rents over the same MLRAs in different states within the regional aggregation, $TOTRENT$ represents total land rent payments from each agricultural activity, $STACRES$ represents the acreage demanded by activity per MLRA in each state, $ACRES$ represents the acreage demanded by activity per MLRA for the regional aggregation, and $RENTACRE$ the rents per acre that will be used in the CGE model.

As stated before, IMPLAN reports payments to land as an intermediate commodity (IMPLAN code 3360) demanded by the different IMPLAN activities. In this case, only the activities included in the *agr* set were considered. For some activities, these real estate intermediate commodity payments were not large enough to accommodate total estimated land rent payments ($TOTRENT$) per activity into the SAM. Hence, as shown in figure 3.5, a portion of the payments to the capital account from each activity was used (when necessary) to fully accommodate total estimated land rent payments.

When the real estate intermediate commodity demand ($ESTATE$) was larger than total land rent payments ($TOTRENT$), the portion that was not distributed to the different MLRAs ($NONAGR$) was still directed to the real estate commodity:

$$\begin{aligned} if \qquad & TOTRENT_{agr} \leq ESTATE_{agr}, \\ then \quad & NONAGR_{agr} = ESTATE_{agr} - TOTRENT_{agr}. \end{aligned} \tag{3.130}$$

When $ESTATE$ was not large enough to accommodate $TOTRENT$, a portion of the payments to the capital account ($CAPDIFF$) was used to fully accommodate TOTRENT in the SAM:

$$\begin{aligned} if \quad & TOTRENT_{agr} > ESTATE_{agr}, \\ then \quad & CAPDIFF_{agr} = TOTRENT_{agr} - ESTATE_{agr}, \\ & NEWCAPITAL_{agr} = CAPITAL_{agr} - CAPDIFF_{agr}, \end{aligned} \tag{3.131}$$

where $NEWCAPITAL$ is the modified activity payment to the capital account and $CAPITAL$ represents the previous payments to the capital account as defined in equation (3.42).

Following SAM conventions, the newly-created MLRA receiving accounts (rows) needed their column counterparts. The row totals of the newly created MLRA accounts, representing land factor receipts, had to equal their column counterparts. Hence, the row and column totals of the MLRA accounts is represented by:

$$TOTLANDPMT_l = \sum_{agr} RENT_{l,agr}. \tag{3.132}$$

Since the activity payments to the real estate commodity had been modified, the row total of the receipts by the real estate commodity was modified as well. Hence, the real estate commodity column total was modified by reducing the payments from the commodity to the activity (production submatrix). The residual payments from the real estate commodity (3360) to the real estate activity (360) were estimated as following:

$$NEWPMT = OLDPMT - \sum_{agr} \left(TOTRENT_{agr} - CAPDIFF_{agr} \right), \tag{3.133}$$

where $OLDPMT$ represents the original payment form the real state commodity (3360) to the real estate activity (360) (before including the MLRAs), $NEWPMT$

represents the new residual payment after considering the payments from the MLRA accounts, and the last summation in parenthesis represents the portion of $TOTRENT$ that comes from the real estate intermediate commodity demand.

Following CGE-modeling conventions, factor income was distributed among factor owners. Hence, agricultural land rents needed to be distributed to the land owners, which in IMPLAN are households and enterprises. Since there is no information on the distribution of land rent per MLRA to each land owner, the distribution of capital income to households and enterprises was used as an approximation in this study. Considering that *housent* is a set including the different categories for households and enterprises, $CAPPMT$ reflects the SAM payments from the capital factor of production account to institutions, $\%CAPPMT$ is the distribution of capital income to institutions, $LANDPMT$ reflect payments from the agricultural land accounts (MLRA) to institutions:

$$\%CAPPMT_{housent} = \frac{CAPPMT_{housent}}{\sum_{housent} CAPPMNT_{housent}}, \tag{3.134}$$

$$LANDPMT_{housent,l} = \%CAPPMT_{housent} * TOTLANDPMT_{l}. \tag{3.135}$$

Now that all the agricultural land rent payments for each MLRA had been distributed between land owners, capital payments to households and enterprises had to be adjusted to avoid double-counting factor payments to their owners. Representing the adjusted capital income distribution to institutions there is:

$$NEWCAPPMT_{housent} = CAPPMT_{housent} - \sum_{l} LANDPMT_{housent,l}. \tag{3.136}$$

Since the agricultural land rent payments from each MLRA were directly allocated to households and enterprises, the real estate activity (360) never received these payments. Since expenditures should be equal to receipts, the real estate activity's expenditures were reduced by the total agricultural land rents across all MLRAs.

This reduction is specifically performed in the real estate activity's payments to capital ($RECAP$) (Olson 2011b). If $NEWRECAP$ reflects the modified real estate activity's expenditure for capital, then:

$$NEWRECAP = RECAP - \sum_{l} TOTRENT_l. \tag{3.137}$$

The modified extended IMPLAN SAM with the payments from agr to the MLRAs and from the MLRAs to land owners looked like figure A.1. The final modified IMPLAN SAM used as an input for the CGE model for this study is shown in A.3 in the appendix with its respective definitions in table A.9.

4. COMPUTABLE GENERAL EQUILIBRIUM (CGE) MODEL

The CGE model structure used in this study was a hybrid between Lofgren et al. (2002) and Bryant, Campiche, and Lu (2011). It is a static IMPLAN SAM-based regional CGE model with special emphasis on the market for agricultural land in any arbitrary state-level aggregation in the U.S.

The model accomodates to the sectorial (activities) and regional aggregations built and imported from IMPLAN (as mentioned in section §3.1), with activities, their respective commodities, basic factors of production (labor and capital), agricultural land as a factor of production dividided into Major Land Resource Areas (MLRA), nine household categories based on income levels, six federal and state government divisions, enterprises, investment, inventory and two trade accounts: the rest of the U.S. and the rest of the world.

The entire model code follows Bryant, Campiche, and Lu (2011); hence, it relies on a nesting structure based on constant returns to scale, nested constant elasticity of substitution (CES) functions to emulate production, consumption and aggregation behavior. The code is structured such that the CES function used in the model encompasses the two generally-used-by-convention limiting cases: Leontief and Cobb-Douglas. The exogenously-set substitution elasticities (σ) required as inputs for the CES functions are the determining factors between the two limiting cases for every producing and consuming entity, and aggregation scheme. The rest of the parameters that go into the CES function are endogenously estimated and calibrated against the exogenous substitution elasticities and the base year prices, quantities and tax rates reflected in the SAM. Prices in the base year are assumed to be unity; hence, the units of measurement of factors and commodities are infered from the SAM. Land, as a factor of production, is the exception since land prices and quantities reflect per-acre rents (not unity) and acreage (not SAM values), respectively. As Bryant, Campiche, and Lu (2011) states, the model follows a bottom-top routine meaning that the model calibrates first bottom nests and top nests afterwards.[1]

Since there is no explicit objective function to optimize, this type of model relies on a set of first order conditions to maximize utilities (consumption side) and profits (production side) subject to a full-budget-allocation and a zero-profit condition, respectively. Hence, the model conforms to a mixed complementarity optimization problem. According to Bryant, Campiche, and Lu (2011), “the heart of the model is a set of excess supply functions describing a Walrasian market equilibrium.” Hence, all market clearances (factors, domestic and foreign commodities) are modeled through these excess supply functions and their respective prices.

Equations preserving accounting identities among institutions and imposing model closures follow a similar structure as the one shown in Lofgren et al. (2002).

The basic CGE model structure can be divided into four major parts:

1. Activities, production and factor markets,

2. institutions,

3. commodity markets, and

4. macroeconomic balances.

The notational convention followed is similar to Lofgren et al. (2002) and explained in table 4.1.The parameters used in the following equations and reflecting base-year SAM relationships are detailed in table A.1 in the appendix. *SAM* represents base-year SAM transactions. Also in the appendix, figure A.4 and its respective formulas in table A.11 are provided to facilitate the interpretation and relate the SAM to the mathematical model.

[1] As will be explained later, for the land markets, the constant elasticity of transformation (CET) specification is used to reflect the perfect- and imperfect-transformability limiting cases for each land category (MLRA).

Table 4.1. Notational Structure

Item	Notation
Endogenous variables	Upper-case Latin letters without a bar
Exogenous variables	Upper-case Latin letters with a bar
Parameters	Lower-case Latin letters (with or without a bar) or lower-case Greek letters (with or without superscripts)
Set indices	Lower-case Latin letters as subscripts to variables and parameters
Commodity and factor quantities	Q or q
Commodity pices	P
Nests' input quantities	QX
Nests' output quantities	QY
Nests' input prices	PX
Nests' output prices	PY
Substitution and transformation elasticities	σ with respective nest as subscript
Factor prices	W
Shares	Start with sh, followed by source and ending with receiving entity. All shares are fixed to the base-year
Transfer parameter	Start with $trns$, followed by source and ending with receiving entity
Transfer variable	Start with receiving entity and end with $TRNS$
Taxes	Start with t

4.1 Activities, production and factor markets

As shown in figure 4.1, the basic CGE model reflects production activities (a) as a set of top nests ($ActTop$) that use as inputs the bundles produced by an intermediate input nest ($ActInt$), a land nest for agricultural activities ($ActLand$) and a value-added nest reflecting the demand of primary factors ($ActVad$). To reflect a certain degree of substitutability among input commodities and factors, the elasticities of substitution used for this study were: 0.5 for σ_{ActTop}, 0.5 for σ_{ActInt}, 0.45 for σ_{ActVad}

and 0.5 for $\sigma_{ActLand}$. The commercial logging activity was the only exception having a σ_{ActTop} of 0.2 to reflect a more accurate ratio between acreage and offset generation as will be explained later.

The *ActLand* nest includes a different specification than the rest of the nests where quantities and are taken directly from the SAM and prices are unity. The *ActLand* nest includes the estimated per-acre rents ($RENTACRE$) as prices and acreage demanded by the different activities ($ACRES$) as quantities.

The model is structured such that it accommodates the possibility of activities producing more than one output. Hence it includes a joint production nest ($JntPrd$). This specification is employed to model CO_2 offsets generated by the existing commercial logging activity as will be explained in more detail in 5.3.2. A zero elasticity of transformation was used for this nest to reflect a constant-proportion production regime.

Each activity is assumed to maximize profits, which are defined as the revenues produced by selling different commodities at producer's prices minus the costs of factors, land and intermediate inputs at factors and consumer's prices, respectively.

Factors of production (f) are assumed inmobile across the region under study and outside regions. However, they are assumed to be mobile across activities. Hence, the model generates long-run equilibria under the different parametrical shocks. Land (l) mobility across agricultural activities will be explained later. The endowments of each primary factor (qf) and land category (MLRA) (ql) are fixed and taken directly from the base-year SAM as shown in equations (4.1) and (4.2), respectively:

$$qf_f \geq \sum_a QXActVad_{a,f}, \tag{4.1}$$

$$ql_l \geq \sum_a QXActLand_{a,l}. \tag{4.2}$$

Estimated factor prices (or wage) and land rents are assumed to be the same across activities for each factor and MLRA, respectively. Each estimated factor price

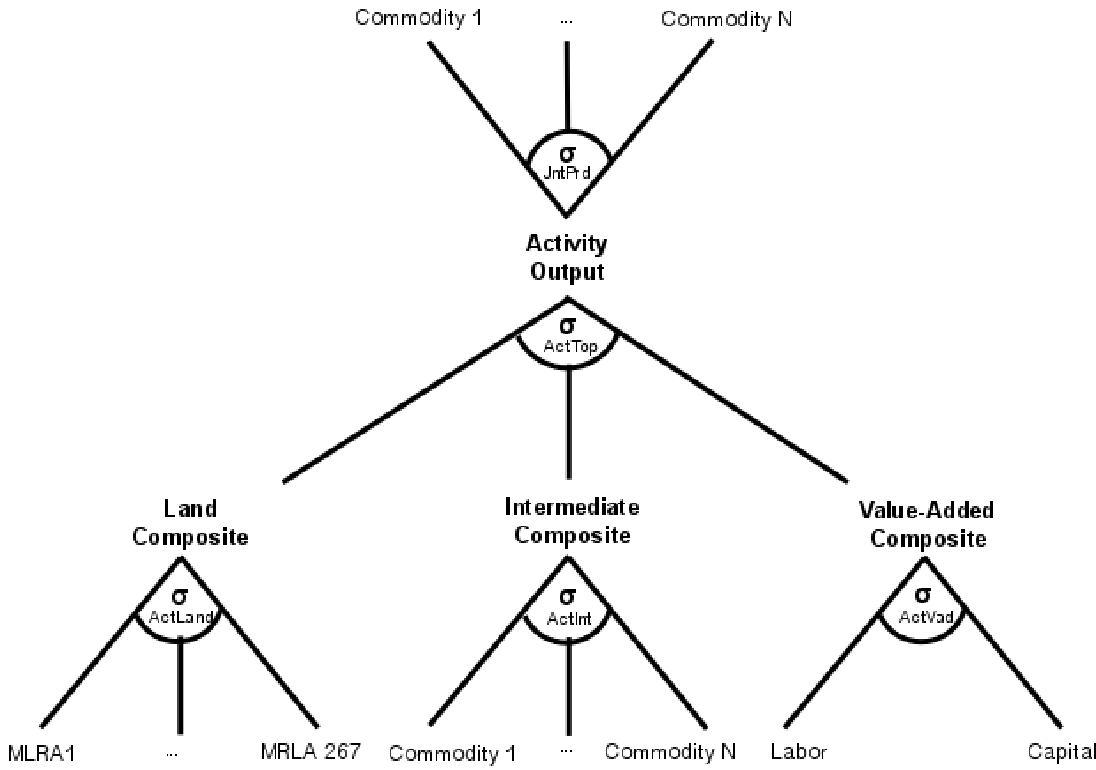


Figure 4.1. Representation of production activities in the CGE model

and land rent vary to ensure factor and land market clearance. Factor income after taxes and depreciation (in the case of capital) and land rents (according to Olson (2011b)) are distributed among the different households and a single representative enterprise.

4.2 Land markets

Similar to Bryant, Campiche, and Lu (2011), land markets have been modeled following Hertel, Tyner, and Birur (2010); Darwin et al. (1995); Ahammad and Mi (2005); and Ahmed, Hertel, and Lubowski (2008) where land supply is determined by a constant elasticity of transformation (CET) revenue function.[2] To reflect land

[2]The only difference in the specification of a CES and a CET function is the sign of σ. A positive sign implies a CES function, a negative sign a CET function.

heterogeneity in the U.S., land endowments have been dividided into 169 different MLRAs (l). From these endowments, land is supplied to three broad land uses (crop, pasture and forestry) and from these to all the different agricultural activities (agr). To reflect rent and transformability differences among the alternative uses, land supply has been divided into three nesting levels as depicted in figure 4.2:

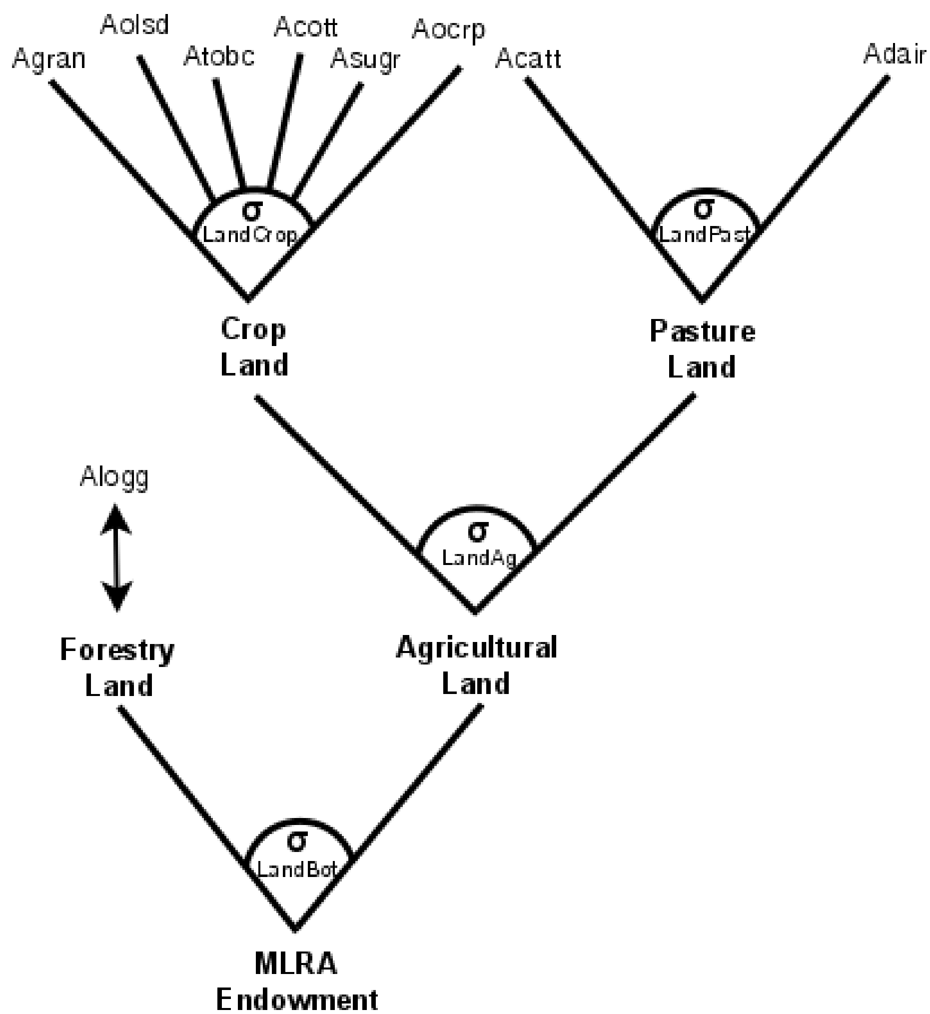


Figure 4.2. Representation of land markets in the CGE model

1. A nest that supplies land to forestry and agricultural purposes (*LandBot*) as formulated in equations (4.3), (4.4) and (4.5). The elasticity of transformation ($\sigma_{LandBot}$) used for the majority of the MLRAs (-0.029) mirror calibrated values

in Bryant, Campiche, and Lu (2011). The low value reflects a low degree of transformation between agricultural land (crop and pastureland) and forestry land. The elasticity of some MLRAs was lower due to the small rent payments coming from the logging activity. The starting values used for prices and quantities for each MLRA are listed in equations (4.6), (4.7), (4.8), (4.9) and (4.10).

$$ql_l \geq QYLandBot_l, \tag{4.3}$$

$$QXLandBot_{l,'ForestryLand'} \geq QXActLand_{alogg,l}, \tag{4.4}$$

$$QXLandBot_{l,'AgriculturalLand'} \geq QYLandAg_l, \tag{4.5}$$

$$QXLandBot_{l,'ForestryLand'} = ACRES_{l,alogg}, \tag{4.6}$$

$$QXLandBot_{l,'AgriculturalLand'} = \sum_{acrop} ACRES_{l,acrop} + \sum_{apast} ACRES_{l,apast}, \tag{4.7}$$

$$PYLandBot_l = \frac{\sum_{agr} RENT_{l,agr}}{\sum_{agr} ACRES_{l,agr}}, \tag{4.8}$$

$$PXLandBot_{l,'ForestryLand'} = \frac{RENT_{l,alogg}}{ACRES_{l,alogg}}, \tag{4.9}$$

$$PXLandBot_{l,'AgriculturalLand'} = \frac{\sum_{acrop} RENT_{l,acrop} + \sum_{apast} RENT_{l,apast}}{\sum_{acrop} ACRES_{l,acrop} + \sum_{apast} ACRES_{l,apast},}. \tag{4.10}$$

2. A nest within agriculture that supplies land to crop- and pasture-related activities ($LandAg$) as formulated in equations (4.11) and (4.12), respectively. The elasticity of transformation (σ_{LandAg}) used for this nest was -0.709 to reflect a relatively high degree of transformation between crop and pastureland. The starting values used for prices and quantities for each MLRA and agricultural land use are listed in equations (4.13), (4.14), (4.15), (4.16) and (4.17).

$$QXLandAg_{l,'CropLand'} \geq QYLandCrop_l, \tag{4.11}$$

$$QXLandAg_{l,'PastureLand'} \geq QYLandPast_l, \tag{4.12}$$

$$QXLandAg_{l,'CropLand'} = \sum_{acrop} ACRES_{l,acrop}, \tag{4.13}$$

$$QXLandAg_{l,'PastureLand'} = \sum_{apast} ACRES_{l,apast}, \tag{4.14}$$

$$PYLandAg_l = PXLandBot_{l,'AgriculturalLand'}, \tag{4.15}$$

$$PXLandAg_{l,'CropLand'} = \frac{\sum_{acrop} RENT_{l,acrop}}{\sum_{acrop} ACRES_{l,acrop}}, \tag{4.16}$$

$$PXLandAg_{l,'PastureLand'} = \frac{\sum_{apast} RENT_{l,apast}}{\sum_{apast} ACRES_{l,apast}}. \tag{4.17}$$

3. Two nests, one within cropland (*LandCrop*) and one within (*LandPast*) pastureland, that supply land to all the agricultural activities as formulated in equations (4.18) and (4.19), respectively. The elasticities of transformation used for both nests ($\sigma_{LandCrop}$ and $\sigma_{LandPast}$) were -5 to reflect a high degree of transformation between activities using cropland and activities using pastureland. The starting values used for prices and quantities for each MLRA and activity are listed in equations (4.20), (4.21), (4.22), (4.23), (4.24) and (4.25).

$$QXLandCrop_{l,acrop} \geq QXActLand_{acrop,l}, \tag{4.18}$$

$$QXLandPast_{l,apast} \geq QXActLand_{apast,l}, \tag{4.19}$$

$$QXLandCrop_{l,acrop} = ACRES_{l,acrop}, \tag{4.20}$$

$$QXLandPast_{l,apast} = ACRES_{l,apast}, \tag{4.21}$$

$$PYLandCrop_l = PXLandAg_{l,'CropLand'}, \tag{4.22}$$

$$PYLandPast_l = PXLandAg_{l,'PastureLand'}, \tag{4.23}$$

$$PXLandCrop_{l,acrop} = RENTACRE_{l,acrop}, \tag{4.24}$$

$$PXLandPast_{l,apast} = RENTACRE_{l,apast}. \tag{4.25}$$

Once land heterogeneity and transformability have been reflected in the model, land in each alternative use is assumed homogeneous. As shown in figure 4.1, activities form a land composite (*ActLand*) from the different MLRAs where imperfect substitution is accounted for as well.

4.3 Institutions

In the basic CGE model, institutions are represented by nine household categories based on income levels, six federal and state government divisions, enterprises, investment, inventory and two trade accounts. For more details see section §3.1. Following, the model's mathematical statements reflecting each institution's income and expenditure will be detailed and explained.

4.3.1 Households

There are 9 household categories (h) based on annual income as listed in section §3.1. Households and enterprises are endowed with primary factors of production (qf) and land (ql). These endowments are assumed to be fixed to the observed base-year quantities. As formulated in equation (4.26), households' incomes ($HHINC$) are partially generated by the sale ($hhsales$) of commodities (c) at producer's prices (PQ). The volume of the sales is fixed at the base year quantity. Households receive a share ($shfinst$) of the net income received ($NETFINC$) by primary factors (f), valued at their respective wage (WF), from renting them to the production activities. They receive a share ($shlinst$) of the income from the land, in different MLRAs (l), rented to agricultural activities at their respective rental rates (WL). Households also receive a share ($shgovhh$) of the government's (gov) transferable income ($GOVTRNS$), a share ($shenthh$) of enterprises' transferable income ($ENTTNRS$), a share ($shinvhh$) of the investment account's transferable income ($INVTRNS$) and transfers ($trnsouthh$) from outside regions (t). The transfers coming from the investment account are considered borrowed capital for consumption.

$$
\begin{aligned}
HHINC_h = {} & \left(\sum_c hhsales_{h,c} * PQ_c\right) + \left(\sum_f NETFINC_f * WF_f * shfinst_{h,f}\right) \\
& + \left(\sum_l ql_l * WL_l * shlinst_{h,l}\right) + \left(\sum_h HHTRNS_h * shhhhh_{h,h}\right) \\
& + \left(\sum_{gov} GOVTRNS_{gov} * shgovhh_{h,gov}\right) + (ENTTNRS * shenthh_h) \\
& + (INVTRNS * shinvhh_h) + \left(\sum_t trnsouthh_{h,t}\right).
\end{aligned}
\tag{4.26}
$$

As shown in equation (4.27), factor income transfered to households and enterprises ($NETFINC$) is net of factor taxes (tf) and depreciation ($deprec$) in the case of capital:

$$
NETFINC_f = qf_f * \left(1 - \sum_{gov} tf_{gov,f} - deprec_f\right). \tag{4.27}
$$

Households' incomes are subject to a tax (th) imposed by the government. As formulated in equation (4.28), after accounting for income taxes, a portion of the income ($HHTRNS$) is transfered to other institutions and, also, devoted to consumption and savings:

$$
HHTRNS_h = HHINC_h * \left(1 - \sum_{gov} th_{gov,h}\right). \tag{4.28}
$$

After accounting for transfers to other households ($shhhhh$) and to outside regions ($shhhout$), the net income ($HHNETINC$) devoted to commodity consumption and savings is formulated as in equation (4.29):

$$HHNETINC_h = HHTRNS_h * \left(1 - \sum_h shhhhh_{h,h} - \sum_t shhhout_{t,h}\right). \quad (4.29)$$

Utility production by each household, as depicted in figure 4.3, was modeled using a top nest ($HhTop$) where utility is maximized through the consumption of a composite consumer good ($QYHhCons$), at price ($PYHhCons$), and savings ($QHHSAV$), valued at their respective prices ($PHHSAV = 1$), up to the point when the budget constraint ($HHNETINC$) is met. A zero elasticity of substitution was specified for this nest (σ_{HhTop}) to reflect a constant marginal propensity to save.

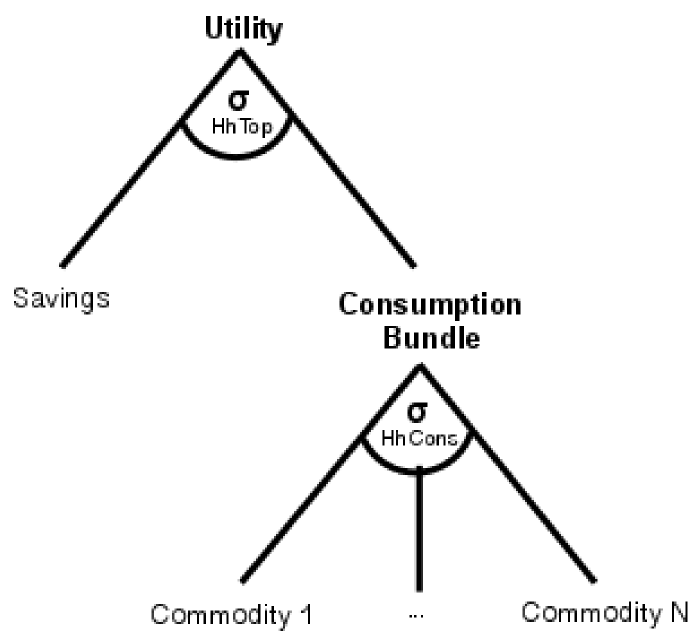


Figure 4.3. Representation of households utility production in the CGE model

The composite consumer good is the product of a subnest ($HhCons$) that reflects substitutability among commodities through an elasticity of substitution (σ_{HhCons})

of 0.5. As previously explained in subsection 3.4.2 and formulated in equation (3.68), households are charged an aggregate sales tax for the consumption of the composite consumer good ($thhcons$):

$$\begin{aligned} HHNETINC_h \geq & \left[(QYHhCons_h * PYHhCons_h) * (1 + thhcons_h)\right] \\ & + \left[(PHHSAV_h) * (QHHSAV_h)\right]. \end{aligned} \tag{4.30}$$

4.3.2 Government

There are 6 government divisions (gov) as mentioned in section §3.1. As formulated in equation (4.31), the different government divisions generate revenues ($GOVINC$) partially by selling commodities ($govsales$) at producer's prices (PQ).[3] The volume of sales is fixed at the base year quantity. Some divisions collect taxes and their respective tax rates are inferred from the base-year SAM. Taxes are levied on factor incomes (tf), households' incomes (th) and enterprises' income ($tent$). To accomodate to the IMPLAN SAM structure, the indirect business taxes aggregate account has been modeled as a production tax (ta) from different activities (a) in the basic CGE model. Hence, the tax is levied on the production by activity ($QYActTop$), valued at their respective representative prices ($PYActTop$). Sales taxes are also collected for commodity purchases from the government ($tgovcons$), households ($thhcons$), inventory ($tnvtcons$) and investment ($tinvcons$) accounts. All taxes are distributed to the different government divisions according to a set of shares ($shtaxgov$) obtained from the base-year SAM. Duties collected from importing commodities from the rest of the world ($timp$) are directed to the federal government's non-defense division.

Some divisions also receive a share ($shgovgov$) from other divisions' transferable incomes ($GOVTRNS$), a share ($shinvgov$) from the investment account's transfer-

[3]Not all of the divisions sell commodities.

able income ($INVTRNS$), and transfers from outside regions ($trnsoutgov$). The transfers coming from the investment account are considered borrowed capital.

$$\begin{aligned} GOVINC_{gov} = & \left(\sum_{c} govsales_{gov,c} * PQ_{c}\right) + \left(\sum_{f} qf_{f} * WF_{f} * tf_{gov,f}\right) \\ & + shtaxgov_{gov} * \left(\sum_{a} QYActTop_{a} * PYActTop_{a} * ta_{a}\right) \\ & + shtaxgov_{gov} * \left(\sum_{c,gov} QGOV_{c,gov} * PD_{c} * tgovcons_{gov}\right) \\ & + shtaxgov_{gov} * \left(\sum_{h} QYHhCons_{h} * PYHhCons_{h} * thhcons_{h}\right) \\ & + shtaxgov_{gov} * \left(\sum_{c} QNVT_{c} * PD_{c} * tnvtcons\right) \\ & + shtaxgov_{gov} * \left(\sum_{c} QINV_{c} * PD_{c} * tinvcons\right) \\ & + 1_{'fed\,non-def'} * \left(\sum_{t,c} QXComImp_{t,c} * PFOBIMP_{t,c} * timp_{t,c}\right) \\ & + \left(\sum_{h} HHINC_{h} * th_{gov,h}\right) \\ & + (ENTINC * tent_{gov}) + \left(\sum_{gov} GOVTRNS_{gov} * shgovgov_{gov,gov}\right) \\ & + (INVTRNS * shinvgov) + \sum_{t} trnsoutgov_{gov,t}. \end{aligned} \tag{4.31}$$

As shown in equation (4.32), government savings ($govsav$) is assumed to be fixed to the observed figures in the base-year SAM. After considering savings, a portion ($GOVTRNS$) of the revenue received by the government divisions is transfered to other institutions:

$$GOVTRNS_{gov} = GOVINC_{gov} - govsav_{gov}. \tag{4.32}$$

The government divisions' disbursements ($GOVEXP$) consist of fixed savings ($govsav$), government consumption of commodities ($QGOV$) valued at purchaser's prices (PD) and subject to an aggregate sales tax ($tgovcons$), and the transfer income ($GOVTRNS$) to households ($shgovhh$), to other government divisions ($shgovgov$), to enterprises ($shgovent$) and to outside regions ($shgovout$) as formulated in equation (4.33):

$$\begin{aligned} GOVEXP_{gov} = & govsav_{gov} \\ & + \left[\left(\sum_{c} QGOV_{c,gov} * PD_{c} \right) * (1 + tgovcons_{gov}) \right] \\ & + GOVTRNS_{gov} * \left(\sum_{h} shgovhh_{h,gov} + \sum_{gov} shgovgov_{gov,gov} \right) \\ & + GOVTRNS_{gov} * \left(shgovent_{gov} + \sum_{t} shgovout \right). \end{aligned} \tag{4.33}$$

To achieve a complete exhaustion of each government division's budget, government commodity consumption ($QGOV$) is flexible and adjusted from its base-year purchases ($qgov$) equi-proportionately ($GOVADJ$) across consumed commodities as shown in equation (4.34):

$$QGOV_{c,gov} = qgov_{c,gov} * GOVADJ_{gov}. \tag{4.34}$$

4.3.3 Enterprises

There is only one representative account for enterprises ($'ent'$). Enterprises neither sell nor purchase commodities. As mentioned before, enterprises are also endowed with primary factors of production (qf) and land (ql). Again, these endowments are assumed to be fixed to the observed base-year quantities. Instead of distributing net factor incomes ($NETFINC$) directly to households, enterprises also receive a share ($shfinst$), valued at their respective wages (WF) as formulated in equation (4.35). Hence, a good portion of the income ($ENTINC$) generated by enterprises comes from primary factors. Enterprises also receive a share ($shlinst$) of the income from the land rented to agricultural activities at their respective rental rates (WL). Some of the government divisions' transferable income ($GOVTRNS$) is also devoted to enterprises ($shgovent$).

$$\begin{aligned} ENTINC = & \left(\sum_{f} NETFINC_f * WF_f * shfinst_{'ent',f} \right) \\ & + \left(\sum_{l} ql_l * WL_l * shlinst_{'ent',l} \right) \\ & + \left(\sum_{gov} GOVTRNS_{gov} * shgovent_{gov} \right). \end{aligned} \tag{4.35}$$

As shown in equation (4.36), after accounting for enterprises' income taxes ($tent$), the rest of the income received by enterprises is transfered ($ENTTRNS$) to other institutions:

$$ENTTRNS = ENTINC * \left(1 - \sum_{gov} tent_{gov} \right). \tag{4.36}$$

As formulated in equation (4.37), enterprises' disbursements ($ENTEXP$) consist of a tax payment ($tent$) levied on total income ($ENTINC$), and transfers ($ENTTRNS$) to households ($shenthh$) and the investment account ($shentinv$). It is important to note that the transfers to households are indirect factor income payments to households. The transfers to the investment account are considered savings and are adjusted proportionately to the income received.

$$\begin{aligned} ENTEXP = & \left(\sum_{gov} tent_{gov} * ENTINC \right) \\ & + \left\{ ENTTRNS * \left(\sum_{h} shenthh_h + shentinv \right) \right\}. \end{aligned} \tag{4.37}$$

4.3.4 Inventory

There is a representative account for inventories that generates income ($NVTINC$), partially, from the use of commodities in inventory ($nvtsales$) at producer's prices (PQ). It receives transfers from outside institutions ($trnsoutnvt$) and from net aditions to inventory ($nvtin$), meaning there are more additions to inventory than sales from it. As shown in equation (4.38), the only variable in the inventory income formulation is price, the rest being parameters fixed to the observed base-year figures:

$$NVTINC = \left(\sum_c nvtsales_c * PQ_c \right) + \sum_t trnsoutnvt_t + nvtin. \tag{4.38}$$

After accounting for fixed net inventory sales ($nvtout$), meaning there are more sales form inventory than additions to it, the inventory account's transferable income ($NVTTRNS$) to other institutions is formulated as in equation (4.39):

$$NVTTRNS = NVTINC - nvtout. \tag{4.39}$$

As shown in equation (4.40), inventory's total disbursements ($NVTEXP$) consist of commodities' purchases ($QNVT$) at purchaser's prices (PD) and charged an aggregate sales tax ($tnvtcons$), inventory's share ($shnvtout$) of transferable income ($NVTTRNS$) to outside regions, and net inventory sales:

$$\begin{aligned} NVTEXP = &\left[\left(\sum_c QNVT_c * PD_c \right) * (1 + tnvtcons) \right] \\ &+ \left(\sum_t shnvtout_t * NVTTRNS \right) \\ &+ nvtout. \end{aligned} \tag{4.40}$$

To completely exhaust its income, inventory's commodity consumption ($QNVT$) is flexible and adjusted from its base-year purchases ($qnvt$) equi-proportionately ($NVTADJ$) across consumed commodities as shown in equation (4.41):

$$QNVT_c = qnvt_c * NVTADJ. \tag{4.41}$$

4.3.5 Investment

There is a representative account for investment and it partially generates income ($INVINC$) from the sale of investment commodities ($invsales$) valued at producer's prices (PQ), as formulated in equation (4.42). It also receives a share ($deprec$) of the income generated by the capital primary factor (qf), valued at its respective price (WF), in the concept of depreciation or capital consumption allowance. Its receipts also consists of the savings generated by households ($QHHSAV$), valued at their respective prices ($PHHSAV$), fixed government savings ($govsav$), a share ($shentinv$) of enterprises' transferable income ($ENTTRNS$), fixed net inventory sales ($nvtout$) and variable net foreign investment (NFI). Net foreign investment is defined as the difference between foreign spending and receipts.

$$\begin{aligned} INVINC = &\left(\sum_c invsales_c * PQ_c\right) + (deprec_{'capital'} * qf_{'capital'} * WF_{'capital'}) \\ &+ \left(\sum_h QHHSAV_h * PHHSAV_h\right) + \sum_{gov} govsav_{gov} \\ &+ (ENTTRNS * shentinv) + nvtout + \sum_t NFI_t. \end{aligned} \tag{4.42}$$

After accounting for fixed net inventory additions ($nvtin$), the investment account's transferable income ($INVTRNS$) to other institutions is formulated as in equation (4.43):

$$INVTRNS = INVINC - nvtin \quad . \tag{4.43}$$

Formulated in equation (4.44), investment's total disbursements consist of commodity purchases ($QINV$) valued at purchaser's prices (PD) and charged an aggregate sales tax ($tinvcons$), net inventory additions ($nvtin$), investment's income transfers ($INVTRNS$) to households ($shinvhh$), goverment divisions ($shinvgov$) and to outside regions ($shinvout$). The transfers to other institutions are considered borrowed capital by the different receiving institutions.

$$\begin{aligned} INVEXP = & \left[\left(\sum_c QINV_c * PD_c \right) * (1 + tinvcons) \right] \\ & + INVTRNS * \left(\sum_h shinvhh_h + \sum_{gov} shinvgov_{gov} + \sum_t shinvout_t \right) \\ & + nvtin. \end{aligned} \tag{4.44}$$

To completely exhaust its income, investment's commodity consumption ($QINV$) is flexible and adjusted from its base-year purchases ($qinv$) equi-proportionately ($INVADJ$) across consumed commodities as shown in equation (4.45):

$$QINV_c = qinv_c * INVADJ \quad . \tag{4.45}$$

4.4 Commodity markets

4.4.1 Domestic

As figure 4.4 shows, all produced and imported commodities enter into the market. A commodity produced by different domestic sources (activities or institutions) is assumed to be perfectly substitutable and bundled into an aggregate domestic output valued at producer's prices (PQ).[4] Aggregate domestic output is allocated under the assumption that suppliers seek to maximize revenues for any given ag-

[4]As opposed to Lofgren et al. (2002) where activity outputs are considered imperfectly substitutable and a CES function is used to aggregate domestic output by activities.

gregate output level subject to imperfect transformability, between exports and domestic demand, expressed through a CET function (*ComDist*). An elasticity of transformation ($\sigma_{ComDist}$) of -2.5 was used for this nest to reflect a high degree of transformation.

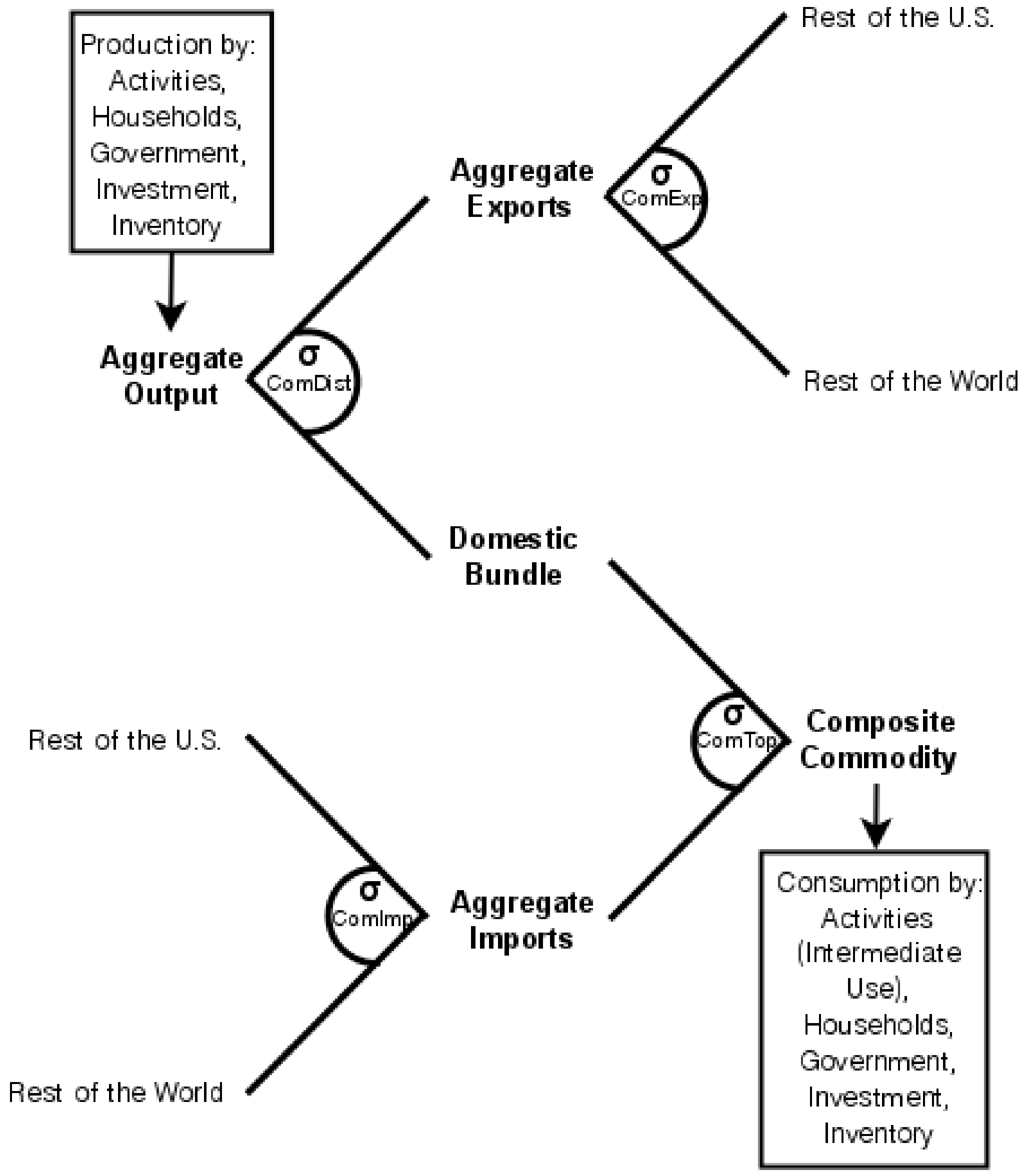


Figure 4.4. Representation of commodity markets in the CGE model

The share of a commodity that is not exported is supplied to the domestic market, at domestic prices ($PDom$), and bundled with imports (if imported) into a composite commodity through a CES function ($ComTop$). This composite commodity is aggregated under the assumption that demanders seek to minize costs subject to imperfect substitutability between imports and domestic supply, according to the Armington convention (Armington 1969). An elasticity of substitution (σ_{ComTop}) of 2.5 was used for this nest to reflect a high degree of substitution. The composite commodity is demanded by end users (activities and institutions) at purcharser's prices (PD).

On the demand side, the model has been designed to find the same market-clearing purchaser's price (PD) across all final consumers for each commodity, equilibrating final demand and composite-commodity supply as shown in equation (4.46). In the CGE model, activity and institutional consumption is flexible.

$$\begin{aligned} QYComTop_c \geq & \sum_h QXHHCons_{h,c} + \sum_a QXActInt_{a,c} \\ & + \sum_{gov} QGOV_{gov,c} + QNVT_c + QINV_c. \end{aligned} \tag{4.46}$$

On the supply side, the model will find the same market-clearing producer's price (PQ) across all domestic producers for each comodity, equilibrating domestic supply and aggregate-output demand as shown in equation (4.47). In the basic CGE model, only production by activities is flexible, institutional production is fixed to the base-year SAM.

$$\begin{aligned} QYComDist_c \leq & \sum_a QXJntPrd_{a,c} + \sum_h hhsales_{h,c} \\ & + \sum govsales_{gov,c} + nvtsales_c + invsales_c. \end{aligned} \tag{4.47}$$

In the modified IMPLAN SAM, indirect business taxes include sales, production and factor-use taxes. Due to the aggregated nature (and treatment as a production tax in this basic model) of the indirect business taxes account and to the non-existence of margin accounts (transportation and retail), all commodity transactions in an IMPLAN SAM are expressed in producer's prices. In the basic CGE model, activities bear the entire burden of the taxes related to commodity production, except import duties. Hence, producer's prices already include these taxes.[5]

4.4.2 Trade

Since the model is designed to acommodate large and small regional aggregations within the U.S., an exchange rate is not necessary due to the negligible effect that small aggregations would exert on world prices. Hence, traded commodities and institutional transfers are valued at the local currency (U.S. dollars). The model assumes the existence of a representative exporter and importer for commodity-trading purposes. The exporter seeks to maximize revenues by selling aggregate export commodities, to the rest of the U.S. and the rest of the world, and subject to imperfect transformability formulated through a CET function ($ComExp$) as depicted in figure 4.4. An elasticity of transformation (σ_{ComExp}) of -2.5 was used for this nest to reflect a high degree of transformation.

On the other side, the importer seeks to minize costs by purchacing commodites, from the rest of the U.S. and the rest of the world, and subject to imperfect substitutability expressed as a CES function ($ComImp$) as depicted in figure 4.4. Commodities imported from the rest of the world were subject to import duties. An elasticity of substitution (σ_{ComImp}) of 2.5 was used for this nest to reflect a high degree of substitution.

[5]For any parametrical shock in the CGE model, the vector of market-clearing prices at a solution shows differences between producer's prices (PQ) and purcharser's prices (PD). This difference is due to the effect of import and export prices, respectively.

As shown in equation (4.48), export demands to outside regions are a function of base-year SAM export quantities ($qexp$) and prices ($pexp$), prices charged by the representative exporter ($PEXP$) and export demand elasticities (ϵ):

$$QEXP_{c,t} = qexp_{c,t} * (1 + \epsilon_{c,t}) * \left(\frac{PEXP_{c,t} - pexp_{c,t}}{pexp_{c,t}}\right), \tag{4.48}$$

where $PEXP$ is estimated as a shadow price of the excess supply equation for exports to each destination:

$$QXComExp_{c,t} \geq QEXP_{c,t}, \tag{4.49}$$

where $QXComExp$ is the quantity supplied by the $ComExp$ nest.

Import supplies from outside regions are a function of base-year SAM import quantities ($qimp$) and prices ($pimp$), free-on-board (FOB) prices charged by the representative foreign exporter at the foreign port ($PFOBIMP$) and import supply elasticities (κ) as formulated in equation (4.50):

$$QIMP_{t,c} = qimp_{t,c} * (1 + \kappa_{t,c}) * \left(\frac{PFOBIMP_{t,c} - pimp_{t,c}}{pimp_{t,c}}\right), \tag{4.50}$$

where the price paid by the representative importer (PIMP) is the FOB price after accounting for import duties:

$$PIMP_{t,c} = PFOBIMP_{t,c} * (1 + timp_{t,c,}), \tag{4.51}$$

where PFOBIMP is estimated as a shadow price of the excess supply equation for imports from each source:

$$QIMP_{t,c} \geq QXComImp_{t,c}, \tag{4.52}$$

where $QXComImp$ is the quantity demanded by the ComImp nest.

4.5 Macroeconomic balances

4.5.1 Government balance

To completely exhaust the different government divisions' budgets, the closure rule followed in the CGE structure is flexible government commodity consumption ($QGOV$) and fixed savings ($govsav$). The adjustment factor ($GOVADJ$) in equation (4.34) helps to achieve this balance and is paired to equation (4.53), following the syntax required by PATH to solve mixed complementarity problems.

$$GOVINC_{gov} = GOVEXP_{gov}. \tag{4.53}$$

4.5.2 Inventory balance

To achieve a balance for the inventory account, the closure rule followed in the basic CGE structure is flexible inventory commodity consumption ($QNVT$) and fixed net inventory deletions ($nvtout$). Again, the adjustement factor ($NVTADJ$) in equation (4.41) helps to achieve this balance and is paired to equation (4.54).

$$NVTINC = NVTEXP. \tag{4.54}$$

4.5.3 Investment balance

The same closure rule followed for the two previous institutions is applied to the investment account - investment commodity consumption ($QINV$) is flexible. However, net foreign income (NFI) is also flexible in this case, as will be explained later. The adjustment factor ($INVADJ$) in equation (4.45) helps to achieve this balance and is paired to equation (4.55).

$$INVINC = INVEXP. \tag{4.55}$$

4.5.4 External balance

As previously mentioned, the model is designed to acommodate large and small regional aggregations within the U.S. Hence, an exchange rate variable is not necessary due to the negligible effect that small aggregations would exert on world prices. Thus, the closure variable for the trade accounts is net foreign investment (NFI). As shown in equation (4.56), the left-hand-side variables reflect receipts by the trade accounts consisting of commodity import quantities ($QIMP$) valued at their respective import FOB prices ($PFOBIMP$), and the different transfers to outside regions by factors ($shfout * NETFINC$), households ($shhhout * HHTRNS$), government divisions ($shgovout * GOVTRNS$), investment ($shinvout * INVTRNS$) and inventory ($shnvtout * NVTTRNS$). The right-hand-side variables and parameters represent transfers from outside regions such as commodity export quantities ($QEXP$) valued at their respective export prices ($PEXP$), foreign transfers to households ($trnsouthh$), government divisions ($trnsoutgov$), inventory ($trnsoutnvt$) and investment account or net foreign investment (NFI).

As previously listed in table 4.1, variables are represented by upper-case latin letters without a bar and parameters with lower-case latin letters without a bar. Hence, $QIMP$, $PFOBIMP$, $NETFINC$, $HHTRNS$, $GOVTRNS$, $INVTRNS$, $NVTTRNS$, $QEXP$, $PEXP$ and NFI are all flexible endogenous variables that adjust according to the model's closure rules such as equation (4.56). The parameters $shfout$, $shhhout$, $shgovout$, $shinvout$, $shnvtout$, $trnsouthh$, $trnsoutgov$, $trnsoutnvt$ are taken and fixed to the 2008 base year SAM.

It is important to mention that all transfers are variables that adjust according to the total income from the different institutions. Prices and quantities of imported and exported commodities are variables. The expenditures from the different institutions that are treated as transfers to outside regions are estimated using shares from the base year SAM multiplied by the transferable institutional income variable. Transfers coming from outside regions to domestic institutions are treated as fixed parameters and do not change from the baseline. Net foreign investment (NFI) is the variable that is adjusted at last and the one that completes the model's closure.

$$\begin{aligned}
&\left(\sum_{c} QIMP_{c,t} * PFOBIMP_{c,t}\right) \\
&+ \left(\sum_{f} shfout_{t,f} * NETFINC_{f}\right) \\
&+ \left(\sum_{h} shhhout_{t,h} * HHTRNS_{h}\right) \\
&+ \left(\sum_{gov} shgovout_{t,gov} * GOVTRNS_{gov}\right) \\
&+ (shinvout_{t} * INVTRNS) \\
&+ (shnvtout_{t} * NVTTRNS) \\
&= \\
&\left(\sum_{c} QEXP_{c,t} * PEXP_{c,t}\right) \\
&+ \sum_{h} trnsouthh_{h,t} \\
&+ \sum_{gov} trnsoutgov_{gov,t} \\
&+ trnsoutnvt_{t} \\
&+ NFI_{t}.
\end{aligned} \tag{4.56}$$

5. AFFORESTATION

This study considers afforestation of agricultural land (cropland and pastureland) using the two major timber categories shown in table 3.4, which are softwood and hardwood. It is assumed that the afforested land will be permanently withdrawn from other uses, including harvest for wood products, to avoid further release of carbon. The practice of leaving tree stands permanently without being harvested is known in the literature as "carbon graveyard" (Richards, Moulton, and Birdsey 1993; Richards and Stokes 2004).

This study is concerned with the additional land-use change to afforestation practices motivated by different government budget allocations. Two different budget allocation schemes are considered:

1. The government only compensates CO_2 offsets generated by land converted to a carbon graveyard, and

2. The government compensates CO_2 offsets generated by land converted to a carbon graveyard and the ones generated, as a by-product, by the existing commercial logging activity.

5.1 Carbon sequestration data

The two most cited studies containing regional data on expected annual changes in growing-stock volume and forest carbon storage from converting cropland and pastureland to forest are Birdsey (1992) and Birdsey (1996). For this study, the regional annual changes in carbon storage data by timber type was obtained from Birdsey (1992) due to the more complete set of regions and timber types considered.[1] Since

[1] Birdsey (1992) estimated rates for eight different regions in the U.S. for softwoods and hardwoods (with the exception of the Rocky Mountains, Mid-Atlantic and Pacific Coast). While Birdsey (1996) reported estimates only for seven regions and mainly for softwoods (with the exception of the Central States).

Birdsey (1992) reports the carbon storage estimates for different forest types and this study only considers the two major timber categories (softwood and hardwood), only one forest type from each major category was used for each region as shown in table 5.1.

The only caveat from using Birdsey (1992) is that different tree-life periods were assumed (from stand establishment to final harvest) and this study considers a carbon graveyard approach. Since some tree species reach their highest carbon uptake rate earlier than others, the problem of considering a short life period is that the annual carbon storage estimate may be higher compared to an estimate that considers the entire life of the tree.

The carbon net annual changes in Birdsey (1992) were published in pounds per acre; hence, they were converted to metric tons (MT) of carbon and then to the equivalent CO_2 weight since most of the previous literature presents cost estimates using these units.

As will be explained later in the document, the afforestation activities in the CGE model reflect inputs and outpus on a per-MT basis. Hence, the CO_2 uptake rates had to be converted to the number of acres necessary to produce a MT of CO_2 annually.

To distribute the different regional CO_2 uptake rates shown in table 5.1 into the MLRAs, a single weighted average ($STCARBON$) was estimated for each timber category in each MLRA in each state. Taking the regional CO_2 uptake rates of both land-use alternatives ($AGCARBON$) and using their respective acreage ($AGACRES$) in each MLRA as weights ($AGWEIGHT$), a single CO_2 uptake rate was estimated for each timber category, MLRA, and state:

$$AGWEIGHT_{carbreg,l,agland} = \frac{AGACRES_{carbreg,l,agland}}{\sum_{agland} AGACRES_{carbreg,l,agland}}, \tag{5.1}$$

Table 5.1. Expected Net Annual Changes in Forest Carbon and CO_2 Equivalent Storage from Converting Agricultural Land to Forest, by Region and Forest Type

Region and forest type	Timber category	Cutting period[a]	Carbon[b]		Carbon[c]		CO_2[d]		Acres for a MT of CO_2	
			Crop	Pasture	Crop	Pasture	Crop	Pasture	Crop	Pasture
		Years	lbs/acre/yr		MT/acre/yr		MT/acre/yr		acres/MT/yr	
Southeast										
Planted pine	Softwood	45	3,436	3,080	1.56	1.40	5.72	5.13	0.17	0.20
Oak-hickory	Hardwood	45	3,247	2,796	1.47	1.27	5.41	4.65	0.19	0.21
South Central										
Planted pine	Softwood	45	3,707	3,284	1.68	1.49	6.17	5.47	0.16	0.18
Oak-hickory	Hardwood	45	3,416	3,042	1.55	1.38	5.69	5.06	0.18	0.20
Northeast										
Spruce-fir	Softwood	80	2,460	2,508	1.12	1.14	4.10	4.18	0.24	0.24
Maple-beech-birch	Hardwood	80	2,850	2,925	1.29	1.33	4.74	4.87	0.21	0.21
Mid-Atlantic										
Oak-hickory	Hardwood	65	2,514	2,823	1.14	1.28	4.19	4.70	0.24	0.21
North Central										
White/red pine	Softwood	80	4,344	4,376	1.97	1.98	7.23	7.28	0.14	0.14
Maple-beech	Hardwood	80	2,531	2,566	1.15	1.16	4.21	4.27	0.24	0.23
Central States										
White/red pine	Softwood	65	1,855	1,911	0.84	0.87	3.09	3.18	0.32	0.31
Oak-hickory	Hardwood	65	2,188	2,243	0.99	1.02	3.64	3.73	0.27	0.27
Rocky Mountains										
Ponderosa pine	Softwood	100	1,644	1,652	0.75	0.75	2.74	2.75	0.37	0.36
Pacific Coast										
Ponderosa pine	Softwood	100	2,071	2,065	0.94	0.94	3.45	3.44	0.29	0.29

[a] Assumed period between stand establishment and final harvest, with no intermediate harvest or treatment. Source: Birdsey, 1992.

[b] Average annual increment over the cutting period.

[c] One pound is the equivalent to 0.000454 metric tons.

[d] One metric ton of carbon is the equivalent to 3.67 metric tons of CO_2

$$STCARBON_{carbreg,l,wood} = \sum_{agland} AGCARBON_{carbreg,agland,wood} * AGWEIGHT_{carbreg,l,agland}, \tag{5.2}$$

where *carbreg* represents the forest carbon storage regions and is a subset of the set *state* and mapped according to table 5.2, *wood* is the set for the major timber categories, l is the set of MLRAs belonging to a specific state in the set *carbreg*, and *agland* is the set representing the crop and pasture land-use alternatives.

Table 5.2. Forest Carbon Storage Regions Considered in the Estimation of Carbon Uptake Rates for Afforestation

Southeast	South Central	Northeast	Mid-Atlantic
Virginia	Texas	Maine	Kentucky
North Carolina	Oklahoma	New York	West Virginia
South Carolina	Arkansas	Connecticut	Ohio
Georgia	Louisiana	Rhode Island	Pennsylvania
Florida	Mississippi	Massachusetts	New Jersey
	Alabama	Vermont	Delaware
	Tennessee	New Hampshire	Maryland
North Central	**Central States**	**Rocky Mountains**	**Pacific Coast**
Michigan	South Dakota	Montana	Washington
Wisconsin	Nebraska	Idaho	Oregon
Minnesota	Kansas	Wyoming	California
North Dakota	Iowa	Nevada	
	Missouri	Utah	
	Illinois	Colorado	
	Indiana	Arizona	
		New Mexico	

As an example, the Southern Coastal Plain MLRA in Florida and belonging to the Southeastern region had acreage figures of 224,039 and 339,102 for cropland and pastureland, respectively. The softwood CO_2 uptake rates for that region are

0.17 and 0.20 acres/MT/year for cropland and pastureland, respectively. Hence, the weighted average of CO_2 uptake for that specific MLRA is 0.187 acres/MT/year:

$$STCARBON_{'Florida','234','soft'} = \left(\frac{224,039}{563,141}\right)(0.17) + \left(\frac{339,102}{563,141}\right)(0.20) = 0.187, \tag{5.3}$$

where 234 is the MLRA code for the Southern Coastal Plain MLRA.

Since regional SAMs are built by aggregating different states in IMPLAN, a single weighted average ($REGCARBON$) was estimated for each MLRA and major timber category present in more than one state for any regional aggregation. Taking the state CO_2 uptake rates of an MLRA ($STCARBON$) and using the acreage of a determined major timber category ($STACRES$) in each state as weights ($STWEIGHT$), a single CO_2 uptake was estimated for each MLRA and major timber category in the regional aggregation ($region$):

$$STWEIGHT_{region,l,wood} = \frac{STACRES_{region,l,wood}}{\sum_{region} STACRES_{region,l,wood}}, \tag{5.4}$$

$$REGCARBON_{l,wood} = \sum_{region} STCARBON_{region,l,wood} * STWEIGHT_{region,l,wood}, \tag{5.5}$$

where $TOTWOOD$ is the total acreage of a specific timber category and $region$ is the IMPLAN regional aggregation.

As an example, if $region$ included Florida and Alabama only, the Southern Coastal Plain MLRA is present in both states and had softwood acreage figures of 2,538,858 and 7,548,325, respectively. The estimated softwood CO_2 uptake averages in the Southern Coastal Plain MLRA in Florida and Alabama are 0.187 and

0.175 acres/MT/year, respectively. Hence, the regional weighted average of CO_2 uptake for that specific MLRA is 0.178 acres/MT/year:

$$REGCARBON_{'234','soft'} = \left(\frac{2,538,858}{10,087,183}\right)(0.187) + \left(\frac{7,548,325}{10,087,183}\right)(0.175) = 0.178. \quad (5.6)$$

Hence, the final result is a matrix of regional annual CO_2 uptake rates for each MLRA included in the IMPLAN regional aggregation and major timber category. As will be explained later, these CO_2 uptake figures will determine the land and establishment costs on a per-CO_2-MT basis.

5.2 Afforestation costs

5.2.1 Initial treatment costs

The most cited study reporting regional afforestation costs for cropland and pastureland is Moulton and Richards (1990). In this study, the activities included in the costs were land preparation, seedlings, planting, and postplanting treatment and care required to ensure establishment.[2] These regional treatment costs were estimated for irrigated and non-irrigated cropland and pastureland. Since the difference among the costs was not great, a simple average was taken of both irrigated and non-irrigated lands. Moulton and Richards (1990) estimated afforestation costs of cropland and pastureland without differentiating between the two major timber categories, as shown in the second and third columns of table 5.4.[3]

Bair and Alig (2006) estimated afforestation costs for each land-use alternative and major timber category, as shown in table 5.3. According to them, afforestation costs for hardwood in any region in the U.S. were 25% higher than for softwood.

[2]According to Richards and Stokes (2004), Moulton and Richards (1990) included provisions for a 15% failure rate increasing the cost estimates.

[3]For each region, Moulton and Richards (1990) estimated the treatment costs using historical planting patterns of a given mixture of tree species.

The problem with Bair and Alig (2006) is that cost estimates were provided only for three major regions in the U.S.

Table 5.3. Site Preparation and Afforestation Costs by Bair and Alig (2006)

Region and timber category	Crop	Pasture
	2002 $/acre	
Southeast		
Softwood	64.92	82.41
Hardwood	81.16	103.01
South Central (Plains)		
Softwood	73.29	80.62
Hardwood	91.61	100.77
Corn Belt		
Softwood	114.36	157.07
Hardwood	142.95	196.34

Table 5.4. Cost of Land Preparation, Seedlings, Planting, and Followup by Moulton and Richards (1990)

Region	Crop	Pasture	Crop	Pasture
	$/acre		Differential	
Southeast	59.50	67.00	1.00	1.00
Lake States	105.00	105.00	1.76	1.57
Corn Belt	136.00	186.00	2.29	2.78
Northern Plains	97.00	102.00	1.63	1.52
Appalachian	62.00	89.00	1.04	1.33
Northeast	150.00	196.00	2.52	2.93
Delta States	69.50	77.00	1.17	1.15
Southern Plains	57.00	63.00	0.96	0.94
Mountain	70.00	109.00	1.18	1.63
Pacific	180.00	215.00	3.03	3.21

Both studies were used to estimate a more complete set of costs for every region in Moulton and Richards (1990) and every major timber category in Bair and Alig (2006). As shown in the fourth and fifth columns of table 5.4, cost differentials were estimated among the different regional aggregations considered in Moulton and Richards (1990). The Southeast region was taken as a reference since 90% of total forest acreage was planted with softwood trees, as reported in Moulton and Richards (1990). Hence, by multiplying the cost differentials of every region in Moulton and Richards (1990) by the cost estimates from Bair and Alig (2006) for softwood and hardwood in the Southeast, and adjusting for inflation, a more complete set of costs was obtained as shown in table 5.5. Since the estimates in Bair and Alig (2006) are in 2002 dollars, to adjust for inflation, a factor of 1.04 was estimated by considering the percent change between the Producers Price Index (PPI) in 2002 to 2008.

Table 5.5. Modified Afforestation Costs from Previous Literature

Region	Softwood		Hardwood	
	Crop	Pasture	Crop	Pasture
	2008 $/acre[a]		2008 $/acre[a]	
Southeast	67.48	85.66	84.36	107.07
Lake States	119.08	134.24	148.85	167.80
Corn Belt	154.23	237.79	192.79	297.24
Northern Plains	110.01	130.40	137.51	163.00
Appalachia	70.31	113.78	87.89	142.23
Northeast	170.11	250.58	212.64	313.22
Delta States	78.82	98.44	98.52	123.05
Southern Plains	64.64	80.54	80.80	100.68
Mountain	79.39	139.35	99.23	174.19
Pacific	204.13	274.87	255.17	343.58

[a] 2002 - 2008 Producers Price Index (PPI) percent change of 1.04

Following previous literature, treatment costs had to be annualized to spread the cost burden throughout the life of the plantation (Moulton and Richards 1990; Adams et al. 1993; Parks and Hardie 1995; and New York State Energy Office, 1991). This carbon accounting approach is known in the literature as the levelization method and it consists on annualizing (levelizing) the present value of the treatment costs over the period of carbon flows and dividing it by the annual carbon capture rate (Richards and Stokes 2004; Stavins and Richards 2005). Hence, the annualized (levelized) costs are shown in the last four columns of table 5.6. Following Moulton and Richards (1990), an interest rate of 10% was considered to estimate different capitalization factors for different regions and major timber categories, depending on the period of carbon flows. The periods and capitalization factors are also shown in table 5.6.

To come up with a single cost estimate for every MLRA and major timber category in any IMPLAN regional aggregation, the same procedure followed previously for carbon uptake rates was followed for costs. Hence, by replacing $STCARBON$ and $REGCARBON$ for the cost estimate at the state level ($STCOST$) and at the regional level ($REGCOST$) in equations (5.2) and (5.5), a single regional treatmet cost would be obtained for each MLRA and major timber category.

5.2.2 Land rent costs

The annual costs of land for afforestation that would have been incurred in the base year of 2008 are reflected in the per-acre rent figures estimated for agricultural land in subsections 3.5.1 and 3.5.3 and formulated in equation (4.10):

$$RENTACRE_{l,'AgriculturalLand'} = PXLandBot_{l,'AgriculturalLand'}, \tag{5.7}$$

where $PXLandBot$ represents the baseline price for the $LandBot$ nest for agricultural land and MLRA l. Hence, $RENTACRE$ represents the per-acre rent estimates for each MLRA for agricultural land.

5.3 Including afforestation in the CGE model

Afforestation is modeled in the CGE as a latent activity meaning that it is present but not active in the model's baseline since there are no government budget allocations for CO_2 offsets. Since this study is concerned only with the additional land-use change to afforestation practices motivated by different government budget allocations, the afforestation latent activity becomes active and profitable in the different counterfactual scenarios.

Table 5.6. Annualized Modified Afforestation Costs

Region	Years		Capitalization factor[a]		Softwood		Hardwood	
	Softwood	Hardwood	Softwood	Hardwood	Crop	Pasture	Crop	Pasture
					2008 $/acre/year		2008 $/acre/year	
Southeast	45	45	0.1014	0.1014	6.84	8.68	8.55	10.86
Lake States	80	80	0.1000	0.1000	11.91	13.43	14.89	16.79
Corn Belt	65	65	0.1002	0.1002	15.45	23.83	19.32	29.78
Northern Plains[b]	65	65	0.1002	0.1002	11.02	13.07	13.78	16.33
Northern Plains[c]	80	80	0.1000	0.1000	11.01	13.05	13.76	16.31
Appalachia[d]	45	45	0.1014	0.1014	7.13	11.54	8.91	14.42
Appalachia[e]	45	65	0.1014	0.1002	7.13	11.54	8.81	14.25
Northeast[f]	80	80	0.1000	0.1000	17.02	25.07	21.27	31.34
Northeast[g]	80	65	0.1000	0.1002	17.02	25.07	21.31	31.39
Delta States	45	45	0.1014	0.1014	7.99	9.98	9.99	12.48
Southern Plains	45	45	0.1014	0.1014	6.55	8.17	8.19	10.21
Mountain	100	100	0.1000	0.1000	7.94	13.94	9.92	17.42
Pacific	100	100	0.1000	0.1000	20.41	27.49	25.52	34.36

[a] Interest rate of 10%

[b] Kansas, Nebraska, South Dakota

[c] North Dakota

[d] Tennessee, Virginia, North Carolina

[e] West Virginia, Kentucky

[f] New Hampshire, Maine, Massachusetts, Connecticut, Vermont, Rhode Island, New York

[g] Delaware, Maryland, Pennsylvania, New Jersey

Regarding the CO_2 offsets generated by the commercial logging activity, revenues are generated in the counterfactual equilibrium when the government budget allocation is greater than zero.

5.3.1 Afforestation activities

An array of afforestation activities was created using combinations of MLRAs and major timber categories based on existing softwood and harwood forest (public and private) acreage planted in the different MLRAs. For example, if softwood was planted in the Southern Coastal Plain MLRA (MLRA code 234), an afforestation activity was created representing the existing combination (i.e. activity MLRA234_SOFT).

Following the same modeling structure of activities explained in section §4.1, afforestation activities are reflected as a set of top nests ($AfforTop$) that use as inputs a specific MLRA and intermediate commodity as shown in figure 5.1. Every afforestation activity uses land only from the activity's respective MLRA. A zero elasticity of substitution was used for the top nest ($\sigma_{AfforTop}$) to reflect a fixed-proportion structure. Every afforestation activity also uses only the aggregate commodity of "other agriculture". This commodity includes the IMPLAN sector of support activities for agriculture and forestry (IMPLAN commodity code 3019). The sector of support activities for agriculture and forestry includes companies that provide afforestation services. Hence, it is assumed that the labor and capital requirements for afforestation are indirectly provided by the afforestation companies under contract.

The afforestation activities in the CGE model reflect inputs and outpus on a per-MT basis. Hence, the costs inputed into the land ($AfforLand$) and intermediate input ($AfforInt$) nests needed to be specified on a per-MT basis. Since the land rent ($ACRERENT$) and treatment ($REGCOST$) costs were estimated on a per-

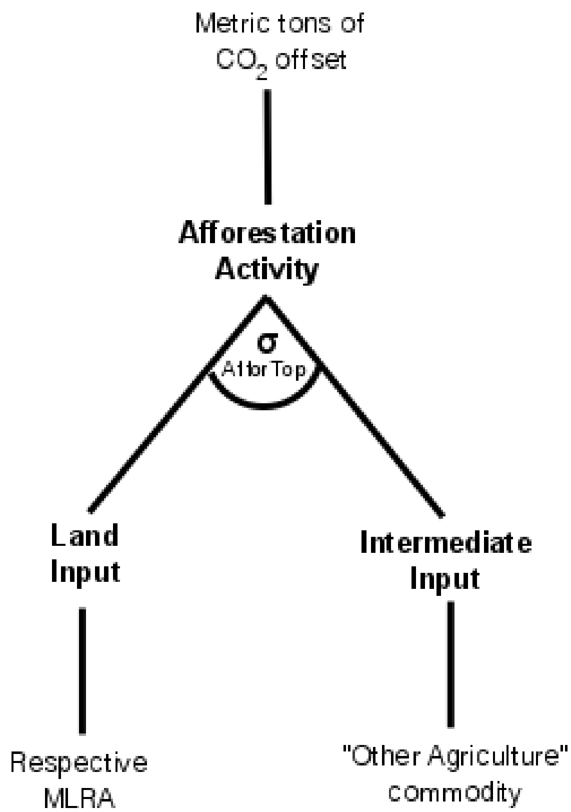


Figure 5.1. Representation of afforestation activities in the CGE Model

acre basis, they had to be converted to a per-MT basis using the regional annual CO_2 uptake rates expressed in acres/MT/year in the following manner:

$$QXAfforLand_{affor,l} = ACRERENT_{l,alogg} * REGCARBON_{l,wood}, \qquad (5.8)$$

$$QXAfforInt_{affor,'othagr'} = REGCOST_{l,wood} * REGCARBON_{l,wood}, \qquad (5.9)$$

where a mapping was developed from the $affor$ set to the l and $wood$ sets, since the $affor$ set is a combination of the l and $wood$ sets.

5.3.2 Commercial logging activity

As stated at the beginning of this chapter, among the government budget allocations considered in this study, one includes payments to the commercial logging activity for generating CO_2 offsets as a by-product. The production of CO_2 offsets by this activity is depicted in figure 5.2.

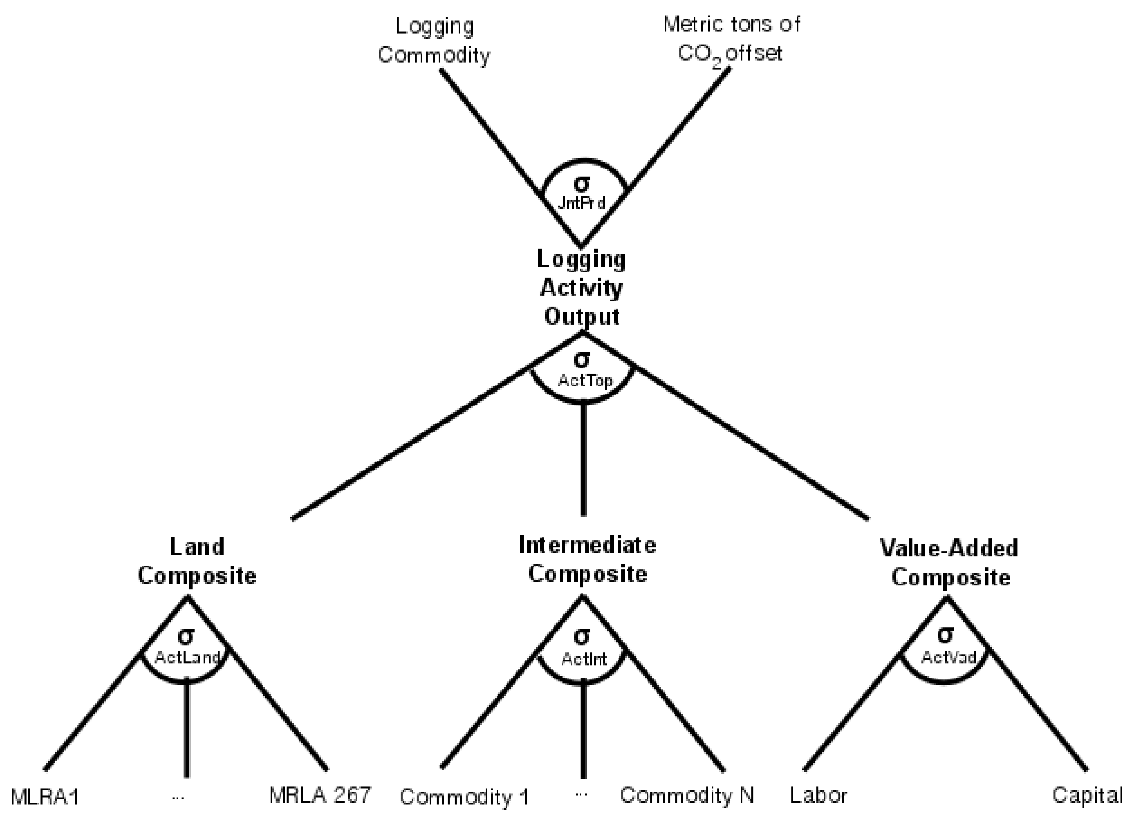


Figure 5.2. Representation of the generation of CO_2 offsets by the commercial logging activity

The joint production ($JntPrd$) nest of the commercial logging activity was calibrated with the logging commodity production value from the SAM and the net annual change in carbon stocks (in MT of CO_2) in the forest and harvested wood pools in 2008. As stated in section §4.1, all the transformation elasticities used for this nest (σ_{JntPrd}) were zero to reflect a fixed-proportion production regime. According to EPA (2012), the total net annual change in carbon stocks for that year in the U.S. was 891 MT of CO_2 coming from all kinds of forestland remaining in forestland. However, the commercial logging activity included in IMPLAN and in this study includes only privately-owned timber land and the regional aggregation covers only 38 states in the continental U.S. Hence, a portion of the 891 MT had to be estimated using the forest carbon inventories from FS (2010) in private timber land per state. According to the EPA (2012), about 50% of the annual carbon stock changes come from aboveground biomass. Hence, as an approximation, by comparing the amount of aboveground carbon in live trees from FS (2010) in privately-owned timber land in the regional aggregation (38 states) to the total amount contained in all national timber land, it was estimated that approximately 632 MT (or 71% of the 891 MT of CO_2) were generated by the logging activity in 2008. Hence, the $JntPrd$ nest was calibrated with a generation of 632 MT of CO_2 offsets. Since the offset generation of the commercial logging activity was calibrated with a value obtained from the literature, regional sequestration rates were not necessary. However, as previously mentioned, the top ($ActTop$) nest of the commercial logging activity was calibrated with a substitution elasticity (σ_{ActTop}) of 0.2 to reflect a more realistic ratio between acreage demanded by the activity and offset generation.

5.3.3 Commodity and land markets

The land demanded by the afforestation activities comes from the agricultural land supplied from each MLRA. As previously specified in equation (4.5), land allocated to the agricultural land-use type was entirely demanded by the agricultural land nest. Now, as formulated in equation (5.10) and depicted in figure 5.3, the agricultural land-use allocation is demanded by the agricultural land nest and the latent afforestation activities.

$$QXLandBot_{l,'AgLand'} \geq QYLandAg_l + \sum_{affor} QXAfforLand_{affor,l}. \quad (5.10)$$

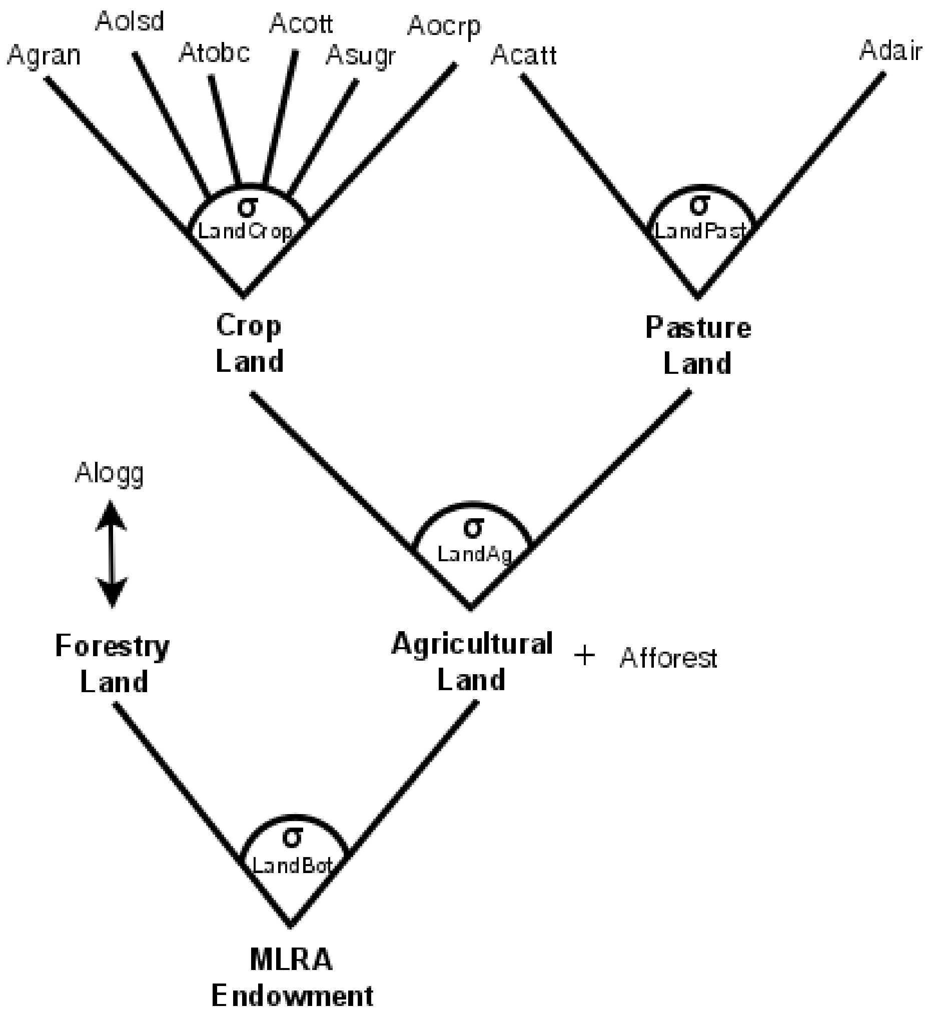


Figure 5.3. Representation of land markets with afforestation in the CGE model

The "other agriculture" intermediate commmodity demanded by the afforestation activities comes from the composite-commodity supply. As previously specified in equation (4.46), composite-commodity supply was entirely demanded by households, activities, government, inventory and investment. Now, as formulated in equation (5.11), the composite-commodity supply is also demanded by the afforestation activities.

$$\begin{aligned} QYComTop_c \geq & \sum_h QXHHCons_{h,c} + \sum_a QXActInt_{a,c} \\ & + \sum_{gov} QGOV_{gov,c} + QNVT_c + QINV_c \\ & + \sum_{affor} QXAfforInt_{affor,c}. \end{aligned} \tag{5.11}$$

5.3.4 Carbon

As shown in figure 5.1, CO_2 offsets are supplied by the afforestation and logging activities in metric tons. The aggregated supply of CO_2 offsets by the different afforestation activities ($QYAfforTop$) and the commercial logging activity ($QXJntPrd$), at their respective prices ($PYAfforTop$ and $PXJntPrd$), is entirely demanded by the government through a budget allocation (*govcarbonbudget*) coming specifically from the federal non-defense division as formulated in equation (5.12). The budget equation was paired with *QCarbonDemand*. The counterfactual scenario with no government payments to the commercial logging activity does not include the last expression in parentheses.

$$\begin{aligned} govcarbonbudget_{'fed\,non-def'} = & \left(\sum_{affor} QYAfforTop_{affor} * PYAfforTop_{affor} \right) \\ & + \left(QXJntPrd_{alogg,carbon} * PXJntPrd_{alogg,carbon} \right). \end{aligned} \tag{5.12}$$

As previously stated, the model estimates market-clearing prices in the form of shadow values from a set of excess supply functions. Equation (5.13) shows the excess supply specification for CO_2 offsets and its price is estimated as a result ($PCarbon$).

The counterfactual scenario with no government payments to the commercial logging activity does not include the $QXJntPrd$ variable on the left-hand side.

$$\sum_{affor} QYAfforTop_{affor} + QXJntPrd_{alogg,carbon} \geq QCarbonDemand. \tag{5.13}$$

Every afforestation activity is required to supply a minimum amount of CO_2 offsets ($carbonmin$) as shown in equation (5.14). When this inequality is binding, a CO_2 offset premium is generated as a shadow value ($PREMCarbon$).

$$QYAfforTop_{affor} \geq carbonmin_{affor}. \tag{5.14}$$

Hence, as formulated in equation (5.15), the price paid to each afforestation activity ($PYAfforTop$) is equal to the CO_2 offset price plus a premium paid only if the activity is supplying the required minimum. If the afforestation activity is supplying more than the minimum requirement, it is paid only the CO_2 offset price.

$$PYAfforTop_{affor} = PCarbon + PREMCarbon_{affor}. \tag{5.15}$$

In the counterfactual scenario with government payments to the commercial logging activity, the price paid by the government to the activity is equal to the CO_2 offset price:

$$PXJntPrd_{alogg,carbon} = PCarbon. \tag{5.16}$$

5.3.5 Government

Since the budget allocation for CO_2 offsets comes from the federal government's non-defense division, it is included in that government division's expenditures as formulated in equation (5.17).

$$
\begin{aligned}
GOVEXP_{'fed\,nondef'} =& govsav_{'fed\,nondef'} \\
&+ \left(\sum_c QGOV_{c,'fed\,nondef'} * PD_c\right) * (1 + tgovcons_{'fed\,nondef'}) \\
&+ GOVTRNS_{'fed\,nondef'} * \left(\sum_h shgovhh_{h,'fed\,nondef'}\right) \\
&+ GOVTRNS_{'fed\,nondef'} * \left(\sum_{gov} shgovgov_{gov,'fed\,nondef'}\right) \\
&+ GOVTRNS_{'fednondef'} * \left(\sum_t shgovout_t\right) \\
&+ GOVTRNS_{'fed\,nondef'} * (shgovent_{'fed\,nondef'}) \\
&+ govcarbonbudget_{'fed\,nondef'},
\end{aligned} \tag{5.17}
$$

6. RESULTS

6.1 Baseline equilibrium

The baseline equilibrium results are detailed in this section to help compare changes to the counterfactual equilibria for the different government payment schemes. First, baseline land acreage and rent distribution among the different IMPLAN agricultural activities, land categories and land-use types are listed. Following, the baseline production, consumption and trade of commodities by the different activities and institutions are detailed. Since income and expenditures are the same for each institution, income levels are listed last.

6.1.1 Land distribution

The baseline equilibrium reflected the solution levels for the model's variables when there was no government budget allocation directed to CO_2 offsets. In other words, the baseline reflected the values of the final modified SAM. Since the market for CO_2 offsets did not exist, the afforestation activities did not produce CO_2 offsets and did not use any land. Hence, there was no land-use change and the price and quantities of land reflected rents and acreages estimated in section §3.5, respectively.

As shown in figure 6.1, the land factor was completely distributed among agriculture- and forestry-related activities in this study. Agricultural land accounted for approximately 63% of the land endowment used and forest land for 37%. As previosly mentioned in 3.5.2, the type of forest land considered in this study is privately-owned timber land.

As shown in figure 6.2, agricultural land was completely distributed between cropland and pastureland. Cropland accounts for approximately 51% of total agricultural land, and pastureland for 49%. As previously mentioned in 3.5.1, the definition of cropland used in this study is harvested cropland considering the value of the land in production over the course of the entire year. The definition of pastureland, as mentioned in 3.5.3, is permanent pasture and rangeland including cropland and timber land pastured.

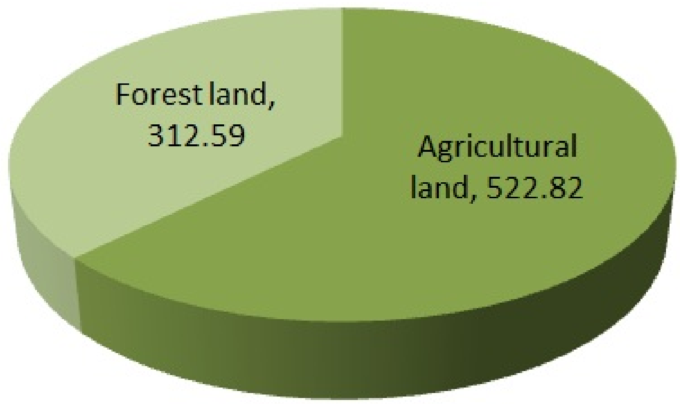


Figure 6.1. Agriculture and forest land distribution in the regional aggregation in millions of acres in 2008

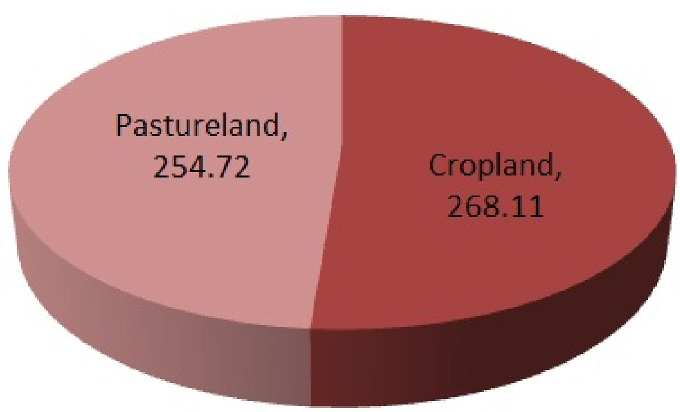


Figure 6.2. Agricultural land distribution in the regional aggregation in millions of acres in 2008

As stated in 3.5.5, to account for land heterogeneity, the land factor was categorized into 169 MLRAs included in the regional aggregation out of a total of 278 MLRAs considered nationally. An entire list of the MLRA codes included in the regional aggregation and their names is shown in table A.10 in the appendix. However, for reporting and conciseness purposes, the concept developed by NRCS of Land Resource Regions (LRR) will be used in this section. According to NRCS, LRRs are "geographically associated MLRAs which approximate broad agricultural market regions." There are 28 LRRs in the continental U.S. of which only 17 were considered in the regional aggregation. A list of the LRRs considered in this study with the MLRAs included in each of them is shown in table 6.1. All results at the MLRA level are included in the appendix of this document. The maps included in the appendix of this document were obtained from NRCS (2006).

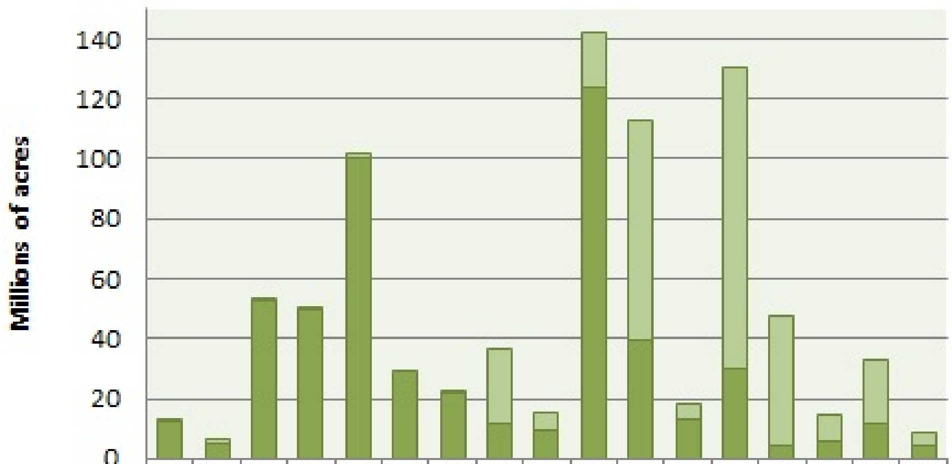
In order of importance, the three LRRs containing most of the agricultural land supplied in the baseline were M, H and F, as shown in figure 6.3. The map of the Central Feed Grains and Livestock Region (LRR M) is shown in figure B.8 in the appendix. For forest land, the three LRRs supplying most of the land were P, N and R. The map of the South Atlantic and Gulf Slope Cash Crops, Forest, and Livestock Region (LRR P) is shown in figure B.10 in the appendix.

In order of importance, the three LRRs containing most of the cropland supplied in the baseline were M, H and F, as shown in figure 6.4. For pastureland, the three LRRs supplying most of the land were H, G and I. The map of the Central Great Plains Winter Wheat and Range Region (LRR H) is shown in figure B.4 in the appendix.

As shown in table C.2, the activities that paid the majority of the rents to the land factor were grains (Agran), oilseeds (Aolsd), logging (Alogg), and cattle (Acatt). Oilseed rents were greater in M, F and O. Grain rents were greater in M, H and F. Logging rents were greater in P, N and T. Cattle rents were greater in H, M and N.

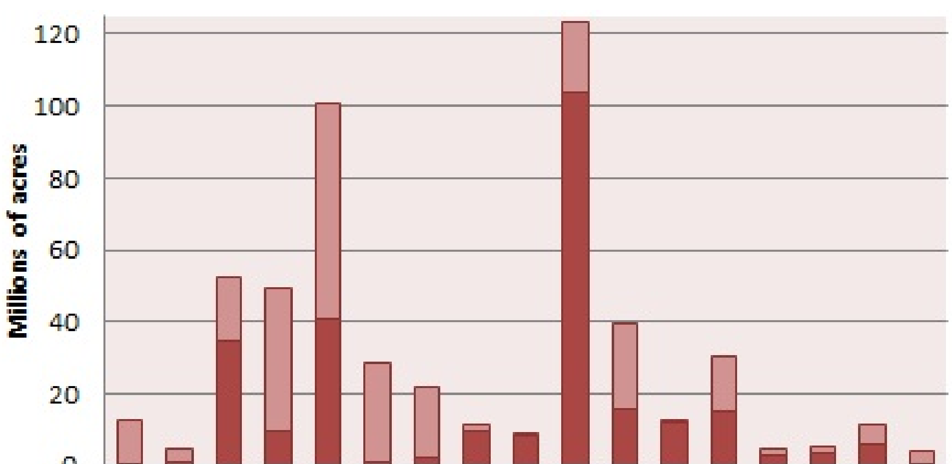
Table 6.1. Land Resource Regions (LRR) List and their Respective MLRAs

LRR code	LRR name	MLRAs included
D	Western Range and Irrigated Region	MLRA043 - 054
E	Rocky Mountain Range and Forest Region	MLRA065 - 070
F	Northern Great Plains Spring Wheat Region	MLRA072 - 079
G	Western Great Plains Range and Irrigated Region	MLRA083 - 100
H	Central Great Plains Winter Wheat and Range Region	MLRA104 - 123
I	Southwest Plateaus and Plains Range and Cotton Region	MLRA125 - 136
J	Southwestern Prairies Cotton and Forage Region	MLRA137 - 148
K	Northern Lake States Forest and Forage Region	MLRA80 , MLRA149 - 166
L	Lake State Fruit, Truck Crop, and Dairy Region	MLRA167 - 172
M	Central Feed Grains and Livestock Region	MLRA173 - 204
N	East and Central Farming and Forest Region	MLRA205 - 228
O	Mississippi Delta Cotton and Feed Grains Region	MLRA230 - 233
P	South Atlantic and Gulf Slope Cash Crops, Forest, and Livestock Region	MLRA234 - 242
R	Northeastern Forage and Forest Region	MLRA243 - 250
S	Northern Atlantic Slope Diversified Farming Region	MLRA252 - 255
T	Atlantic and Gulf Coast Lowland Forest and Crop Region	MLRA256 - 264
U	Florida Subtropical Fruit, Truck Crop, and Range Region	MLRA265 - 267



	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U
Forest	0.6	1.8	0.8	1.1	1	0	1.4	25	6.3	19	73	5.2	100	43	9.3	21	4.3
Agriculture	12	5	52	49	101	29	22	12	9.2	123	39	13	30	4.5	5.4	12	4.3

Figure 6.3. Land distribution in Land Resource Regions (LRRs) in 2008



	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U
Pasture	12	4.1	18	40	59	28	19	2.1	0.6	20	24	0.8	15	1.3	1.7	5.7	3.9
Crops	0.4	0.8	35	9.5	41	1.3	2.3	9.6	8.6	104	16	12	15	3.2	3.7	5.8	0.4

Figure 6.4. Agricultural land distribution in Land Resource Regions (LRRs) in 2008

By separating land rents by land-use type instead of activities, table 6.2 shows that cropland received approximately 77% of the rents, and pastureland and forest land 11% each. Cropland rents were distributed mainly in M, H and F. Pastureland rents in M, H and N. Forest land rents in P, N and T. Clearly the LRRs receiving most of the rents from agriculture- and forestry-related activities were M, H, N and P. The map of the East and Central Farming and Forest Region (LRR N) is shown in figure B.9.

Table 6.2. Total Land Rent Paid by Land-use Type in Millions of Dollars to the Land Resource Regions (LRRs) in 2008

LRR code	Cropland		Pastureland		Forestry land	
	$	%	$	%	$	%
D	14.83	0%	25.62	1%	0.70	0%
E	62.65	0%	21.58	1%	2.47	0%
F	1,658.16	7%	295.96	9%	1.00	0%
G	549.87	2%	375.40	11%	1.40	0%
H	2,384.43	10%	596.33	17%	1.04	0%
I	70.61	0%	166.09	5%	-	0%
J	56.62	0%	219.34	6%	13.60	0%
K	762.35	3%	51.93	2%	50.65	1%
L	754.49	3%	19.44	1%	10.49	0%
M	14,017.60	58%	588.32	17%	24.50	1%
N	923.16	4%	497.54	15%	598.17	18%
O	1,093.76	5%	17.85	1%	61.96	2%
P	948.83	4%	293.73	9%	1,969.77	58%
R	135.03	1%	32.44	1%	77.65	2%
S	221.98	1%	44.20	1%	49.16	1%
T	332.96	1%	83.72	2%	459.22	13%
U	79.58	0%	84.03	2%	88.50	3%
Total	24,066.92		3,413.52		3,410.28	

6.1.2 Production

As stated in 4.4.1, commodities were produced by activities and institutions. The IMPLAN SAM included a multi-product production structure per activity. Hence, by including the joint-production ($JntPrd$) nest, the CGE accommodated this multi-product production. Commodity production by institutions was fixed at the baseline levels; hence, it does not change for the counterfactual equilibria.

The total value of production by activity in the baseline is listed in table C.1 in the appendix. These are the values for $QYActTop$ in the base year data. Percentages were estimated with respect to the total value produced by all activities and by only the agricultural activities. Out of all the aggregated activities considered in this study, manufacturing (26%), health (6%), and government employment (6%) accounted for the three largest shares of total value of production. A reason for the large share of the aggregated manufacturing activity is that it includes 278 IMPLAN activities.

The total value of agriculture-related production was approximately 1.76% of the total value of all production. Out of the agricultural activities, other agriculture (32%), grains (22%), and cattle (13%) accounted for the three largest shares of total value of production in agriculture. It is worth mentioning that a reason for the large share from the "other agriculture" activity is that it includes the production of fruits, vegetables, ornamentals, poultry, other animals, forest products, fishing, hunting and support activities for agriculture and forestry.

The total value of factors of production used by activity in the baseline is listed in table C.3 in the appendix. These values are the inputs to the $ActVad$ nest and their total per activity is the value-added composite that goes into the $ActTop$ nest. The last two columns show the shares of capital and labor requirements per activity. About half of the agriculture-related activities were labor intensive, tobacco being one of the top ones having 91% of its value-added coming from labor. Among the agricultural activities with a large capital share, grains (78%) and dairy (86%) were the two top ones. Most of the activities not directly related to agriculture were labor intensive having mining, utilities, real estate, and other rentals as the exception.

The total value of production by institutions is included in table C.4, table C.5, table C.6 in the appendix for households, government divisions and inventory, respectively. Households mainly produced scrap, used and secondhand commodities included in the unclassified commodity aggregate (Cuncl). The non-education division of the state government produced the largest portion of commodities across all government divisions. Health (Chlth), education (Ceduc) and waste administration (Cadmw) being the largest commodity aggregates produced. The commodity production by the inventory account is interpreted as the supply of commodities in inventories for that year. Oilseeds (Colsd), tobacco (Ctobc), mining (Cmini) and manufacturing (Cmanf) accounted for the largest shares of the values of commodities supplied by the inventory.

6.1.3 Consumption

The total value of consumption of intermediate commodities by activity in the baseline is listed in table C.7 in the appendix. This matrix is the input to the *ActInt* nest and their total per activity is the intermediate composite that goes into the *ActTop* nest. The manufacturing (Cmanf) and other agriculture (Coagr) commodity aggregates were two of the most demanded intermediate commodities by the agriculture-related activities due to their high degree of aggregation. However, it is worth mentioning that the financial services (Cfinc) commodity aggregate was one of the most demanded by the tobacco (Atobc) and sugar (Asugr) activities. The wholesale commodity aggregate (Cwhol) was also of great importance to the dairy (Adair) and logging (Alogg) industries.

As listed in table 6.3, the first six household income categories spent their net income (after taxes and other obligations) on consumption commodities entirely, leaving no shares for savings. The last four categories increased their savings share, obviously, due to the higher annual income.

Table 6.3. Distribution of Net Income Between Consumption and Savings by Household Income Category in the Baseline (2008)

Household	Value (millions of $)		Share	
income categories	Consumption	Savings	Consumption	Savings
< 10 K	299,347		100%	
10 - 15 K	214,495		100%	
15 - 25 K	517,652		100%	
25 - 35 K	622,107		100%	
35 - 50 K	1,022,495		100%	
50 - 75 K	1,615,958		100%	
75 - 100 K	1,090,602	12,174	99%	1%
100 - 150 K	1,065,773	66,293	94%	6%
> 150 K	1,463,216	242,507	86%	14%

The total value of household consumption by commodity and income category in the baseline is listed in table C.8 in the appendix. Listed in the last row of the table are estimated shares of the total net income spent on consumption goods by all income categories. It is evident that the highest share of the net income devoted to consumption was spent on the manufacturing (Cmanf), health (Chlth) and other property rent (Cornt) commodity aggregates. It is worth mentioning that the "other property rent" commodity aggregate included housing, automotive, commercial and industrial equipment rentals.

The total value of institutional consumption by commodity in the baseline is listed in table C.9 in the appendix. As listed on the last row of the table, the three largest shares of total institutional consumption were accounted for by the investment account, and the investment and non-education divisions of the state government. It is worth mentioning that the construction (Ccons) commodity aggregate was the most demanded by the investment account and the investment division of the state government. Professional services (Cprof), information (Cinfon) and construction

(Ccons) were among the commodity aggregates highly demanded by all government divisions. The consumption of commodities by the inventory account are interpreted as commodities that went into the inventory in that year. Hence, the transportation (Ctrns), other agriculture (Coagr), wholesale (Cwhol), information (Cinfo) and manufacturing (Cmanf) commodity aggregates were highly demanded by the inventory account.

6.1.4 Trade

Besides trade with the rest of the world, the SAM also accounts for trade within the U.S. Hence, the states that were left out of the regional aggregation represent the region with wich this type of trade took place. The states not considered in the regional aggregation are located on the Western or Pacific coast and in the mountainous and dessertic regions of the U.S.

The total value of exports to the rest of the U.S. by commodity in the baseline is listed in table C.10 in the appendix. Percentages were estimated with respect to the total value of all exported commodities and to the total value of the ones related to agriculture. Out of all the commodity aggregates included in this study, manufacturing (51%), mining (7%), and unclassified (7%) accounted for the three largest shares of total value of exports to the rest of the U.S. The total value of agricultural commodities exported to the rest of the U.S. accounted for 1.57% of the total value. The three agricultural commodity aggregates with the highest shares were grains (41%), other agriculture (31%), and oilseeds (15%).

The total value of exports to the rest of the world by commodity in the baseline is listed in table C.11 in the appendix. Out of all the commodity aggregates, manufacturing (60%), unclassified (12%), and wholesale (7%) accounted for the largest shares. The total value of agricultural commodities exported to the rest of the world accounted for 3.30% of the total value. The three agricultural commodity aggregates with the highest shares were grains (59%), oilseeds (14%), and other agriculture (11%).

The total value of imports from the rest of the U.S. by commodity in the baseline is listed in table C.12 in the appendix. Out of all the commodity aggregates, manufacturing (48%), information (7%), and real estate (7%) accounted for the largest shares. The total value of agricultural commodities imported from the rest of the U.S. accounted for 11% of the total value. The three agricultural commodity aggregates with the highest shares were other agriculture (55%), other crops (23%), and dairy (16%).

The total value of imports from the rest of the world by commodity in the baseline is listed in table C.13 in the appendix. The three commodity aggregates with the largest shares of total value imported were manufacturing (71%), mining (16%), and finance (2%). Agriculture accounted for 1.55% of total value of imported commodities with other agriculture (92%), other crops (3%), and cattle (2%) as the commodity aggregates with the highest shares.

6.1.5 Institutional income

By convention, the incomes (row totals) and expenditures (column totals) of the institutions included in the SAM needed to be equal. Hence, for reporting purposes, only incomes are listed in table C.14, as well as net foreign investment. The figures listed for the different household income categories are gross incomes before deducting income taxes and other obligations. The government divisions with the highest income figures were the federal non-defense and state non-education divisions. The budget allocations dedicated to CO_2 offsets came from the federal non-defense government division. Net foreign investment is interpreted as the total value of exports minus the total value of imports. Hence, the difference for the trade account with the rest of the U.S. was high compared to the account for the rest of the world.

6.2 First counterfactual scenario - carbon graveyard

As previously mentioned, one of the two government budget allocation schemes considered in this study is the economic compensation for CO_2 offsets generated by the conversion of land into a carbon graveyard. Hence, by exogenously altering the magnitude of the budget allocated to the CO_2-offset-generating carbon graveyard and endogenously estimating the price for CO_2 offsets, a CO_2-offset supply curve was identified.

6.2.1 Supply of CO_2 offsets

Table 6.4 shows some of the different budget magnitudes considered in this scenario, the quantity of CO_2 offsets in million MT generated and the price paid on a per-MT basis. Figure 6.5 shows a graphical version of table 6.4. Each represent an equilibrium found by the CGE model when accommodating the exogenously altered budget allocation. Each equilibrium contains the endogenously estimated prices and quantities for commodities and factors of production, as well as institutional income. For conciseness and reporting purposes, the results presented in this section refer to the highest budget allocation ($6,900 million). The reason to consider this budget allocation is to report the effects of such a relatively large allocation on the prices and quantities of commodities and factors directly and indirectly related to agriculture and forestry.

With a budget of $6,900 million, a total of 421 million MT of CO_2 offsets were generated by the carbon graveyard of which:[1]

- 266 million MT came from softwood forests (63%) and
- 155 million MT from hardwood forests (37%).

[1]According to EPA (2012), total net U.S. GHG emissions were 7 and 6.8 billion MT of CO_2 equivalent in 2008 and 2010, respectively. This means that approximately 6% of 2008 total net GHG emissions would be sequestered with a production of 421 million MT of CO_2 offsets. About 6.1% with 2010 total net levels.

Table 6.4. CO_2 Offset Supply Schedule for Different Budget Allocations in First Counterfactual Scenario

	Carbon offsets	
Government budget	Supply	Price
Millions of $	Millions of MT of CO_2	$ / MT of CO_2
170	32.64	5.21
800	99.23	8.06
1,860	179.22	10.38
2,700	230.59	11.71
3,700	283.03	13.07
4,000	297.98	13.42
5,000	345.09	14.49
6,000	387.14	15.50
6,900	420.94	16.39

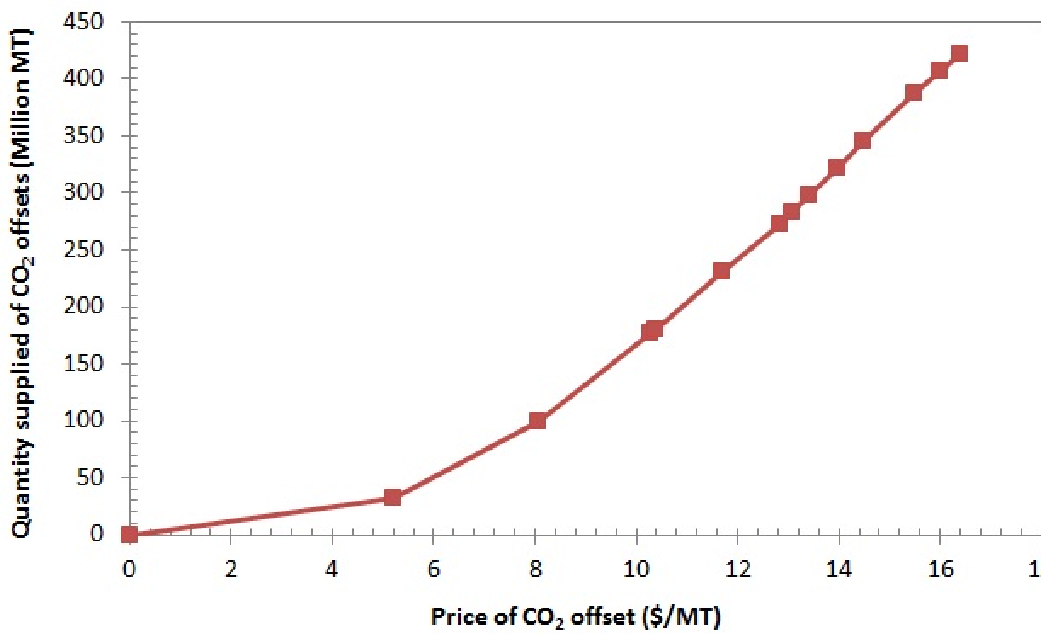


Figure 6.5. CO_2 offset supply curve in first counterfactual scenario

The production of CO_2 offsets from the carbon graveyard by timber category and MLRA is listed in table D.3 in the appendix. The same figures were aggregated by LRR and listed in table D.2 in the appendix.

A graphic version of table D.2 is included in figure 6.6 showing total production of CO_2 offsets (from softwood and hardwood) by LRR. By looking at the bar graph, it is evident that a large share of the generation came from (in order of importance) LRRs: F (20%), H (14%), N (13%), G (13%) and P (13%).

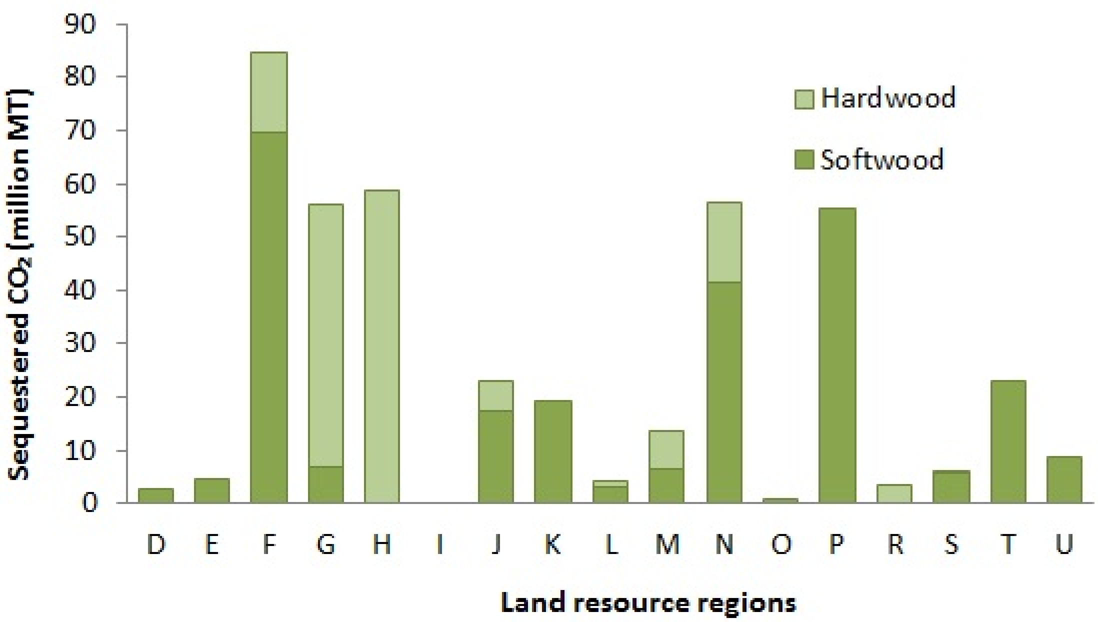


Figure 6.6. CO_2 offsets generated by the carbon graveyard by Land Resource Region (LRR) in first counterfactual scenario

By looking at their respective maps in figures B.1, B.3, B.4, B.9 and B.10, it is evident that most of the offset generation came from the Northern, Central and Western Great Plains; the Western and Eastern regions bordering the Appalachian mountains; and the South Atlantic and Gulf regions.

However, it is worth mentioning that only certain MLRAs accounted for most of the offset generation per LRR. For example, only the Rolling Soft Shale Plain MLRA (code 75) accounted for approximately 66% of the total offset generated in LRR F.

As can be seen in the map of MLRA 75 in figure B.2, it covers a small portion of the Northern South Dakota and a fairly large portion of the Southwestern part of North Dakota.

Hence, it is important to pay attention to the MLRAs that contribute the most to the total generation of CO_2 offsets. From table D.3 in the appendix, it is evident that most of the generation comes from MLRAs: 75 and 79 in LRR F; 119 and 122 in H; 212 and 224 in N; 85, 91 and 92 in G; and 234, 235 and 240 in P.

6.2.2 Land-use change

All this production of CO_2 offsets resulted in the diversion of land from its actual use to the carbon graveyard. Again, a budget of $6,900 million and a total generation of 421 million MT of CO_2 offsets resulted in the following land-use change figures:

- 87.34 million acres were diverted from their current use to the carbon graveyard:
  - 85.88 million acres from agricultural land (98% of land diverted to graveyard),
  - 1.46 million acres from commercial logging (2% of land diverted to graveyard), and[2]
- 0.014 million acres were diverted from agricultural land to commercial logging.

To identify the areas where most of the land-use change took place, table D.4 in the appendix lists the agricultural and forest land acreage change per MLRA in the first counterfactual scenario. By aggregating the MLRAs into their respective LRRs, the figures in table 6.5 were estimated to present the acreage change more concisely.

A graphic representation of the second and third columns of table 6.5 is included in figure 6.7. By considering the LRRs that produced most of the CO_2 offsets and by

[2] A more detailed explanation on the assumptions followed for this type of land diversion is given at the end of this subsection.

Table 6.5. Agricultural and Forest Land Acreage Change due to CO_2 Payments per LRR in First Counterfactual Scenario

LRR code	Logging	Agriculture	Graveyard
		Million acres	
D	-0.01	-1.05	1.07
E	-0.02	-1.65	1.67
F	-0.01	-13.27	13.28
G	-0.03	-15.71	15.74
H	-0.01	-15.90	15.91
I	-	-	-
J	-0.05	-4.67	4.72
K	-0.10	-2.58	2.68
L	-0.02	-0.67	0.69
M	0.00	-2.72	2.72
N	-0.45	-10.60	11.06
O	0.00	-0.13	0.13
P	-0.53	-9.54	10.07
R	-0.04	-0.73	0.77
S	-0.04	-1.02	1.06
T	-0.09	-4.00	4.09
U	-0.06	-1.64	1.70
Total	**-1.46**	**-85.88**	**87.34**

looking at figure 6.7, it is evident that the LRRs that contain most of the diversion to the carbon graveyard were (in order of importance): H (18%), G (18%), F (15%), N (13%) and P (11%).

All the previous land-use changes resulted in increased land prices depending on the predominant and final use. The price changes for each MLRA endowment expressed in percentage changes from the baseline are listed in table D.5 in the appendix. Since these prices could not be aggregated for each LRR, the table shows the LRRs to which each MLRA belongs to for a more intuitive representation of the regional effects on prices. As expected, the LRRs that contained most of the land diversion and offset production are the ones with the highest price changes. In particular, the MLRAs located in LRR G experienced the most drastic price

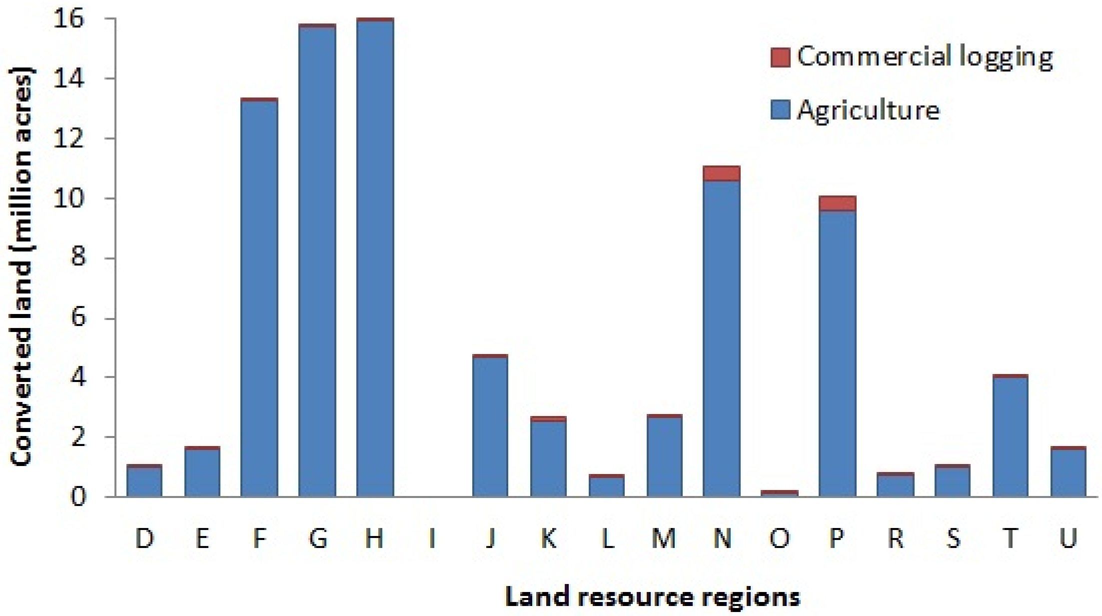


Figure 6.7. Acreage diverted out of agriculture and commercial forestry due to CO_2 payments per Land Resource Region (LRR) in first counter-factual scenario

changes. MLRA 75 (in LRR F) experienced the highest price change of 588% from the baseline. Although, LRRs H and P largely contributed to the production of offsets, their land prices did not change much (except for MLRA 115). This was the result of the presence of highly profitable agricultural land in that region. The negative price changes in some MLRAs were the result of no acreage change.

Price percentage changes were also estimated for the two broad land-use types. These price changes are closer to the per-acre rent changes paid by the agricultural activities since the nests that produce these changes are higher up in the land supply nesting structure. The percent changes of agricultural land prices per MLRA and LRR are listed table D.6 in the appendix. Most of the agricultural land prices increased drastically as a result of the acreage diversion to a highly profitable carbon graveyard alternative. As expected, the highest changes were located in the MLRAs that contributed the most to offset generation. The negative price changes were the result of no acreage change.

Price percentage changes of forest land per MLRA and LRR are listed in table D.7 in the appendix. These changes were relatively low in magnitude for the MLRAs that contributed the most to offset production. The highest change was located in MLRA 84 (31%). The negative changes were the result of no acreage change.

The 1.46 million acres diverted from commercial logging into the carbon graveyard were considered forest land that remained forest land and were a result of the structure of the nest supplying agricultural and forest land. They are not considered afforestation. However, CO_2 offsets were generated from this land and, hence, receiving the same CO_2 offset price. Reforestation costs were not considered in this study since its main objective targeted afforestation and its impact on agricultural commodities. The literature mentions several different reforestation management intensities with their respective costs. A very intensive reforestation management approach would consist of entirely harvesting the forest and planting a carbon graveyard. The costs considered for afforestation in this study are relatively closer to the intensive reforestation approach compared to the less intensive ones. Hence, it was assumed in this study that the cost of converting an acre of forest land under commercial logging was the same as afforesting agricultural land.

The same applies to the sequestration rates used for the converted land from commercial logging to the carbon graveyard. Different carbon uptake rates are listed in the literature depending on the reforestation intensity. The uptake rates for afforestation are relatively close to a high intensity management level. Hence, it was also assumed in this study that any acre converted from forest land under commercial logging generated the same amount of MT of CO_2 as an afforested acre.

The second counterfactual scenario was considered in this study to compensate offsets generated in existing commercial forestland in the baseline. The general equilibrium effects of such land movement on the commercial logging activity under the first counterfactual scenario will be detailed in the following subsections. The general equilibrium effects under the second counterfactual scenario will be detailed in the next section.

6.2.3 Production

As previously mentioned in section §1.1.5, one of the great advantages of CGE models is the inclusion and analysis of general equilibrium effects on economic agents (activities and institutions) directly and indirectly related to the sector in question (i.e. agriculture and forestry). Since, the main objective of this study included the analysis of the impacts of land-use change on quantities and prices of commodities and factors, the next subsections will detail these impacts generated by a carbon sequestration policy economically supported by the government.

The land displacement detailed in the previous subsections directly affected the agricultural activities that demanded land to a great extent. All activities were capable of substituting their composite inputs depending on their elasticities of substitution (σ), and the prices charged for intermediate commodities, labor, capital and land. Regarding the displacement of land, some activities decreased their levels of production due to higher agricultural or forest land prices. Hence, these decreased commodity production by certain agricultural activities indirectly affected (positively or negatively) other activities that used these agricultural commodities as intermediate inputs. These other activities did not necessarily demand land but were, nevertheless, affected by the land displacement motivated by a CO_2 offset market.

The percentage changes of quantities and prices of total production by activity are listed in table D.1 in the appendix. As expected, the activities that were affected the most by the land displacement effect were the ones that demanded land to a great extent. The other crops (Aocrp) and cattle activities (Acatt) were the most affected ones decreasing production by approximately 6% and 5%, respectively. The only agricultural activity that increased production by 1% was the "other agriculture" activity (Aoagr) since it offered the contractual services for afforestation. The rest of the agricultural activities were affected to a lesser extent. Tobacco (Atobc) and cotton (Acott) reduced their production by 2.4% and 3%, respectively. The activities affected by this reduction in the production of agricultural commodities were manufacturing (Amanf) and government employment (Agvem), reducing their production levels by 0.08% and 0.27%, respectively. All reductions in production levels are reflected in higher prices for the composite outputs.

Some activities were able to substitute the land composite input for either the value-added composite or the intermediate commodity composite input. Table D.8 in the appendix shows the percentage changes of quantities and prices of composite inputs to the top activity nest. No agricultural activity was able to increase the demand for a substitute composite input; however, the drop in demand was lower for the other inputs compared to the land composite input. This changes in demand were reflected in the intermediate commodity consumption by activity to be explained in more detail in the following subsection. The changes in the demand for factors of production is detailed following.

The percentage changes of quantities and prices of factors used by activities are listed in table D.9 in the appendix. The prices of both factors of production increased. As expected, most of the agricultural activities that decreased their production levels also decreased their demands for labor and capital. For example, the activity for other crops (Aocrp) decreased both labor and capital demands by 3% each. Other agriculture, on the contrary, increased its demand for labor and capital by 1% each. Government employment (Agvem) was the most negatively affected non-agricultural activity decreasing its factor demand by approximately 0.27% each. Construction (Acons) was the most positively impacted by increasing its factor demand by approximately 0.17%.

6.2.4 Consumption

The changes in the intermediate commodity composite input in table D.8 are broken down by commodity in table D.10 in the appendix. These two tables list the percentage changes of intermediate commodity consumption quantities by activity. Table 6.6 lists the percentage changes of their respective prices. As expected, the price increase of the cattle (Ccatt) commodity drastically impacted the oilseeds (Aolsd), grains (Agran), cotton (Acott) and other crops (Aocrp) activities due to the reduced feed demand. The most impacted activity was other crops (Aocrp) since hay constitutes a large share of the activity.

The price increase for the other crops (Cocrp) commodity aggregate impacted mainly the tobacco (Atobc) and cotton (Acott) activities. The other crops (Cocrp) aggregate includes clover and other inputs that are used in the tobacco (Atobc) activity.

The sharp cattle (Ccatt) and other crops (Cocrp) price increase indirectly affected the construction (Acons) and manufacturing (Amanf) activities. However, the construction (Acons) activity substituted the other crop commodity (Cocrp) for other commodities as reflected by the positive changes in the construction column.

Activities were not the only economic agents affected by the commodity price changes. Households were also affected by the income they received from the factors they offered to the activities and by the prices of the commodities they consumed. Table 6.7 lists the changes in the distribution of net income between consumption and savings per household category. The net income of most household categories increased as a result of the high labor price under the first scenario. The net income of households receiving between $50 and $150 thousand annually decreased as a result of the reduced factor use by some activities. This reduction in net income drives consumption and savings down by the same percentage. The price percentage changes listed on the last column are the percent changes of the representative

Table 6.6. Percentage Changes of Intermediate Commodity Consumption Prices in First Counterfactual Scenario

Commodity	% change	Commodity	% change
Colsd	2.889	Ctrns	0.081
Cgran	3.237	Cinfo	0.069
Coagr	0.402	Cfinc	0.046
Ctobc	1.221	Cland	0.071
Ccott	3.783	Cornt	0.070
Csugr	3.415	Cprof	0.048
Cocrp	6.136	Cmgmt	0.048
Ccatt	10.557	Cadmw	0.056
Cdair	0.871	Ceduc	0.052
Clogg	0.932	Chlth	0.058
Cmini	0.077	Centt	0.066
Cutil	0.067	Chotl	0.083
Ccons	0.111	Coser	0.063
Cmanf	0.216	Cgven	0.081
Cwhol	0.057	Cuncl	0.052
Cretl	0.050	Cgvem	0.028

consumption bundle price. It increased for all income categories by approximately 0.1%.

The changes in the consumption of the commodity composite by households are broken down by commodity in table D.11 in the appendix. This table lists the percentage changes of prices and quantities of household consumption by commodity. All household categories reduced their consumption of agricultural commodities (Coagr) due to higher prices. The most relevant one was the consumption reduction of the beef cattle commodity (Ccatt) due to its high price. The high cattle (Ccatt) price is the result of its reduced supply due to the acreage diverted out of pastureland. The consumption of the manufacturing (Cmanf) commodity also decreased for some household categories as a result of its high price. However, some household categories substituted these two commodities for others as reflected by the positive

Table 6.7. Percentage Changes of Quantities and Prices of Total Household Commodity Consumption and Savings in First Counterfactual Scenario

Households' income categories	Quantity		Price
	Consumption	Savings	Consumption
< 10 K	0.109		0.093
10 - 15 K	0.060		0.098
15 - 25 K	0.033		0.097
25 - 35 K	0.013		0.098
35 - 50 K	0.007		0.096
50 - 75 K	-0.007		0.093
75 - 100 K	-0.009	-0.009	0.094
100 - 150 K	-0.004	-0.004	0.092
> 150 K	0.070	0.07	0.090

changes in some columns. None of the household categories was directly affected by the high prices for oilseeds (Colsd), tobacco (Ctobc), cotton (Ccott), sugar (Csugr), and dairy (Cdair).

The other economic agents that were indirectly affected by land-use change were the government, inventory and investment institutions. The commodity consumption of these institutions was equally and proportionally adjusted across commodities to help the model converge. Table 6.8 lists the proportional changes resulting from the closure equations previously explained. For example, the commodity consumption by the non-defense division of the federal government decreased due to the budget allocated to the CO_2 offset market.

6.2.5 Trade

The changes in the levels of production by the activities were also reflected in the trade accounts. The export levels of all commodities decreased except for other agriculture as shown in table D.12 in the appendix. The exported quantity of the

Table 6.8. Percentage Changes of Institutional Commodity Consumption in First Counterfactual Scenario

Institution	% change
Government	
Fed. non-defense	-3.215
Fed. defense	0.080
Fed. investment	-0.051
State non-education	0.087
State education	0.116
State investment	0.028
Inventory	1.382
Investment	0.217

other agriculture (Coagr) increased due to the increased level of production motivated by the high demand from the afforestation activities. The rest of the agricultural commodities experienced a decrease in their exported quantities. The exported quantity of the manufacturing (Cmanf) commodity dropped drastically reflecting its decreased production caused by the price increase of the intermediate beef cattle (Ccatt) commodity.

The percentage changes of prices and quantities of imported commodities are listed in table D.13 in the appendix. All the imported quantities of the agricultural commodities increased, especially cattle (Ccatt) and other crops (Cocrp). From the non-agricultural activities, the manufacturing (Cmanf) commodity imports increased relatively more than the others.

6.2.6 Institutional income

Some institutions were affected more directly than others by the new CO_2 offset market. Land owners for example, households and enterprises were directly affected by the price changes. The government, investment and the inventory accounts were indirectly affected through taxes charged, depreciation deducted from the use of capital and from the closure rules, respectively. The government collects the taxes from the production of commodities by activities (indirect business taxes), the income received by the factors of production (factor income taxes), and the income received by households coming from the factors of production (income and personal tax). The investment account was indirectly affected by household savings and the depreciation charges made to the capital account. Inventory was indirectly affected by the closure rules as stated before. As listed in table D.14 in the appendix, all institutional incomes increased. The net foreign investment variables adjusted to balance the closure rules; hence, were indirectly affected by the new CO_2 offset market.

6.3 Second counterfactual scenario - commercial logging and carbon graveyard

As previously mentioned, the second government budget allocation scheme considered in this study is the economic compensation for CO_2 offsets generated by:

- the commercial logging industry as a by-product of their regular timber production, and
- the converted land into a carbon graveyard.

The reason to consider this payment scheme was to analyze the economic implications of compensating offsets generated in existing commercial forestland in the baseline. More generally, this may very well be how a sequestration payment would be implemented. Hence, as explained in subsection 5.3.2, the commercial logging activity's joint production ($JntPrd$) of CO_2 offsets was calibrated with the estimated total net annual change in CO_2-equivalent stocks from private timber land of 632 MT. The nest was also calibrated with a zero elasticity of substitution to represent the generation of offsets in fixed proportions relative to the production of the logging commodity (Clogg).

Table 6.9. CO_2 Offset Supply Schedule for Different Budget Allocations in Second Counterfactual Scenario

Government budget	Carbon offsets Supply: Logging	Carbon offsets Supply: Graveyard	Price
Millions of $	Millions of MT of CO_2		$ / MT of CO_2
2,000	645.614	0.001	3.098
3,000	657.367	16.691	4.451
3,800	665.540	35.945	5.417
4,500	672.159	51.541	6.218
5,900	683.788	84.916	7.675
6,900	690.609	115.006	8.565
7,500	694.465	131.750	9.078
8,000	697.589	144.650	9.498

6.3.1 Supply of CO_2 offsets

The CO_2-offset supply schedule identified under the second scenario, by exogenously altering the budget allocation magnitude, is listed in table 6.9. Figure 6.8 shows a graphical version of table 6.9. As expected, the quantity of CO_2 offsets supplied was higher due to the contribution from the existing forest under commercial logging. For a CO_2-offset price of $9.5/MT, approximately 842 MT were supplied in this scenario compared to 500 MT under the first one.

For comparative purposes, the CO_2-offset production, land-use change and general equilibrium results presented in this section refer to the same budget allocation ($6,900 million) considered in the first counterfactual scenario. Hence, with a budget of $6,900 million, a total of 806 million MT of CO_2 offsets were generated of which:[3]

- 115 million MT came from carbon graveyards (14%):

[3]According to EPA (2012), total net U.S. GHG emissions were 7 and 6.8 billion MT of CO_2 equivalent in 2008 and 2010, respectively. This means that approximately 11.5% of 2008 total net GHG emissions would be sequestered with a production of 806 million MT of CO_2 offsets. About 11.8% with 2010 total net levels.

- 100 million MT from softwood forests,
- 15 million MT from hardwood forests, and

- 691 million MT came from commercial logging (86%).

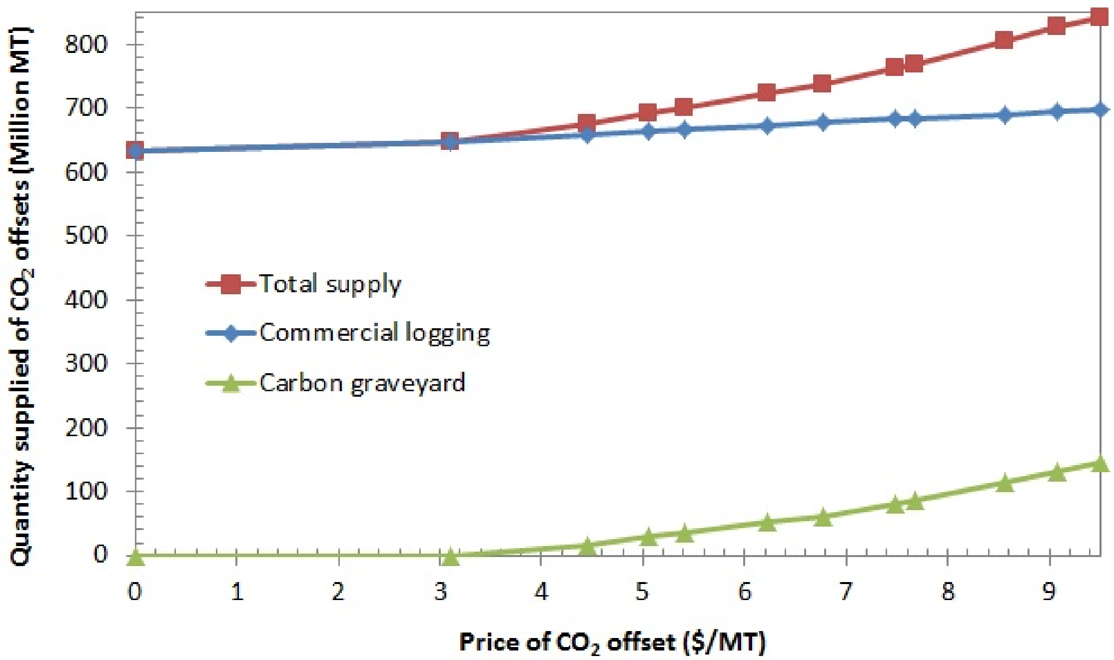


Figure 6.8. CO_2 offset supply curve in second counterfactual scenario

The production of CO_2 offsets from the carbon graveyard by timber category and MLRA is listed in table E.2 in the appendix. The same figures were aggregated by LRR and listed in table E.3.

A graphic version of table E.3 is included in figure 6.9 showing total production of CO_2 offsets generated by the carbon graveyard by LRR. By looking at the bar graph and comparing it to the one obtained under the first scenario, a similar regional pattern is identified under the second one. The only exception is that LRR J is now one of the largest contributors of offset generation. The largest share of the generation came from (in order of importance) LRRs: F (35%), N (14%), P (12%)

and J (12%). LRRs G and M still produced offsets to a lower extent compared to its high production under the first scenario.

By looking at the maps of the only four LRRs producing offsets in figures B.1, B.9, B.10 and B.5, the regions producing offsets from the carbon graveyard are located in the Northern Great Plains; Eastern and Western boundaries of the Appalachian mountains; Northeastern part of Texas; and central region of Oklahoma.

By looking at table E.2, the MLRAs that contribute the most to the total generation of CO_2 offsets are: 75 in LRR F; 147 in LRR J; 235 in LRR P; and 256 in LRR T.

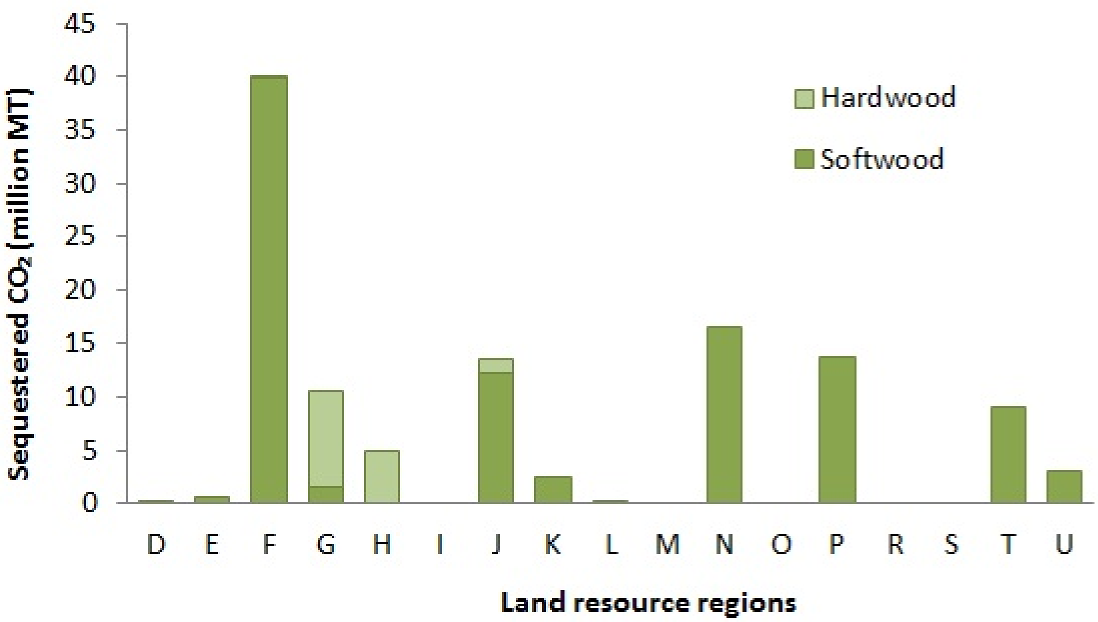


Figure 6.9. CO_2 offsets generated by the carbon graveyard by Land Resource Region (LRR) in second counterfactual scenario

6.3.2 Land-use change

Since the government paid the commercial logging activity for the generation of CO_2 offsets under this scenario, it was expected that land would be diverted from agricultural use to forest land under commercial logging. This type of land diversion increased as the price of CO_2 offsets increased. However, for conciseness purposes, only the acreage change experienced at a price of \$9.5/MT, or a budget of \$6,900 million, will be reported in this subsection. Hence, the acreage change experienced at this budget level was:

- 22 million acres from agricultural to forestry land:
  - 20.65 million acres to carbon graveyard (94% of land diverted from agriculture)
  - 1.35 million acres to commercial logging (6% of land diverted from agriculture)
- 20.7 million acres into carbon graveyard:
  - 20.65 million acres from agricultural land (99.8% of land diverted into the graveyard)
  - 0.05 million acres from commercial logging (0.2% of land diverted into the graveyard)

To identify the areas where most of the land-use change took place, table E.4 in the appendix lists the agricultural and forest land acreage change per MLRA in the second counterfactual scenario. Table 6.10 lists the acreage change by LRR.

A graphic representation of the third column of table 6.10 is included in figure 6.10. LRRs F, N, P and J produced most of the CO_2 offsets generated by the graveyard; hence, the land diverted out of agriculture and commercial forestry in these LRRs went to the carbon graveyard.

However, the acreage diversion out of agricultural land in the LRRs that did not produce graveyard-generated offsets went to commercial logging as shown in figure 6.11. Hence, the LRRs that diverted a great share of agricutural land to commercial logging where (in order of importance): N (22%), P (21%), and M

Table 6.10. Agricultural and Forest Land Acreage Change due to CO_2 Payments per Land Resource Region (LRR) in Second Counterfactual Scenario

LRR code	Logging	Agriculture	Graveyard
		Million acres	
D	0.009	-0.078	0.069
E	0.022	-0.230	0.208
F	0.012	-5.538	5.526
G	0.016	-3.001	2.985
H	0.020	-1.367	1.347
I	-	-	-
J	-0.010	-2.554	2.564
K	0.083	-0.437	0.354
L	0.058	-0.065	0.007
M	0.278	-0.278	-
N	0.302	-3.271	2.969
O	0.067	-0.067	-
P	0.285	-2.783	2.498
R	0.065	-0.065	-
S	0.061	-0.061	-
T	0.063	-1.654	1.591
U	0.018	-0.622	0.604
Total	**1.349**	**-22.071**	**20.722**

(20%). Hence, as shown in figures B.9, B.10, and B.8, 64% of the land diverted from agriculture into commercial logging took place in the Western and Eastern regions bordering the Appalachian mountains; and the Midwest including Iowa, Kansas and Missouri.

Although the acreage diversion under this scenario caused land price to change, the percentage changes were not as drastic as in the first counterfactual scenario. Percent changes of land endowment prices per MLRA and LRR are listed in table E.5 in the appendix. The most drastic percentage changes took place in LRRs F, J and N, as expected, since all most of the land diverted went to the carbon graveyard. The negative price changes in some MLRAs were the result of no acreage change.

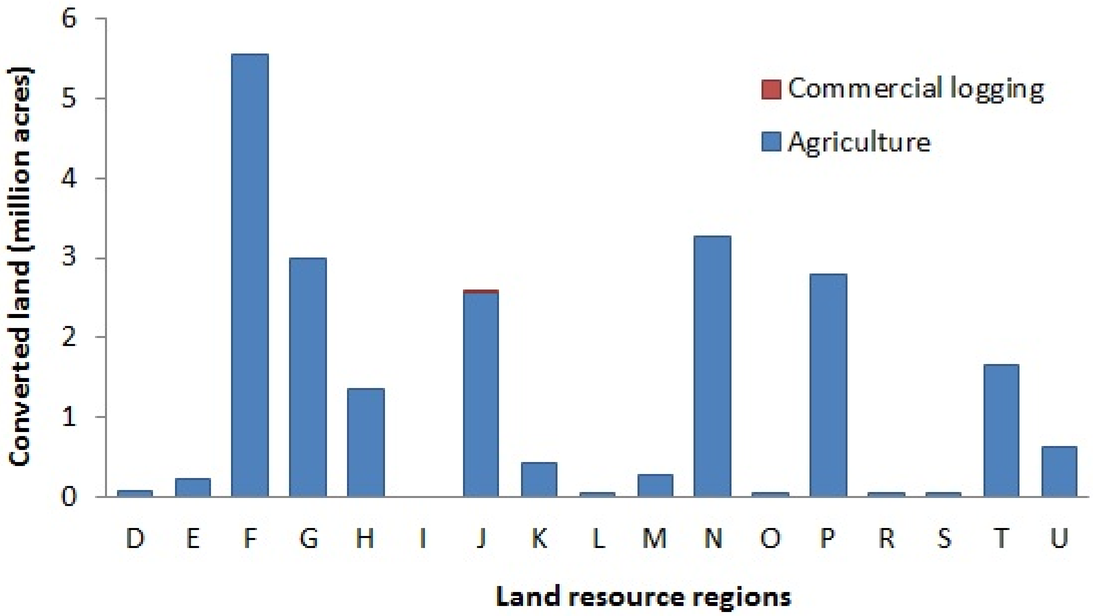


Figure 6.10. Acreage diverted out of agriculture and commercial forestry due to CO_2 payments per Land Resource Region (LRR) in second counterfactual scenario

As previously done for the first scenario, price percentage changes were also estimated for the two broad land-use types under the second scenario. Percent changes of agricultural and forestland land prices per MLRA are listed in tables E.6 and E.7 in the appendix, respectively. The land prices of both land-use types followed the same regional pattern as under the first scenario. However, the percentage changes were noticeably lower and more moderate. Negative changes reflected no acreage change.

6.3.3 Production

As previously stated, under the first scenario, most of the agricultural activities were forced to decrease their levels of production as a result of the land diversion to the carbon graveyard. The most affected one was the cattle activity decreasing

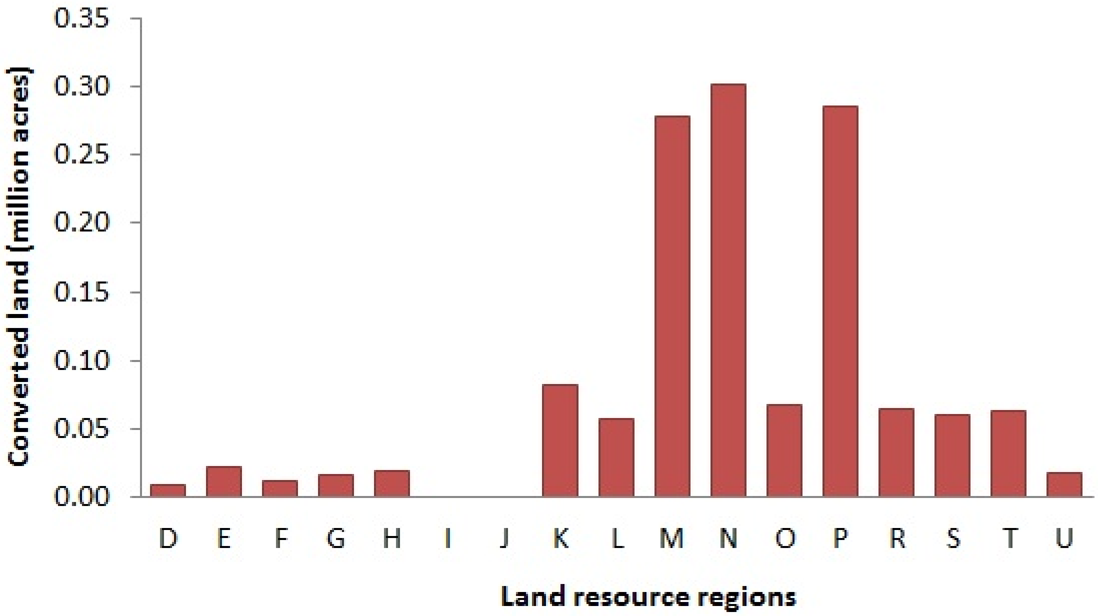


Figure 6.11. Acreage diverted into commercial forestry due to CO_2 payments per LRR in second counterfactual scenario

its production by 5%. Hence, one of the reasons for considering this second scenario was to counteract the economic losses under the first scenario by considering the contribution of offset-generation from existing commercial forests towards the emission-reduction objective.

The percentage changes of quantities and prices of total production by activity under the second counterfactual scenario are listed in table E.1 in the appendix. As expected, the production level of the logging activity increased by approximately 11% and the representative price of the composite output increased by 9.5%. Although most of the agricultural activities still decreased their production levels, the change was more moderate as opposed to the decrease under the first scenario. The other agriculture activity (Aoagr) increased its production level as a result of the demand of its output from the afforestation activities. The manufacturing activity (Amanf) increased its output level by 0.07% as opposed to the 0.08% decrease in the first scenario. The reason for this will be explained in the next subsection. An activity that was negatively affected was the government employment (Agvem) activity. The reason might have been the decreased consumption of the commodity produced by this activity (Cgvem) by the non-defense federal government due to the budget reallocation towards CO_2 offsets. Under both scenarios, the construction (Acons) increased its production relatively more than the rest.

Since most of the agricultural activities were directly impacted by the acreage diversion under the second scenario, the impact was more moderate than under the first one. The percentage changes of quantities and prices of composite inputs to the top activity nest in the second counterfactual scenario are listed in table E.8 in the appendix. As expected, the agricultural activities demanded less land aggregate due to the price increase as listed on the last column of the table. However, the more moderate price increases allowed some activities (e.g. dairy) to substitute the land composite by the value-added composite as reflected by the positive changes in their demands. The logging activity (Alogg) increased its demand for the intermediate commodity aggregate by 14% as a result of its lowest price.

Some activities increased their demand for the value-added composite. The changes in the demands for the value-added composite are broken down by factors of production in table E.9 in the appendix. This table lists the percentage changes of quantities and prices of factors used by activities in the second counterfactual scenario. The prices of both factors increased more moderately than under the first scenario. As expected, the logging (Alogg) and other agriculture (Aoagr) activities increased their demands for both capital and labor, drastically. Most of the activities decreased the demand for capital and substituted it for labor. For example, the oilseeds (Aolsd), sugar (Asugr), and cattle (Acatt) substituted labor for capital. Construction (Acons) was the non-agricultural activity that increased the demand of both factors most drastically. The government employment (Agvem) activity decreased its demand of both factors. All these changes will be reflected in the incomes received by factor owners such as households and enterprises.

6.3.4 Consumption

The changes in the intermediate commodity composite input in table E.8 are broken down by commodity in table E.10 in the appendix. These tables list the percentage changes of intermediate commodity consumption quantities by activity in the second counterfactual scenario. It is worth mentioning that the moderate decrease in the production of most of the agricultural activities is, in part, the result of the increased supply of one of their highly demanded commodities: manufacturing (Cmanf). Table 6.11 lists the percentage changes in the prices of the intermediate commodities under the second scenario. As expected, the price of the logging (Clogg) commodity dropped as a result of its oversupply.

Table 6.11. Percentage Changes of Intermediate Commodity Consumption Prices in Second Counterfactual Scenario

Commodity	% change	Commodity	% change
Colsd	0.278	Ctrns	0.053
Cgran	0.459	Cinfo	0.061
Coagr	0.244	Cfinc	0.055
Ctobc	0.170	Cland	0.079
Ccott	0.562	Cornt	0.083
Csugr	0.495	Cprof	0.046
Cocrp	0.974	Cmgmt	0.054
Ccatt	2.238	Cadmw	0.048
Cdair	0.191	Ceduc	0.047
Clogg	-13.039	Chlth	0.046
Cmini	0.086	Centt	0.054
Cutil	0.081	Chotl	0.053
Ccons	0.046	Coser	0.049
Cmanf	0.042	Cgven	0.004
Cwhol	0.055	Cuncl	0.053
Cretl	0.051	Cgvem	0.041

It is worth mentioning that since the government pays the commercial logging activity for the generation of CO_2 offsets as a by-product, the production of the logging commodity (Clogg) increases proportionally due to the zero elasticity of transformation in the joint-production nest ($JntPrd$). Due to this increase in the production of the logging commodity (Clogg), there is an oversupply of the commodity in the market driving its price down by almost 13% as reflected in table 6.11. The logging commodity (Clogg) is demanded solely by the logging (Alogg) and manufacturing (Amanf) activities as reflected in table C.7. As expected, these two activities increased their demands of the logging commodity (Clogg) since its price decreased as shown in table E.10. The 7% increased demand of the logging (Clogg) commodity by the manufacturing (Amanf) activity resulted in an increased production level of the latter. This increased production level of the manufacturing commodity (Cmanf) resulted in higher demands of the commodity by oilseeds (Aolsd), other agriculture (Aoagr), sugar (Asugr), dairy (Adair) and commercial logging (Alogg).

Table 6.12 lists the changes in the distribution of net income between consumption and savings per household category. The net income of all household categories increased as reflected in their increased consumption and savings. It is worth noting that the net income of three categories decreased in the first scenario. The price of the representative consumption bundle increased more moderately by 0.06% as opposed to 0.09% in the first scenario.

The changes in the consumption of the commodity composite by households are broken down by commodity in table E.11 in the appendix. This table lists the percentage changes of prices and quantities of household commodity consumption in the second counterfactual scenario. All household categories reduced their consumption of agricultural commodities (Coagr) due to higher prices. However, the changes were not as drastic as under the first scenario.

The institutional commodity consumption increased for all institutions except for the non-defense division of the federal government as shown in table 6.13. The decreased consumption by the federal government is the result of the budget allocated to the CO_2 offset market. The consumption increments were more moderate than

Table 6.12. Percentage Changes of Quantities and Prices of Total Household Commodity Consumption and Savings in Second Counterfactual Scenario

Households' income categories	Quantity		Price
	Consumption	Savings	Consumption
< 10 K	0.081		0.056
10 - 15 K	0.054		0.056
15 - 25 K	0.037		0.056
25 - 35 K	0.024		0.056
35 - 50 K	0.021		0.056
50 - 75 K	0.010		0.056
75 - 100 K	0.010	0.010	0.056
100 - 150 K	0.012	0.012	0.056
> 150 K	0.054	0.054	0.056

in the first scenario. However, the consumption of the investment divisions of the federal and state government increased more drastically than in the first scenario. This is just the result of the closure equations of the model.

6.3.5 Trade

The percentage changes of prices and quantities of exported commodities in the second counterfactual scenario are listed in table E.12 in the appendix. As expected, most of the exports of the agricultural commodities decreased as in the first scenario but more moderately. The exceptions are the logging (Clogg) and other agriculture (Coagr) commodities. The other agriculture (Coagr) commodity exports increased, more drastically that in the first scenario, due to the increased level of production motivated by the high demand from the afforestation activities. The logging (Clogg) commodity exports increased, as opposed of the decrease experienced in the first scenario, as a result of the higher production level by its activity.

Table 6.13. Percentage Changes of Institutional Commodity Consumption in Second Counterfactual Scenario

Institution	% change
Government	
Fed. non-defense	-3.262
Fed. defense	0.063
Fed. investment	0.038
State non-education	0.070
State education	0.071
State investment	0.063
Inventory	0.322
Investment	0.187

The percentage changes of prices and quantities of imported commodities in the second counterfactual scenario are listed in table E.13 in the appendix. All imports increased more moderately than in the first scenario. However, the imports of the logging (Clogg) commodity decreased by 4% as opposed to the increase of 0.3% in the first scenario. The higher local production of the logging (Clogg) commodity motivated by the CO_2 offset payments supplied the local market resulting in less imports from the rest of the U.S. and the rest of the world.

6.3.6 Institutional income

Although all institutional incomes increased as listed in table E.14 in the appendix, they increased more moderately than in the first scenario. Comparing the increase of the net foreign investment from the first scenario, the one obtained in the second scenario is extremely lower. This is the result of a less drastic change and adjustment in the closure rules.

7. DISCUSSION AND CONCLUSIONS

As stated in section §1.2, the economic impacts of a government-funded, forest-based sequestration program were presented and analyzed under two different payment schemes. The impacts were obtained by developing a regional, static CGE model built to accommodate a modified IMPLAN SAM for a determined region in the U.S. for 2008. The IMPLAN SAM was modified to accommodate the more conventional factors of production (labor, capital and land) and to account for land heterogeneity. Land heterogeneity was included in the model by separating productive land into different geoclimatic regions known as MLRAs. Rents were obtained for each county and land-use type in the U.S. and referenced to every MLRA.

The regional aggregation considered in this study included the Southern, Northeastern, Southwestern and Midwestern regions of the U.S. as shown in figure 3.2. The criteria followed to consider this region was the vast and continuous extensions of crop and pastureland that could be potentially converted to forest under a forest-based carbon sequestration policy. The forest-based sequestration practice considered was the carbon graveyard since it requires that the carbon sequestered in the forested land to be contained by not harvesting the timber.

To model land conversion from agricultural uses to forest, afforestation latent activities were included such that they would become active when the price of CO_2 offsets became positive. To model the latent activities, regional afforestation establishment costs and carbon sequestration estimates were obtained from the literature and modified according to the objectives of this study.

By analyzing the baseline with no CO_2-offset payments from the government and using the geographic concept of LRRs, the regions that played an important role in agriculture and forestry were LRRs M, H, N and P. Their maps are included in the appendix. The three most valuable sector aggregates in the region were other agriculture (Aoagr), grains (Agran) and cattle (Acatt). The other agriculture (Aoagr) aggregate includes the production of fruits, vegetables, ornamentals, poultry, other animals, forest products, fishing, hunting and support activities for agriculture and forestry. The three most valuable non-agriculture sector aggregates were manufacturing (Amanf), health (Ahlth) and government employment (Agvem).

The two counterfactual equilibria considered in this study consisted on two different CO_2-offset payment schemes: 1) the government compensates the generation of CO_2-offsets only by the land converted to a carbon graveyard and 2) the government additionally compensates the CO_2 offsets generated as a by-product by the existing commercial logging activity. By doing an analysis of the model with different budget magnitudes under the two scenarios, two different CO_2-offset supply schedules were obtained with their respective CO_2-offset price and quantity sets.

Since the second scenario considered the offset generation from existing commercial forests and the carbon graveyard, the supply of CO_2 offsets was higher than in the first scenario at the same prices. For instance, approximately 842 MT of CO_2 offsets were supplied at a price of \$9.5/MT compared to 500 MT under the first scenario at the same price. For comparative purposes, the budget allocation considered for both scenarios was \$6,900 million. For this budget allocation, approximately 421 million MT of CO_2 offsets were produced in the first scenario versus 806 million MT produced in the second one. Although there were no offset payments to the commercial logging activity in the first scenario, offsets were still generated as shown in table 7.1. The only difference is that commercial logging decreased its generation from the baseline to 629 million MT.

Table 7.1. CO_2-offset Generation Under the Two Offset Payment Scenarios Considered

Scenarios	Baseline	First	Second
Commercial forestry (Million MT)	632	629	691
Carbon graveyard (Million MT)	0	421	115
Total (Million MT)	632	1,050	806
Absolute change (Million MT)	*0*	*418*	*174*
Relative change (%)	*0*	*66*	*27*
2008 total emissions (%)	*9*	*15*	*11*

When comparing the results from this study to the previous literature on forest-based carbon sequestration studies it is important to consider that all the previous studies considered a wide variety of sequestration alternatives, not only afforestation to a carbon graveyard as is the case in the first scenario. Furthermore, most of the regional aggregations considered previously included the entire U.S., making the comparison difficult since this study used a different aggregation. However, the final quantity of CO_2 offsets obtained in the first scenario (421 million MT) is a little higher than the one obtained by Parks and Hardie (1995) nationally (400 million MT). By normalizing the costs on a per-CO_2-MT basis, the upper limit obtained by Parks and Hardie (1995) was a little lower ($11/MT) than the one obtained in the first scenario ($16/MT). When comparing the highest potential production of CO_2 offsets estimated in the second scenario (842 million MT) as listed in table 6.9, the closest estimation was the one obtained in Richards, Moulton, and Birdsey (1993) at the national level (1,492 million MT). However, when comparing costs, the upper limit in the range obtained in Richards, Moulton, and Birdsey (1993) is way higher ($24/MT) than the upper limit in this study ($9.5/MT). It is worth noting that the

Table 7.2. Land-use Change Under the Two Offset Payment Scenarios Considered

Scenarios	Baseline	First	Second
Agriculture (Million Acres)	523	437	501
Absolute change (Million Acres)		*-86*	*-22*
Relative change (%)		*-16*	*-4*
Commercial forestry (Million Acres)	313	311.5	314.3
Absolute change (Million Acres)		*-1.5*	*1.3*
Relative change (%)		*-0.5*	*0.4*
Carbon graveyard (Million Acres)	0	87	21

lowest cost under the second scenario was due to the contribution from the existing forests under commercial logging.

Only Lubowski, Plantinga, and Stavins (2006), belonging to the econometric-approach literature, considered a national aggregation with the rest considering small regional aggregations. The total offset production potential estimated by Lubowski, Plantinga, and Stavins (2006) was extremely high compared to the highest one in this study (842 million MT in second scenario). Hence, none of the econometric studies is directly comparable to the results obtained here. When comparing the sectorial optimization studies, the prices obtained from the two most common studies are too high for similar supplied quantities.

The second scenario also resulted in a lower acreage diversion out of agricultural land (22 million) compared to the first scenario (86 million acres) as shown in table 7.2. In the first scenario, commercial forest land decreased by 0.5 % as a result of the payments directed solely to graveyard forests. However, in the second scenario commercial forest land increased by 0.4% due to the offset payments to the logging activity.This fact ameliorated the negative economic effects suffered by most of the agricultural and manufacturing activities as a result of the massive land movement under the first scenario.

Under both scenarios, the regions that produced most of the CO_2 offsets generated by the carbon graveyard were relatively the same. In the first scenario, most of the production came from the Northern, Central and Western Great Plains; the Western and Eastern regions bordering the Appalachian mountains; and the South Atlantic and Gulf regions. Under the second scenario, most of the production came from the Northern Great Plains; Eastern and Western Boundaries of the Appalachian mountains; Northeastern part of Texas and Central region of Oklahoma. However, under the second scenario land was also converted into commercial logging and the regions where this phenomenon was more notorious included the Western and Eastern regions bordering the Appalachian mountains; and the Midwest including Iowa, Kansas and Missouri.

By contrasting the regional effects of acreage change to forest land among the studies that consider the entire U.S., Moulton and Richards (1990) estimated that for a 10% reduction policy 71 million acres had to be diverted to forest land of which 31% came from pastureland, 52% from forestland, and 17% from cropland. The regions where most of the acreage diversion took place were: Mountain (13,785 acres), Pacific (8,989 acres), and Southern Plains (7,906 acres). Parks and Hardie (1995) concluded that for a 3.5% reduction, 22.2 million acres were diverted to forest land mostly coming from the eastern half of the U.S., specifically from the Southeast. Alig et al. (1997) analyzed five different scenarios concluding that the following acreage had to be diverted to achieve the goal in each scenario: 31 million acres for target 1, 21 million acres for target 2, 34 million acres for target 3, 8 million acres for afforestation scenario, and 12 million acres for the BASE scenario. Lubowski, Plantinga, and Stavins (2006) concluded that 349 million acres were afforested with a \$100 per acre subsidy/tax. Lewandrowski et al. (2004) considered four scenarios of which the following land acreage had to be diverted to forest land: 64.6 million acres in scenario 1, 133.5 million acres in 2, 69.2 million acres in 3, and 60.8 million acres in 4. Most of the land diversion took place in Southeast, Delta States and Appalachia.

EPA (2005) concluded that 162 million acres were afforested for a price of \$50/t CO_2 mainly in the South-Central and Corn Belt regions.

Among the negative effects identified under the first scenario, higher land prices were the most critical ones. Higher land prices directly affected the activities that depended on land to a great extent, cattle and other crops being the most affected ones, and indirectly affecting others. Higher land prices drove agricultural production down and prices up. Although, all activities were capable of substituting land for other composite inputs, the majority of the agricultural activities decreased their demands for factors of production and intermediate commodities as well. The non-agricultural activities (e.g. manufacturing) that heavily depended on agricultural commodities (e.g. other crops) were negatively impacted by dropping their production. The drop in the demand of factors of production by most of the agricultural activities decreased the net income received by some household categories. Hence, the consumption and saving patterns of some households were negatively impacted. All household categories reduced their consumption of agricultural commodities as the result of their high prices. Agricultural exports also decreased, cattle being the commodity that suffered the most. Agricultural imports increased due to the lower domestic production. The cattle commodity was the one that experienced the sharpest increase.

The second scenario ameliorated the negative effects from the first scenario. Land prices increased as a result of the land movement to commercial logging or to the carbon graveyard. However, the percentage changes were definitely more moderate than under the first scenario. This fact allowed some of the agricultural activities to substitute land for other composite inputs. As expected, the activity that benefited the most from the second payment scheme was commercial logging as reflected by the drastic increase of its production level. The tight relationship between the manufacturing and logging activities drove the production of the former up. The increased supply of the manufacturing commodity was one of the reasons why most of the agricultural activities were not as heavily impacted as in the first scenario. The net income received by all household categories increased as well as their consumption and saving patterns. Although households still consumed less agricultural products than in the baseline, the reduction in consumption was not as drastic as under the first scenario. Trade followed the same pattern as under the first scenario with the exception of the logging commodity. The latter increased exports and decreased imports as opposed to the results from the first scenario.

In general, the economic outcomes experienced under the second scenario were more beneficial to the society as a whole. However, this study has not considered the costs of implementing, enforcing and evaluating the outcomes of such a policy. The evaluation of the carbon sequestered in existing commercial forests would definitely add a burden to the budget allocated by the government to CO_2 offsets. Enforcement is also an important factor since if the carbon graveyard practice is to be implemented, prohibiting the harvest of timber from this type of land would require a great amount of funding. However, the objective of this study focuses on the land-use phenomenon and its impacts on the prices and quantities of agricultural commodities rather than the total cost of implementing a certain policy. Although the budget magnitude has been the exogenously determined parameter in the model, the fact that the government pays for the generated CO_2 offsets is a starting point to what could potentially evolve to a private carbon market such as the cap-and-trade system presented in the American Clean Energy and Security Act of 2009.

It has also been difficult to compare the general equilibrium results obtained in this study with previous literature since CGE models have not been used to address such a specific policy (i.e. forest-based carbon sequestration). The closest group of models dealing with forest-based carbon sequestration are the sector optimization models. However, they do not consider the change in quantities and prices of commodities not directly related to agriculture and forestry. The impact on households, government and other institutions is also hard to compare to other studies since these are economic agents specifically used with SAM-based CGE models.

To contrast the implications of a similar global forest-based GHG-reduction policy to a "no policy" scenario where GHG emissions follow the path forecasted by the Intergovernmental Panel for Climate Change (IPCC), two of the four broad "Special Report on Emissions Scenarios" (SRES) developed by IPCC will be used as well as their physiological indices (IPCC 2000). The "no policy" scenario in this case refers to the A1 SRES, which among its assumptions includes a strong commitment to growth based on a carbon-intensive energy path, a great amount of deforestation by 2050 decreasing forestland by 265 million acres. Forest land is diverted to the production of energy biomass and grassland as the result of an increased consumption of meat and dairy products. The B1 SRES goes more along the lines of the forest-based sequestration policy presented in this study. In the B1 SRES there is a high level of environmental and social consciousness, a strong welfare net prevents social exclusion on the basis of poverty. There are strong incentives for low-input, low-impact agriculutre, along with maintenance of large areas of wilderness. This contributes to high food prices with a much lower consumption of meat and dairy products. Forest land increases 685 million acres worldwide by 2050 and comes mainly from grassland and cropland.

As listed in table 7.3, the physiological consequences of the representative "no policy" scenario (SRES A1) will result in a greater food insecure population, higher sea levels, a higher temperature change and higher CO_2 emission levels. Food insecurity is the result of lower production levels as listed in table 7.4. Hence, by contrasting the long-run consequences of taking no action versus implementing environmentally conscious policies, such as a forest-based carbon sequestration, will prove to be more costly to the society as a whole.

Table 7.3. Physiological Indices for the Two Global and Macro Scenarios Contrasted (SRES A1 and B1)

Indices	**A1**	**B1**
Food insecure population (in the U.S. by 2050)[a]	539,000	188,000
Sea level rise (meters in 2090-2099 relative to 1980-1999)[b]	0.26 - 0.59	0.18 - 0.38
Global mean temperature changes (by 2050 in degree C relative to the pre-industrial reference mean)[b]	2.56	1.86
CO_2 emission levels (GtC/yr by 2050)[b]	23.1	11.7

[a]Source: Wang (2012).[b]Source: (IPCC 2007)

Table 7.4. Agricultural Production Change for theTwo Global and Macro Scenarios Contrasted (

Scenario	% change of four commodities	% change of grains	% change of protein feed	% change of coarse grains	% change of rice	% change of wheat
IS95a emission	-6	-7	-4	-24	1	2
CO_2 stabilization	3	-1	14	-5	0	3

Source: Iglesias and Rosenzweig (2009)

REFERENCES

Adams, D., R. Alig, B. McCarl, J. Callaway, and S. Winnett. 1999. Minimum Cost Strategies for Sequestering Carbon in Forests. *Land Economics* 75(3): 360–374.

Adams, R., D. Adams, J. Callaway, C. Chang, and B. McCarl. 1993. Sequestering Carbon on Agricultural Land: Social Cost and Impacts on Timber Markets. *Contemporary Policy Issues* XI(1): 76–87.

Ahammad, H., and R. Mi. 2005. Land Use Change Modeling in GTEM: Accounting for Forest Sinks. In *EMF22: Climate Change Control Scenarios*, Standford University, California. Australian Bureau of Agricultural and Resource Economics.

Ahmed, S. A., T. W. Hertel, and R. Lubowski. 2008. *Calibration of a Land Cover Supply Function Using Transition Probabilities*. Center for Global Trade Analysis, Purdue University.

Alig, R., D. Adams, and B. McCarl. 1998. Ecological and Economic Impacts of Forest Policies: Interactions across Forestry and Agriculture. *Ecological Economics* 27: 63–78.

Alig, R., D. Adams, B. McCarl, J. Callaway, and S. Winnett. 1997. Assessing Effects of Mitigation Strategies for Global Climate Change with an Intertemporal Model of the U.S. Forest and Agriculture Sectors. *Environmental Resource Economics* 9: 259–274.

Armington, P. S. 1969. *A Theory of Demand for Products Distinguished by Place of Production*. International Monetary Fund.

Babiker, M., A. Gurgel, S. Paltsev, and J. M. Reilly. 2008. *A Forward Looking Version of the MIT Emissions Predictions and Policy Analysis (EPPA) Model*. The MIT Joint Program on the Science and Policy of Global Change.

Bair, L. S., and R. J. Alig. 2006. *Regional Cost Information for Private Timberland Convertion and Management*. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Birdsey, R. A. 1992. *Changes in Forest Carbon Storage from Increasing Forest Area and Timber Growth*, volume 1: Opportunities for Increasing Forest Cover of *Forests and Global Change*, chapter 3, 23–39. American Forests, Washington, D.C.

Birdsey, R. A. 1996. *Regional Estimates of Timber Volume and Forest Carbon for Fully Stocked Timberland, Average Management After Cropland or Pasture Reversion to Forest*, volume 2: Forest Management Opportunities for Mitigating Carbon Emissions of *Forests and Global Change*, chapter 3rd appendix, 309–333. American Forests, Washington, D.C.

Boden, T. A., G. Marland, and R. J. Andres. 2012. Global, Regional, and National Fossil-Fuel CO2 Emissions. http://cdiac.ornl.gov/trends/emis/tre_glob_2008.html (accessed January 2012).

Bryant, H. L., J. L. Campiche, and J. Lu. 2011. *A Static Computable General Equilibrium Model of World Energy and Agricultural Markets (WEAM)*. Agricultural and Food Policy Center, Texas A&M University, College Station, Texas.

Bureau of Economic Analysis (BEA). 2011. Regional Economic Accounts. http://www.bea.gov/regional/spi/ (accessed February 2011).

Bureau of Labor Statistics (BLS). 2011. Quarterly Census of Employment and Wages (QCEW). http://data.bls.gov/cgi-bin/dsrv?en (accessed February 2011).

Christensen, L. R. 1971. Entrepreneurial Income: How Does It Measure Up? *The American Economic Review* 61(4): 575–585.

Congressional Budget Office (CBO). 2007. *The Potential for Carbon Sequestration in the U.S.* The Congress of the U.S.

Darwin, R., M. Tsigas, J. Lewandrowski, and A. Raneses. 1995. *World Agricutlure and Climate Change: Economic Adaptations*. Economic Research Service, U.S. Department of Agriculture, 341 Victory Drive. Herndon, VA, U.S.A.

Dimaranan, B. V., and R. A. McDougall. 2002. *The GTAP 5 Data Base*. Center for Global Trade Analysis, Purdue University.

Dixon, P., and R. Maureen. 2001. *MONASH-USA: Creating a 1992 Benchmark Input-Output Database*. Centre of Policy Studies, Monash University. (Revised June 2002).

Environmental Protection Agency (EPA). 2005. *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture*. Office of Atmospheric Programs, U.S. Environmental Protection Agency, Washington, D.C.

Environmental Protection Agency (EPA). 2008. *EPA Analysis of the Lieberman-Warner Climate Security Act of 2008*. Office of Atmospheric Programs, U.S. Environmental Protection Agency, Washington, D.C.

Environmental Protection Agency (EPA). 2012. *Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010*. U.S. Environmental Protection Agency, 1200 Pennsylvania Ave., N.W. Washington, DC 20460 U.S.A.

Farm Service Agency (FSA). 2011. Conservation Programs: Contract Summary and Statistics. http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns-css (accessed February 2011).

Fofana, I., A. Lemelin, and J. Cockburn. 2005. *Balancing a Social Accounting Matrix: Theory and Application*. Centre Interuniversitaire sur le Risque les Politiques Economiques et L'Emploi (CIRPEE), Universite Laval.

Forest Service (FS). 2010. Forest Inventory Data Online (FIDO). http://fiatools.fs.fed.us/fido/index.html (accesed December 2010).

Giesecke, J. A. 2009. *Development of a Large-Scale Single U.S. Region CGE Model Using IMPLAN Data: A Los Angeles County Example with a Productivity Shock Application*. Centre of Policy Studies, Monash University.

Goettle, R. J., M. S. Ho, D. W. Jorgenson, D. T. Slesnick, and P. J. Wilcoxen. 2012. Analyzing Environmental Policies with IGEM, an Intertemporal General Equilibrium Model of U.S. Growth and the Environment. http://www.igem.insightworks.com/docs/190.html (accessed January 2012).

Gollin, D. 2002. Getting Income Shares Right. *The Journal of Political Economy* 110(2): 458–474.

Graham, R. L. 1994. An Analysis of the Potential Land Base for Energy Crops in the Conterminous United States. *Biomass and Bioenergy* 6(3): 175–189.

Hanson, K. A., and S. Robinson. 1991. Data, Linkages and Models: U.S. National Income and Product Accounts in the Framework of a Social Accounting Matrix. *Economic Systems Research* 3(3): 18.

Hertel, T. W. 1997. *Global Trade Analysis: Modeling and Applications*. Cambridge, MA: Cambridge University Press.

Hertel, T. W., W. E. Tyner, and D. K. Birur. 2010. The Global Impacts of Biofuel Mandates. *The Energy Journal* 31(1): 75–100.

Holland, D., L. Stodick, and S. Devadoss. 2010. Regional CGE Models. http://www.agribusiness-mgmt.wsu.edu/Holland_model/original-regional-model.htm (accessed September 2010).

Iglesias, A., and C. Rosenzweig. 2009. Effects of Climate Change on Global Food Production under Special Report on Emissions Scenarios (SRES) Emissions and Socioeconomic Scenarios: Data from a Crop Modeling Study. http://sedac.ciesin.columbia.edu/mva/cropclimate/ (accessed April 2011).

Intergovernmental Panel on Climate Change (IPCC). 2000. *Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*: New York, NY: Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: The Physical Science Basis*: New York, NY: Cambridge University Press.

Johnson, R., J. L. Ramseur, and R. W. Gorte. 2010. *Estimates of Carbon Mitigation Potential from Agricultural and Forestry Activities*. Congressional Research Service, Washington, D.C.

Koh, Y. K. 1991. *Analysis of Oklahoma's Boom and Bust Economy*. Ph.D. thesis, Department of Agricultural Economics, Oklahoma State University, Stillwater, OK.

Kravis, I. B. 1959. Relative Income Shares in Fact and Theory. *The American Economic Review* 49(5): 917–949.

Kretschmer, B., and S. Peterson. 2010. Integrating Bioenergy into Computable General Equilibrium Models: A Survey. *Energy Economics* 32(3): 673–686.

Lewandrowski, J., M. Peters, C. Jones, R. House, M. Sperow, M. Eve, and K. Paustian. 2004. *Economics of Sequestering Carbon in the U.S. Agricultural Sector*. Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Lofgren, H., R. L. Harris, S. Robinson, M. Thomas, and M. El-Said. 2002. *A Standard Computable General Equilibrium (CGE) Model in GAMS*. International Food Policy Research Institute, 2033 K Street, N.W., Washington, D.C., 20006-1002, U.S.A.

Lubowski, R. N. 2002. *Determinants of Land-Use Transitions in the United States: Econometric Analysis of Changes Among the Major Land-Use Categories*. Ph.D. thesis, Harvard University.

Lubowski, R. N., A. J. Plantinga, and R. N. Stavins. 2006. Land-Use Change and Carbon Sinks: Econometric Estimation of the Carbon Sequestration Supply Function. *Journal of Environmental Economics and Management* 51: 135–152.

MacDonald, J. M., E. J. O'Donoghue, W. D. McBride, R. F. Nehring, C. L. Sandretto, and R. Mosheim. 2007. *Profits, Costs, and the Changing Structure of Dairy Farming*. Economic Research Service, U.S. Department of Agriculture.

Marcouiller, D. W., D. F. Schreiner, and D. K. Lewis. 1993. Constructing a Social Accounting Matrix to Address Distributive Economic Impacts of Forest Management. *Regional Science Perspectives* 23(2): 60–90.

MIG, Inc. 1997. IMPLAN System (2008 data).

MIG, Inc. 1998. *Elements of the Social Accounting Matrix*. Minnesota IMPLAN Group, Inc.

Moulton, R., and K. Richards. 1990. *Costs of Sequestering Carbon through Tree Planting and Forest Management in the United States*. U.S. Department of Agriculture, Washington, D.C.

National Agricultural Statistics Service (NASS). 2011. Quick Stats. http://quickstats.nass.usda.gov/ (accessed February 2011).

Natural Resources Conservation Service (NRCS). 1997. Livestock Nutrition, Husbandry, and Behavior. In *National Range and Pasture Handbook*, handbook 6. U.S. Department of Agriculture, 2. Revised on Dec 2003.

Natural Resources Conservation Service (NRCS). 2006. *Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin*. U.S. Department of Agriculture.

Natural Resources Conservation Service (NRCS). 2011. Geospatial Data Gateway. http://datagateway.nrcs.usda.gov/ (accessed January 2011).

New York State Energy Office. 1991. *Analysis of Carbon Reduction in New York State*. NYS Energy Office, New York.

Newell, R., and R. N. Stavins. 2000. Climate Change and Forest Sinks: Factors Affecting the Cost of Carbon Sequestration. *Journal of Environmental Economics and Management* 40(3): 211–235.

Olson, D. 2011a. Land Rents in a CGE. Personal Communication. IMPLAN Support Forum. http://implan.com/V4/index.php?option=com_kunena&func=view&catid=80&id=8075&Itemid=35 (accessed February 2011).

Olson, D. 2011b. Real Estate Industry Treated as a Factor. Personal Communication. IMPLAN Support Forum. http://implan.com/V4/index.php?option=com_kunena&func=view&catid=80&id=8545&Itemid=35 (accessed April 2011).

Paltsev, S., J. M. Reilly, H. D. Jacoby, R. S. Eckaus, J. McFarland, M. Sarofim, M. Asadoorian, and M. Babiker. 2005. *The MIT Predictions and Policy Analysis (EPPA) Model: Version 4*. The MIT Joint Program on the Science and Policy of Global Change.

Parks, P., and I. Hardie. 1995. Least-Cost Forest Carbon Reserves: Cost-Effective Subsidies to Convert Marginal Agricultural Land to Forests. *Land Economics* 71(1): 122–136.

Plantinga, A. J., and T. Mauldin. 2001. A Method for Estimating the Cost of CO2 Mitigation through Afforestation. *Climatic Change* 49(1-2): 21–40.

Plantinga, A. J., T. Mauldin, and D. Miller. 1999. An Econometric Analysis of the Costs of Sequestering Carbon in Forests. *American Journal of Agricultural Economics* 81(4): 812–824.

Pyatt, G. 1988. A SAM Approach to Modeling. *Journal of Policy Modeling* 10(3): 327–352.

Richards, K. 1997. *Estimating the Cost of Carbon Sequetration for a United States Greenhouse Gas Policy*. Charles River Associates. Report prepared for the Charles River Associates.

Richards, K., R. Moulton, and R. Birdsey. 1993. Costs of Creating Carbon Sinks in the U.S. *Energy Conservation and Management* 34(9-11): 905–912.

Richards, K. R., D. H. Rosenthal, J. A. Edmonds, and M. Wise. 1993. *The Carbon Dioxide Emissions Game: Playing the Net*. U.S. Department of Energy, Washington, D. C. Presented at the Carbon Sinks Workshop for the Interagency National Action Plan Development Process.

Richards, K. R., and C. Stokes. 2004. A Review of Forest Carbon Sequestration Cost Studies: A Dozen Years of Research. *Climactic Change* 63(1-2): 1–48.

Robinson, S., A. Cattaneo, and M. El-Said. 2000. *Updating and Estimating a Social Accounting Matrix Using Cross Entropy Methods*. Trade and Macroeconomics Division, International Food Policy Research Institute, 2033 K Stree, N.W. Washington, D.C. 20006, U.S.A.

Robinson, S., and M. El-Said. 2000. *GAMS Code for Estimating a Social Accounting Matrix (SAM) Using Cross Entropy (CE) Methods*. Trade and Macroeconomics Division, International Food Policy Research Institute, 2033 K Street, N.W. Washington, D.C. 20006, U.S.A.

Ross, M. T. 2008. *Documentation of the Applied Dynamic Analysis of the Global Economy (ADAGE) Model*. Research Triangle Institute.

Sedjo, R., and A. Solomon. 1989. *Greenhouse Warming: Abatement and Adaptation*, chapter 8: Climate and Forests, 105–119. RFF Proceedings. RFF Press.

Sedjo, R., J. Wisniewski, A. Sample, and J. Kinsman. 1995. The Economics of Managing Carbon via Forestry: Assessment of Existing Studies. *Environmental and Resource Economics* 6: 139–165.

Sohngen, B. 2010. Global Timber Market and Forestry Data Project. http://aede.ag.ohio-state.edu/people/sohngen.1/forests/GTM/index.htm (accessed September 2010).

Sohngen, B., and R. Mendelsohn. 1999. Forest Management, Conservation, and Global Timber Markets. *American Journal of Agricultural Economics* 81(1): 1–13.

Sohngen, B., and R. Mendelsohn. 2003. An Optimal Control Model of Forest Carbon Sequestration. *American Journal of Agricultural Economics* 85(2): 448–457.

Sohngen, B., and R. Mendelsohn. 2007. *Human-Induced Climate Change: An Interdisciplinary Assessment*, chapter 19: A Sensitivity Analysis of Forest Carbon Sequestration, 227–237. New York, NY: Cambridge University Press.

Sohngen, B., C. Tennity, M. Hnytka, and K. Meeusen. 2008. *Global Forestry Data for the Economic Modeling of Land Use*. Center for Global Trade Analysis, Purdue University, West Lafayette, IN, USA.

Stavins, R. N. 1999. The Costs of Carbon Sequestration: A Revealed-Preference Approach. *American Economic Review* 89: 994–1009.

Stavins, R. N., and K. R. Richards. 2005. *The Cost of U.S. forest-based Carbon Sequestration*. Pew Center on Global Climate Change.

Thordvalson, J. 2011. Self-Employment and Proprietary Income. Personal Communication. Implan Support Forum. http://implan.com/V4/index.php?option=com_kunena&func=view&catid=80&id=8210&Itemid=35 (accessed March 2011).

van Kooten, G. C., A. J. Eagle, J. Manley, and T. Smolak. 2004. How Costly are Carbon Offsets? A Meta-Analysis of Carbon Forest Sinks. *Environmental Science and Policy* 7(4): 239–251.

Vargas, E., D. Schreiner, G. Tembo, and D. Marcouiller. 2010. Computable General Equilibrium Modeling for Regional Analysis. http://rri.wvu.edu/WebBook/Schreiner/contents.htm (accessed July 2010).

Wang, W. 2012. *Three Essays on Climate Change Impacts, Adaptation and Mitigation in Agriculture*. Ph.D. thesis, Texas A&M University.

Wisconsin Agricultural Statistics Service. 2005. *Wisconsin Dairy Grazing Operations 2004 and 2009*. National Agricultural Statistics Service, U.S. Department of Agriculture in cooperation with WI Department of Agriculture, Trade and Consumer Protection.

APPENDIX A

GENERAL LISTS, TABLES AND SAM FIGURES

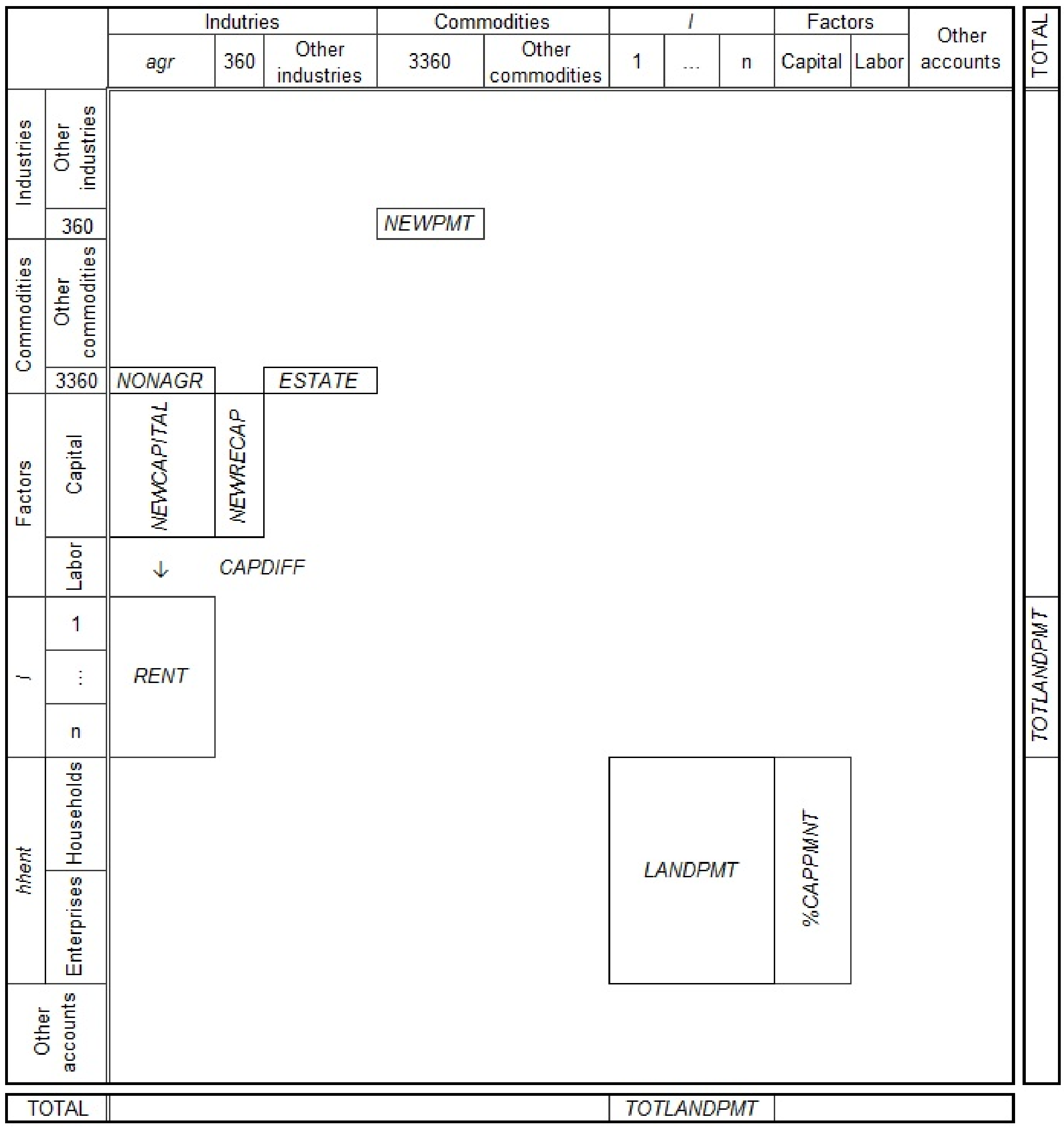


Figure A.1. Extended IMPLAN SAM with the Major Land Resource Areas (MLRAs) included

Table A.1. Base Year Social Accounting Matrix (SAM) Parameters

Param	SAM	Param	SAM
tf	$\frac{SAM_{gov,f}}{SAM_{'total',f}}$	$shhhhh$	$\frac{SAM_{h,h}}{SAM_{'total',h}-SAM_{gov,h}}$
th	$\frac{SAM_{gov,h}}{SAM_{'total',h}}$	$shgovhh$	$\frac{SAM_{h,gov}}{SAM_{'total',gov}-SAM_{'inv',gov}}$
ta	$\frac{SAM_{'ibt',a}}{SAM_{'total',a}}$	$shenthh$	$\frac{SAM_{h,'ent'}}{SAM_{'total','ent'}-SAM_{gov,'ent'}}$
$tent$	$\frac{SAM_{gov,'ent'}}{SAM_{'total','ent'}}$	$shinvhh$	$\frac{SAM_{h,'inv'}}{SAM_{'total','inv'}-SAM_{'nvt','inv'}}$
$timp$	$\frac{SAM_{'imptax',c}}{SAM_{'row',c}}$	$shgovgov$	$\frac{SAM_{gov,gov}}{SAM_{'total',gov}-SAM_{'inv',gov}}$
$tgovcons$	$\frac{SAM_{'ibt',gov}}{SAM_{c,gov}}$	$shinvgov$	$\frac{SAM_{gov,'inv'}}{SAM_{'total','inv'}-SAM_{'nvt','inv'}}$
$thhcons$	$\frac{SAM_{'ibt',h}}{SAM_{c,h}}$	$shgovent$	$\frac{SAM_{'ent',gov}}{SAM_{'total',gov}-SAM_{'inv',gov}}$
$tnvtcons$	$\frac{SAM_{'ibt','nvt'}}{SAM_{c,'nvt'}}$	$shentinv$	$\frac{SAM_{'inv','ent'}}{SAM_{'total','ent'}-SAM_{gov,'ent'}}$
$tinvcons$	$\frac{SAM_{'ibt','inv'}}{SAM_{c,'inv'}}$	$shfout$	$\frac{SAM_{t,f}}{SAM_{'total',f}-SAM_{gov,f}-SAM_{'inv',f}}$
$deprec$	$\frac{SAM_{'inv','capital'}}{SAM_{'total','capital'}}$	$shhhout$	$\frac{SAM_{t,h}}{SAM_{'total',h}-SAM_{gov,h}}$
qf	$SAM_{'total',f}$	$shgovout$	$\frac{SAM_{t,gov}}{SAM_{'total',gov}-SAM_{'inv',gov}}$
ql	$SAM_{'total',l}$	$shnvtout$	$\frac{SAM_{t,'nvt'}}{SAM'_{total','nvt'}-SAM_{'inv','nvt'}}$
$shfinst$	$\frac{SAM_{hhent,f}}{SAM_{'total',f}-SAM_{gov,f}-SAM_{'inv',f}}$	$shinvout$	$\frac{SAM_{t,'inv'}}{SAM_{'total','inv'}-SAM_{'nvt','inv'}}$
$shlinst$	$\frac{SAM_{hhent,l}}{SAM_{'total',l}}$	$shtaxgov$	$\frac{SAM_{gov,'ibt'}}{SAM_{'total','ibt'}}$
$hhsales$	$SAM_{h,c}$	$trnsouthh$	$SAM_{hh,t}$
$govsales$	$SAM_{gov,c}$	$trnsoutgov$	$SAM_{gov,t}$
$nvtsales$	$SAM_{'nvt',c}$	$trnsoutnvt$	$SAM_{'nvt',t}$
$invsales$	$SAM_{'inv',c}$	$nvtin$	$SAM_{'nvt','inv'}$
$qgov$	$SAM_{c,gov}$	$nvtout$	$SAM_{'inv','nvt'}$
$qnvt$	$SAM_{c,'nvt'}$	$govsav$	$SAM_{'inv',gov}$
$qinv$	$SAM_{c,'inv'}$	$qexp$	$SAM_{c,t}$
$qimp$	$SAM_{t,c}$		

Table A.2. Aggregation of IMPLAN Activities and Commodities

Aggregated activities and commodities	Activities		Commodities	
	Abbrev.	IMPLAN codes	Abbrev.	IMPLAN codes
Oilseed farming	Aolsd	1	Colsd	3001
Grain farming	Agran	2	Cgran	3002
Tobacco farming	Atobc	7	Ctobc	3007
Cotton farming	Acott	8	Ccott	3008
Sugarcane and sugar beet farming	Asugr	9	Csugr	3009
All other crop farming	Aocrp	10	Cocrp	3010
Cattle ranching and farming	Acatt	11	Ccatt	3011
Dairy cattle and milk production	Adair	12	Cdair	3012
Logging	Alogg	16	Clogg	3016
Other agriculture	Aoagr	3-6,13-15,17-19	Coagr	3003-3006,3013-3015,3017-3019
Mining	Amini	20-30	Cmini	3020-3030
Utilities	Autil	31-33	Cutil	3031-3033
Construction	Acons	34-40	Ccons	3034-3040
Manufacturing	Amanf	41-318	Cmanf	3041-3318
Wholesale trade	Awhol	319	Cwhol	3319
Retail trade	Aretl	320-331	Cretl	3320-3331
Transportation and warehousing	Atrns	332-340	Ctrns	3332-3340
Information	Ainfo	341-353	Cinfo	3341-3353
Financial services	Afinc	354-359	Cfinc	3354-3359
Real estate	Aland	360	Cland	3360
Other property rent	Aornt	361-366	Cornt	3361-3366
Professional, scientific and technical services	Aprof	367-380	Cprof	3367-3380
Management of companies and enterprises	Amgmt	381	Cmgmt	3381
Administrative and waste services	Aadmw	382-390	Cadmw	3382-3390
Education services	Aeduc	391-393	Ceduc	3391-3393
Health services	Ahlth	394-401	Chlth	3394-3401
Amusement and recreational services	Aentt	402-410	Centt	3402-3410
Accomodation and food services	Ahotl	411-413	Chotl	3411-3413
Other services	Aoser	414-426	Coser	3414-3426
Government utilities and enterprises	Agven	427-432	Cgven	3427-3432
Unclassified	Auncl	433-436	Cuncl	3433-3436
Government employment and payroll	Agvem	437-440	Cgvem	3437-3440

	Activities	Commodities	Factors	Indirect business taxes	Households	Government	Enterprises	Investment[a]	Inventory	Rest of the US	Rest of the world
Activities		5								38	
Commodities	1				16	21		30	35		
Factors	2										
Indirect business taxes	3										
Households		6	10		17	22	27	31		39	
Government		7	11	15	18	23	28	32		40	
Enterprises			12			24					
Investment ***		8	13		19	25	29		36	41	
Inventory		9						33		42	
Rest of the US	4		14		20	26		34	37	43	
Rest of the world											

[a] Investment account: (1) Payments by capital to institutions is considered net borrowing and (2) payments by institutions to capital is considered net saving

Figure A.2. Detailed structure of an IMPLAN SAM

Table A.3. Concepts of the Detailed Structure of an IMPLAN SAM in Figure A.2

SAM ID	Concept	SAM ID	Concept
1	Domestic intermediate commodity inputs	23	Intergovernment transfers
2	Payments to factors	24	Transfers to enterprises
3	Producer, factor use and sales taxes	25	Government savings
4	Imports of goods and services by activities	26	Commodity imports and transfers by government
5	Domestic commodity output	27	Surplus to households, dividends
6	Households production of commodities and services	28	Corporate profit tax, surplus to government
7	Government production of commodities and services	29	Enterprise savings, retained earnings
8	Used and second hand goods [a]	30	Domestic capital goods consumption
9	Use of inventory to produce commodities	31	Dis-savings or withdrawals of capital for consumption
10	Factor income to households	32	Dis-savings or net borrowing by the government
11	Factor income to government, factor taxes	33	Net inventory change. Dis-savings of inventory [b]
12	Factor income to enterprises, corporate profits	34	Commodity imports and transfers by investment
13	Depreciation or capital consumption allowance	35	Stored commodities or in inventory
14	Factor imports and transfers	36	Net inventory change [c]
15	Sales excise and property taxes, etc.	37	Commodity imports and transfers by inventory
16	Domestic households consumption	38	Exports of goods and services by activities
17	Interhousehold transfers, interests	39	Commodity exports and transfers by households
18	Income and personal tax	40	Commodity exports and transfers by government
19	Savings (surplus or deficit)	41	Net foreign investment [d]
20	Commodity imports and transfers by households	42	Commodity exports and transfers by inventory
21	Domestic government consumption	43	Trans-shipments: imports to exports
22	Transfers to households		

[a] Old equipment or tear down of structures and selling off parts

[b] Capital payments to inventory represent dis-savings of inventory. In other words, there are more additions to inventory than sales from it.

[c] Inventory payments to capital is a net balance of inventory. In other words, there are more sales from inventory than additions to it.

[d] Net foreign investment = Exports - Imports

Table A.4. Total of County-level Recorded Acreage of Crops in 2008

IMPLAN Code	IMPLAN Industries	% of Acres recorded	Crop	% of Acres recorded	County Acreage	National Acreage
1	Oilseeds	98%	Canola	93%	924,440	989,000
			Flaxseed	97%	328,581	340,000
			Soybean	99%	74,080,516	74,641,000
			Sunflower	77%	1,856,337	2,396,000
			Mustard	41%	29,217	71,500
			Safflower	34%	67,159	195,000
			Rapeseed	90%	954	1,060
			Sesame	52%	2,596	4,978
2	Grains	98%	Corn Grain	100%	78,425,062	78,570,000
			Corn Silage	87%	5,176,837	5,965,000
			Barley	98%	3,721,051	3,779,000
			Beans Dry Edible	87%	1,256,177	1,445,200
			Oats	91%	1,275,587	1,400,000
			Rice	99%	2,955,900	2,976,000
			Rye	81%	216,675	267,361
			Sorghum Grain	97%	7,060,754	7,271,000
			Sorghum Silage	87%	391,879	450,041
			Wheat	97%	54,193,521	55,699,000
			Pea Dry Edible	85%	722,220	847,300
			Cowpea	58%	10,664	18,544
			Lentils	65%	169,900	261,000
			Buckwheat	63%	15,568	24,760
			Popcorn	76%	153,286	201,623
			Wild Rice	46%	26,109	57,204
7	Tobacco	89%	Tobacco	89%	317,232	354,490
8	Cotton	99%	Cotton Upland	99%	7,304,839	7,400,000
			Cotton Pima	100%	168,700	168,700
9	Sugarcane and beets	99%	Sugarbeets	100%	1,004,000	1,004,500
			Sugarcane Sugar	99%	815,472	821,600
			Sugarcane Seed	82%	41,563	50,722
10	All others	78%	Hay	78%	46,832,789	60,152,000
			Peanuts	93%	1,402,943	1,507,000
			Alfalfa	74%	89,762	121,467
			Birdsfoot	80%	811	1,014
			Crimson Clover	80%	2,801	3,496
			Red Clover	66%	14,135	21,387
			White Clover	60%	2,453	4,059
			Lespedeza	18%	862	4,909
			Vetch	63%	1,026	1,618
			Bahia Grass	30%	5,215	17,326
			Bentgrass	94%	6,374	6,809
			Bermuda Grass	7%	2,768	37,750
			Bluegrass	80%	121,100	151,299
			Bromegrass	23%	1,218	5,287
			Fescue	84%	323,217	386,122
			Ochardgrass	90%	19,365	21,517
			Ryegrass	97%	299,120	307,722
			Sudangrass	61%	7,189	11,867
			Timothy	56%	2,181	3,882
			Wheatgrass	56%	11,823	21,214
			Guar	83%	4,956	5,946
			Hops	74%	22,907	31,145
			Mint Oil	68%	60,737	89,783

Table A.5. State-level Forest Land Net Present Value (NPV) in 2000 Dollars

States	Soft	Hard	Oak / Hickory	Maple / Beech / Birch	Oak / Pine	Oak / Gum / Cypress	Other hard
Alabama	643.22	138.43			320.04	170.48	138.43
Arkansas	607.67	138.43			340.69	193.48	138.43
Florida	646.13	138.43			440.05	314.72	138.43
Georgia	644.50	138.43			313.04	201.30	138.43
Kentucky	514.41	138.43			514.41	205.45	138.43
Louisiana	643.82	138.43			217.96	251.19	138.43
Mississippi	635.39	138.43			248.11	166.05	138.43
North Carolina	608.22	138.43			362.64	181.05	138.43
Oklahoma	623.73	138.43			396.49	138.43	138.43
South Carolina	619.07	138.43			299.86	184.77	138.43
Tennessee	595.30	138.43			525.06	216.96	138.43
Texas	612.53	138.43			180.37	191.40	138.43
Virginia	638.65	138.43			390.68	172.03	138.43
Connecticut	33.41		73.44	24.05	33.41	73.44	48.74
Delaware	33.41		73.44	24.05	72.35	73.43	48.74
Maine	33.41		73.44	24.05	33.41		48.74
Maryland	33.41		73.44	24.05	67.92	72.35	48.74
Massachusetts	33.41		73.44	24.05	33.41	73.44	48.74
New Hampshire	33.41		73.44	24.05	33.41		48.74
New Jersey	33.41		73.44	24.05	33.41	73.44	48.74
New York	33.41		73.44	24.05	33.41		48.74
Pennsylvania	33.41		73.44	24.05	33.41		48.74
Rhode Island	33.41		73.44	24.05	33.41		48.74
Vermont	33.41		73.44	24.05	33.41		48.74
Ohio	33.41		73.44	24.05	35.41	73.32	48.74
West Virginia	33.41		73.44	24.05	33.41		48.74
Illinois	75.49		15.40	27.59	43.27	21.00	21.49
Indiana	75.49		15.40	27.59	55.45	15.40	21.49
Iowa	75.49		15.40	27.59	75.49		21.49
Michigan	75.49		15.40	27.59	75.49	15.40	21.49
Minnesota	75.49		15.40	27.59	75.49		21.49
Wisconsin	75.49		15.40	27.59	75.49		21.49
Arizona	27.86	19.07					19.07
California	27.86	19.07					19.07
Colorado	27.86	19.07					19.07
Idaho	27.86	19.07					19.07
Kansas	27.86	19.07			27.86	19.07	19.07
Missouri	27.86	19.07			26.25	19.07	19.07
Montana	27.86	19.07					19.07
Nebraska	27.86	19.07			23.08		19.07
Nevada	27.86	19.07					19.07
New Mexico	27.86	19.07					19.07
North Dakota	27.86	19.07					19.07
South Dakota	27.86	19.07					19.07
Utah	27.86	19.07					19.07
Wyoming	27.86	19.07					19.07
Oregon	285.57	19.07					19.07
Washington	285.57	19.07					19.07

Table A.6. State-level Forest Land Rents in 2008 Dollars

States	Soft	Hard	Oak / Hickory	Maple / Beech / Birch	Oak / Pine	Oak / Gum / Cypress	Other hard
Alabama	33.64	7.24			16.74	8.92	7.24
Arkansas	31.78	7.24			17.82	10.12	7.24
Florida	33.79	7.24			23.01	16.46	7.24
Georgia	33.71	7.24			16.37	10.53	7.24
Kentucky	26.90	7.24			26.90	10.75	7.24
Louisiana	33.67	7.24			11.40	13.14	7.24
Mississippi	33.23	7.24			12.98	8.68	7.24
North Carolina	31.81	7.24			18.97	9.47	7.24
Oklahoma	32.62	7.24			20.74	7.24	7.24
South Carolina	32.38	7.24			15.68	9.66	7.24
Tennessee	31.13	7.24			27.46	11.35	7.24
Texas	32.04	7.24			9.43	10.01	7.24
Virginia	33.40	7.24			20.43	9.00	7.24
Connecticut	1.75		3.84	1.26	1.75	3.84	2.55
Delaware	1.75		3.84	1.26	3.78	3.84	2.55
Maine	1.75		3.84	1.26	1.75		2.55
Maryland	1.75		3.84	1.26	3.55	3.78	2.55
Massachusetts	1.75		3.84	1.26	1.75	3.84	2.55
New Hampshire	1.75		3.84	1.26	1.75		2.55
New Jersey	1.75		3.84	1.26	1.75	3.84	2.55
New York	1.75		3.84	1.26	1.75		2.55
Pennsylvania	1.75		3.84	1.26	1.75		2.55
Rhode Island	1.75		3.84	1.26	1.75		2.55
Vermont	1.75		3.84	1.26	1.75		2.55
Ohio	1.75		3.84	1.26	1.85	3.83	2.55
West Virginia	1.75		3.84	1.26	1.75		2.55
Illinois	3.95		0.81	1.44	2.26	1.10	1.12
Indiana	3.95		0.81	1.44	2.90	0.81	1.12
Iowa	3.95		0.81	1.44	3.95		1.12
Michigan	3.95		0.81	1.44	3.95	0.81	1.12
Minnesota	3.95		0.81	1.44	3.95		1.12
Wisconsin	3.95		0.81	1.44	3.95		1.12
Arizona	1.46	1.00					1.00
California	1.46	1.00					1.00
Colorado	1.46	1.00					1.00
Idaho	1.46	1.00					1.00
Kansas	1.46	1.00			1.46	1.00	1.00
Missouri	1.46	1.00			1.37	1.00	1.00
Montana	1.46	1.00					1.00
Nebraska	1.46	1.00			1.21		1.00
Nevada	1.46	1.00					1.00
New Mexico	1.46	1.00					1.00
North Dakota	1.46	1.00					1.00
South Dakota	1.46	1.00					1.00
Utah	1.46	1.00					1.00
Wyoming	1.46	1.00					1.00
Oregon	14.94	1.00					1.00
Washington	14.94	1.00					1.00
2000-2008 PPI change =		1.046					
Interest rate =	0.05						

Table A.7. State-level Animal Units (AU) for Different Categories

States	Beef cattle	Dairy cattle	Goats	Sheep	Horses and mules	Alpacas	Bisons	Deer	Elks	Llamas
Alabama	0.83	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Alaska	0.87	0.95	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Arizona	0.81	0.96	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Arkansas	0.83	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
California	0.76	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Colorado	0.83	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Connecticut	0.75	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Delaware	0.80	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Florida	0.85	0.95	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Georgia	0.83	0.96	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Hawaii	0.84	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Idaho	0.81	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Illinois	0.82	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Indiana	0.80	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Iowa	0.82	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Kansas	0.81	0.92	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Kentucky	0.84	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Louisiana	0.85	0.95	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Maine	0.77	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Maryland	0.80	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Massachusetts	0.79	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Michigan	0.77	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Minnesota	0.78	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Mississippi	0.84	0.95	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Missouri	0.83	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Montana	0.89	0.92	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Nebraska	0.84	0.95	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Nevada	0.86	0.95	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
New Hampshire	0.78	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
New Jersey	0.82	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
New Mexico	0.84	0.95	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
New York	0.75	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
North Carolina	0.82	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
North Dakota	0.86	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Ohio	0.80	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Oklahoma	0.82	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Oregon	0.85	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Pennsylvania	0.75	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Rhode Island	0.84	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
South Carolina	0.83	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
South Dakota	0.85	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Tennessee	0.83	0.92	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Texas	0.83	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Utah	0.85	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Vermont	0.72	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Virginia	0.82	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Washington	0.82	0.94	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
West Virginia	0.84	0.95	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Wisconsin	0.74	0.93	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20
Wyoming	0.87	0.92	0.13	0.18	1.25	0.10	1.00	0.18	0.60	0.20

Table A.8. Estimated Average Annual Number of Pasture-grazing Heads for each Category, 2007

States	Beef cattle	Dairy cattle	Goats	Sheep	Horses	Mules	Alpacas	Bisons	Deer	Elks	Llamas
Alabama	1,178,483	78	80,436	14,500	87,111	10,829	378	250	971	76	870
Alaska	13,553	27	352	408	1,850	45	196	246	-	217	44
Arizona	640,082	40	42,141	112,368	68,745	1,984	1,357	21	108	-	786
Arkansas	1,782,065	1,049	50,579	14,609	78,968	7,647	92	189	235	19	688
California	2,459,005	3,011	130,771	569,290	180,723	7,144	7,669	1,081	260	-	6,779
Colorado	1,502,276	622	48,616	397,146	119,040	4,946	7,709	9,854	10	2,403	7,452
Connecticut	18,239	1,020	4,578	5,767	11,510	428	1,052	8	56	-	615
Delaware	11,698	376	3,530	903	3,964	106	79	-	-	-	63
Florida	1,573,139	211	57,613	11,763	120,498	6,233	1,220	237	1,980	-	850
Georgia	1,037,544	1,209	83,757	10,025	76,706	8,877	686	307	36	-	1,263
Hawaii	151,473	1	9,169	744	6,547	209	-	-	-	-	-
Idaho	1,261,360	2,442	16,822	189,237	74,029	3,748	2,144	844	229	2,346	2,889
Illinois	779,642	6,281	33,653	51,771	79,481	4,364	2,102	202	1,467	44	1,974
Indiana	562,235	9,008	47,090	48,792	81,155	4,374	1,822	332	2,252	370	2,590
Iowa	1,961,011	14,266	55,144	199,026	71,994	4,166	240	306	2,978	471	1,999
Kansas	4,450,630	2,543	48,195	77,495	89,898	4,381	827	2,659	18	332	2,208
Kentucky	2,248,065	9,751	98,128	36,294	175,434	11,800	1,332	393	-	-	2,329
Louisiana	843,507	1,474	21,550	8,077	60,487	4,740	63	57	1,906	-	121
Maine	36,742	1,995	5,902	10,918	12,157	389	1,758	65	2,976	-	614
Maryland	104,048	4,334	16,889	22,143	30,747	1,113	1,917	416	-	-	756
Massachusetts	22,730	1,165	8,184	11,555	20,553	976	1,556	28	127	-	1,308
Michigan	399,015	14,326	27,741	80,457	101,138	4,385	3,812	1,970	16,393	1,758	3,539
Minnesota	1,055,196	35,715	36,752	136,206	90,140	3,690	1,016	3,993	6,829	5,419	2,371
Mississippi	963,042	725	30,399	7,243	65,277	7,001	119	60	1,621	110	283
Missouri	4,067,398	10,213	96,396	76,261	149,165	11,979	1,465	1,808	4,043	570	3,096
Montana	2,530,334	485	9,631	266,083	105,243	4,356	536	5,601	-	855	2,435
Nebraska	4,000,118	1,307	32,846	68,587	65,624	2,468	33	5,795	6	63	1,122
Nevada	425,253	10	11,894	37,398	18,396	392	439	76	-	-	831
New Hampshire	15,938	727	3,616	7,671	9,900	703	1,537	80	919	230	586
New Jersey	23,275	742	10,555	14,767	29,993	1,179	2,226	-	150	-	708
New Mexico	1,036,678	83	35,665	126,773	53,616	1,889	1,457	427	-	-	1,507
New York	440,957	38,589	39,834	63,119	84,997	2,814	6,939	738	5,200	863	2,363
North Carolina	754,773	1,314	98,241	26,088	78,377	8,512	1,137	124	105	21	1,571
North Dakota	1,722,403	1,524	3,461	76,450	44,750	773	36	9,631	289	2,708	208
Ohio	711,522	22,760	69,505	123,161	119,198	6,605	10,188	848	6,206	19	4,501
Oklahoma	5,112,345	2,490	125,303	76,215	165,555	12,411	478	2,004	3,885	823	3,845
Oregon	1,132,244	1,635	38,070	206,507	89,420	4,762	7,760	751	33	168	9,380
Pennsylvania	635,962	59,230	59,152	96,762	116,332	9,750	5,427	1,769	21,803	2,084	2,932
Rhode Island	3,371	5	543	1,459	3,486	86	123	-	-	-	123
South Carolina	379,804	48	43,589	6,787	43,283	4,541	418	60	64	-	424
South Dakota	3,095,120	2,470	9,366	335,534	70,225	1,743	57	20,661	15	138	676
Tennessee	2,017,310	3,846	130,867	28,324	141,860	18,328	896	263	647	53	2,205
Texas	10,868,029	2,259	1,134,156	906,478	438,827	60,724	1,908	4,379	120,452	3,727	11,977
Utah	693,501	1,514	13,915	273,567	59,783	1,922	1,115	530	72	1,055	1,411
Vermont	66,362	8,151	6,593	13,925	13,285	948	1,435	-	195	-	694
Virginia	1,400,532	5,297	63,059	76,821	90,363	6,739	4,119	482	6	80	3,696
Washington	645,261	2,114	32,840	53,220	89,739	3,793	13,117	1,069	145	-	8,126
West Virginia	395,134	940	27,789	37,934	37,728	2,684	814	34	1,038	-	673
Wisconsin	1,192,622	107,641	55,500	89,452	119,963	5,711	3,088	3,815	8,290	4,875	6,513
Wyoming	1,247,758	161	7,575	390,271	80,476	2,245	387	3,295	-	-	1,340

	Activities	Commodities	Agricultural land	Factors	Indirect business taxes	Households	Enterprises	Government	Investment[a]	Inventory	Import taxes	Rest of the US	Rest of the world
Activities		5											
Commodities	1					20		29	36	42		47	
Agricultural land	2												
Factors	3											48	
Indirect business taxes	4					21		30	37	43			
Households		6	12	14		22	26	31	38			49	
Enterprises			13	15				32					
Government		7		16	19	23	27	33	39		46	50	
Investment ***		8		17		24	28	34		44		51	
Import taxes		9											
Inventory		10							40			52	
Rest of the US		11		18		25		35	41	45			
Rest of the world													

[a] Investment account: (1) Payments by capital to institutions is considered net borrowing and (2) payments by institutions to capital is considered net saving

Figure A.3. Final modified Social Accounting Matrix (SAM)

Table A.9. Concepts of the Final Modified Social Accounting Matrix (SAM) in Figure A.3

SAM ID	Concept	SAM ID	Concept
1	Aggregate domestic and imported intermediate inputs	27	Corporate profit tax, surplus to government
2	Agricultural land rent payments	28	Enterprise savings, retained earnings
3	Payments to factors	29	Aggregate domestic and imported government consumption
4	Sales, Production, factor use taxes	30	Sales taxes to government
5	Aggregate domestic and exported commidity output	31	Transfers to households
6	Aggregate domestic and exported households production	32	Intergovernment transfers
7	Aggregate domestic and exported government production	33	Transfers to enterprises
8	Aggregate domestic and expoted production second hand goods [a]	34	Government savings
9	Import duties by commodity	35	Transfers from government to outside regions
10	Inventories used for domestic production or exports	36	Aggregate domestic and imported purchase of capital goods
11	Imports of commodities and services	37	Sales taxes to the investment account
12	Households income from agricultural land rents	38	Dis-savings or withdrawals of capital for consumption
13	Enterprises Income from agricutlural land rents	39	Dis-savings or net borrowing by the government
14	Factor income to households	40	Net inventory change. Dis-savings for inventory [b]
15	Factor income to enterprises, corporate profits	41	Transfers from investment to outside regions
16	Factor income to government, factor taxes	42	Aggregate domestic and imported commodities in inventory
17	Depreciation or capital consumption allowance	43	Sales taxes from inventory
18	Factor imports and transfers	44	Net inventory change [c]
19	Sales, Production, factor use taxes	45	Transfers from inventory to outside regions
20	Aggregate domestic and imported households consumption	46	Import duties
21	Sales taxes to households	47	Exports of goods and services
22	Interhousehold transfers, interests	48	Transfers from outside regions to factors
23	Income and personal tax	49	Transfers from outside regions to households
24	Savings (surplus or deficit)	50	Transfers from outside regions to government
25	Transfers from households to outside regions	51	Net foreign investment [d]
26	Surplus to households, dividends	52	Transfers from outside regions to inventory

[a] Old equipment or tear down of structures and selling off parts

[b] Capital payments to inventory represent dis-savings of inventory. In other words, there are more additions to inventory than sales from it.

[c] Inventory payments to capital is a net balance of inventory. In other words, there are more sales from inventory than additions to it.

[d] Net foreign investment = Exports - Imports

Table A.10. List of Major Land Resource Areas (MLRAs) Included in the Regional Aggregation

CODE	MLRA Name	CODE	MLRA Name
MLRA043	Cool Central Desertic Basins and Plateaus	MLRA101	Central New Mexico Highlands
MLRA044	Warm Central Desertic Basins and Plateaus	MLRA102	Southern Desert Foothills
MLRA045	Colorado Plateau	MLRA104	Central Nebraska Loess Hills
MLRA046	Southwestern Plateaus, Mesas, and Foothills	MLRA105	Central High Tableland
MLRA050	Mogollon Transition	MLRA106	Rolling Plains and Breaks
MLRA051	Arizona and New Mexico Mountains	MLRA107	Central Kansas Sandstone Hills
MLRA052	Sonoran Basin and Range	MLRA108	Central Loess Plains
MLRA053	Southeastern Arizona Basin and Range	MLRA109	Bluestem Hills
MLRA054	Southern Desertic Basins, Plains, and Mountains	MLRA111	Southern High Plains, Northern Part
MLRA059	Northern Rocky Mountains	MLRA112	Southern High Plains, Northwestern Part
MLRA060	Central Rocky Mountains	MLRA113	Southern High Plains, Southern Part
MLRA061	Blue and Seven Devils Mountains	MLRA114	Southern High Plains, Southwestern Part
MLRA062	Northern Rocky Mountain Valleys	MLRA115	Southern High Plains, Breaks
MLRA063	Northern Rocky Mountain Foothills	MLRA117	Rolling Limestone Prairie
MLRA064	Wasatch and Uinta Mountains	MLRA118	Central Rolling Red Plains, Western Part
MLRA065	Southern Rocky Mountains	MLRA119	Central Rolling Red Plains, Eastern Part
MLRA066	Southern Rocky Mountain Parks	MLRA121	Great Bend Sand Plains
MLRA067	Southern Rocky Mountain Foothills	MLRA122	Central Rolling Red Prairies
MLRA070	High Intermountain Valleys	MLRA123	Texas North-Central Prairies
MLRA071	Brown Glaciated Plain	MLRA125	Edwards Plateau, Western Part
MLRA072	Northern Dark Brown Glaciated Plains	MLRA126	Edwards Plateau, Central Part
MLRA073	Central Dark Brown Glaciated Plains	MLRA127	Edwards Plateau, Eastern Part
MLRA074	Southern Dark Brown Glaciated Plains	MLRA128	Southern Edwards Plateau
MLRA075	Rolling Soft Shale Plain	MLRA130	Texas Central Basin
MLRA076	Northern Black Glaciated Plains	MLRA131	Wichita Mountains
MLRA077	Central Black Glaciated Plains	MLRA132	Northern Rio Grande Plain
MLRA078	Southern Black Glaciated Plains	MLRA133	Western Rio Grande Plain
MLRA079	Red River Valley of the North	MLRA134	Central Rio Grande Plain
MLRA080	Northern Minnesota Gray Drift	MLRA135	Lower Rio Grande Plain
MLRA081	Northern Rolling High Plains, Northern Part	MLRA136	Sandsheet Prairie
MLRA082	Northern Rolling High Plains, Southern Part	MLRA137	North Cross Timbers
MLRA083	Northern Rolling High Plains, Northeastern Part	MLRA138	West Cross Timbers
MLRA084	Northern Rolling High Plains, Eastern Part	MLRA139	East Cross Timbers
MLRA085	Pierre Shale Plains	MLRA140	Grand Prairie
MLRA086	Pierre Shale Plains, Northern Part	MLRA144	Texas Blackland Prairie, Northern Part
MLRA087	Black Hills Foot Slopes	MLRA145	Texas Blackland Prairie, Southern Part
MLRA088	Black Hills	MLRA147	Texas Claypan Area, Southern Part
MLRA089	Northern Rolling Pierre Shale Plains	MLRA148	Texas Claypan Area, Northern Part
MLRA090	Southern Rolling Pierre Shale Plains	MLRA149	Northern Minnesota Glacial Lake Basins
MLRA091	Mixed Sandy and Silty Tableland and Badlands	MLRA150	Wisconsin Central Sands
MLRA092	Nebraska Sand Hills	MLRA152	Wisconsin and Minnesota Thin Loess and Till, N Part
MLRA093	Dakota-Nebraska Eroded Tableland	MLRA153	Wisconsin and Minnesota Thin Loess and Till, S Part
MLRA095	Central High Plains, Northern Part	MLRA155	Central Minnesota Sandy Outwash
MLRA096	Central High Plains, Southern Part	MLRA156	Wisconsin and Minnesota Sandy Outwash
MLRA097	Upper Arkansas Valley Rolling Plains	MLRA157	Superior Lake Plain
MLRA099	Canadian River Plains and Valleys	MLRA159	Superior Stony and Rocky Loamy Plains and Hills, W Part
MLRA100	Upper Pecos River Valley	MLRA160	Superior Stony and Rocky Loamy Plains and Hills, E Part

Table A.10. Continued

CODE	MLRA Name	CODE	MLRA Name
MLRA161	Northern Michigan and Wisconsin Sandy Drift	MLRA217	Kentucky Bluegrass
MLRA162	Michigan Eastern Upper Peninsula Sandy Drift	MLRA218	Highland Rim and Pennyroyal
MLRA163	Michigan Northern Lower Peninsula Sandy Drift	MLRA219	Nashville Basin
MLRA164	Northern Highland Sandy Drift	MLRA220	Western Allegheny Plateau
MLRA165	Northeastern Wisconsin Drift Plain	MLRA221	Cumberland Plateau and Mountains
MLRA166	Southern Wisconsin and Northern Illinois Drift Plain	MLRA222	Central Allegheny Plateau
MLRA167	Western Michigan Fruit Belt	MLRA223	Eastern Allegheny Plateau and Mountains
MLRA168	Southwestern Michigan Fruit and Truck Crop Belt	MLRA224	Southern Appalachian Ridges and Valleys
MLRA169	Southern Michigan and Northern Indiana Drift Plain	MLRA225	Sand Mountain
MLRA170	Erie-Huron Lake Plain	MLRA227	Northern Blue Ridge
MLRA172	Ontario-Erie Plain and Finger Lakes Region	MLRA228	Southern Blue Ridge
MLRA173	Rolling Till Prairie	MLRA230	Southern Mississippi River Alluvium
MLRA174	Till Plains	MLRA231	Arkansas River Alluvium
MLRA175	Loess Uplands	MLRA232	Red River Alluvium
MLRA176	Central Iowa and Minnesota Till Prairies	MLRA233	Southern Mississippi River Terraces
MLRA177	Eastern Iowa and Minnesota Till Prairies	MLRA234	Southern Coastal Plain
MLRA178	Northern Mississippi Valley Loess Hills	MLRA235	Western Coastal Plain
MLRA179	Nebraska and Kansas Loess-Drift Hills	MLRA236	Southern Mississippi Valley Loess
MLRA181	Iowa and Minnesota Loess Hills	MLRA238	Alabama and Mississippi Blackland Prairie
MLRA182	Iowa and Missouri Deep Loess Hills	MLRA239	Cretaceous Western Coastal Plain
MLRA184	Illinois and Iowa Deep Loess and Drift, Eastern Part	MLRA240	Southern Piedmont
MLRA185	Illinois and Iowa Deep Loess and Drift, East-Central Part	MLRA241	Carolina and Georgia Sand Hills
MLRA186	Illinois and Iowa Deep Loess and Drift, West-Central Part	MLRA242	North-Central Florida Ridge
MLRA187	Illinois and Iowa Deep Loess and Drift, Western Part	MLRA243	Lake Erie Glaciated Plateau
MLRA188	Iowa and Missouri Heavy Till Plain	MLRA244	Glaciated Allegheny Plateau and Catskill Mountains
MLRA189	Northern Illinois and Indiana Heavy Till Plain	MLRA245	Tughill Plateau
MLRA191	Indiana and Ohio Till Plain, Central Part	MLRA246	St. Lawrence-Champlain Plain
MLRA192	Indiana and Ohio Till Plain, Northeastern Part	MLRA247	Northeastern Mountains
MLRA193	Indiana and Ohio Till Plain, Northwestern Part	MLRA248	New England and Eastern New York Upland, S Part
MLRA194	Indiana and Ohio Till Plain, Western Part	MLRA249	New England and Eastern New York Upland, N Part
MLRA195	Indiana and Ohio Till Plain, Eastern Part	MLRA250	Connecticut Valley
MLRA196	Cherokee Prairies	MLRA251	Aroostook Area
MLRA197	Central Claypan Areas	MLRA252	Northern Appalachian Ridges and Valleys
MLRA199	Southern IL and IN Thin Loess and Till Plain, E Part	MLRA253	Northern Piedmont
MLRA200	Southern IL and IN Thin Loess and Till Plain, W Part	MLRA254	Northern Coastal Plain
MLRA202	Central MS Valley Wooded Slopes, Eastern Part	MLRA255	Long Island-Cape Cod Coastal Lowland
MLRA203	Central MS Valley Wooded Slopes, Western Part	MLRA256	Gulf Coast Prairies
MLRA204	Central MS Valley Wooded Slopes, Northern Part	MLRA257	Gulf Coast Saline Prairies
MLRA205	Ozark Highland	MLRA258	Gulf Coast Marsh
MLRA206	Springfield Plain	MLRA259	Eastern Gulf Coast Flatwoods
MLRA207	St. Francois Knobs and Basins	MLRA260	Western Gulf Coast Flatwoods
MLRA208	Boston Mountains	MLRA261	Atlantic Coast Flatwoods
MLRA210	Arkansas Valley and Ridges, Eastern Part	MLRA262	Tidewater Area
MLRA211	Arkansas Valley and Ridges, Western Part	MLRA263	Mid-Atlantic Coastal Plain
MLRA212	Ouachita Mountains	MLRA264	Northern Tidewater Area
MLRA214	KY and IN Sandstone and Shale Hills and Valleys, S Part	MLRA265	South-Central Florida Ridge
MLRA215	KY and IN Sandstone and Shale Hills and Valleys, N Part	MLRA266	Southern Florida Flatwoods
MLRA216	KY and IN Sandstone and Shale Hills and Valleys, NE Part	MLRA267	Florida Everglades and Associated Areas

	Activities	Commodities	Agricultural Land	Factors	Indirect Business Taxes	Households	Enterprises	Government	Investment	Inventory	Import duties	Trade	TOTAL
Activities		6											60
Commodities	1					23		34	42	49		55	
Agricultural Land	2												61
Factors	3												62
Indirect Business Taxes	4					24		35	43	50			
Households		7	13	16		25	30	36	44			56	63
Enterprises			14	17				37					64
Government		8		18	22	26	31	38	45		54	57	65
Investment		9		19		27	32	39		51		58	66
Inventory		10							46			59	67
Import duties		11											
Trade		12		20		28		40	47	52			
TOTAL	5		15	21		29	33	41	48	53			

Figure A.4. Mathematical interpretation of the Computable General Equilibrium (CGE) Model and Social Accounting Matrix (SAM)

Table A.11. Formulas for Mathematical Interpretation of the Computable General Equilibrium (CGE) and Social Accounting Matrix (SAM) Included in Figure A.4

SAM ID	Formula	SAM ID	Formula
1	$QXActInt_{c,a} * PXActInt_{c,a}$	18	$tf_{gov,f} * qf_f * WF_f$
2	$QXActLand_{l,a} * PXActLand_{l,a}$	19	$deprec_f * qf_f * WF_f$
3	$QXActVad_{f,a} * PXActVad_{f,a}$	20	$shfout_{t,f} * qf_f * WF_f$
4	$QYActTop_a * PYActTop_a * ta_a$	21	$qf_f * WF_f$
5	$QYActTop_a * PYActTop_a$	22	$QYActTop_a * PYActTop_a * ta_a * shtaxgov_{gov}$
6	$QXJntPrd_{a,c} * PXJntPrd_{a,c}$	23	$QXHhCons_{c,h} * PXHhCons_{c,h}$
7	$hhsales_{h,c} * PQ_c$	24	$QYHhCons_h * PYHhCons_h * thhcons_h$
8	$govsales_{gov,c} * PQ_c$	25	$shhhhh_{h,h} * HHTRNS_h$
9	$invsales_c * PQ_c$	26	$th_{gov,h} * HHINC_h$
10	$nvtsales_c * PQ_c$	27	$QHHSAV_h * PHHSAV_h$
11	$QXComImp_{t,c} * PFOBIMP_{t,c} * timp_{t,c}$	28	$shhhout_{t,h} * HHTRANS_h$
12	$QXComImp_{t,c} * PFOBIMP_{t,c}$	29	$HHEXP_h$
13	$shlinst_{h,l} * q_l * WL_l$	30	$shenthh_h * ENTTRNS$
14	$shlinst_{'ent',l} * q_l * WL_l$	31	$tent_{gov} * ENTINC$
15	$ql_l * WL_l$	32	$shentinv * ENTTRNS$
16	$shfinst_{h,f} * qf_f * WF_f$	33	$ENTEXP$
17	$shfinst_{'ent',f} * qf_f * WF_f$	34	$QGOV_{c,gov} * PD_c$

Table A.11. Continued

SAM ID	Formula	SAM ID	Formula
35	$\sum_c QGOV_{c,gov} * PD_c * tgovcons_{gov}$	52	$shnvtout_t * NVTTRNS$
36	$shgovhh_{h,gov} * GOVTRNS_{gov}$	53	$NVTEXP$
37	$shgovgov_{gov,gov} * GOVTRNS_{gov}$	54	$\sum_{t,c} QXComImp_{t,c} * PFOBIMP_{t,c} * timp_{t,c}$
38	$shgovent_{gov} * GOVTRNS_{gov}$	55	$QEXP_{c,t} * PEXP_{c,t}$
39	$govsav_{gov}$	56	$trnsouthh_{h,t}$
40	$shgovout_{t,gov} * GOVTRNS_{gov}$	57	$trnsoutgov_{gov,t}$
41	$GOVEXP_{gov}$	58	NFI_t
42	$QINV_c * PD_c$	59	$trnsoutnvt_t$
43	$\sum_c QGOV_{c,gov} * PD_c * tgovcons_{gov}$	60	$QYActTop_a * PQActTop_a$
44	$shinvhh_h * INVTRNS$	61	$\sum_a ActLand_{l,a}$
45	$shinvgov_h * INVTRNS$	62	$\sum_a ActVad_{f,a}$
46	$nvtin$	63	$HHINC_h$
47	$shinvout_{t,gov} * INVTRNS_{gov}$	64	$ENTINC$
48	$INVEXP$	65	$GOVINC_{gov}$
49	$QNVT_c * PD_c$	66	$INVINC$
50	$\sum_c QNVT_c * PD_c * tnvtcons$	67	$NVTINC$
51	$nvtout$		

APPENDIX B

MAPS

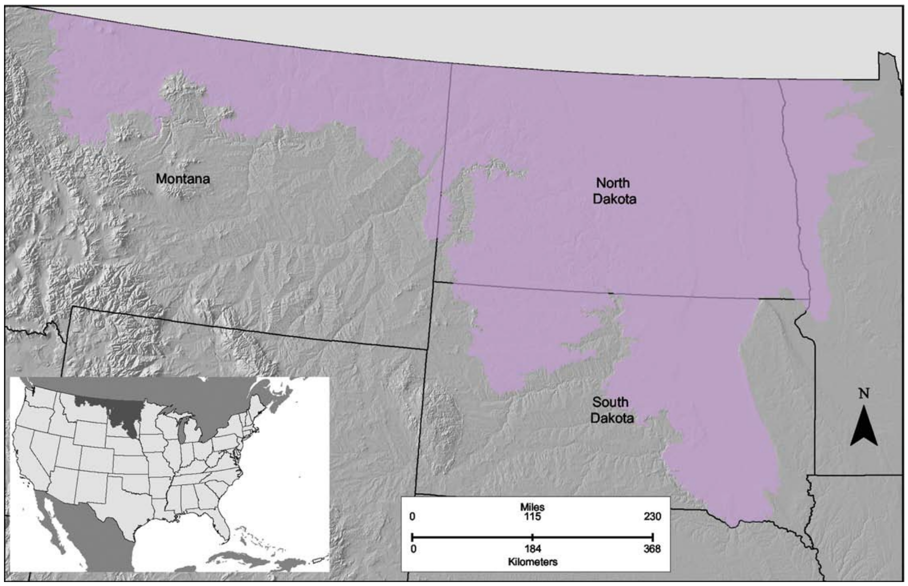


Figure B.1. Northern Great Plains Spring Wheat Region (Land Resource Region F)

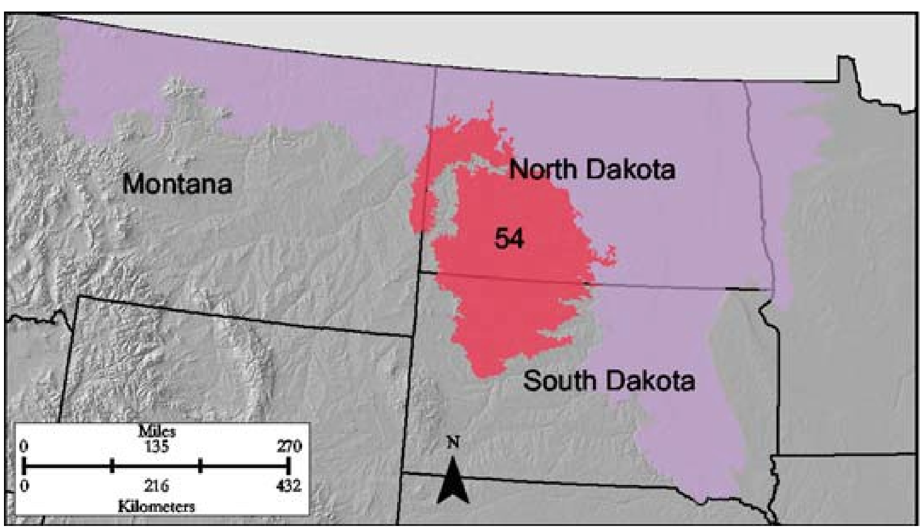


Figure B.2. Rolling Soft Shale Plain (Major Land Resource Area 75)

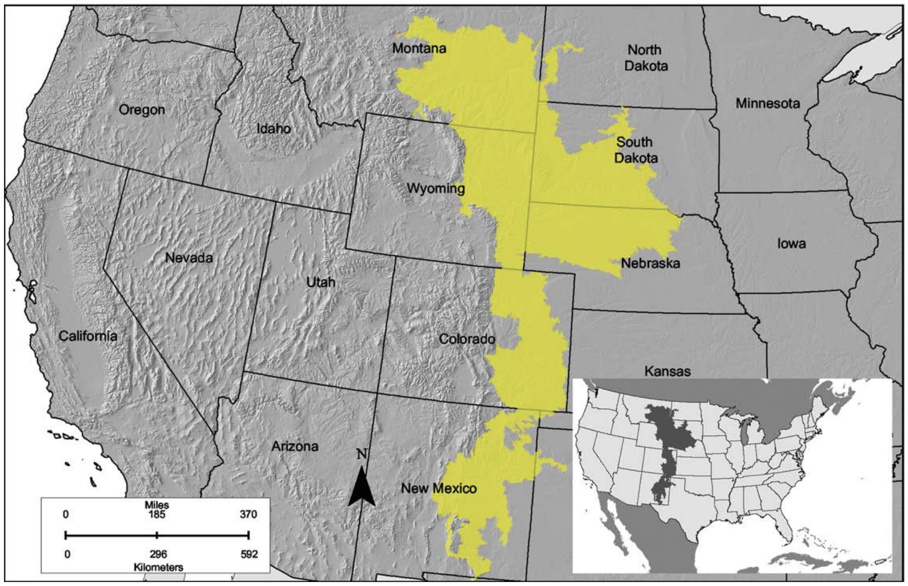


Figure B.3. Western Great Plains Range and Irrigated Region (Land Resource Region G)

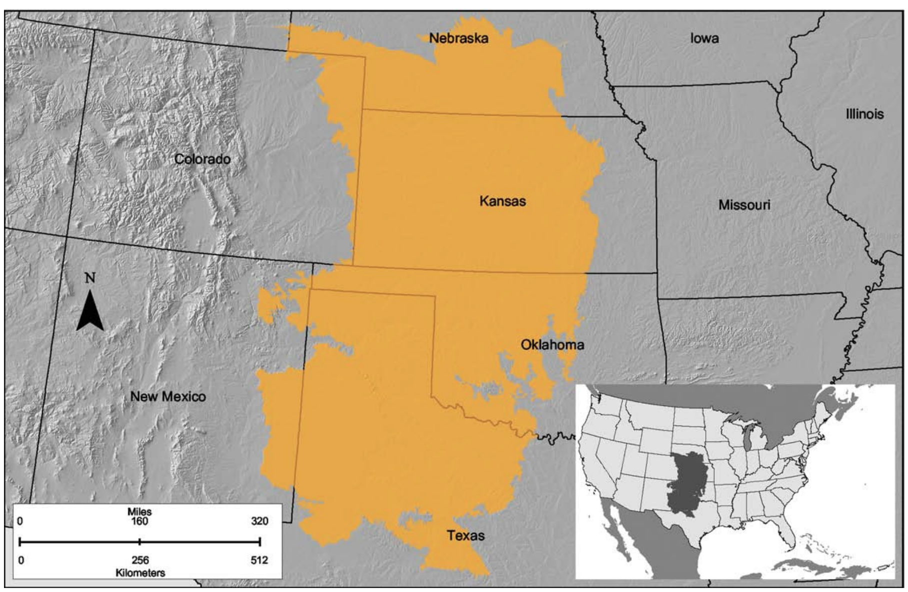


Figure B.4. Central Great Plains Winter Wheat and Range Region (Land Resource Region H)

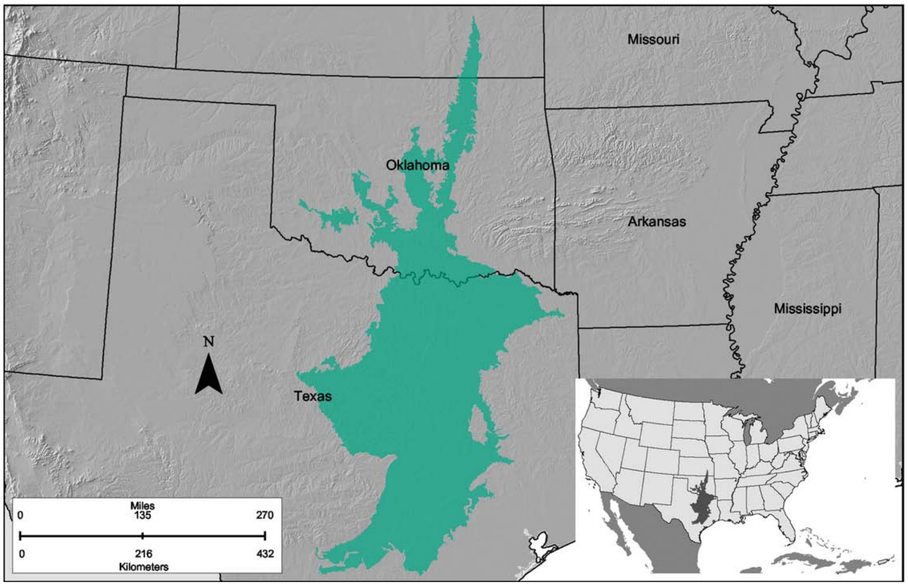


Figure B.5. Southwestern Prairies Cotton and Forage Region (Land Resource Region J)

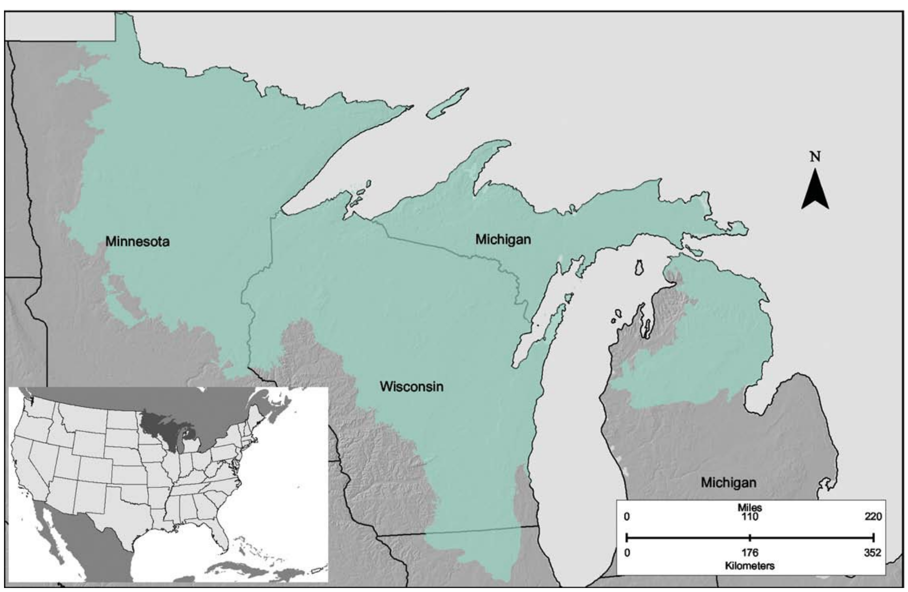


Figure B.6. Northern Lake States and Forage Region (Land Resource Region K)

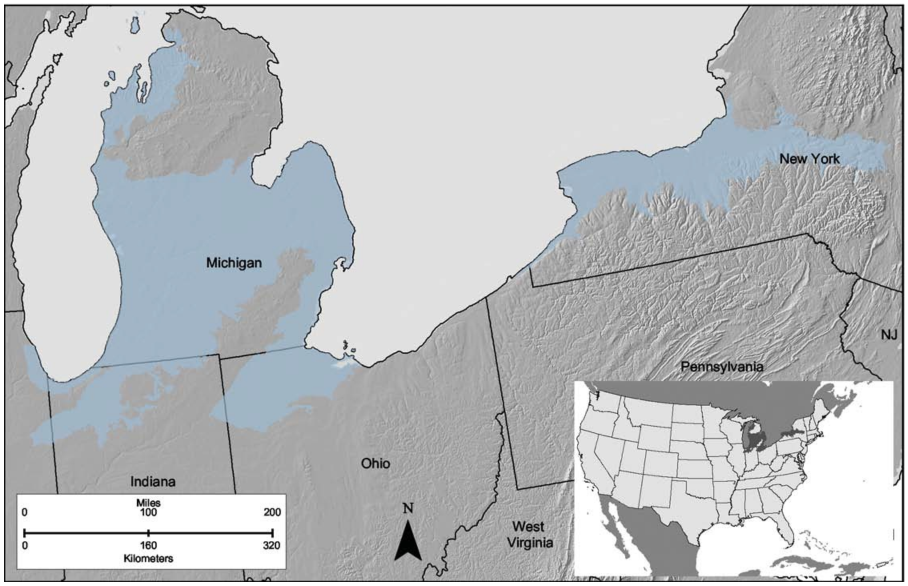


Figure B.7. Lake States Fruit, Truck Crop, and Dairy Region (Land Resource Region L)

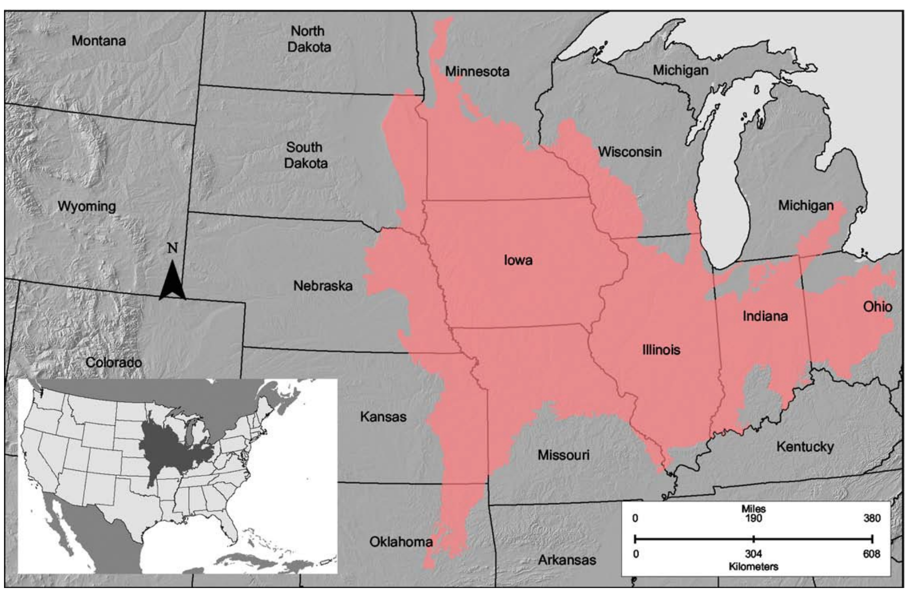


Figure B.8. Central Feed Grains and Livestock Region (Land Resource Region M)

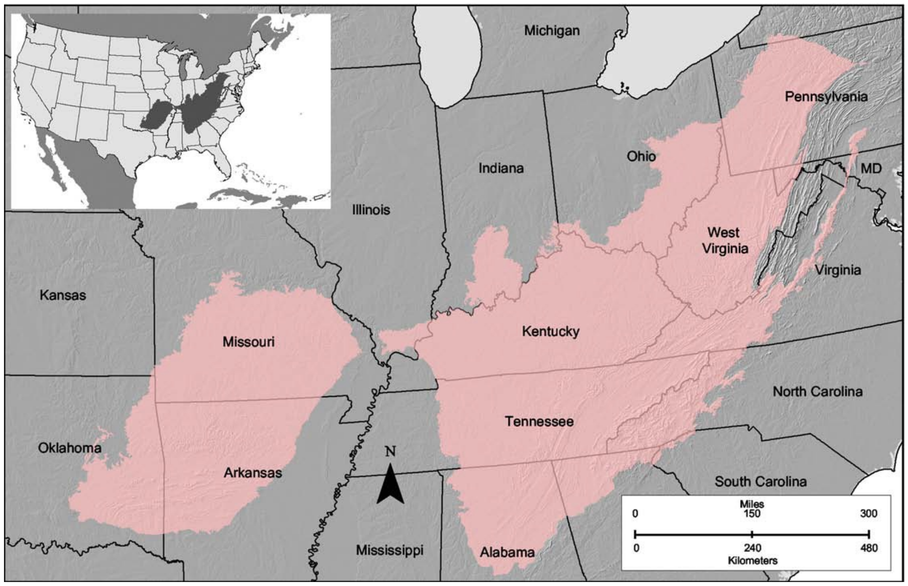


Figure B.9. East and Central Farming and Forest Region (Land Resource Region N)

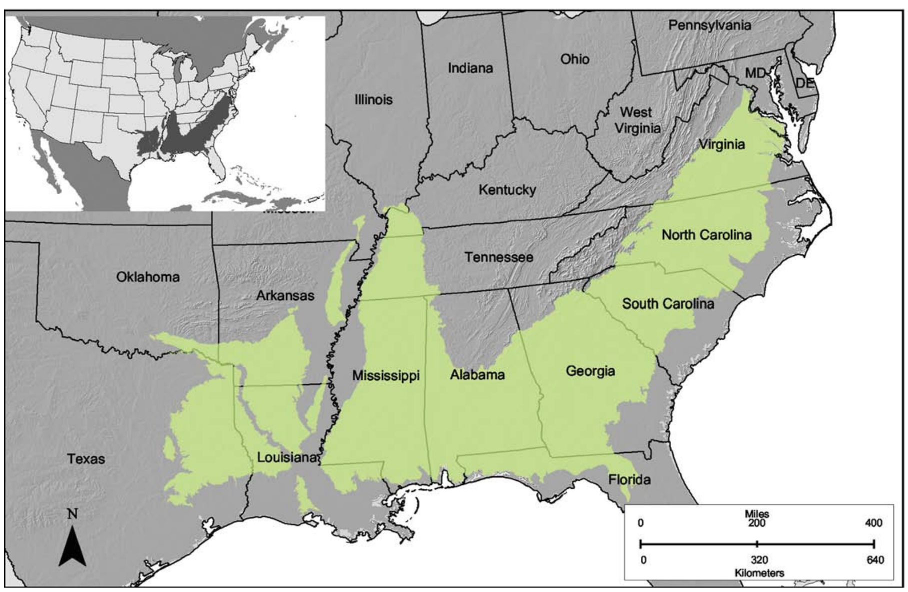


Figure B.10. South Atlantic and Gulf Slope Cash Crops, Forest, and Livestock Region (Land Resource Region P)

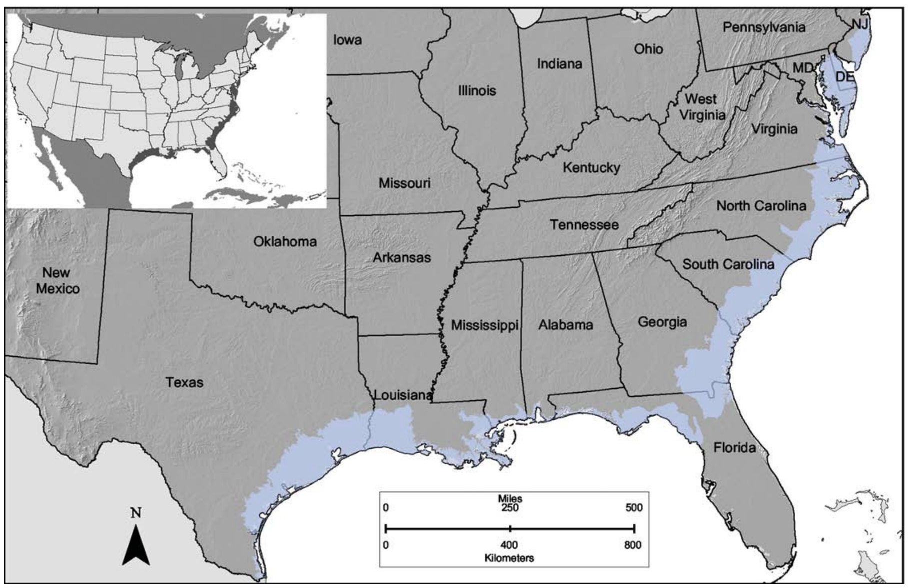


Figure B.11. Atlantic and Gulf Coast Lowland Forest and Crop Region (Land Resource Region T)

APPENDIX C

BASELINE

Table C.1. Total Value of Production by Activity in the Baseline

Activities	Value of production (millions of $)	Percent of total All	Percent of total Agriculture
Aolsd	30,079	0.14%	9.71%
Agran	69,732	0.33%	22.50%
Aoagr	100,141	0.47%	32.31%
Atobc	1,442	0.01%	0.47%
Acott	4,815	0.02%	1.55%
Asugr	1,686	0.01%	0.54%
Aocrp	17,519	0.08%	5.65%
Acatt	40,316	0.19%	13.01%
Adair	21,725	0.10%	7.01%
Alogg	22,466	0.11%	7.25%
Amini	480,383	2.26%	
Autil	379,903	1.79%	
Acons	1,166,264	5.49%	
Amanf	5,507,120	25.94%	
Awhol	848,467	4.00%	
Aretl	924,945	4.36%	
Atrns	622,313	2.93%	
Ainfo	1,045,889	4.93%	
Afinc	1,599,876	7.54%	
Aland	765,962	3.61%	
Aornt	1,153,528	5.43%	
Aprof	1,329,024	6.26%	
Amgmt	369,914	1.74%	
Aadmw	527,572	2.49%	
Aeduc	172,561	0.81%	
Ahlth	1,255,870	5.92%	
Aentt	211,494	1.00%	
Ahotl	546,121	2.57%	
Aoser	502,094	2.37%	
Agven	261,965	1.23%	
Agvem	1,247,897	5.88%	
Total agriculture	309,920		
Total all activities	21,229,083		

Table C.2. Total Land Rent Paid by Activity in Millions of Dollars in 2008

LRR code	Aolsd	Agran	Atobc	Acott	Asugr	Aocrp	Acatt	Adair	Alogg
D	-	3.19	-	0.84	-	10.79	25.61	0.01	0.70
E	0.21	14.61	-	-	0.18	47.65	21.57	0.01	2.47
F	535.42	895.85	-	-	31.52	195.38	295.69	0.27	1.00
G	32.97	297.18	-	-	3.40	216.32	375.33	0.07	1.40
H	345.36	1,730.83	-	114.03	1.70	192.52	596.18	0.15	1.04
I	1.30	56.56	-	9.00	3.32	0.43	166.09	0.01	-
J	2.63	35.35	-	3.26	-	15.38	219.25	0.09	13.60
K	170.85	429.56	-	-	1.15	160.78	47.95	3.97	50.65
L	273.62	440.97	-	-	13.35	26.55	18.46	0.98	10.49
M	5,693.04	7,423.00	0.29	-	15.07	886.21	582.82	5.50	24.50
N	197.91	252.55	5.15	6.23	-	461.32	495.23	2.31	598.17
O	502.54	452.96	-	115.08	19.23	3.95	17.85	0.00	61.96
P	334.29	333.94	8.98	131.83	1.57	138.23	293.40	0.33	1,969.77
R	24.93	53.90	-	-	-	56.20	29.22	3.22	77.65
S	32.48	110.82	0.47	-	-	78.21	42.00	2.20	49.16
T	101.33	177.61	2.73	35.20	3.23	12.85	83.68	0.04	459.22
U	-	0.04	-	-	79.44	0.09	84.02	0.01	88.50
Total	8,248.87	12,708.94	17.61	415.47	173.15	2,502.88	3,394.36	19.16	3,410.28
Share	26.70%	41.14%	0.06%	1.34%	0.56%	8.10%	10.99%	0.06%	11.04%

Table C.3. Value of Factors of Production by Activity in the Baseline

Activity	Value (millions of $)		Share	
	Capital	Labor	Capital	Labor
Aolsd	4,096	2,796	59%	41%
Agran	21,214	5,931	78%	22%
Aoagr	15,449	24,646	39%	61%
Atobc	24	233	9%	91%
Acott	1,310	811	62%	38%
Asugr	293	306	49%	51%
Aocrp	764	2,512	23%	77%
Acatt	2,692	2,008	57%	43%
Adair	6,811	1,115	86%	14%
Alogg	1,375	1,840	43%	57%
Amini	182,919	77,920	70%	30%
Autil	163,134	54,639	75%	25%
Acons	35,651	430,806	8%	92%
Amanf	480,427	821,038	37%	63%
Awhol	132,850	373,822	26%	74%
Aretl	120,869	420,734	22%	78%
Atrns	86,188	238,482	27%	73%
Ainfo	182,537	222,349	45%	55%
Afinc	284,769	583,565	33%	67%
Aland	380,767	129,016	75%	25%
Aornt	616,621	33,687	95%	5%
Aprof	106,277	690,412	13%	87%
Amgmt	55,012	172,699	24%	76%
Aadmw	68,075	264,320	20%	80%
Aeduc	7,316	91,464	7%	93%
Ahlth	99,451	680,840	13%	87%
Aentt	23,975	65,961	27%	73%
Ahotl	66,504	185,903	26%	74%
Aoser	44,871	202,612	18%	82%
Agven	485	105,213	0%	100%
Agvem	185,039	1,062,858	15%	85%

Table C.4. Total Value of Production by Households in the Baseline

Institution	Cuncl
	millions of $
Households	
< 10 K	2,218
10 - 15 K	3,984
15 - 25 K	5,506
25 - 35 K	11,250
35 - 50 K	18,470
50 - 75 K	34,252
75 - 100 K	21,615
100 - 150 K	15,997
> 150 K	18,907

Table C.5. Total Value of Production by the Government in the Baseline

Institution	Colsd	Coagr	Cutil	Cinfo	Cprof	Cadmw	Ceduc	Chlth	Centt	Chotl	Cuncl
	millions of $										
Government											
Fed. non-defense	587	87									5,815
Fed. defense											
Fed. investment											10,123
State non-education		2,780	994	1,281	768	15,419	81,942	185,467	5,623	866	6,355
State education											
State investment											3,569

Table C.6. Total Value of Production by Inventory in the Baseline

Institution	Colsd	Cgran	Coagr	Ctobc	Ccott	Ccatt	Cmini	Cmanf	Ctrns	Cinfo
	millions of $									
Inventory	3,954	708	62	3,654	1,234	485	3,615	35,443	225	329

Table C.7. Total Value of Consumption of Intermediate Commodities by Activity in the Baseline

	Aolsd	Agran	Aoagr	Atobc	Acott	Asugr	Aocrp	Acatt	Adair	Alogg	Amini	Autil	Acons	Amanf	Awhol
	millions of $														
Colsd	1,803.3	19.1	1.5	5.1				0.7	0.7					23,323.8	
Cgran	553.1	2,546.8	2,450.2	43.9	11.6		591.4	2,140.0	612.8					24,941.0	
Coagr	1,689.8	3,995.2	13,097.0	145.3	344.2	117.0	1,703.1	725.9	616.8	7,236.1		3.0	113.3	59,656.5	27.3
Ctobc				44.5										3,776.3	
Ccott	298.9				201.5									1,124.2	
Csugr						38.0								1,445.1	
Cocrp	11.5	410.8	929.3	1.0	1.6	3.2	205.2	7,119.8	1,950.8		898.1		2,721.0	6,151.8	
Ccatt	20.8	63.8	203.0		3.1	2.0	2.8	9,644.2	290.9					30,507.2	
Cdair			10.8					70.8	30.2					27,561.5	
Clogg										5,554.0				17,483.6	
Cmini	41.7	295.5	213.9	2.4	5.0	2.5	229.0	16.2	39.7	0.7	32,236.0	81,709.5	7,539.0	439,665.5	431.9
Cutil	560.4	1,184.2	2,072.5	35.4	139.3	60.5	815.1	717.7	494.1	5.0	10,453.4	238.3	7,107.5	115,584.7	7,900.8
Ccons	156.8	217.8	367.7	9.4	43.4	27.0	12.8		48.5	1.6	11,221.5	3,079.8	854.6	14,779.1	1,300.3
Cmanf	6,378.6	15,152.8	28,267.3	482.7	1,135.3	427.5	5,165.3	6,302.8	6,779.9	544.2	47,941.0	6,793.1	374,965.2	2,272,416.5	52,395.9
Cwhol	523.0	1,334.9	2,137.4	28.6	77.5	27.2	421.5	1,116.7	781.3	790.7	4,591.0	468.8	32,584.0	233,169.4	32,609.4
Cretl	28.1	43.4	69.3	1.7	4.5	2.2	24.6	22.0	18.8	3.4	1,022.0	32.3	47,302.7	14,436.4	1,401.2
Ctrns	399.8	1,127.1	1,997.2	32.3	61.5	21.2	489.9	1,100.1	364.0	425.1	6,972.6	14,476.8	18,985.2	126,168.2	34,134.2
Cinfo	40.4	51.5	114.0	3.1	5.5	2.3	15.9	14.1	36.4	38.6	1,313.0	779.1	12,741.8	56,462.6	11,202.0
Cfinc	957.5	1,923.6	1,398.6	64.7	111.5	65.2	719.8	1,676.8	319.8	71.9	7,602.0	2,200.4	15,541.8	36,692.2	19,875.1
Cland			1,919.1								2,212.5	673.4	8,272.0	26,105.3	20,410.1
Cornt	127.0	271.1	311.4	8.1	32.0	9.9	146.3	102.9	71.9	126.6	29,329.1	148.8	14,775.9	44,526.2	9,179.1
Cprof	117.8	379.3	1,405.2	42.7	26.1	15.0	203.9	196.4	131.7	313.4	21,526.5	6,916.4	105,994.2	214,574.2	66,661.6
Cmgmt											13,153.2		2,819.6	191,754.4	24,447.2
Cadmw	12.3	44.6	183.8	6.5	1.2	1.4	49.5	20.2	30.4	24.3	2,004.3	814.0	10,921.7	54,959.7	28,799.8
Ceduc	52.7	169.1	614.5	3.8	8.8	4.7	55.7	94.1	3.6		4.9	56.2	58.6	142.7	690.2
Chlth															
Centt	10.5	11.8	64.3	0.2	1.4	0.5	2.3	3.6	9.7	0.3	61.4	49.9	524.6	2,287.7	1,100.1
Chotl	18.3	19.8	49.4	0.8	2.6	1.1	3.5	8.4	18.0	0.4	616.8	1,616.5	4,042.4	17,959.2	4,017.4
Coser	185.1	72.5	216.8	4.9	10.0	5.4	26.6	14.7	52.0	352.6	758.9	271.0	16,289.0	24,222.6	8,108.9
Cgven	5.0	7.3	22.3	0.4	1.2	0.4	1.4		6.8	0.7	17.5	92.2	63.8	2,906.1	7,654.9
Cuncl	10.0	14.4	9.0				0.1	5.5	2.5	2.6	1,067.4	86.4	153.3	33,669.7	4,264.3

Table C.7. Continued

	Aretl	Atrns	Ainfo	Afinc	Aland	Aornt	Aprof	Amgmt	Aadmw	Aeduc	Ahlth	Aentt	Ahotl	Aoser	Agven
							millions of $								
Colsd															
Cgran	8.3						94.9	7.6		9.7	9.9	1.8	830.6		
Coagr	1,307.7	10.2	8.5	12.3	12.8	47.1	193.4	7.8	215.7	149.5	75.5	409.7	3,485.2	90.1	18.7
Ctobc															
Ccott							13.1	3.1							
Csugr							14.1	3.1							
Cocrp					1,355.8	193.2	169.9	6.3	137.5	1.7		210.9			
Ccatt							35.7	3.4							
Cdair							12.2								
Clogg															
Cmini	360.6	2,616.2	988.9	56.4	231.5	916.9	956.8	151.2	199.6	97.4	470.2	475.5	662.1	399.3	26,710.9
Cutil	17,000.4	2,866.2	6,747.3	2,673.9	18,651.3	4,751.6	7,836.7	2,900.0	3,168.5	10,412.0	11,634.9	6,943.1	17,548.0	6,926.8	9,195.2
Ccons	2,988.5	2,902.7	5,266.2	3,949.4	7,528.0	32,445.3	3,345.2	752.8	380.8	336.4	2,029.4	785.0	2,209.1	2,269.2	11,471.6
Cmanf	35,073.3	119,189.7	70,766.2	16,157.6	5,475.1	30,647.0	50,359.6	9,954.8	42,004.3	10,511.5	133,255.9	14,230.6	89,620.5	54,840.6	41,867.8
Cwhol	10,965.6	5,524.2	8,131.6	1,584.3	446.4	9,628.3	5,668.0	1,362.2	1,845.5	1,508.1	15,325.9	1,875.2	12,882.0	6,728.4	3,104.4
Cretl	3,862.1	2,114.3	408.1	567.9	243.1	6,359.1	856.9	5.4	452.7	34.2	2,831.3	398.6	2,235.3	3,912.2	16.9
Ctrns	26,336.6	48,179.5	14,551.7	8,562.3	1,469.0	5,552.1	22,776.4	1,328.4	8,327.6	1,632.4	9,043.6	4,179.6	5,861.2	8,451.3	7,802.7
Cinfo	14,318.9	4,717.5	245,372.8	34,304.6	3,915.8	6,650.3	57,329.9	13,568.2	17,651.4	10,628.9	16,628.8	4,530.7	10,070.4	16,310.7	2,403.6
Cfinc	27,227.9	16,452.8	17,763.7	404,549.7	24,912.9	135,916.4	41,336.0	9,961.5	12,569.0	2,556.8	34,440.6	8,113.6	9,438.8	40,977.2	10,821.5
Cland	55,170.5	8,759.6	23,801.7	31,473.6	44,983.9	63,975.7	56,993.8	7,917.5	9,061.8	14,383.9	75,685.9	9,495.8	23,833.9	24,079.3	7,623.8
Cornt	9,003.3	7,784.8	16,666.1	5,788.5	509.0	4,264.5	14,968.7	9,189.3	4,927.4	1,196.7	5,883.3	2,153.7	6,089.0	2,164.2	593.1
Cprof	62,528.7	13,493.4	112,575.0	97,376.8	18,113.1	33,128.6	132,175.8	64,679.7	30,550.7	8,794.1	48,595.7	25,627.1	29,956.1	28,311.7	18,640.6
Cmgmt	8,097.8	3,928.9	8,615.9	10,049.7	1,970.9	6,583.6	10,768.7		6,727.4	464.1	16,892.2	5,537.0	12,790.1	3,071.7	
Cadmw	24,170.3	18,573.3	33,538.3	31,908.4	27,991.4	20,031.3	57,518.5	5,862.2	28,680.1	4,223.6	38,291.8	8,191.8	10,694.0	16,014.1	8,823.3
Ceduc	2,724.2	69.3	505.8	83.2	6.1		118.4		111.5	855.8	189.2	456.1		1,842.5	163.9
Chlth	8.0						311.1		34.9		23,252.7	67.3		89.3	
Centt	1,522.7	353.1	12,169.8	2,043.6	568.1	346.9	5,054.9	2,047.2	1,641.1	232.3	882.7	7,637.2	2,093.6	1,967.4	146.7
Chotl	3,923.5	3,889.9	10,123.7	14,306.4	3,757.8	2,437.7	27,336.0	2,673.6	10,057.5	1,314.9	10,077.6	2,262.5	6,984.0	4,313.6	1,512.5
Coser	7,071.1	2,793.2	9,501.2	11,616.6	1,738.4	19,349.6	10,747.0	5,356.3	5,301.0	1,915.4	10,620.7	3,760.4	5,936.2	6,279.4	1,777.3
Cgven	5,803.6	6,709.4	3,571.8	5,447.1	446.7	1,363.1	5,007.2	233.1	1,896.4	764.7	5,871.8	1,552.9	5,839.1	2,477.2	2,707.8
Cuncl	243.7	6,555.8	5,804.4	10,950.2	43.7	1,662.5	3,343.7	265.0	532.2	11.4	12.8	92.3	125.3	30.0	381.1

Table C.8. Total Value of Household Consumption by Commodity and Income Category in the Baseline

Commodity	Household income categories								
	< 10 K	10 - 15 K	15 - 25 K	25 - 35 K	35 - 50 K	50 - 75 K	75 - 100 K	100 - 150 K	> 150 K
	milions of $								
Cgran	37	32	70	90	138	192	130	113	131
Coagr	1,936	1,567	3,525	4,509	7,069	10,048	6,647	6,100	7,984
Cocrp	14	12	27	34	52	74	51	46	56
Ccatt	5	4	10	12	20	30	21	20	27
Cmini	9	8	16	19	34	56	37	36	41
Cutil	8,308	7,452	16,745	20,135	28,070	39,516	23,887	22,265	24,164
Cmanf	53,326	46,352	106,595	130,996	209,652	303,325	212,384	194,259	243,205
Cwhol	6,156	3,527	7,132	11,828	38,104	70,469	47,364	42,736	30,680
Cretl	27,476	14,833	46,316	44,600	100,032	148,977	132,157	139,337	175,687
Ctrns	7,938	4,098	11,460	11,425	20,142	28,474	19,105	19,875	36,269
Cinfo	9,666	7,659	15,911	19,430	31,080	50,197	34,484	32,342	37,305
Cfinc	12,211	14,297	26,060	41,645	74,727	122,285	92,256	87,692	116,528
Cland	20,000	16,523	33,655	35,224	52,554	71,827	41,643	23,615	16,987
Cornt	30,388	16,896	52,092	62,686	97,760	195,794	133,556	151,344	235,157
Cprof	3,672	1,542	7,559	10,095	15,439	22,239	14,080	14,446	18,584
Cadmw	1,224	886	2,492	2,941	4,496	7,207	4,573	4,588	7,018
Ceduc	23,549	8,701	9,548	14,120	19,789	40,123	20,144	27,569	53,847
Chlth	42,256	42,381	112,676	127,281	183,379	287,314	168,137	159,073	243,252
Centt	8,495	4,269	10,789	15,779	24,378	38,108	23,822	24,635	44,390
Chotl	20,457	9,638	20,547	27,756	49,877	86,367	60,160	59,296	81,470
Coser	13,427	7,912	20,112	27,209	46,044	65,832	39,815	41,743	74,366
Cgven	1,673	1,119	2,849	3,299	5,418	8,071	5,476	5,291	8,315
Cuncl	7,123	4,787	11,467	10,991	14,243	19,435	10,673	9,351	7,751
Total	299,347	214,495	517,652	622,107	1,022,495	1,615,958	1,090,602	1,065,773	1,463,216
Share	4%	3%	7%	8%	13%	20%	14%	13%	18%

Table C.9. Total Value of Institutional Consumption by Commodity in the Baseline

Commodity	Federal government			State government			Inventory	Investment
	Defense	Investment	Non-defense	Education	Investment	Non-education		
	millions of $							
Cgran			78.36	29.58		53.31		
Coagr	12.47			161.22		1,646.27	463.52	
Ccott			40.95					
Csugr							6.05	
Cocrp			130.29	16.01		114.09	17.66	
Cdair							44.68	
Clogg							162.27	
Cmini			116.13	21.81		884.82	67.46	118,381.14
Cutil	3,830.44		1,153.48	4,236.10		18,901.19		
Ccons	6,318.20	17,378.45	2,703.52	1,376.55	250,700.78	28,557.49		779,336.73
Cmanf	95,414.34	62,641.25	8,819.71	21,748.61	33,834.47	126,154.85	13,169.65	656,295.88
Cwhol	4,718.43	1,529.21	1,247.67	3,428.96	3,034.57	16,297.03	554.61	56,363.32
Cretl	4.62		23.34	146.55		33.37		27,619.89
Ctrns	11,521.32	710.59	2,248.71	6,665.17	938.15	15,537.11	389.26	12,016.34
Cinfo	16,180.32	1,522.08	8,369.08	12,786.50	1,287.06	39,116.56	102.59	40,908.43
Cfinc			1,968.77	90.92		16,770.27		
Cland	361.01		3,065.56	845.87		22,835.01		
Cornt	469.12		240.57	637.75		4,698.54		
Cprof	80,216.68	13,136.73	26,832.34	11,957.95	5,987.52	56,861.47		129,370.63
Cadmw	17,218.66		3,224.46	10,598.14		48,067.64		
Ceduc	490.45		3,755.97			11,935.68		
Chlth			499.09			5,576.11		
Centt	1,696.88		196.22	314.10		3,407.99		
Chotl	1,940.53		1,262.07	164.39		19,732.07		
Coser	2,919.87		717.46	4,221.93		18,738.17		
Cgven	372.11		393.01	654.84		8,255.40		
Cuncl	22,273.86							
Total	265,959.31	96,918.31	67,086.76	80,102.96	295,782.55	464,174.45	14,977.76	1,820,292.37
Share	9%	3%	2%	3%	10%	15%	0%	59%

Table C.10. Total Value of Exports to the Rest of the U.S. by Commodity in the Baseline

Commodity	Value of exports (millions of $)	Percent of total: All	Percent of total: Agriculture
Colsd	2,002	0.23%	14.60%
Cgran	5,581	0.64%	40.70%
Coagr	4,238	0.49%	30.90%
Ctobc	47	0.01%	0.35%
Ccott	30	0.00%	0.22%
Csugr	217	0.02%	1.58%
Cocrp	1,486	0.17%	10.84%
Ccatt	54	0.01%	0.40%
Cdair	24	0.00%	0.17%
Clogg	35	0.00%	0.26%
Cmini	62,691	7.20%	
Cutil	23,332	2.68%	
Ccons	2,829	0.33%	
Cmanf	439,850	50.53%	
Cwhol	5,812	0.67%	
Cretl	7,898	0.91%	
Ctrns	16,133	1.85%	
Cinfo	30,199	3.47%	
Cfinc	61,338	7.05%	
Cland	2,489	0.29%	
Cornt	3,996	0.46%	
Cprof	15,953	1.83%	
Cmgmt	15,769	1.81%	
Cadmw	7,409	0.85%	
Ceduc	15,128	1.74%	
Chlth	53,977	6.20%	
Centt	1,571	0.18%	
Chotl	16,456	1.89%	
Coser	10,966	1.26%	
Cuncl	62,468	7.18%	
Cgvem	489	0.06%	
Total agriculture	13,715		
Total all activities	870,467		

Table C.11. Total Value of Exports to the Rest of the World by Commodity in the Baseline

Commodity	Value of exports (millions of $)	Percent of total	
		All	Agriculture
Colsd	6,611	0.47%	14.15%
Cgran	27,555	1.95%	58.99%
Coagr	4,992	0.35%	10.69%
Ctobc	1,243	0.09%	2.66%
Ccott	4,053	0.29%	8.68%
Csugr	34	0.00%	0.07%
Cocrp	731	0.05%	1.57%
Ccatt	170	0.01%	0.36%
Cdair	68	0.00%	0.15%
Clogg	1,254	0.09%	2.68%
Cmini	13,161	0.93%	
Cutil	1,183	0.08%	
Ccons	86	0.01%	
Cmanf	853,071	60.25%	
Cwhol	103,534	7.31%	
Ctrns	73,741	5.21%	
Cinfo	14,810	1.05%	
Cfinc	55,155	3.90%	
Cland	984	0.07%	
Cornt	23,702	1.67%	
Cprof	23,175	1.64%	
Cmgmt	33,319	2.35%	
Cadmw	2,230	0.16%	
Ceduc	998	0.07%	
Chlth	197	0.01%	
Centt	276	0.02%	
Chotl	672	0.05%	
Coser	258	0.02%	
Cgven	402	0.03%	
Cuncl	168,315	11.89%	
Total agriculture	46,710		
Total all activities	1,415,979		

Table C.12. Total Value of Imports from the Rest of the U.S. by Commodity in the Baseline

Commodity	Value of imports (millions of $)	Percent of total	
		All	Agriculture
Cgran	474	0.05%	1.18%
Coagr	22,246	2.15%	55.50%
Ccott	4	0.00%	0.01%
Csugr	124	0.01%	0.31%
Cocrp	9,070	0.87%	22.63%
Cdair	6,369	0.61%	15.89%
Clogg	1,796	0.17%	4.48%
Cmini	47,998	4.63%	
Cutil	26,055	2.51%	
Ccons	33,796	3.26%	
Cmanf	493,307	47.58%	
Cwhol	3,288	0.32%	
Cretl	27,250	2.63%	
Ctrns	12,215	1.18%	
Cinfo	74,818	7.22%	
Cfinc	8,580	0.83%	
Cland	70,180	6.77%	
Cornt	4,395	0.42%	
Cprof	65,480	6.32%	
Cmgmt	6,847	0.66%	
Cadmw	13,815	1.33%	
Ceduc	2,572	0.25%	
Chlth	8,145	0.79%	
Centt	19,892	1.92%	
Chotl	46,704	4.51%	
Coser	21,929	2.12%	
Cgven	6,522	0.63%	
Cuncl	2,356	0.23%	
Cgvem	464	0.04%	
Total agriculture	114,136		
Total all activities	1,036,692		

Table C.13. Total Value of Imports from the Rest of the World by Commodity in the Baseline

Commodity	Value of imports (millions of $)	Percent of total	
		All	Agriculture
Colsd	120	0.01%	0.42%
Cgran	445	0.02%	1.56%
Coagr	26,245	1.44%	92.11%
Ctobc	73	0.00%	0.26%
Ccott	2	0.00%	0.01%
Csugr	1	0.00%	0.00%
Cocrp	727	0.04%	2.55%
Ccatt	689	0.04%	2.42%
Cdair	78	0.00%	0.27%
Clogg	113	0.01%	0.40%
Cmini	297,419	16.28%	
Cutil	3,285	0.18%	
Cmanf	1,294,600	70.84%	
Ctrns	27,275	1.49%	
Cinfo	5,193	0.28%	
Cfinc	41,084	2.25%	
Cornt	274	0.01%	
Cprof	13,624	0.75%	
Cadmw	140	0.01%	
Ceduc	1,004	0.05%	
Chlth	279	0.02%	
Centt	172	0.01%	
Coser	2,964	0.16%	
Cuncl	111,617	6.11%	
Total agriculture	28,493		
Total all activities	1,827,426		

Table C.14. Institutional Income in the Baseline

Institution	Income in millions $
Households	
< 10 K	368,737.09
10 - 15 K	267,298.22
15 - 25 K	639,844.93
25 - 35 K	798,477.95
35 - 50 K	1,353,477.60
50 - 75 K	2,214,855.55
75 - 100 K	1,564,687.87
100 - 150 K	1,645,040.40
> 150 K	2,518,409.98
Government	
Fed. non-defense	2,526,771.22
Fed. defense	587,974.79
Fed. investment	131,856.08
State non-education	2,130,839.27
State education	606,456.09
State investment	315,204.56
Investment	5,128,210.73
Inventory	56,957.10
Enterprises	1,055,928.31
Net foreign investment	
Rest of the U.S.	2,843,671.00
Rest of the world	25.00

APPENDIX D

SCENARIO 1

Table D.1. Percentage Changes of Quantities and Prices of Total Production by Activity in First Counterfactual Scenario

Activities	Quantities	Prices
Aolsd	-1.789	2.760
Agran	-1.914	3.071
Aoagr	1.009	0.299
Atobc	-2.426	1.169
Acott	-3.060	3.452
Asugr	-1.949	3.387
Aocrp	-6.447	6.963
Acatt	-5.147	10.529
Adair	-0.610	0.943
Alogg	-0.511	0.958
Amini	0.019	0.085
Autil	0.011	0.066
Acons	0.143	0.110
Amanf	-0.082	0.226
Awhol	0.029	0.054
Aretl	0.052	0.050
Atrns	0.002	0.079
Ainfo	-0.008	0.066
Afinc	0.025	0.045
Aland	0.013	0.071
Aornt	0.029	0.070
Aprof	-0.002	0.048
Amgmt	0.012	0.046
Aadmw	0.012	0.056
Aeduc	0.003	0.051
Ahlth	0.039	0.057
Aentt	0.044	0.066
Ahotl	0.013	0.082
Aoser	0.033	0.062
Agven	0.010	0.073
Agvem	-0.271	0.028

Table D.2. CO_2 Offsets by the Carbon Graveyard by Timber Category and Land Resource Region (LRR) in First Scenario

LRR code	Softwood	Hardwood
	Million MT	
D	2.92	0.00
E	4.56	0.00
F	69.65	15.11
G	6.98	49.03
H	0.00	58.70
I	0.00	0.00
J	17.37	5.72
K	19.19	0.00
L	3.21	1.07
M	6.68	7.02
N	41.62	14.69
O	0.80	0.00
P	55.55	0.00
R	0.00	3.59
S	5.63	0.00
T	23.15	0.00
U	8.70	0.00
Total	**266.01**	**154.93**

Table D.3. CO_2 Offsets by the Carbon Graveyard by Timber Category and Major Land Resource Area (MLRA) in First Scenario

MLRA code	Softwood	Hardwood	MLRA code	Softwood	Hardwood	MLRA code	Softwood	Hardwood
	Million MT			Million MT			Million MT	
MLRA043	1.033	-	MLRA149	0.300	-	MLRA224	8.434	-
MLRA044	0.147	-	MLRA150	1.122	-	MLRA225	1.874	-
MLRA046	1.740	-	MLRA152	4.741	-	MLRA227	0.120	-
MLRA065	1.778	-	MLRA153	3.008	-	MLRA228	1.905	-
MLRA066	0.394	-	MLRA155	1.635	-	MLRA231	0.215	-
MLRA067	2.393	-	MLRA156	0.687	-	MLRA232	0.248	-
MLRA072	-	2.448	MLRA157	0.213	-	MLRA233	0.338	-
MLRA073	-	9.060	MLRA159	0.103	-	MLRA234	19.145	-
MLRA074	-	0.496	MLRA160	0.061	-	MLRA235	13.734	-
MLRA075	55.998	-	MLRA161	0.753	-	MLRA236	4.151	-
MLRA077	-	3.111	MLRA162	0.402	-	MLRA238	2.814	-
MLRA079	13.650	-	MLRA163	0.256	-	MLRA239	2.097	-
MLRA080	3.839	-	MLRA164	0.027	-	MLRA240	12.388	-
MLRA084	-	2.870	MLRA165	2.042	-	MLRA241	0.858	-
MLRA085	-	9.422	MLRA167	0.142	-	MLRA242	0.366	-
MLRA088	-	1.162	MLRA168	0.350	-	MLRA244	-	1.872
MLRA089	-	7.222	MLRA169	2.388	-	MLRA246	-	0.707
MLRA090	-	2.194	MLRA170	0.329	-	MLRA247	-	0.376
MLRA091	-	9.410	MLRA172	-	1.069	MLRA248	-	0.476
MLRA092	-	14.009	MLRA173	6.681	-	MLRA249	-	0.153
MLRA093	-	1.669	MLRA196	-	7.016	MLRA250	-	0.003
MLRA095	-	1.073	MLRA205	-	5.948	MLRA252	4.397	-
MLRA097	6.981	-	MLRA207	-	0.057	MLRA253	1.234	-
MLRA105	-	5.213	MLRA208	2.387	-	MLRA255	-	0.001
MLRA106	-	6.338	MLRA210	2.857	-	MLRA256	16.242	-
MLRA107	-	1.618	MLRA211	4.665	-	MLRA258	1.137	-
MLRA109	-	3.269	MLRA212	6.231	-	MLRA259	0.496	-
MLRA115	-	8.877	MLRA217	-	2.565	MLRA260	1.081	-
MLRA119	-	18.373	MLRA218	5.906	-	MLRA261	3.122	-
MLRA121	-	1.860	MLRA219	4.159	-	MLRA262	0.686	-
MLRA122	-	13.150	MLRA220	-	0.949	MLRA264	0.386	-
MLRA137	-	5.719	MLRA221	3.078	-	MLRA265	2.164	-
MLRA147	13.270	-	MLRA222	-	3.144	MLRA266	6.536	-
MLRA148	4.102	-	MLRA223	-	2.028			

Table D.4. Agricultural and Forest Land Change due to CO_2 Payments per Major Land Resource Area (MLRA) in First Scenario

MLRA code	Logging	Agriculture	Graveyard	MLRA code	Logging	Agriculture	Graveyard	MLRA code	Logging	Agriculture	Graveyard
	Million acres				Million acres				Million acres		
MLRA043	-0.003	-0.374	0.377	MLRA155	-0.003	-0.224	0.227	MLRA222	-0.034	-0.676	0.710
MLRA044	-0.001	-0.053	0.054	MLRA156	-0.004	-0.092	0.096	MLRA223	-0.025	-0.442	0.467
MLRA046	-0.009	-0.627	0.636	MLRA157	-0.004	-0.027	0.031	MLRA224	-0.069	-1.452	1.521
MLRA065	-0.014	-0.636	0.650	MLRA159	-0.001	-0.013	0.014	MLRA225	-0.017	-0.316	0.333
MLRA066	-0.002	-0.142	0.144	MLRA160	-0.001	-0.007	0.008	MLRA227	-0.002	-0.021	0.023
MLRA067	-0.006	-0.867	0.873	MLRA161	-0.006	-0.099	0.105	MLRA228	-0.020	-0.338	0.358
MLRA072	-0.001	-0.578	0.579	MLRA162	-0.004	-0.052	0.056	MLRA230	0.002	-0.002	-
MLRA073	-0.001	-2.217	2.218	MLRA163	-0.003	-0.033	0.036	MLRA231	-0.001	-0.035	0.036
MLRA074	-	-0.135	0.135	MLRA164	-0.001	-0.003	0.004	MLRA232	-0.001	-0.041	0.042
MLRA075	-0.006	-7.708	7.714	MLRA165	-0.007	-0.276	0.283	MLRA233	-0.001	-0.054	0.055
MLRA077	-	-0.747	0.747	MLRA166	0.001	-0.001	-	MLRA234	-0.164	-3.268	3.432
MLRA079	-0.005	-1.882	1.887	MLRA167	-0.002	-0.018	0.020	MLRA235	-0.156	-2.313	2.469
MLRA080	-0.016	-0.518	0.534	MLRA168	-0.001	-0.047	0.048	MLRA236	-0.020	-0.697	0.717
MLRA084	-	-0.771	0.771	MLRA169	-0.006	-0.339	0.345	MLRA238	-0.025	-0.474	0.499
MLRA085	-0.005	-2.530	2.535	MLRA170	-	-0.045	0.045	MLRA239	-0.021	-0.362	0.383
MLRA088	-0.005	-0.309	0.314	MLRA172	-0.008	-0.218	0.226	MLRA240	-0.126	-2.216	2.342
MLRA089	-0.001	-1.946	1.947	MLRA173	-0.001	-0.923	0.924	MLRA241	-0.009	-0.149	0.158
MLRA090	-0.001	-0.591	0.592	MLRA178	0.002	-0.002	-	MLRA242	-0.004	-0.067	0.071
MLRA091	-0.006	-2.525	2.531	MLRA188	0.001	-0.001	-	MLRA243	0.001	-0.001	-
MLRA092	-0.004	-3.763	3.767	MLRA192	0.001	-0.001	-	MLRA244	-0.019	-0.391	0.410
MLRA093	-0.002	-0.448	0.450	MLRA196	-0.013	-1.782	1.795	MLRA246	-0.008	-0.141	0.149
MLRA095	-0.001	-0.289	0.290	MLRA197	0.001	-0.001	-	MLRA247	-0.005	-0.073	0.078
MLRA097	-0.005	-2.537	2.542	MLRA200	0.001	-0.001	-	MLRA248	-0.005	-0.095	0.100
MLRA105	-	-1.414	1.414	MLRA203	0.001	-0.001	-	MLRA249	-0.003	-0.029	0.032
MLRA106	-0.001	-1.720	1.721	MLRA204	0.001	-0.001	-	MLRA250	-	-0.001	0.001
MLRA107	-0.001	-0.440	0.441	MLRA205	-0.046	-1.458	1.504	MLRA252	-0.033	-0.796	0.829
MLRA109	-0.004	-0.879	0.883	MLRA206	0.001	-0.001	-	MLRA253	-0.005	-0.225	0.230
MLRA115	-	-2.407	2.407	MLRA207	-	-0.015	0.015	MLRA256	-0.030	-2.804	2.834
MLRA119	-0.002	-4.950	4.952	MLRA208	-0.023	-0.417	0.440	MLRA258	-0.004	-0.198	0.202
MLRA121	-0.001	-0.506	0.507	MLRA210	-0.023	-0.493	0.516	MLRA259	-0.006	-0.089	0.095
MLRA122	-0.001	-3.586	3.587	MLRA211	-0.018	-0.826	0.844	MLRA260	-0.012	-0.182	0.194
MLRA137	-0.003	-1.535	1.538	MLRA212	-0.070	-1.064	1.134	MLRA261	-0.028	-0.537	0.565
MLRA147	-0.023	-2.404	2.427	MLRA214	0.001	-0.001	-	MLRA262	-0.005	-0.120	0.125
MLRA148	-0.024	-0.732	0.756	MLRA217	-0.012	-0.576	0.588	MLRA264	-0.002	-0.066	0.068
MLRA149	-0.002	-0.040	0.042	MLRA218	-0.030	-1.076	1.106	MLRA265	-0.022	-0.402	0.424
MLRA150	-0.006	-0.150	0.156	MLRA219	-0.023	-0.712	0.735	MLRA266	-0.037	-1.239	1.276
MLRA152	-0.036	-0.632	0.668	MLRA220	-0.008	-0.209	0.217				
MLRA153	-0.011	-0.408	0.419	MLRA221	-0.033	-0.513	0.546				

Table D.5. Percent Changes of Land Prices per Major Land Resource Area (MLRA) in First Counterfactual Scenario

LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change
D	MLRA043	270.690		MLRA109	63.585		MLRA156	180.087		MLRA195	-1.134		MLRA235	63.650
	MLRA044	117.476		MLRA111	-0.911		MLRA157	153.030		MLRA196	43.144		MLRA236	20.818
	MLRA046	156.987		MLRA112	-0.779		MLRA159	24.778		MLRA197	-1.107		MLRA238	81.516
	MLRA054	-0.718		MLRA113	-1.709		MLRA160	29.388		MLRA199	-1.492		MLRA239	118.380
E	MLRA065	74.860		MLRA114	-1.078		MLRA161	110.039		MLRA200	-1.074		MLRA240	52.444
	MLRA066	209.507		MLRA115	295.905		MLRA162	76.735		MLRA202	-0.967		MLRA241	27.722
	MLRA067	301.285		MLRA117	-0.662		MLRA163	147.719		MLRA203	-1.985		MLRA242	41.019
	MLRA070	-4.799		MLRA118	-1.027		MLRA164	31.667		MLRA204	-1.099	R	MLRA243	-1.820
F	MLRA072	163.856		MLRA119	209.806		MLRA165	52.446	N	MLRA205	41.192		MLRA244	52.199
	MLRA073	81.855		MLRA121	40.401		MLRA166	-1.437		MLRA206	-2.848		MLRA246	92.911
	MLRA074	12.552		MLRA122	124.710	L	MLRA167	138.028		MLRA207	12.587		MLRA247	20.003
	MLRA075	588.682		MLRA123	-0.571		MLRA168	36.264		MLRA208	127.739		MLRA248	29.709
	MLRA076	-1.301	I	MLRA125	-0.925		MLRA169	18.890		MLRA210	154.978		MLRA249	20.273
	MLRA077	19.544		MLRA126	-0.614		MLRA170	1.787		MLRA211	501.397		MLRA250	12.026
	MLRA078	-1.493		MLRA127	-0.580		MLRA172	32.897		MLRA212	104.684	S	MLRA252	60.991
	MLRA079	68.187		MLRA130	-0.558	M	MLRA173	27.197		MLRA214	-1.585		MLRA253	23.966
G	MLRA083	-1.938		MLRA132	-0.680		MLRA174	-1.204		MLRA215	-1.549		MLRA254	-1.433
	MLRA084	543.153		MLRA133	-0.558		MLRA175	-1.250		MLRA216	-2.710		MLRA255	4.242
	MLRA085	338.431		MLRA134	-0.570		MLRA176	-0.991		MLRA217	37.498	T	MLRA256	235.450
	MLRA088	330.621		MLRA135	-0.824		MLRA177	-1.108		MLRA218	44.371		MLRA257	-0.868
	MLRA089	216.469		MLRA136	-0.801		MLRA178	-1.847		MLRA219	137.344		MLRA258	132.911
	MLRA090	66.258	J	MLRA137	248.073		MLRA179	-1.298		MLRA220	25.647		MLRA259	15.182
	MLRA091	271.014		MLRA138	-0.904		MLRA181	-1.004		MLRA221	66.696		MLRA260	56.221
	MLRA092	82.176		MLRA140	-0.920		MLRA182	-1.115		MLRA222	97.963		MLRA261	22.086
	MLRA093	95.857		MLRA144	-0.710		MLRA184	-0.906		MLRA223	80.930		MLRA262	21.653
	MLRA095	56.284		MLRA145	-0.560		MLRA185	-0.958		MLRA224	99.463		MLRA263	-0.910
	MLRA096	-1.847		MLRA147	517.047		MLRA186	-1.216		MLRA225	83.306		MLRA264	19.086
	MLRA097	297.722		MLRA148	348.823		MLRA187	-1.536		MLRA227	72.766	U	MLRA265	98.753
	MLRA100	-0.606	K	MLRA080	96.927		MLRA188	-2.153		MLRA228	56.827		MLRA266	116.639
H	MLRA104	-1.450		MLRA149	42.897		MLRA189	-0.927	O	MLRA230	-0.998		MLRA267	-0.433
	MLRA105	25.484		MLRA150	97.163		MLRA191	-1.036		MLRA231	7.671			
	MLRA106	41.096		MLRA152	169.768		MLRA192	-1.019		MLRA232	47.600			
	MLRA107	26.629		MLRA153	117.676		MLRA193	-1.060		MLRA233	9.070			
	MLRA108	-1.046		MLRA155	75.583		MLRA194	-1.007	P	MLRA234	34.971			

Table D.6. Percent Changes of Agricultural Land Prices per Major Land Resource Area (MLRA) in First Counterfactual Scenario

LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change
D	MLRA043	274.112		MLRA109	63.772		MLRA156	193.881		MLRA195	-1.157		MLRA235	375.166
	MLRA044	118.590		MLRA111	-0.911		MLRA157	361.603		MLRA196	43.567		MLRA236	25.175
	MLRA046	161.391		MLRA112	-0.779		MLRA159	39.952		MLRA197	-1.114		MLRA238	207.193
	MLRA054	-0.718		MLRA113	-1.709		MLRA160	202.866		MLRA199	-1.532		MLRA239	431.175
E	MLRA065	78.139		MLRA114	-1.078		MLRA161	160.537		MLRA200	-1.082		MLRA240	171.815
	MLRA066	212.837		MLRA115	295.912		MLRA162	163.760		MLRA202	-0.972		MLRA241	170.865
	MLRA067	306.550		MLRA117	-0.662		MLRA163	235.890		MLRA203	-2.015		MLRA242	159.052
	MLRA070	-4.823		MLRA118	-1.027		MLRA164	157.679		MLRA204	-1.104	R	MLRA243	-2.058
F	MLRA072	163.905		MLRA119	209.848		MLRA165	53.723	N	MLRA205	46.461		MLRA244	66.144
	MLRA073	81.864		MLRA121	40.439		MLRA166	-1.447		MLRA206	-2.891		MLRA246	126.496
	MLRA074	12.553		MLRA122	124.718	L	MLRA167	218.462		MLRA207	13.586		MLRA247	84.566
	MLRA075	589.018		MLRA123	-0.571		MLRA168	36.749		MLRA208	285.918		MLRA248	56.182
	MLRA076	-1.302	I	MLRA125	-0.925		MLRA169	19.040		MLRA210	307.061		MLRA249	84.623
	MLRA077	19.547		MLRA126	-0.614		MLRA170	1.787		MLRA211	635.141		MLRA250	79.854
	MLRA078	-1.494		MLRA127	-0.580		MLRA172	35.296		MLRA212	540.565	S	MLRA252	75.054
	MLRA079	68.264		MLRA130	-0.558	M	MLRA173	27.205		MLRA214	-1.773		MLRA253	26.176
G	MLRA083	-1.938		MLRA132	-0.680		MLRA174	-1.204		MLRA215	-1.591		MLRA254	-1.937
	MLRA084	543.458		MLRA133	-0.558		MLRA175	-1.251		MLRA216	-2.946		MLRA255	37.208
	MLRA085	339.655		MLRA134	-0.570		MLRA176	-0.992		MLRA217	42.197	T	MLRA256	265.456
	MLRA088	342.725		MLRA135	-0.824		MLRA177	-1.109		MLRA218	51.301		MLRA257	-0.868
	MLRA089	216.540		MLRA136	-0.801		MLRA178	-1.864		MLRA219	182.325		MLRA258	153.571
	MLRA090	66.312	J	MLRA137	248.423		MLRA179	-1.302		MLRA220	32.358		MLRA259	188.088
	MLRA091	272.041		MLRA138	-0.904		MLRA181	-1.004		MLRA221	195.951		MLRA260	360.746
	MLRA092	82.244		MLRA140	-0.920		MLRA182	-1.117		MLRA222	135.768		MLRA261	72.110
	MLRA093	96.184		MLRA144	-0.710		MLRA184	-0.907		MLRA223	134.321		MLRA262	36.807
	MLRA095	56.356		MLRA145	-0.560		MLRA185	-0.959		MLRA224	187.776		MLRA263	-0.962
	MLRA096	-1.847		MLRA147	570.036		MLRA186	-1.218		MLRA225	230.754		MLRA264	21.158
	MLRA097	298.648		MLRA148	522.917		MLRA187	-1.539		MLRA227	252.158	U	MLRA265	322.460
	MLRA100	-0.606	K	MLRA080	100.193		MLRA188	-2.165		MLRA228	170.433		MLRA266	180.572
H	MLRA104	-1.451		MLRA149	51.105		MLRA189	-0.928	O	MLRA230	-1.087		MLRA267	-0.594
	MLRA105	25.486		MLRA150	104.240		MLRA191	-1.043		MLRA231	8.819			
	MLRA106	41.114		MLRA152	201.558		MLRA192	-1.024		MLRA232	57.494			
	MLRA107	26.650		MLRA153	120.125		MLRA193	-1.063		MLRA233	10.012			
	MLRA108	-1.046		MLRA155	76.052		MLRA194	-1.012	P	MLRA234	90.645			

Table D.7. Percent Changes of Forest Land Prices per Major Land Resource Area (MLRA) in First Counterfactual Scenario

LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change
D	MLRA043	11.794		MLRA109	4.260		MLRA156	7.379		MLRA195	1.421		MLRA235	4.262
	MLRA044	10.204		MLRA111			MLRA157	10.359		MLRA196	3.500		MLRA236	2.542
	MLRA046	6.874		MLRA112			MLRA159	3.131		MLRA197	1.423		MLRA238	4.856
	MLRA054			MLRA113			MLRA160	4.636		MLRA199	1.401		MLRA239	5.924
E	MLRA065	4.642		MLRA114			MLRA161	5.698		MLRA200	1.424		MLRA240	3.858
	MLRA066	12.399		MLRA115	24.996		MLRA162	4.806		MLRA202	1.430		MLRA241	2.855
	MLRA067	9.517		MLRA117			MLRA163	8.505		MLRA203	1.373		MLRA242	3.415
	MLRA070	1.085		MLRA118			MLRA164	5.273		MLRA204	1.423	R	MLRA243	1.382
F	MLRA072	14.205		MLRA119	12.409		MLRA165	3.858	N	MLRA205	3.422		MLRA244	3.848
	MLRA073	7.094		MLRA121	4.037		MLRA166	1.404		MLRA206	1.324		MLRA246	5.207
	MLRA074	3.020		MLRA122	10.591	L	MLRA167	9.747		MLRA207	2.146		MLRA247	2.504
	MLRA075	13.194		MLRA123			MLRA168	3.221		MLRA208	6.168		MLRA248	2.942
	MLRA076	1.412	I	MLRA125			MLRA169	2.452		MLRA210	6.828		MLRA249	2.851
	MLRA077	2.805		MLRA126			MLRA170	1.583		MLRA211	11.973		MLRA250	3.243
	MLRA078	1.289		MLRA127			MLRA172	3.079		MLRA212	5.549	S	MLRA252	4.169
	MLRA079	4.419		MLRA130		M	MLRA173	2.832		MLRA214	1.396		MLRA253	2.687
G	MLRA083			MLRA132			MLRA174	1.184		MLRA215	1.398		MLRA254	1.404
	MLRA084	31.017		MLRA133			MLRA175	1.415		MLRA216	1.174		MLRA255	2.083
	MLRA085	10.050		MLRA134			MLRA176	1.429		MLRA217	3.272	T	MLRA256	8.446
	MLRA088	9.941		MLRA135			MLRA177	1.423		MLRA218	3.548		MLRA257	
	MLRA089	14.724		MLRA136			MLRA178	1.381		MLRA219	6.409		MLRA258	6.299
	MLRA090	5.347	J	MLRA137	11.274		MLRA179	1.412		MLRA220	2.763		MLRA259	2.274
	MLRA091	9.047		MLRA138			MLRA181	1.334		MLRA221	4.368		MLRA260	3.997
	MLRA092	4.877		MLRA140			MLRA182	1.422		MLRA222	5.356		MLRA261	2.601
	MLRA093	6.634		MLRA144			MLRA184	1.434		MLRA223	4.838		MLRA262	2.581
	MLRA095	5.629		MLRA145			MLRA185	1.431		MLRA224	5.399		MLRA263	1.434
	MLRA096	1.199		MLRA147	12.131		MLRA186	1.417		MLRA225	4.913		MLRA264	2.461
	MLRA097	12.378		MLRA148	10.191		MLRA187	1.398		MLRA227	6.596	U	MLRA265	5.379
	MLRA100		K	MLRA080	5.326		MLRA188	1.363		MLRA228	4.019		MLRA266	5.878
H	MLRA104	1.344		MLRA149	3.490		MLRA189	1.433	O	MLRA230	1.429		MLRA267	1.460
	MLRA105	3.542		MLRA150	5.332		MLRA191	1.427		MLRA231	1.897			
	MLRA106	3.418		MLRA152	7.159		MLRA192	1.428		MLRA232	3.674			
	MLRA107	2.807		MLRA153	5.906		MLRA193	1.425		MLRA233	1.969			
	MLRA108	1.421		MLRA155	4.665		MLRA194	1.428	P	MLRA234	3.167			

Table D.8. Percentage Changes of Quantities and Prices of Composite Inputs to the Top Activity Nest in First Counterfactual Scenario

Activities	Quantities			Prices		
	Value-added	Intermediate	Land	Value-added	Intermediate	Land
Aolsd	-0.468	-0.819	-4.436	0.049	0.759	8.532
Agran	-0.448	-0.701	-7.435	0.058	0.570	15.735
Aoagr	1.140	0.918		0.039	0.479	
Atobc	-1.870	-2.035	-26.852	0.026	0.364	80.013
Acott	-1.426	-1.677	-16.434	0.050	0.563	39.215
Asugr	-0.325	-0.496	-12.976	0.044	0.388	31.247
Aocrp	-3.260	-3.473	-20.520	0.032	0.475	48.198
Acatt	-0.303	-2.644	-27.201	0.048	4.918	87.642
Adair	-0.174	-0.836	-18.608	0.062	1.403	50.522
Alogg	-0.329	-0.428	-1.050	0.041	0.538	3.739
Amini	0.037	-0.004		0.051	0.132	
Autil	0.015	0.002		0.057	0.083	
Acons	0.186	0.114		0.025	0.168	
Amanf	0.011	-0.112		0.039	0.285	
Awhol	0.039	0.014		0.034	0.084	
Aretl	0.061	0.037		0.032	0.080	
Atrns	0.025	-0.024		0.034	0.131	
Ainfo	0.004	-0.015		0.043	0.081	
Afinc	0.030	0.020		0.037	0.055	
Aland	0.021	-0.010		0.057	0.117	
Aornt	0.030	0.026		0.066	0.076	
Aprof	0.008	-0.018		0.027	0.079	
Amgmt	0.019	0.001		0.033	0.069	
Aadmw	0.025	-0.010		0.031	0.100	
Aeduc	0.016	-0.015		0.025	0.088	
Ahlth	0.054	0.015		0.028	0.106	
Aentt	0.060	0.031		0.034	0.093	
Ahotl	0.037	-0.011		0.034	0.130	
Aoser	0.049	0.016		0.030	0.096	
Agven	0.036	-0.007		0.021	0.109	
Agvem	-0.271			0.028		

Table D.9. Percentage Changes of Quantities and Prices of Factors Used by Activities in First Counterfactual Scenario

Activities	Quantities		Prices	
	Labor	Capital	Labor	Capital
Aolsd	-0.455	-0.476	0.021	0.069
Agran	-0.431	-0.453	0.021	0.069
Aoagr	1.148	1.127	0.021	0.069
Atobc	-1.868	-1.889	0.021	0.069
Acott	-1.413	-1.434	0.021	0.069
Asugr	-0.314	-0.336	0.021	0.069
Aocrp	-3.255	-3.276	0.021	0.069
Acatt	-0.291	-0.312	0.021	0.069
Adair	-0.155	-0.177	0.021	0.069
Alogg	-0.320	-0.342	0.021	0.069
Amini	0.050	0.029	0.021	0.069
Autil	0.031	0.010	0.021	0.069
Acons	0.187	0.166	0.021	0.069
Amanf	0.019	-0.002	0.021	0.069
Awhol	0.045	0.023	0.021	0.069
Aretl	0.066	0.044	0.021	0.069
Atrns	0.030	0.009	0.021	0.069
Ainfo	0.014	-0.008	0.021	0.069
Afinc	0.037	0.015	0.021	0.069
Aland	0.037	0.015	0.021	0.069
Aornt	0.051	0.029	0.021	0.069
Aprof	0.011	-0.010	0.021	0.069
Amgmt	0.024	0.002	0.021	0.069
Aadmw	0.029	0.008	0.021	0.069
Aeduc	0.018	-0.003	0.021	0.069
Ahlth	0.057	0.036	0.021	0.069
Aentt	0.066	0.044	0.021	0.069
Ahotl	0.043	0.021	0.021	0.069
Aoser	0.053	0.032	0.021	0.069
Agven	0.036	0.015	0.021	0.069
Agvem	-0.268	-0.289	0.021	0.069

Table D.10. Percentage Changes of Intermediate Commodity Consumption Quantities by Activity in First Counterfactual Scenario

	Aolsd	Agran	Aoagr	Atobc	Acott	Asugr	Aocrp	Acatt	Adair	Alogg	Amini	Autil	Acons	Amanf	Awhol
Colsd	-1.851	-1.827	-0.271	-3.245				-1.689	-1.555					-1.384	
Cgran	-2.016	-1.993	-0.439	-3.408	-2.959		-4.773	-1.855	-1.721					-1.550	
Coagr	-0.643	-0.618	0.957	-2.054	-1.599	-0.502	-3.438	-0.479	-0.343	-0.361		-0.157	-0.003	-0.170	-0.145
Ctobc				-2.451										-0.574	
Ccott	-2.275				-3.215									-1.810	
Csugr						-1.963								-1.635	
Cocrp	-3.364	-3.340	-1.808	-4.737	-4.294	-3.228	-6.083	-3.204	-3.072		-2.874		-2.741	-2.904	
Ccatt	-5.316	-5.293	-3.791		-6.227	-5.182	-7.980	-5.159	-5.030					-4.865	
Cdair			0.722					-0.710	-0.575					-0.402	
Clogg										-0.623				-0.432	
Cmini	-0.481	-0.457	1.121	-1.895	-1.439	-0.341	-3.281	-0.317	-0.181	-0.199	0.024	0.006	0.160	-0.008	0.018
Cutil	-0.476	-0.452	1.126	-1.890	-1.434	-0.336	-3.276	-0.312	-0.176	-0.194	0.029	0.010	0.165	-0.003	0.023
Ccons	-0.498	-0.474	1.104	-1.912	-1.456	-0.358	-3.298		-0.198	-0.216	0.007	-0.012	0.143	-0.025	0.001
Cmanf	-0.551	-0.526	1.051	-1.963	-1.508	-0.410	-3.349	-0.387	-0.250	-0.268	-0.046	-0.064	0.090	-0.077	-0.052
Cwhol	-0.471	-0.447	1.131	-1.885	-1.429	-0.331	-3.272	-0.307	-0.171	-0.189	0.034	0.015	0.170	0.002	0.028
Cretl	-0.468	-0.444	1.134	-1.882	-1.426	-0.328	-3.268	-0.304	-0.168	-0.186	0.037	0.019	0.173	0.006	0.031
Ctrns	-0.483	-0.459	1.119	-1.897	-1.441	-0.343	-3.283	-0.319	-0.183	-0.201	0.022	0.003	0.158	-0.010	0.016
Cinfo	-0.478	-0.453	1.125	-1.891	-1.435	-0.337	-3.278	-0.313	-0.177	-0.195	0.027	0.009	0.163	-0.004	0.021
Cfinc	-0.466	-0.442	1.137	-1.880	-1.424	-0.326	-3.266	-0.302	-0.166	-0.183	0.039	0.021	0.175	0.008	0.033
Cland			1.124	-1.892					-0.178		0.027	0.008	0.163	-0.005	0.020
Cornt	-0.478	-0.454	1.124	-1.892	-1.436	-0.338	-3.278	-0.314	-0.178	-0.196	0.027	0.009	0.163	-0.005	0.021
Cprof	-0.467	-0.443	1.136	-1.881	-1.425	-0.326	-3.267	-0.303	-0.166	-0.184	0.038	0.020	0.174	0.007	0.032
Cmgmt											0.038		0.174	0.006	0.032
Cadmw	-0.471	-0.447	1.132	-1.885	-1.429	-0.331	-3.271	-0.307	-0.171	-0.189	0.034	0.016	0.170	0.003	0.028
Ceduc	-0.469	-0.445	1.134	-1.883	-1.427	-0.329	-3.269	-0.305	-0.169		0.036	0.018	0.172	0.005	0.030
Chlth															
Centt	-0.476	-0.452	1.126	-1.890	-1.434	-0.336	-3.276	-0.312	-0.176	-0.194	0.029	0.011	0.165	-0.003	0.023
Chotl	-0.484	-0.460	1.118	-1.898	-1.442	-0.344	-3.284	-0.320	-0.184	-0.202	0.021	0.003	0.157	-0.011	0.015
Coser	-0.474	-0.450	1.128	-1.888	-1.432	-0.334	-3.274	-0.310	-0.174	-0.192	0.031	0.012	0.167	-0.001	0.025
Cgven	-0.483	-0.459	1.119	-1.897	-1.441	-0.343	-3.283		-0.183	-0.201	0.022	0.003	0.158	-0.010	0.016
Cuncl	-0.469	-0.445	1.134				-3.269	-0.305	-0.169	-0.187	0.036	0.018	0.172	0.005	0.030

Table D.10. Continued

	Aretl	Atrns	Ainfo	Afinc	Aland	Aornt	Aprof	Amgmt	Aadmw	Aeduc	Ahlth	Aentt	Ahotl	Aoser	Agven
Colsd															
Cgran	-1.505						-1.559	-1.546		-1.552	-1.514	-1.505	-1.527		
Coagr	-0.124	-0.159	-0.175	-0.152	-0.151	-0.137	-0.178	-0.165	-0.160	-0.172	-0.133	-0.124	-0.147	-0.137	-0.154
Ctobc															
Ccott							-1.818	-1.805							
Csugr							-1.643	-1.631							
Cocrp					-2.886	-2.872	-2.912	-2.900	-2.895	-2.906		-2.859			
Ccatt							-4.873	-4.861							
Cdair							-0.411								
Clogg															
Cmini	0.039	0.003	-0.013	0.010	0.011	0.025	-0.016	-0.003	0.002	-0.010	0.030	0.039	0.015	0.026	0.009
Cutil	0.044	0.008	-0.008	0.015	0.016	0.030	-0.011	0.002	0.007	-0.005	0.035	0.044	0.020	0.031	0.014
Ccons	0.021	-0.014	-0.030	-0.007	-0.006	0.008	-0.033	-0.020	-0.015	-0.027	0.012	0.022	-0.002	0.008	-0.009
Cmanf	-0.031	-0.066	-0.083	-0.060	-0.059	-0.044	-0.086	-0.073	-0.068	-0.079	-0.040	-0.031	-0.054	-0.044	-0.061
Cwhol	0.049	0.013	-0.003	0.020	0.021	0.035	-0.006	0.007	0.012	0.000	0.039	0.049	0.025	0.035	0.018
Cretl	0.052	0.017	0.000	0.023	0.024	0.038	-0.003	0.010	0.015	0.004	0.043	0.052	0.029	0.039	0.022
Ctrns	0.037	0.001	-0.015	0.008	0.009	0.023	-0.018	-0.005	0.000	-0.012	0.027	0.037	0.013	0.023	0.006
Cinfo	0.042	0.007	-0.009	0.013	0.014	0.029	-0.013	0.000	0.005	-0.006	0.033	0.042	0.019	0.029	0.012
Cfinc	0.054	0.019	0.002	0.025	0.026	0.041	-0.001	0.012	0.017	0.006	0.045	0.054	0.031	0.041	0.024
Cland	0.041	0.006	-0.010	0.012	0.014	0.028	-0.013	0.000	0.005	-0.007	0.032	0.042	0.018	0.028	0.011
Cornt	0.042	0.006	-0.010	0.013	0.014	0.028	-0.013	0.000	0.005	-0.007	0.033	0.042	0.019	0.029	0.012
Cprof	0.053	0.018	0.002	0.024	0.025	0.040	-0.002	0.011	0.016	0.005	0.044	0.053	0.030	0.040	0.023
Cmgmt	0.053	0.017	0.001	0.024	0.025	0.039	-0.002		0.016	0.004	0.044	0.053	0.030	0.040	
Cadmw	0.049	0.014	-0.003	0.020	0.021	0.036	-0.006	0.007	0.012	0.001	0.040	0.049	0.026	0.036	0.019
Ceduc	0.051	0.016	-0.001	0.022	0.023		-0.004		0.014	0.003	0.042	0.051		0.038	0.021
Chlth	0.048						-0.007		0.011		0.039	0.048		0.035	
Centt	0.044	0.008	-0.008	0.015	0.016	0.030	-0.011	0.002	0.007	-0.005	0.035	0.044	0.021	0.031	0.014
Chotl	0.036	0.000	-0.016	0.007	0.008	0.022	-0.019	-0.006	-0.001	-0.013	0.027	0.036	0.012	0.023	0.006
Coser	0.046	0.010	-0.006	0.017	0.018	0.032	-0.009	0.004	0.009	-0.003	0.037	0.046	0.022	0.033	0.016
Cgven	0.037	0.001	-0.015	0.008	0.009	0.023	-0.018	-0.005	0.000	-0.012	0.027	0.037	0.013	0.023	0.006
Cuncl	0.051	0.016	-0.001	0.022	0.023	0.038	-0.004	0.009	0.014	0.003	0.042	0.051	0.028	0.038	0.021

Table D.11. Percentage Changes of Prices and Quantities of Household Commodity Consumption in First Counterfactual Scenario

Commodities	Quantities									Prices
	< 10 K	10 - 15 K	15 - 25 K	25 - 35 K	35 - 50 K	50 - 75 K	75 - 100 K	100 - 150 K	> 150 K	
Colsd										2.889
Cgran	-1.428	-1.473	-1.500	-1.520	-1.526	-1.541	-1.543	-1.539	-1.467	3.237
Coagr	-0.045	-0.091	-0.119	-0.139	-0.146	-0.161	-0.162	-0.158	-0.086	0.402
Ctobc										1.221
Ccott										3.783
Csugr										3.415
Cocrp	-2.783	-2.828	-2.854	-2.874	-2.880	-2.895	-2.897	-2.893	-2.822	6.136
Ccatt	-4.747	-4.790	-4.816	-4.836	-4.842	-4.857	-4.858	-4.854	-4.785	10.557
Cdair										0.871
Clogg										0.932
Cmini	0.117	0.071	0.043	0.023	0.017	0.001	0.000	0.004	0.077	0.077
Cutil	0.122	0.076	0.048	0.028	0.022	0.006	0.005	0.009	0.081	0.067
Ccons										0.111
Cmanf	0.047	0.001	-0.026	-0.047	-0.053	-0.068	-0.070	-0.066	0.007	0.216
Cwhol	0.127	0.081	0.053	0.033	0.027	0.011	0.010	0.014	0.086	0.057
Cretl	0.130	0.084	0.057	0.036	0.030	0.014	0.013	0.017	0.090	0.050
Ctrns	0.115	0.069	0.041	0.021	0.015	-0.001	-0.002	0.002	0.074	0.081
Cinfo	0.121	0.075	0.047	0.027	0.020	0.005	0.003	0.007	0.080	0.069
Cfinc	0.132	0.086	0.059	0.038	0.032	0.017	0.015	0.019	0.092	0.046
Cland	0.120	0.074	0.046	0.026	0.019	0.004	0.003	0.007	0.079	0.071
Cornt	0.120	0.074	0.047	0.026	0.020	0.004	0.003	0.007	0.080	0.070
Cprof	0.131	0.086	0.058	0.038	0.031	0.016	0.014	0.018	0.091	0.048
Cmgmt										0.048
Cadmw	0.127	0.081	0.054	0.033	0.027	0.012	0.010	0.014	0.087	0.056
Ceduc	0.129	0.083	0.056	0.035	0.029	0.014	0.012	0.016	0.089	0.052
Chlth	0.126	0.080	0.053	0.032	0.026	0.011	0.009	0.013	0.086	0.058
Centt	0.122	0.076	0.049	0.028	0.022	0.006	0.005	0.009	0.082	0.066
Chotl	0.114	0.068	0.040	0.020	0.014	-0.002	-0.003	0.001	0.073	0.083
Coser	0.124	0.078	0.050	0.030	0.024	0.008	0.007	0.011	0.083	0.063
Cgven	0.115	0.069	0.041	0.021	0.015	-0.001	-0.002	0.002	0.074	0.081
Cuncl	0.129	0.083	0.056	0.035	0.029	0.014	0.012	0.016	0.089	0.052
Cgvem										0.028

Table D.12. Percentage Changes of Prices and Quantities of Exported Commodities in First Counterfactual Scenario

Commodity	Quantities		Prices	
	Rest of the world	Rest of the U.S.	Rest of the world	Rest of the U.S.
Colsd	-1.891	-1.891	2.701	2.701
Cgran	-2.144	-2.144	3.062	3.062
Coagr	0.003	0.003	-0.004	-0.004
Ctobc	-0.806	-0.806	1.152	1.152
Ccott	-2.527	-2.527	3.610	3.610
Csugr	-2.331	-2.331	3.330	3.330
Cocrp	-5.708	-5.708	8.154	8.154
Ccatt	-6.854	-6.854	9.791	9.791
Cdair	-0.656	-0.656	0.937	0.937
Clogg	-0.642	-0.642	0.917	0.917
Cmini	-0.036	-0.036	0.051	0.051
Cutil	-0.034	-0.034	0.048	0.048
Ccons	-0.029	-0.029	0.041	0.041
Cmanf	-0.142	-0.142	0.202	0.202
Cwhol	-0.023	-0.023	0.033	0.033
Cretl		-0.016		0.023
Ctrns	-0.042	-0.042	0.061	0.061
Cinfo	-0.040	-0.040	0.057	0.057
Cfinc	-0.019	-0.019	0.027	0.027
Cland	-0.036	-0.036	0.052	0.052
Cornt	-0.032	-0.032	0.046	0.046
Cprof	-0.027	-0.027	0.038	0.038
Cmgmt	-0.023	-0.023	0.032	0.032
Cadmw	-0.028	-0.028	0.040	0.040
Ceduc	-0.028	-0.028	0.039	0.039
Chlth	-0.023	-0.023	0.034	0.034
Centt	-0.030	-0.030	0.042	0.042
Chotl	-0.042	-0.042	0.061	0.061
Coser	-0.027	-0.027	0.038	0.038
Cgven	-0.042		0.060	
Cuncl	-0.016	-0.016	0.023	0.023
Cgvem		-0.075		0.107

Table D.13. Percentage Changes of Prices and Quantities of Imported Commodities in First Counterfactual Scenario

Commodity	Quantities		FOB Prices	
	Rest of the world	Rest of the U.S.	Rest of the world	Rest of the U.S.
Colsd	0.957		1.914	
Cgran	1.071	1.071	2.142	2.142
Coagr	0.276	0.276	0.551	0.551
Ctobc	0.408		0.815	
Ccott	1.208	1.208	2.415	2.415
Csugr	1.137	1.137	2.274	2.274
Cocrp	2.017	2.017	4.033	4.033
Ccatt	3.443		6.886	
Cdair	0.295	0.295	0.591	0.591
Clogg	0.310	0.310	0.620	0.620
Cmini	0.037	0.037	0.075	0.075
Cutil	0.030	0.030	0.060	0.060
Ccons		0.070		0.140
Cmanf	0.087	0.087	0.174	0.174
Cwhol		0.030		0.060
Cretl		0.030		0.059
Ctrns	0.036	0.036	0.071	0.071
Cinfo	0.028	0.028	0.057	0.057
Cfinc	0.024	0.024	0.048	0.048
Cland		0.032		0.064
Cornt	0.034	0.034	0.069	0.069
Cprof	0.019	0.019	0.039	0.039
Cmgmt		0.023		0.046
Cadmw	0.025	0.025	0.051	0.051
Ceduc	0.022	0.022	0.045	0.045
Chlth	0.030	0.030	0.060	0.060
Centt	0.033	0.033	0.066	0.066
Chotl		0.037		0.074
Coser	0.032	0.032	0.064	0.064
Cgven		0.036		0.071
Cuncl	0.027	0.027	0.055	0.055
Cgvem		-0.033		-0.067

Table D.14. Percentage Changes of Institutional Incomes in First Counterfactual Scenario

Institution	% change
Households	
< 10 K	0.202
10 - 15 K	0.159
15 - 25 K	0.130
25 - 35 K	0.110
35 - 50 K	0.103
50 - 75 K	0.086
75 - 100 K	0.084
100 - 150 K	0.083
> 150 K	0.147
Government	
Fed. non-defense	0.174
Fed. defense	0.151
Fed. investment	0.117
State non-education	0.160
State education	0.155
State investment	0.149
Investment	0.356
Inventory	0.631
Enterprises	0.518
Net foreign investment	
Rest of the U.S.	33,993.395
Rest of the world	0.256

APPENDIX E

SCENARIO 2

Table E.1. Percentage Changes of Quantities and Prices of Total Production by Activity in Second Counterfactual Scenario

Activities	Quantities	Prices
Aolsd	-0.104	0.262
Agran	-0.193	0.418
Aoagr	1.100	0.102
Atobc	-0.110	0.158
Acott	-0.460	0.518
Asugr	-0.217	0.486
Aocrp	-0.923	0.982
Acatt	-1.077	2.231
Adair	-0.044	0.200
Alogg	11.767	9.533
Amini	0.053	0.071
Autil	0.006	0.080
Acons	0.136	0.045
Amanf	0.066	0.027
Awhol	0.053	0.050
Aretl	0.039	0.051
Atrns	0.035	0.049
Ainfo	-0.008	0.059
Afinc	0.019	0.054
Aland	0.002	0.080
Aornt	0.016	0.082
Aprof		0.046
Amgmt	0.036	0.050
Aadmw	0.016	0.048
Aeduc	-0.016	0.047
Ahlth	0.033	0.046
Aentt	0.026	0.053
Ahotl	0.020	0.053
Aoser	0.040	0.048
Agven	0.045	0.046
Agvem	-0.303	0.041

Table E.2. CO_2 Offsets by the Carbon Graveyard by Timber Category and Major Land Resource Area (MLRA) in Second Scenario

MLRA code	Softwood	Hardwood	MLRA code	Softwood	Hardwood
	Million MT			Million MT	
MLRA043	0.190	-	MLRA164	0.004	-
MLRA066	0.013	-	MLRA167	0.054	-
MLRA067	0.559	-	MLRA208	1.177	-
MLRA072	-	0.140	MLRA210	1.508	-
MLRA075	39.885	-	MLRA211	3.417	-
MLRA084	-	1.582	MLRA212	4.206	-
MLRA085	-	3.533	MLRA219	1.251	-
MLRA088	-	0.436	MLRA221	0.988	-
MLRA089	-	0.954	MLRA224	2.722	-
MLRA091	-	2.464	MLRA225	0.792	-
MLRA097	1.580	-	MLRA227	0.049	-
MLRA115	-	2.956	MLRA228	0.452	-
MLRA119	-	2.025	MLRA235	8.009	-
MLRA137	-	1.194	MLRA238	1.029	-
MLRA147	9.470	-	MLRA239	1.298	-
MLRA148	2.833	-	MLRA240	3.159	-
MLRA152	1.702	-	MLRA241	0.224	-
MLRA153	0.134	-	MLRA242	0.077	-
MLRA156	0.237	-	MLRA256	8.101	-
MLRA157	0.120	-	MLRA258	0.240	-
MLRA160	0.017	-	MLRA259	0.144	-
MLRA161	0.170	-	MLRA260	0.617	-
MLRA162	0.089	-	MLRA265	1.162	-
MLRA163	0.108	-	MLRA266	1.941	-

Table E.3. CO_2 Offsets by the Carbon Graveyard by Land Resource Region (LRR) in Second Scenario

LRR code	Softwood	Hardwood
	Million MT	
D	0.19	-
E	0.57	-
F	39.89	0.14
G	1.58	8.97
H	-	4.98
I	-	-
J	12.30	1.19
K	2.58	-
L	0.05	-
M	-	-
N	16.56	-
O	-	-
P	13.80	-
R	-	-
S	-	-
T	9.10	-
U	3.10	-
Total	**99.72**	**15.28**

Table E.4. Agricultural and Forest Land Change due to CO_2 Payments per Major Land Resource Area (MLRA) in Second Scenario

MLRA	Logg	Agr	Grave	MLRA	Logg	Agr	Grave	MLRA	Logg	Agr	Grave	MLRA	Logg	Agr	Grave
	Million acres				Million acres				Million acres				Million acres		
MLRA043	0.001	-0.070	0.069	MLRA122	0.001	-0.001	-	MLRA187	0.004	-0.004	-	MLRA228	0.009	-0.094	0.085
MLRA044	0.001	-0.001	-	MLRA137	0.001	-0.322	0.321	MLRA188	0.024	-0.024	-	MLRA230	0.051	-0.051	-
MLRA046	0.007	-0.007	-	MLRA147	-0.006	-1.721	1.727	MLRA189	0.004	-0.004	-	MLRA231	0.007	-0.007	-
MLRA065	0.017	-0.017	-	MLRA148	-0.005	-0.512	0.517	MLRA191	0.012	-0.012	-	MLRA232	0.002	-0.002	-
MLRA066	0.001	-0.006	0.005	MLRA149	0.003	-0.003	-	MLRA192	0.013	-0.013	-	MLRA233	0.008	-0.008	-
MLRA067	0.002	-0.205	0.203	MLRA150	0.006	-0.006	-	MLRA193	0.004	-0.004	-	MLRA234	0.170	-0.170	-
MLRA070	0.002	-0.002	-	MLRA152	0.011	-0.244	0.233	MLRA194	0.007	-0.007	-	MLRA235	-0.013	-1.419	1.432
MLRA072	-	-0.034	0.034	MLRA153	0.009	-0.027	0.018	MLRA195	0.004	-0.004	-	MLRA236	0.063	-0.063	-
MLRA073	0.001	-0.001	-	MLRA155	0.003	-0.003	-	MLRA196	0.026	-0.026	-	MLRA238	0.007	-0.188	0.181
MLRA075	-0.002	-5.491	5.493	MLRA156	0.001	-0.034	0.033	MLRA197	0.018	-0.018	-	MLRA239	-0.003	-0.233	0.236
MLRA076	0.002	-0.002	-	MLRA157	-	-0.016	0.016	MLRA199	0.009	-0.009	-	MLRA240	0.055	-0.649	0.594
MLRA077	0.002	-0.002	-	MLRA159	0.002	-0.002	-	MLRA200	0.014	-0.014	-	MLRA241	0.004	-0.045	0.041
MLRA078	0.001	-0.001	-	MLRA160	-	-0.003	0.003	MLRA202	0.007	-0.007	-	MLRA242	0.002	-0.017	0.015
MLRA079	0.007	-0.007	-	MLRA161	0.003	-0.026	0.023	MLRA203	0.012	-0.012	-	MLRA243	0.018	-0.018	-
MLRA080	0.016	-0.016	-	MLRA162	0.002	-0.014	0.012	MLRA204	0.023	-0.023	-	MLRA244	0.025	-0.025	-
MLRA084	-	-0.425	0.425	MLRA163	0.001	-0.015	0.014	MLRA205	0.084	-0.084	-	MLRA246	0.007	-0.007	-
MLRA085	0.001	-0.950	0.949	MLRA164	-	-0.001	0.001	MLRA206	0.008	-0.008	-	MLRA247	0.005	-0.005	-
MLRA088	0.001	-0.118	0.117	MLRA165	0.012	-0.012	-	MLRA207	0.003	-0.003	-	MLRA248	0.008	-0.008	-
MLRA089	0.001	-0.258	0.257	MLRA166	0.013	-0.013	-	MLRA208	0.002	-0.216	0.214	MLRA249	0.003	-0.003	-
MLRA090	0.001	-0.001	-	MLRA167	0.001	-0.008	0.007	MLRA210	0.001	-0.270	0.269	MLRA252	0.040	-0.040	-
MLRA091	0.002	-0.664	0.662	MLRA168	0.003	-0.003	-	MLRA211	-0.005	-0.609	0.614	MLRA253	0.017	-0.017	-
MLRA092	0.004	-0.004	-	MLRA169	0.026	-0.026	-	MLRA212	-0.016	-0.744	0.760	MLRA254	0.004	-0.004	-
MLRA093	0.003	-0.003	-	MLRA170	0.011	-0.011	-	MLRA214	0.021	-0.021	-	MLRA256	0.003	-1.413	1.410
MLRA095	0.001	-0.001	-	MLRA172	0.018	-0.018	-	MLRA215	0.005	-0.005	-	MLRA258	0.003	-0.045	0.042
MLRA096	0.001	-0.001	-	MLRA173	0.003	-0.003	-	MLRA216	0.001	-0.001	-	MLRA259	0.002	-0.030	0.028
MLRA097	0.001	-0.576	0.575	MLRA175	0.003	-0.003	-	MLRA217	0.024	-0.024	-	MLRA260	-0.001	-0.110	0.111
MLRA104	0.002	-0.002	-	MLRA176	0.008	-0.008	-	MLRA218	0.052	-0.052	-	MLRA261	0.035	-0.035	-
MLRA105	0.001	-0.001	-	MLRA177	0.006	-0.006	-	MLRA219	0.009	-0.228	0.219	MLRA262	0.010	-0.010	-
MLRA106	0.003	-0.003	-	MLRA178	0.037	-0.037	-	MLRA220	0.020	-0.020	-	MLRA263	0.004	-0.004	-
MLRA107	0.002	-0.002	-	MLRA179	0.009	-0.009	-	MLRA221	0.011	-0.184	0.173	MLRA264	0.008	-0.008	-
MLRA108	0.002	-0.002	-	MLRA181	0.001	-0.001	-	MLRA222	0.027	-0.027	-	MLRA265	-	-0.226	0.226
MLRA109	0.006	-0.006	-	MLRA182	0.010	-0.010	-	MLRA223	0.020	-0.020	-	MLRA266	0.015	-0.392	0.377
MLRA115	-	-0.801	0.801	MLRA184	0.005	-0.005	-	MLRA224	0.025	-0.511	0.486	MLRA267	0.003	-0.003	-
MLRA119	0.001	-0.547	0.546	MLRA185	0.005	-0.005	-	MLRA225	0.003	-0.143	0.140				
MLRA121	0.002	-0.002	-	MLRA186	0.008	-0.008	-	MLRA227	-	-0.010	0.010				

Table E.5. Percent Changes of Land Prices per Major Land Resource Area (MLRA) in Second Counterfactual Scenario

LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change
D	MLRA043	21.318		MLRA109	0.161		MLRA156	41.045		MLRA195	0.794		MLRA235	94.145
	MLRA044	0.509		MLRA111	0.011		MLRA157	99.267		MLRA196	0.800		MLRA236	17.532
	MLRA046	2.372		MLRA112	0.032		MLRA159	36.804		MLRA197	0.232		MLRA238	72.001
	MLRA054	0.008		MLRA113	-0.156		MLRA160	82.247		MLRA199	1.179		MLRA239	103.749
E	MLRA065	3.632		MLRA114	-0.047		MLRA161	43.274		MLRA200	0.294		MLRA240	70.903
	MLRA066	3.958		MLRA115	43.901		MLRA162	58.547		MLRA202	0.211		MLRA241	79.750
	MLRA067	29.706		MLRA117	0.026		MLRA163	68.691		MLRA203	0.660		MLRA242	72.469
	MLRA070	-0.253		MLRA118	-0.040		MLRA164	76.083		MLRA204	0.204	R	MLRA243	6.148
F	MLRA072	4.587		MLRA119	10.306		MLRA165	2.207	N	MLRA205	10.956		MLRA244	20.105
	MLRA073	-0.098		MLRA121	0.069		MLRA166	0.245		MLRA206	0.614		MLRA246	25.028
	MLRA074	-0.037		MLRA122	-0.057	L	MLRA167	63.519		MLRA207	7.555		MLRA247	70.257
	MLRA075	222.257		MLRA123	0.040		MLRA168	1.366		MLRA208	84.249		MLRA248	44.727
	MLRA076	0.017	I	MLRA125	-0.024		MLRA169	0.853		MLRA210	89.303		MLRA249	70.334
	MLRA077	-0.014		MLRA126	0.033		MLRA170	0.340		MLRA211	215.582		MLRA250	78.825
	MLRA078	-0.066		MLRA127	0.038		MLRA172	6.632		MLRA212	109.097	S	MLRA252	17.932
	MLRA079	0.115		MLRA130	0.040	M	MLRA173	0.008		MLRA214	5.316		MLRA253	8.401
G	MLRA083	-0.172		MLRA132	0.023		MLRA174	-0.014		MLRA215	1.202		MLRA254	13.597
	MLRA084	126.488		MLRA133	0.040		MLRA175	-0.004		MLRA216	4.886		MLRA255	83.290
	MLRA085	55.281		MLRA134	0.038		MLRA176	0.043		MLRA217	10.686	T	MLRA256	75.188
	MLRA088	56.766		MLRA135	0.021		MLRA177	0.037		MLRA218	13.032		MLRA257	-0.002
	MLRA089	12.698		MLRA136	0.001		MLRA178	0.335		MLRA219	45.961		MLRA258	28.422
	MLRA090	-0.067	J	MLRA137	22.807		MLRA179	0.079		MLRA220	20.398		MLRA259	84.821
	MLRA091	31.366		MLRA138	-0.013		MLRA181	0.029		MLRA221	72.044		MLRA260	92.676
	MLRA092	-0.159		MLRA140	-0.014		MLRA182	0.067		MLRA222	26.173		MLRA261	64.438
	MLRA093	0.085		MLRA144	0.026		MLRA184	0.058		MLRA223	37.232		MLRA262	40.020
	MLRA095	0.011		MLRA145	0.040		MLRA185	0.063		MLRA224	61.408		MLRA263	2.011
	MLRA096	-0.128		MLRA147	205.863		MLRA186	0.059		MLRA225	77.803		MLRA264	10.141
	MLRA097	27.437		MLRA148	159.105		MLRA187	0.023		MLRA227	81.293	U	MLRA265	91.106
	MLRA100	0.039	K	MLRA080	2.916		MLRA188	0.124		MLRA228	68.471		MLRA266	52.153
H	MLRA104	-0.037		MLRA149	15.271		MLRA189	0.077	O	MLRA230	3.221		MLRA267	7.171
	MLRA105	-0.013		MLRA150	6.394		MLRA191	0.240		MLRA231	15.115			
	MLRA106	0.021		MLRA152	48.426		MLRA192	0.231		MLRA232	16.819			
	MLRA107	0.035		MLRA153	4.752		MLRA193	0.125		MLRA233	10.701			
	MLRA108	0.022		MLRA155	0.496		MLRA194	0.211	P	MLRA234	57.158			

Table E.6. Percent Changes of Agricultural Land Prices per Major Land Resource Area (MLRA) in Second Counterfactual Scenario

LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change
D	MLRA043	20.451		MLRA109	-0.112		MLRA156	37.274		MLRA195	0.036		MLRA235	123.563
	MLRA044	-0.341		MLRA111	0.011		MLRA157	114.564		MLRA196	-0.117		MLRA236	0.885
	MLRA046	-0.125		MLRA112	0.032		MLRA159	1.627		MLRA197	0.013		MLRA238	44.786
	MLRA054	0.008		MLRA113	-0.156		MLRA160	39.710		MLRA199	-0.001		MLRA239	146.244
E	MLRA065	-0.267		MLRA114	-0.047		MLRA161	21.453		MLRA200	0.020		MLRA240	27.402
	MLRA066	2.596		MLRA115	43.900		MLRA162	22.303		MLRA202	0.033		MLRA241	28.733
	MLRA067	28.650		MLRA117	0.026		MLRA163	56.297		MLRA203	-0.111		MLRA242	21.789
	MLRA070	-0.594		MLRA118	-0.040		MLRA164	19.837		MLRA204	0.009	R	MLRA243	0.173
F	MLRA072	4.562		MLRA119	10.290		MLRA165	-0.021	N	MLRA205	0.308		MLRA244	0.615
	MLRA073	-0.108		MLRA121	-0.018		MLRA166	-0.044		MLRA206	-0.264		MLRA246	0.890
	MLRA074	-0.044		MLRA122	-0.063	L	MLRA167	48.291		MLRA207	-0.031		MLRA247	2.738
	MLRA075	222.336		MLRA123	0.040		MLRA168	0.112		MLRA208	78.599		MLRA248	1.721
	MLRA076	-0.036	I	MLRA125	-0.024		MLRA169	0.071		MLRA210	90.049		MLRA249	4.070
	MLRA077	-0.030		MLRA126	0.033		MLRA170	0.044		MLRA211	250.651		MLRA250	10.256
	MLRA078	-0.073		MLRA127	0.038		MLRA172	0.163		MLRA212	200.114	S	MLRA252	0.673
	MLRA079	0.010		MLRA130	0.040	M	MLRA173	-0.019		MLRA214	0.176		MLRA253	0.233
G	MLRA083	-0.172		MLRA132	0.023		MLRA174	-0.017		MLRA215	-0.013		MLRA254	0.563
	MLRA084	126.510		MLRA133	0.040		MLRA175	-0.026		MLRA216	0.150		MLRA255	12.598
	MLRA085	55.158		MLRA134	0.038		MLRA176	0.019		MLRA217	0.179	T	MLRA256	73.421
	MLRA088	55.567		MLRA135	0.021		MLRA177	0.000		MLRA218	0.412		MLRA257	-0.002
	MLRA089	12.673		MLRA136	0.001		MLRA178	-0.105		MLRA219	31.392		MLRA258	18.688
	MLRA090	-0.143	J	MLRA137	22.712		MLRA179	-0.028		MLRA220	0.719		MLRA259	34.202
	MLRA091	31.143		MLRA138	-0.013		MLRA181	0.018		MLRA221	37.692		MLRA260	116.751
	MLRA092	-0.236		MLRA140	-0.014		MLRA182	0.001		MLRA222	0.885		MLRA261	2.656
	MLRA093	-0.228		MLRA144	0.026		MLRA184	0.033		MLRA223	1.375		MLRA262	1.859
	MLRA095	-0.108		MLRA145	0.040		MLRA185	0.023		MLRA224	35.930		MLRA263	0.128
	MLRA096	-0.135		MLRA147	218.290		MLRA186	-0.015		MLRA225	57.490		MLRA264	0.553
	MLRA097	27.243		MLRA148	195.642		MLRA187	-0.068		MLRA227	61.976	U	MLRA265	97.193
	MLRA100	0.039	K	MLRA080	-0.091		MLRA188	-0.163		MLRA228	25.158		MLRA266	31.192
H	MLRA104	-0.066		MLRA149	0.239		MLRA189	0.031	O	MLRA230	0.164		MLRA267	0.429
	MLRA105	-0.019		MLRA150	0.151		MLRA191	0.024		MLRA231	0.785			
	MLRA106	-0.021		MLRA152	40.616		MLRA192	0.027		MLRA232	0.887			
	MLRA107	-0.043		MLRA153	2.942		MLRA193	0.012		MLRA233	0.578			
	MLRA108	0.006		MLRA155	-0.076		MLRA194	0.026	P	MLRA234	2.324			

Table E.7. Percent Changes of Forest Land Prices per Major Land Resource Area (MLRA) in Second Counterfactual Scenario

LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change	LRR	MLRA	% change
D	MLRA043	82.516		MLRA109	82.149		MLRA156	85.599		MLRA195	82.212		MLRA235	88.879
	MLRA044	76.283		MLRA111			MLRA157	89.525		MLRA196	82.212		MLRA236	83.753
	MLRA046	82.367		MLRA112			MLRA159	84.147		MLRA197	82.156		MLRA238	87.629
	MLRA054			MLRA113			MLRA160	87.789		MLRA199	82.250		MLRA239	89.379
E	MLRA065	82.489		MLRA114			MLRA161	85.759		MLRA200	82.162		MLRA240	87.563
	MLRA066	78.640		MLRA115	80.958		MLRA162	86.735		MLRA202	82.154		MLRA241	88.083
	MLRA067	84.748		MLRA117			MLRA163	87.027		MLRA203	82.198		MLRA242	87.657
	MLRA070	79.888		MLRA118			MLRA164	86.803		MLRA204	82.153	R	MLRA243	82.729
F	MLRA072	75.408		MLRA119	79.605		MLRA165	82.351	N	MLRA205	83.174		MLRA244	83.971
	MLRA073	77.995		MLRA121	79.931		MLRA166	82.157		MLRA206	82.194		MLRA246	84.377
	MLRA074	72.771		MLRA122	76.176	L	MLRA167	86.149		MLRA207	82.861		MLRA247	87.524
	MLRA075	94.385		MLRA123			MLRA168	82.268		MLRA208	88.338		MLRA248	85.861
	MLRA076	82.134	I	MLRA125			MLRA169	82.218		MLRA210	88.617		MLRA249	87.162
	MLRA077	79.920		MLRA126			MLRA170	82.167		MLRA211	93.977		MLRA250	86.916
	MLRA078	78.000		MLRA127			MLRA172	82.775		MLRA212	89.649	S	MLRA252	83.787
	MLRA079	82.144		MLRA130		M	MLRA173	82.134		MLRA214	82.651		MLRA253	82.940
G	MLRA083			MLRA132			MLRA174	72.776		MLRA215	82.252		MLRA254	83.410
	MLRA084	93.403		MLRA133			MLRA175	82.132		MLRA216	78.784		MLRA255	87.542
	MLRA085	86.580		MLRA134			MLRA176	82.137		MLRA217	83.149	T	MLRA256	87.818
	MLRA088	86.677		MLRA135			MLRA177	82.136		MLRA218	83.360		MLRA257	
	MLRA089	78.458		MLRA136			MLRA178	82.166		MLRA219	85.948		MLRA258	84.648
	MLRA090	79.913	J	MLRA137	82.681		MLRA179	82.141		MLRA220	83.996		MLRA259	88.370
	MLRA091	84.877		MLRA138			MLRA181	78.015		MLRA221	87.632		MLRA260	88.800
	MLRA092	82.117		MLRA140			MLRA182	82.139		MLRA222	84.469		MLRA261	87.167
	MLRA093	79.933		MLRA144			MLRA184	82.139		MLRA223	85.320		MLRA262	85.525
	MLRA095	78.012		MLRA145			MLRA185	82.139		MLRA224	86.976		MLRA263	82.332
	MLRA096	76.163		MLRA147	93.644		MLRA186	82.139		MLRA225	87.971		MLRA264	83.100
	MLRA097	83.182		MLRA148	91.891		MLRA187	82.135		MLRA227	87.904	U	MLRA265	88.715
	MLRA100		K	MLRA080	82.420		MLRA188	82.145		MLRA228	87.416		MLRA266	86.372
H	MLRA104	79.917		MLRA149	83.557		MLRA189	82.140	O	MLRA230	82.449		MLRA267	82.826
	MLRA105	78.008		MLRA150	82.753		MLRA191	82.157		MLRA231	83.544			
	MLRA106	82.135		MLRA152	86.119		MLRA192	82.156		MLRA232	83.692			
	MLRA107	82.136		MLRA153	82.597		MLRA193	82.145		MLRA233	83.151			
	MLRA108	81.929		MLRA155	82.182		MLRA194	82.154	P	MLRA234	86.703			

Table E.8. Percentage Changes of Quantities and Prices of Composite Inputs to the Top Activity Nest in Second Counterfactual Scenario

Activities	Quantities			Prices		
	Value-added	Intermediate	Land	Value-added	Intermediate	Land
Aolsd	-0.010	-0.039	-0.292	0.073	0.132	0.641
Agran	-0.027	-0.048	-0.874	0.086	0.128	1.803
Aoagr	1.122	1.085		0.058	0.132	
Atobc	-0.050	-0.081	-2.752	0.038	0.100	5.674
Acott	-0.239	-0.267	-2.567	0.074	0.131	4.913
Asugr	-0.007	-0.027	-1.826	0.065	0.105	3.809
Aocrp	-0.462	-0.498	-3.306	0.047	0.121	6.020
Acatt	-0.016	-0.462	-7.669	0.071	0.970	17.348
Adair	0.011	-0.073	-2.012	0.091	0.259	4.267
Alogg	13.808	14.929	0.433	0.061	-4.728	86.955
Amini	0.051	0.056		0.075	0.065	
Autil	0.005	0.009		0.084	0.074	
Acons	0.141	0.133		0.036	0.051	
Amanf	0.051	0.071		0.057	0.018	
Awhol	0.053	0.052		0.049	0.052	
Aretl	0.041	0.036		0.047	0.057	
Atrns	0.034	0.035		0.050	0.049	
Ainfo	-0.010	-0.006		0.064	0.055	
Afinc	0.019	0.019		0.054	0.054	
Aland		0.007		0.083	0.069	
Aornt	0.008	0.029		0.098	0.057	
Aprof	0.003	-0.005		0.040	0.055	
Amgmt	0.037	0.034		0.048	0.054	
Aadmw	0.018	0.014		0.045	0.052	
Aeduc	-0.010	-0.023		0.036	0.061	
Ahlth	0.035	0.029		0.041	0.054	
Aentt	0.028	0.025		0.050	0.057	
Ahotl	0.022	0.018		0.050	0.056	
Aoser	0.042	0.037		0.044	0.053	
Agven	0.052	0.040		0.031	0.057	
Agvem	-0.303			0.041		

Table E.9. Percentage Changes of Quantities and Prices of Factors Used by Activities in Second Counterfactual Scenario

Activities	Quantities		Prices	
	Labor	Capital	Labor	Capital
Aolsd	0.009	-0.022	0.031	0.101
Agran	-0.002	-0.034	0.031	0.101
Aoagr	1.134	1.102	0.031	0.101
Atobc	-0.047	-0.079	0.031	0.101
Acott	-0.220	-0.251	0.031	0.101
Asugr	0.008	-0.023	0.031	0.101
Aocrp	-0.454	-0.486	0.031	0.101
Acatt	0.003	-0.029	0.031	0.101
Adair	0.038	0.006	0.031	0.101
Alogg	13.823	13.787	0.031	0.101
Amini	0.071	0.039	0.031	0.101
Autil	0.028	-0.003	0.031	0.101
Acons	0.143	0.112	0.031	0.101
Amanf	0.063	0.031	0.031	0.101
Awhol	0.061	0.030	0.031	0.101
Aretl	0.048	0.016	0.031	0.101
Atrns	0.043	0.011	0.031	0.101
Ainfo	0.004	-0.027	0.031	0.101
Afinc	0.030	-0.002	0.031	0.101
Aland	0.024	-0.008	0.031	0.101
Aornt	0.038	0.006	0.031	0.101
Aprof	0.007	-0.025	0.031	0.101
Amgmt	0.044	0.013	0.031	0.101
Aadmw	0.024	-0.007	0.031	0.101
Aeduc	-0.008	-0.039	0.031	0.101
Ahlth	0.039	0.008	0.031	0.101
Aentt	0.036	0.005	0.031	0.101
Ahotl	0.030	-0.002	0.031	0.101
Aoser	0.048	0.016	0.031	0.101
Agven	0.053	0.021	0.031	0.101
Agvem	-0.298	-0.330	0.031	0.101

Table E.10. Percentage Changes of Intermediate Commodity Consumption Quantities by Activity in Second Counterfactual Scenario

	Aolsd	Agran	Aoagr	Atobc	Acott	Asugr	Aocrp	Acatt	Adair	Alogg	Amini	Autil	Acons	Amanf	Awhol
Colsd	-0.112	-0.123	1.011	-0.170				-0.119	-0.082					-0.059	
Cgran	-0.202	-0.213	0.920	-0.260	-0.430		-0.666	-0.209	-0.172					-0.149	
Coagr	-0.095	-0.106	1.028	-0.153	-0.324	-0.096	-0.559	-0.102	-0.065	12.043		-0.075	0.037	-0.042	-0.044
Ctobc				-0.116										-0.005	
Ccott	-0.253				-0.482									-0.201	
Csugr						-0.221								-0.167	
Cocrp	-0.457	-0.468	0.662	-0.515	-0.685	-0.458	-0.920	-0.464	-0.427		-0.395		-0.325	-0.404	
Ccatt	-1.074	-1.085	0.038		-1.300	-1.075	-1.534	-1.081	-1.045					-1.022	
Cdair			1.055					-0.075	-0.039					-0.016	
Clogg										20.296				7.321	
Cmini	-0.016	-0.027	1.108	-0.074	-0.245	-0.017	-0.481	-0.023	0.014	12.132	0.046	0.004	0.116	0.037	0.035
Cutil	-0.014	-0.025	1.110	-0.072	-0.243	-0.015	-0.478	-0.020	0.016	12.134	0.048	0.006	0.118	0.039	0.037
Ccons	0.004	-0.007	1.128	-0.054	-0.225	0.002	-0.461		0.033	12.154	0.065	0.023	0.136	0.056	0.055
Cmanf	0.006	-0.005	1.130	-0.052	-0.223	0.005	-0.459	-0.001	0.035	12.156	0.068	0.026	0.138	0.059	0.057
Cwhol	-0.001	-0.011	1.124	-0.058	-0.229	-0.002	-0.465	-0.007	0.029	12.149	0.061	0.019	0.132	0.052	0.051
Cretl	0.001	-0.010	1.126	-0.057	-0.228	0.000	-0.463	-0.005	0.031	12.151	0.063	0.021	0.134	0.054	0.052
Ctrns	0.000	-0.011	1.124	-0.058	-0.229	-0.001	-0.464	-0.007	0.030	12.150	0.062	0.020	0.132	0.053	0.051
Cinfo	-0.004	-0.015	1.121	-0.062	-0.232	-0.005	-0.468	-0.010	0.026	12.146	0.058	0.016	0.129	0.049	0.047
Cfinc	-0.001	-0.012	1.124	-0.059	-0.229	-0.002	-0.465	-0.007	0.029	12.149	0.061	0.019	0.132	0.052	0.050
Cland			1.111	-0.071					0.017		0.049	0.007	0.120	0.040	0.038
Cornt	-0.015	-0.026	1.110	-0.073	-0.243	-0.016	-0.479	-0.021	0.015	12.133	0.047	0.005	0.118	0.038	0.036
Cprof	0.004	-0.007	1.128	-0.054	-0.225	0.003	-0.461	-0.003	0.034	12.154	0.066	0.024	0.136	0.057	0.055
Cmgmt											0.062		0.132	0.053	0.051
Cadmw	0.003	-0.008	1.127	-0.055	-0.226	0.002	-0.462	-0.004	0.032	12.153	0.065	0.023	0.135	0.056	0.054
Ceduc	0.003	-0.008	1.128	-0.055	-0.226	0.002	-0.461	-0.003	0.033		0.065	0.023	0.136	0.056	0.054
Chlth															
Centt	0.000	-0.011	1.124	-0.058	-0.229	-0.001	-0.465	-0.007	0.030	12.150	0.062	0.020	0.132	0.053	0.051
Chotl	0.000	-0.011	1.125	-0.058	-0.229	-0.001	-0.464	-0.006	0.030	12.150	0.062	0.020	0.133	0.053	0.051
Coser	0.002	-0.009	1.127	-0.056	-0.227	0.001	-0.462	-0.004	0.032	12.152	0.064	0.022	0.134	0.055	0.053
Cgven	0.025	0.014	1.149	-0.033	-0.204	0.023	-0.440		0.054	12.177	0.086	0.044	0.157	0.077	0.076
Cuncl	0.000	-0.011	1.125				-0.464	-0.006	0.030	12.150	0.062	0.020	0.133	0.053	0.051

Table E.10. Continued

	Aretl	Atrns	Ainfo	Afinc	Aland	Aornt	Aprof	Amgmt	Aadmw	Aeduc	Ahlth	Aentt	Ahotl	Aoser	Agven
Colsd															
Cgran	-0.164						-0.206	-0.168		-0.221	-0.173	-0.176	-0.182		
Coagr	-0.057	-0.062	-0.100	-0.075	-0.080	-0.065	-0.099	-0.061	-0.081	-0.114	-0.066	-0.069	-0.075	-0.058	-0.054
Ctobc															
Ccott							-0.257	-0.219							
Csugr							-0.224	-0.186							
Cocrp					-0.442	-0.427	-0.461	-0.423	-0.444	-0.476		-0.431			
Ccatt							-1.078	-1.040							
Cdair							-0.073								
Clogg															
Cmini	0.021	0.016	-0.021	0.004	-0.001	0.014	-0.020	0.018	-0.003	-0.035	0.013	0.010	0.004	0.021	0.025
Cutil	0.024	0.019	-0.019	0.006	0.001	0.016	-0.018	0.020	0.000	-0.033	0.015	0.012	0.006	0.024	0.027
Ccons	0.041	0.036	-0.002	0.023	0.019	0.034	0.000	0.038	0.017	-0.015	0.032	0.030	0.023	0.041	0.045
Cmanf	0.043	0.038	0.000	0.025	0.021	0.036	0.002	0.040	0.019	-0.013	0.034	0.032	0.025	0.043	0.047
Cwhol	0.037	0.032	-0.006	0.019	0.014	0.030	-0.004	0.034	0.013	-0.019	0.028	0.025	0.019	0.037	0.041
Cretl	0.039	0.034	-0.004	0.021	0.016	0.031	-0.003	0.035	0.015	-0.018	0.030	0.027	0.021	0.039	0.043
Ctrns	0.038	0.033	-0.005	0.020	0.015	0.030	-0.004	0.034	0.014	-0.019	0.029	0.026	0.020	0.037	0.041
Cinfo	0.034	0.029	-0.009	0.016	0.011	0.026	-0.007	0.030	0.010	-0.023	0.025	0.022	0.016	0.034	0.038
Cfinc	0.037	0.032	-0.006	0.019	0.014	0.030	-0.004	0.034	0.013	-0.019	0.028	0.025	0.019	0.037	0.041
Cland	0.025	0.020	-0.018	0.007	0.002	0.017	-0.017	0.021	0.001	-0.032	0.016	0.013	0.007	0.025	0.029
Cornt	0.023	0.018	-0.020	0.005	0.000	0.015	-0.019	0.019	-0.001	-0.034	0.014	0.011	0.005	0.023	0.027
Cprof	0.041	0.036	-0.001	0.023	0.019	0.034	0.000	0.038	0.017	-0.015	0.033	0.030	0.023	0.041	0.045
Cmgmt	0.037	0.032	-0.005	0.020	0.015	0.030	-0.004		0.013	-0.019	0.029	0.026	0.020	0.037	
Cadmw	0.040	0.035	-0.003	0.022	0.018	0.033	-0.001	0.037	0.016	-0.016	0.031	0.029	0.022	0.040	0.044
Ceduc	0.041	0.036	-0.002	0.023	0.018		-0.001		0.017	-0.016	0.032	0.029		0.041	0.045
Chlth	0.041						0.000		0.017		0.032	0.030		0.041	
Centt	0.038	0.032	-0.005	0.020	0.015	0.030	-0.004	0.034	0.013	-0.019	0.029	0.026	0.020	0.037	0.041
Chotl	0.038	0.033	-0.005	0.020	0.015	0.030	-0.004	0.034	0.014	-0.019	0.029	0.026	0.020	0.038	0.041
Coser	0.040	0.035	-0.003	0.022	0.017	0.032	-0.002	0.036	0.016	-0.017	0.031	0.028	0.022	0.039	0.043
Cgven	0.062	0.057	0.019	0.044	0.040	0.055	0.021	0.059	0.038	0.006	0.053	0.051	0.044	0.062	0.066
Cuncl	0.038	0.033	-0.005	0.020	0.015	0.031	-0.003	0.035	0.014	-0.018	0.029	0.026	0.020	0.038	0.042

Table E.11. Percentage Changes of Prices and Quantities of Household Commodity Consumption in Second Counterfactual Scenario

Commodities	Quantities									Prices
	< 10 K	10 - 15 K	15 - 25 K	25 - 35 K	35 - 50 K	50 - 75 K	75 - 100 K	100 - 150 K	> 150 K	
Colsd										0.278
Cgran	-0.119	-0.147	-0.164	-0.176	-0.180	-0.191	-0.191	-0.189	-0.147	0.459
Coagr	-0.012	-0.040	-0.057	-0.069	-0.073	-0.083	-0.084	-0.082	-0.040	0.244
Ctobc										0.170
Ccott										0.562
Csugr										0.495
Cocrp	-0.375	-0.402	-0.419	-0.432	-0.436	-0.446	-0.446	-0.444	-0.402	0.974
Ccatt	-0.992	-1.019	-1.037	-1.049	-1.053	-1.063	-1.063	-1.061	-1.019	2.238
Cdair										0.191
Clogg										-13.039
Cmini	0.067	0.039	0.022	0.009	0.005	-0.005	-0.005	-0.003	0.039	0.086
Cutil	0.069	0.042	0.024	0.012	0.008	-0.002	-0.003	-0.001	0.041	0.081
Ccons										0.046
Cmanf	0.088	0.061	0.044	0.031	0.027	0.017	0.017	0.019	0.061	0.042
Cwhol	0.082	0.055	0.037	0.025	0.021	0.011	0.010	0.012	0.055	0.055
Cretl	0.084	0.057	0.039	0.027	0.023	0.013	0.012	0.014	0.057	0.051
Ctrns	0.083	0.056	0.038	0.026	0.022	0.012	0.011	0.013	0.055	0.053
Cinfo	0.079	0.052	0.034	0.022	0.018	0.008	0.007	0.009	0.052	0.061
Cfinc	0.082	0.055	0.037	0.025	0.021	0.011	0.010	0.012	0.055	0.055
Cland	0.070	0.043	0.025	0.013	0.009	-0.001	-0.002	0.000	0.043	0.079
Cornt	0.068	0.041	0.023	0.011	0.007	-0.003	-0.004	-0.002	0.041	0.083
Cprof	0.087	0.059	0.042	0.029	0.025	0.015	0.015	0.017	0.059	0.046
Cmgmt										0.054
Cadmw	0.085	0.058	0.041	0.028	0.024	0.014	0.014	0.016	0.058	0.048
Ceduc	0.086	0.059	0.041	0.029	0.025	0.015	0.014	0.016	0.059	0.047
Chlth	0.086	0.059	0.041	0.029	0.025	0.015	0.014	0.016	0.059	0.046
Centt	0.083	0.055	0.038	0.026	0.022	0.011	0.011	0.013	0.055	0.054
Chotl	0.083	0.056	0.038	0.026	0.022	0.012	0.011	0.013	0.055	0.053
Coser	0.085	0.058	0.040	0.028	0.024	0.014	0.013	0.015	0.057	0.049
Cgven	0.107	0.080	0.062	0.050	0.046	0.036	0.035	0.037	0.080	0.004
Cuncl	0.083	0.056	0.038	0.026	0.022	0.012	0.011	0.013	0.056	0.053
Cgvem										0.041

Table E.12. Percentage Changes of Prices and Quantities of Exported Commodities in Second Counterfactual Scenario

Commodity	Quantities		Prices	
	Rest of the world	Rest of the U.S.	Rest of the world	Rest of the U.S.
Colsd	-0.166	-0.166	0.237	0.237
Cgran	-0.276	-0.276	0.395	0.395
Coagr	0.161	0.161	-0.231	-0.231
Ctobc	-0.095	-0.095	0.136	0.136
Ccott	-0.378	-0.378	0.540	0.540
Csugr	-0.320	-0.320	0.458	0.458
Cocrp	-0.857	-0.857	1.225	1.225
Ccatt	-1.460	-1.460	2.086	2.086
Cdair	-0.120	-0.120	0.172	0.172
Clogg	10.449	10.449	-13.879	-13.879
Cmini	-0.029	-0.029	0.042	0.042
Cutil	-0.041	-0.041	0.058	0.058
Ccons	0.005	0.005	-0.007	-0.007
Cmanf	-0.001	-0.001	0.001	0.001
Cwhol	-0.016	-0.016	0.023	0.023
Cretl		-0.019		0.027
Ctrns	-0.019	-0.019	0.028	0.028
Cinfo	-0.035	-0.035	0.050	0.050
Cfinc	-0.025	-0.025	0.035	0.035
Cland	-0.043	-0.043	0.062	0.062
Cornt	-0.042	-0.042	0.059	0.059
Cprof	-0.025	-0.025	0.036	0.036
Cmgmt	-0.020	-0.020	0.028	0.028
Cadmw	-0.023	-0.023	0.032	0.032
Ceduc	-0.028	-0.028	0.040	0.040
Chlth	-0.019	-0.019	0.027	0.027
Centt	-0.024	-0.024	0.034	0.034
Chotl	-0.024	-0.024	0.035	0.035
Coser	-0.018	-0.018	0.025	0.025
Cgven	0.008		-0.011	
Cuncl	-0.015	-0.015	0.021	0.021
Cgvem		-0.089		0.127

Table E.13. Percentage Changes of Prices and Quantities of Imported Commodities in Second Counterfactual Scenario

Commodity	Quantities		FOB Prices	
	Rest of the world	Rest of the U.S.	Rest of the world	Rest of the U.S.
Colsd	0.105		0.211	
Cgran	0.174	0.174	0.348	0.348
Coagr	0.234	0.234	0.468	0.468
Ctobc	0.070		0.139	
Ccott	0.181	0.181	0.362	0.362
Csugr	0.178	0.178	0.356	0.356
Cocrp	0.339	0.339	0.679	0.679
Ccatt	0.755		1.509	
Cdair	0.077	0.077	0.154	0.154
Clogg	-4.067	-4.067	-8.010	-8.010
Cmini	0.045	0.045	0.091	0.091
Cutil	0.037	0.037	0.074	0.074
Ccons		0.042		0.083
Cmanf	0.029	0.029	0.058	0.058
Cwhol		0.033		0.066
Cretl		0.028		0.056
Ctrns	0.029	0.029	0.059	0.059
Cinfo	0.025	0.025	0.049	0.049
Cfinc	0.027	0.027	0.053	0.053
Cland		0.034		0.068
Cornt	0.037	0.037	0.075	0.075
Cprof	0.019	0.019	0.039	0.039
Cmgmt		0.030		0.059
Cadmw	0.023	0.023	0.046	0.046
Ceduc	0.018	0.018	0.036	0.036
Chlth	0.024	0.024	0.049	0.049
Centt	0.027	0.027	0.053	0.053
Chotl		0.026		0.052
Coser	0.027	0.027	0.055	0.055
Cgven		0.009		0.018
Cuncl	0.028	0.028	0.056	0.056
Cgvem		-0.033		-0.067

Table E.14. Percentage Changes of Institutional Incomes in Second Counterfactual Scenario

Institution	% change
Households	
< 10 K	0.138
10 - 15 K	0.110
15 - 25 K	0.093
25 - 35 K	0.080
35 - 50 K	0.076
50 - 75 K	0.066
75 - 100 K	0.065
100 - 150 K	0.064
> 150 K	0.102
Government	
Fed. non-defense	0.121
Fed. defense	0.105
Fed. investment	0.082
State non-education	0.117
State education	0.113
State investment	0.109
Investment	0.235
Inventory	0.088
Enterprises	0.321
Net foreign investment	
Rest of the U.S.	1,152.183
Rest of the world	0.161