UNDERSTANDING SUSTAINABLE DEVELOPMENT PROGRESS IN A METACOUPLED WORLD

By

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ABSTRACT

With industrialization and human development over the past centuries, one of the primary challenges to humans is the global biodiversity loss at a massively accelerated rate. The United Nations (UN) has adopted the 17 Sustainable Development Goals (SDGs), aiming to provide human welfare and conserve the planet, now and into the future. Two of the SDGs directly address biodiversity conservation and sustainable development - SDG 14 (life below water) and SDG 15 (life on land). Although the UN has issued annual reports on SDGs, the reports do not consistently reveal the progress over time, because of inconsistent methods such as estimation based on different indicators across years. Besides the lack of a consistent assessment of integrated efforts (e.g., SDGs 14 and 15) in biodiversity conservation and sustainable development, the other challenge for conservation science is to identify key drivers for the socioecological changes and achieve environmental and socioeconomic sustainability within and across boundaries. The main objective of this dissertation is to fill the knowledge gaps by providing a consistent assessment of SDGs 14 and 15 over time (Chapter 2), exploring the key drivers for socioecological changes (Chapter 3), and conducting scenario analysis through the metacoupling framework and modeling approaches (Chapter 4). This dissertation would better inform countries to review their sustainable development progress associated with Life below Water and Life on Land and empower decisionmakers with support for future conservation planning and sustainable development. The opensource database would contribute to future research in biodiversity conservation, sustainability science, and other disciplines. The methodology used in this study can also be generalized and contribute to the broader scientific community and beyond.

To my dearest parents, grandparents, and myself

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PREFACE

The chapters in this dissertation were conceptualized as individual research projects under the primary theme and common goals. While the chapters principally represent my own work, I use the pronoun *we* throughout the dissertation as an acknowledgement for the contributions of my collaborators. I am deeply honored to work with them and genuinely grateful for their contribution, enlightenment, and guidance along this journey. Without them, none of this would have been possible.

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CHAPTER 1: INTRODUCTION

1.1 Background

With industrialization and human development over the past centuries, one of the primary challenges to humans is the global biodiversity loss at a massively accelerated rate (Mace et al. 2005, Rockström et al. 2009). The United Nations (UN) has called for sustainable development and adopted the 17 Sustainable Development Goals (SDGs), aiming to provide human welfare and conserve the planet, now and into the future. Two of the SDGs take the initiative for an integrative assessment of biodiversity conservation efforts and economic development – SDG 14 (Life below Water) and SDG 15 (Life on Land).

This initiative appears hopeful to fill the current gap of estimating conservation efforts and economic development separately. Although annual reports were produced by the United Nations to inform how sustainable development progress is being made on a global scale, those annual assessments were considered problematic, because the assessed values and indicators selections were inconsistent from one year to the other (Xu et al. 2020). Therefore, this dissertation aims to evaluate global SDGs 14 and 15 progress over time, identify countries that have high and low SDG scores, and explore the drivers for countries' SDGs 14 and 15 score variation.

It is challenging for conservation science to achieve environmental and socioeconomic sustainability within and across boundaries due to the complex system dynamics (interactions among system components, emergent behavior, etc.). To advance the knowledge of complex socio-environmental interactions within and across systems, this dissertation applies the metacoupling framework (Liu 2017) and uses System Dynamics to simulate the complex system interactions and processes.

The outcomes of this dissertation (1) fill the current knowledge gap in the SDGs 14 and 15 assessments at a global scale, (2) identify countries that did better or worse in SDGs 14 and 15, (3) provide potential explanations that drive the SDGs score variation, and (4) discover the impact of endogenous and exogenous environmental and social variables on SDG 15. This dissertation hopes to better inform countries on how to review their sustainable development progress associated with Life below Water and Life on Land and empowers decision-makers with support for future conservation planning and sustainable development. The methodology used in this study can also be generalized and contribute to the broader scientific community and beyond.

1.2 Theoretical framework

The metacoupling framework (Liu 2017) is a powerful tool for understanding the complex system interactions within and across different scales and borders. Three types of human-nature interactions (couplings) are delineated under the complete metacoupling framework (Figure 1.1): (1) within a coupled system (intracoupling), (2) between distant coupled systems (telecoupling), and (3) between adjacent coupled systems (pericoupling).



Figure 1.1. Three categories of the conceptual metacoupling framework – intracoupling, telecoupling, and pericoupling (Liu, 2017).

Systems can be defined as sending, receiving, and/or spillover systems depending on the directional movement of flows. Within each system, causes, agents, and effects are included for analysis. Between systems, there are direct or indirect flows (e.g., material, money, information).



Figure 1.2. Sending, receiving, spillover systems and major system components under the metacoupling framework (Liu et al., 2013). Within each system, causes and effects are interrelated through agents. Between systems, flows of directional movement (e.g., materials, energy, and information) influence system interactions.

1.3 Objectives and research questions

Chapter 2: Global Decadal Assessment of Life below Water and on Land

<u>Research questions:</u> (1) How had sustainable development in terms of life below water and on land progressed, as measured in SDGs 14 and 15? (2) How did the SDG scores change before and after the adoption of SDGs in 2015? (3) Which countries had high or low SDG scores? (4) Which countries experienced drastic changes (increase or decrease) in SDG scores?

This chapter evaluates countries' SDGs 14 and 15 scores (at goal and target levels) between 2010 and 2020, based on the indicator selection and guidance from the United Nations. I also compare countries' SDG progress before and after 2015 (when SDGs were adopted by United Nations member states).

Chapter 3: Analyzing Global Threats and Opportunities for Life below Water and on Land

<u>Research questions:</u> (1) What drives the sustainable development progress variation among countries, in terms of the SDGs 14 and 15 measurements? (2) How different are the drivers for different groups of countries (e.g., income level, biodiversity hotspot)? (3) Are there any synergies and trade-offs between SDGs and their Targets?

This chapter uses multivariate regressions with regularization techniques to explore the drivers for countries' SDG variation. Several environmental and social variables are used for analysis. The data are either from publicly available databases or from the previous chapter.

Chapter 4: Sustaining Life on Land through a Metacoupling Approach: Simulating Spain's SDG 15 Progress

<u>Research questions:</u> (1) How does the change of forest area impact a country's SDG 15 progress? (2) What parameter has the largest impact on a country's SDG 15 progress?

This chapter frames the interactions among forest, land transformation, population, and SDG 15 with the metacoupling framework, then applies the system dynamics model (SDM) to simulate the stocks (e.g., forest area, population) change over the interactions. The data are either from publicly available databases or from the previous chapters.

CHAPTER 2: GLOBAL DECADAL ASSESSMENT OF LIFE BELOW WATER AND ON LAND

2.1 Abstract

The United Nations (UN) has adopted the 17 Sustainable Development Goals (SDGs), aiming to provide human welfare and conserve the planet, now and into the future. Two of the SDGs directly address biodiversity conservation and sustainable development – SDG 14 (life below water) and SDG 15 (life on land). Although the UN has issued annual reports on SDGs, the reports did not consistently reveal the progress over time, because of inconsistent methods such as estimation based on different indicators across years. Our research examined the dynamics of the same 10 indicators for SDGs 14 and 15 between 2010 and 2020. Results indicate that the overall SDG 14 scores had a small growth between 2010 and 2020, whereas the substantial increase in SDG 15 scores spotlighted the conservation efforts and sustainable use of terrestrial ecosystem services, especially in countries with biodiversity hotspots. Globally, there was more progress in terms of SDG 15 scores during 2015–2020 than during 2010–2015 (before the UN adopted SDGs in 2015). Surprisingly, SDG 14 score had smaller progress during 2015–2020 than during 2010–2015 (before the UN adopted SDGs in 2015). Special attention should be given to low-income countries lagging in sustainable development performance when implementing the post-2020 global biodiversity framework.

2.2 Summary

In this chapter, I evaluated countries' SDGs 14 and 15 performances between 2010 and 2020, based on the indicator selection and guidance from the United Nations. This delineates how countries did in SDGs 14 and 15 over the past decade, and that through comparisons, which countries did well or poorly. This evaluation step fills the current knowledge gap at a global scale of estimating conservation efforts and economic development separately, and it also provides

significant data for the following chapters. With collaborative efforts, I designed the research, collected raw data, performed data analysis, interpreted the results, and wrote the chapter. This chapter has been published in an open-access journal with details below.

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CHAPTER 3: ANALYZING GLOBAL THREATS AND OPPORTUNITIES FOR LIFE BELOW WATER AND ON LAND

3.1 Abstract

Anthropogenic activities have increasingly altered the environment and challenged global socioecological sustainability. Two of the 17 Sustainable Development Goals (SDGs) – SDGs 14 (life below water) and 15 (life on land) - aim to conserve biodiversity and sustainably use natural resources for sustainable development. Countries have achieved significant positive progress in SDGs 14 and 15 in the past decade at different rates. But what drives or impedes countries' SDG progress remains unknown. Here, we identified key factors that directly and indirectly affect countries' SDG 14 (52 countries) and 15 (143 countries) progress between 2010 and 2020. Our results demonstrate mixed expected and unexpected impacts of multiple drivers on SDG progress for countries across different income and biodiversity hotspot groups. Fish Production has the most profound negative impact on SDG 14 progress, and the impact on SDG 15 progress for countries of different income levels and biodiversity hotspot status varied substantially among drivers such as Agricultural Land Percentage, Forestry Import, Forestry Production, Forest Rents in GDP Percentage, and Political Stability. Synergies and trade-offs between SDGs and their Targets call for special attention for policy making to maximize the common benefits of multiple socioecological sustainability goals while minimizing the conflicting interests. Incorporating the significant direct and indirect drivers for SDG progress in future planning is imperative as the deadline for the 2030 agenda approaches.

3.2 Introduction

In 2015, the United Nations Member States adopted 17 Sustainable Development Goals (SDGs) and aimed to address big sustainability challenges globally. Two of the 17 SDGs directly

aim to prevent biodiversity loss and buttress sustainable natural resources management: SDG 14 (life below water) – Conserve and sustainably use the oceans, seas and marine resources for sustainable development and SDG 15 (life on land) – Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. The progress of SDGs 14 and 15 revealed countries' integrated efforts in biodiversity conservation and socioeconomic sustainable development. Countries have achieved significant positive progress in SDGs 14 and 15 between 2010 and 2020 at different paces (Zhang et al., 2023); however, what drives countries' SDG progress and what factors affect the rate of progress remain yet unclear.

Studies have shown the drivers for environmental stress and sustainability from the disciplines of sociology, economics, geography, etc. and interdisciplinary perspectives over past decades (Stern et al., 1992, Dietz and Rosa, 1994, Dietz et al., 2015, Dietz, 2017, Jorgenson et al., 2019). The spirit of SDGs is to achieve both environmental and socioeconomic sustainability; therefore, it is important to investigate socioecological stressors for environment and human wellbeing. But the literature that explained the drivers for the SDG progress is rather limited, nor does an exhaustive theory exist. Earlier studies have explored the linkage between environmental impact and population, affluence, and technology (Stern et al., 1992, Dietz and Rosa, 1994, Ehrlich and Holdren, 1971), which structured the debate about the effects of population, affluence and technology on the environment and provided a simple and robust framework for broader study references. Recent research has examined additional factors such as social dimensions of economic system, power, social stratification, inequality, and governance impact on global climate change (Jorgenson et al., 2019). The study of direct and indirect drivers (Díaz et al., 2019) further investigates their environmental impacts on terrestrial, freshwater, and marine ecosystems.

Important direct factors include land/sea use change, direct exploitation, climate change, pollution, invasive alien species; indirect factors are grouped into four categories: demographic and sociocultural, economic and technological, institutions and governance, conflicts and epidemics (Díaz et al., 2019). This provides guidelines for research on environmental impact and sheds light on studying the drivers for SDG progress. The metacoupling framework (Liu, 2017) that helps understand environmental and socioeconomic interactions within and across adjacent and distant systems is also useful to identify important natural and social, internal and external variables and map the interactions among them within and across systems (Wu et al., 2021, Chung and Liu, 2022). The metacoupling framework is more general and broader than the world systems framework that has sometimes been used to explain differences across countries in stress placed on the environment (Burns et al., 1994, Burns et al., 2003, Jorgenson and Givens, 2013).

A major barrier to social scientific inquiry into the human–environment relationship is the difficulty in selecting appropriate analytic techniques and models that allow for a precise specification of the functional form of the relationship between driving forces and environmental impacts (York et al., 2003). Although linear regression is a simple, interpretable, and useful tool to estimate the direct and indirect drivers' impact on SDG progress, it is limited by the knowledge of specification and data availability, and the misspecification of regression can lead to biased, inconsistent, inefficient, and misleading predictions (Dewey et al., 2000). To reduce the number of irrelevant variables while balancing the explaining power of the regression model, the Least Absolute Shrinkage and Selection Operator (LASSO) (Tibshirani, 1996) regression is a machine learning process to regulate the number of variables by adding a penalty term to the traditional regression model and shrinking some coefficients towards zero. Studies that used the LASSO regression for variable selection have yielded interpretable models by selecting appropriate

variables and reducing the risk of overfitting (Muthukrishnan and Rohini, 2016, Shortreed and Ertefaie, 2017, Wang et al., 2018). LASSO regression is useful as an exploratory method and a parsimonious model, but it may produce spurious conclusions if interpreted causally without care.

The Environmental Kuznets Curve (Kuznets, 2019, Grossman and Krueger 1991) has shown that income differences among countries could lead to different patterns of energy use, economic growth, and the environmental outcomes (Stern, 2004, Leal and Marques, 2022). Earlier research has observed that countries of different income levels and biodiversity hotspot status performed significantly differently in terms of SDG 14 and 15 progress (Zhang et al., 2023). To prevent capturing only the average impact and to draw policy implications that are salient for specific countries, in this article we studied different drivers' impact on SDG progress by allowing interactions of countries' income level and biodiversity hotspot status with other independent variables. In particular, we addressed the following questions: (1) What drives the sustainable development progress variation among countries, in terms of the SDGs 14 and 15 measurements? (2) How different are the drivers for different groups of countries (e.g., income level, biodiversity hotspot)? (3) Are there any synergies and trade-offs between SDGs and their Targets?

We first selected drivers for SDG progress analysis based on the inclusion of relevant direct and indirect drivers (Díaz et al., 2019) with the best available data for the study period between 2010 and 2020: 21 independent variables for SDG 14 among 52 countries/regions and 25 variables for SDG 15 among 143 countries/regions. Then interaction terms were generated based on countries' income level and biodiversity hotspot status, which expanded to 40 independent variables for SDG 14 (19 high-income countries, 33 low-income countries) and 71 for SDG 15 (53 biodiversity-hotspot countries, and 90 non-hotspot countries. See Methods section for details about income level and biodiversity hotspot status classification for SDGs 14 and 15). We utilized the LASSO technique to reduce the number of irrelevant variables and establish reliable statistical inferences. Besides SDG progress at the Goal level, we regressed the drivers against each SDG Target, and analyzed 3 Targets under SDG 14 and 6 Targets under SDG 15. Finally, we compared the multiple regression results and scrutinized the synergies and trade-offs between SDGs and Targets.

3.3 Methodology

3.3.1 Selection of drivers for SDG score change

The goal of this study is to find drivers for SDGs 14 and 15 score change and analyze their impact as completely as possible. Studies have shown that land/sea use change, direct exploitation, climate change, pollution, and invasive alien species were considered the direct drivers for terrestrial, freshwater, and marine ecosystem change (Díaz et al., 2019, Didham et al., 2005, Nelson, 2005, Nelson et al., 2006). Other indirect drivers that may cause those social and ecosystem changes were categorized as demographic and sociocultural (e.g., population size and growth, age distribution), economic and technological (e.g., economic growth, consumption), institutions and governance (e.g., rule of laws, governance performance), and conflicts and epidemics (Díaz et al., 2019, Didham et al., 2005, Nelson, 2005). Based on the metacoupling framework, we developed a conceptual framework of drivers and effects between natural and human systems to understand the relationship between direct and indirect drivers for SDG progress within and across countries (Figure 3.1). To be inclusive whilst relatable to SDG score change with data limitation, we first included 21 variables for SDG 14 (Control of corruption index, Crops and animals export, Crops and animals import, Fish export, Fish import, Fish production, GDP, Government effectiveness index, Political stability index, Population density, Population growth rate, Total population, Regulatory quality index, Rule of law index, Temperature change, Tourist number, Voice and accountability index, Population ages between 0 and 14, Population ages between 15 and 64, Population ages over 65, GDP per capita), and 25 variables for SDG 15 (Agricultural land percentage of total land area, Agricultural land square kilometer, Control of corruption index, Crops and animals export, Crops and animals import, Forest area in square kilometer, Forest Rents percentage of GDP, Forest export, Forest import, Forestry production, GDP, Government effectiveness index, Political stability index, Air Pollution of PM 2.5, Population density, Population growth rate, Total population, Regulatory quality index, Rule of law index, Temperature change, Voice and accountability index, Population ages between 0 and 14, Population ages between 15 and 64, Population ages over 65, GDP per capita).



Figure 3.1. Direct and indirect causes of natural and human elements for SDG progress. The internal causes are natural processes and human activities within a country. The effect of the focal country (e.g., country X) could be impacted by its neighboring (country Y) and distant (country Z) countries through trade, which is considered as an external cause.

This study period was between 2010 and 2020, with a coverage of 52 countries/regions for SDG 14 (in 2011, 2013, 2015, 2017, and 2019) and 143 for SGD 15 (annually from 2010 to 2019) analysis (Figure 3.2). We used the SDGs 14 and 15 scores from a published database (Zhang et al., 2023), and we collected the independent variable data from publicly available sources including the World Bank Group (Worldwide Governance Indicators, World Development Indicators), World Health Organization, and United Nations Food and Agriculture Organization (FAO Statistics and Climate).



Figure 3.2. Countries' spatial distribution by (A) income level for SDG 14 analysis, (B) income level and biodiversity hotspot status for SDG 15 analysis.

3.3.2 Regression form specification from STIRPAT and empirical observation

We used the ordinary least square regression model to analyze the impact of drivers for SDG score change. To minimize the residual square of error term and make the estimated impact (coefficient) of drivers (independent variable) on SDG score (dependent variable) change comparable, we normalized each independent variable with scale function in R (Becker et al., 1988).

$$X_{scaled} = \frac{\left(X_{original} - \bar{X}\right)}{S}$$

Where $X_{original}$ is the original X value, \overline{X} is the sample mean, and S is the sample standard deviation.

We did not use this method to standardize SDG score (dependent variable) because they had been normalized in sourced data (ranging from 0 to 100).

To determine the appropriate specification form of variables included in the model, we plotted each independent variable against SDG 14 and 15 scores (dependent variable) separately (Figures A3.2 and A3.4]. This step provided empirical evidence besides theories of anthropogenic impacts on the environment such as the Stochastic Impacts by Regression Population, Affluence and Technology (STIRPAT) (Dietz and Rosa, 1994, York et al., 2003) of determining the appropriate form (e.g., original form, log form) of each independent variable in the regression. We kept the following variables in the original form: for SDG 14, they are Control of corruption index, Government effectiveness index, Political stability index, Population growth rate, Regulatory quality index, Rule of law index, Temperature change, Voice and accountability index, GDP per capita; and for SDG 15, they are Agricultural land percentage of total land area, Control of corruption index, Forest Rents percentage of GDP, Forest export, Forest import, Forestry production, Government effectiveness index, Political stability index, Population density, Population growth rate, Regulatory quality index, Rule of law index, Temperature change, Voice and accountability index, GDP per capita. We converted the following variables into the log form: for SDG 14, they are Crops and animals export, Crops and animals import, Fish export, Fish import, Fish production, GDP, Population density, Total population, Tourist number, Population ages between 0 and 14, Population ages between 15 and 64, Population ages over 65; for SDG 15, they are Agricultural land square kilometer, Crops and animals export, Crops and animals import,

Forest area in square kilometer, GDP, Air Pollution of PM 2.5, Total population, Population ages between 0 and 14, Population ages between 15 and 64, Population ages over 65.

Because some independent variables explained SDG score change differently across income levels and/or biodiversity hotspots, we created additional interaction terms of high-income * independent variable in the regression for SDG 14; for SDG 15, we added biodiversity-hotspot * independent variable interaction terms besides the income level [Supplementary Methods]. The classification of countries into high/low-income and biodiversity/non-biodiversity hotspots (Figure 3.2) was adapted from the sourced SDG 14 and 15 data (Zhang et al., 2023, Chung and Liu, 2022). For SDG 14, countries with more than \$12,696 gross national income per capita (World Bank Country and Leading Groups, 2021) were categorized as high-income countries (n=19); otherwise, they were low-income countries (n=33). For SDG 15, countries identified as high biodiversity hotspots in the literature (Zhang et al., 2023, Chung and Liu, 2022) were categorized as biodiversity-hotspot countries (n=53); otherwise, they were non-hotspot countries (n=90) in this study. The addition of interaction terms effectively differentiated the impact of several variables on SDG scores when countries were in different income and biodiversity groups.

3.3.3 LASSO regression model building

With all those interaction terms included in the Ordinary Least Square regression, 40 independent variables were analyzed for SDG 14, and 71 for SDG 15. To reduce the number of irrelevant variables while balancing the explaining power of the regression model, we applied the machine learning regression shrinkage and selection approach via the LASSO regularization technique (Tibshirani,1996) to eliminate those statistically insignificant variables (Figures A3.5 and A3.6). The LASSO regression is intended to balance model simplicity and accuracy, by adding a penalty term to the traditional linear regression model and shrinking some coefficients towards

zero. The LASSO regression provides an interpretable model and reduces the risk of overfitting. Studies that used the LASSO regression for variable selection while comparing with other selection approaches have shown the effectiveness in selecting appropriate variables (Muthukrishnan and Rohini, 2016, Shortreed and Ertefaie, 2017, Wang et al., 2018). However, the limitation of the LASSO regression as a variable selector is that when there exist dependence structures among variables (Freijeiro-González et al. 2022), the model did not fully resolve multicollinearity issues in the regression. Therefore, we manually removed all variables with generalized variation inflation factor (GVIF) larger than 5 (Fox and Monette, 1992, O'brien, 2007): we only removed one variable at a time when the variable had the highest GVIF, while we observed the adjusted R-square value change and the GVIFs for other independent variables. After several iterations of eliminating variables, we concluded the final regression model. The coefficient values across different independent variables (shown in Table 3.1 and Table 3.2) were comparable because of data normalization in previous steps.

3.3.4 Regression at Target level

Each SDG has several Targets, and those Targets are closely linked to the SDG and can be used as subgoals to quantify and measure the SDG progress. After we had the regressions for SDGs 14 and 15 at a Goal level, we used the same independent variables to regress against each SDG Target score. This allowed us to detect potential similar and different estimates of variables at a Target level from a Goal level and examine synergies and trade-offs between SDGs and their Targets. For SDG 14, the Targets are 14.1 (By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution), 14.5 (By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information), and 14.7 (By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism). For SDG 15, the Targets are 15.1 (By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements), 15.4 (By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development), 15.5 (Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species), 15.6 (Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed), 15.8 (By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species), and 15.9 (By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts). Different Targets were explained differently by those independent variables across income levels and biodiversity hotspot statuses.

3.4 Results

3.4.1 Drivers for SDGs 14 and 15 at a Goal level

After controlling the multicollinearity in the regression, 11 variables are used in the regression for SDG 14 including 1 interaction term. Nine out of the 11 variables are statistically significant with the significance level of p < 0.05. Two variables are not significant, one of which is the interaction term (Political Stability * High Income) meaning there is no difference in the

effect of Political Stability between high-income and low-income countries for its impact on SDG 14 progress.

The significant variables are relevant to climate change, direct exploitation, institutions and governance, and demographic and sociocultural, economic, and technological pathways (Figure 3.3.A). Among the 9 significant variables, Fish Export (in the log form) has the most important positive role contributing to SDG 14 progress, with the estimate of 0.58, followed by Tourist (in the log form, 0.4) and GDP per Capita (0.23). Fish Production (in the log form) has the most important negative role dragging the SDG 14 progress, with an estimate of -0.51. Many other variables also have negative impacts on SDG 14 progress, such as Fish Import (in the log form, -0.26), Political Stability (-0.25), Population Density (in the log form, -0.18), and Population Growth Rate (-0.12).

Both direct and indirect drivers have impacts on SGD 14 progress, but the average effect that direct drivers have is negative, while the effect of indirect drivers is positive. By summing the coefficient estimates of direct and indirect drivers respectively, the direct sum is -0.36 and the indirect sum is 0.4 (Figure 3.4.A).



Figure 3.3. Statistically significant drivers' impact on SDGs. (A) Impact on SDG 14 for both highand low-income countries. (B) Impact on SDG 15 for high-income, biodiversity-hotspot [HB] countries. (C) Impact on SDG 15 for high-income, no-biodiversity-hotspot [HN] countries. (D) Impact on SDG 15 for low-income, biodiversity-hotspot [LB] countries. (E) Impact on SDG 15 for low-income, no-biodiversity-hotspot [LN] countries. (F) Drivers differentiate impact on SDG 15 across country groups.







Figure 3.3 (cont'd)





Figure 3.4. Sum estimates of direct and indirect drivers' impact on SDGs. (A) Impact on SDG 14 for both high- and low-income countries. (B) Impact on SDG 15 for countries of different income levels and biodiversity hotspot status.

For SDG 15 regression, 24 variables are analyzed in the model, including 13 interaction terms. Seventeen out of the 24 variables are statistically significant, including 8 primary variables

and 9 interaction terms, ranging from direct and indirect driver categories of climate change, land use change, pollution, institutions and governance, and economic and technological pathways.

The differences are significant among high-income vs. low-income, and biodiversityhotspot vs. non-hotspot countries across different variables (Figures 3.3.B, 3.3.C, 3.3.D, 3.3.E). Specifically, Political Stability has the most important positive impact (with an estimate of 0.3) on SDG 15 progress in high-income, non-hotspot countries (HN), while for low-income, non-hotspot countries (LN), the most important variable for positive impact is Forest Rents Percentage in GDP (0.26). Forest Area has the same estimate (0.23) across all countries, which is deemed as the most important positive factor in both high-income, biodiversity-hotspot (HB) and low-income, biodiversity-hotspot (LB) countries, as well as considered as the second most important positive driver for HN and LN countries. On the contrary, Forestry Production has the most important negative impacts on SDG 15 progress in HB (-0.23), HN (-0.14), and LB (-0.08) countries, followed by Population Growth Rate, which also has profound negative impacts for HN (-0.17) and HB (-0.15) countries.

Some variables have opposite impacts on different country groups. For example, Agricultural Land Percentage has a positive impact (0.12) for SDG 15 progress in HB and HN countries and a negative impact (-0.07) in LB and LN countries; Forestry Import has a positive impact (0.01) in HB and LB countries and a negative impact (-0.04) in HN and LN countries (Figure 3.3.F).

The average effects of both direct and indirect drivers on SGD 15 progress are positive yet they are different across country groups. For HB countries, the direct drivers have more prevailing impacts where the direct impact is summed at 0.26 (to the indirect impact sum estimate of 0.21). However, for other country groups (HN, LB, LN), the indirect drivers play more important roles. For instance, the sum estimated for HN countries is 0.42 (to the direct impact sum estimate of 0.35) and indirect driver estimates are higher than direct driver estimates for all low-income countries (Figure 3.4.B).

Variable nome	Coefficient estimate of				
	SDG 14	Target 14.1	Target 14.5	Target 14.7	
Log of Fish Export	0.58***	-0.18	0.6***	0.27***	
Log of Fish Import	-0.26***	0.1	-0.14	-0.43***	
Log of Fish Production	-0.51***	0.18	-0.65***	0.25**	
GDP per Capita	0.23***	-0.06	0.23***	0.22**	
Political Stability	-0.25***	0.12	-0.25***	0.38***	
Log of Population Density	-0.18***	0.14**	-0.18***	0.02	
Population Growth Rate	-0.12**	0.01	0.1	0.23**	
Temperature Change	0.15**	0.16*	0.05	0.15**	
Log of Tourist	0.40***	0.1	0.48***	-0.35***	

Table 3.1. Regression variable estimates for SDG 14.

Note: p (<0.1)*, (<0.05)**, (<0.01)***

Variable name	Coefficient estimate of						
	SDG 15	Target 15.1	Target 15.4	Target 15.5	Target 15.6	Target 15.8	Target 15.9
Agricultural Land Percentage	-0.07***	-0.15***	-0.03	-0.05*	-0.07**		-0.04
Agricultural Land Percentage * High Income (0/1)	0.19***	0.21***	0.2***	0.11***	0.15***		0.09***
Percentage of Forest Rents in GDP	0.26***	0.4***	0.43***	-0.01	0.17***	0.03*	0.01
Percentage of Forest Rents in GDP * Biodiversity Hotspot (0/1)	-0.17***	-0.27***	-0.37***	0.05	-0.07*		-0.04
Percentage of Forest Rents in GDP * High Income (0/1)	-0.06**	-0.09***	-0.01	-0.07**	-0.1***	0.1***	-0.03
Forestry Import	-0.04*	-0.08**	-0.12***	-0.08**	-0.04		0.12***
Forestry Import * Biodiversity Hotspot (0/1)	0.05**	0	0.05	0.12***	-0.01		0.02
Forestry Production	0.01	-0.19***	0	-0.1***	0.12***	0.05**	-0.03
Forestry Production * Biodiversity Hotspot (0/1)	-0.09***	-0.11***	-0.11***	-0.15***	0.03	0.05**	
Forestry Production * High Income (0/1)	-0.15***	-0.11***	-0.14***	0.16***	-0.13***	-0.11***	-0.14***
Log of Forest Land Area	0.23***	0.48***	0.14***	-0.13***	0.09***		0.2***
Log of PM2.5	0.1***	0.14***	0.04	0.26***	0.08**	-0.03	0.07
Population Growth Rate	-0.04	-0.31***	-0.19***	0.01	0.16***		0.05*
Population Growth Rate * Biodiversity Hotspot (0/1)	0.02	0.14***	0.11***	-0.08**	-0.09***		-0.06*
Population Growth Rate * High Income (0/1)	-0.13***	-0.07**	-0.05	-0.11***	-0.11***		-0.02
Political Stability	0.13***	0.22***	0.06	0.15***	0.21***		0.03
Political Stability * Biodiversity Hotspot (0/1)	-0.11***	0.01	-0.05	-0.35***	-0.12***		-0.04
<i>Political Stability</i> * <i>High Income</i> (0/1)	0.17***	0.07**	0.11***	0.23***			
Regulatory Quality	0.13***						
Temperature Change	0.04**	0	0	0.19***	0.04*	0.02	0.01

Table 3.2. Regression variable estimates for SDG 15.

Note: $p (<0.1)^*$, $(<0.05)^{**}$, $(<0.01)^{***}$; all variables of interaction terms are italicized.

3.4.2 Synergies and Trade-offs Between Sustainable Development Goals and Targets

At the Target level, regression estimates showed different impacts. Some variables have the same positive impacts on SDG Targets as they do on SDG progress, while others have the opposite negative impacts. Here, we list some variables that have statistically significant estimates in regressions. For instance, Fish export has both positive impacts on Targets 14.5 and 14.7, with estimates of 0.6 and 0.27 respectively; GDP per capita also has both positive impacts on those Targets (0.23 and 0.22). Fish import has a negative impact (-0.43) on Target 14.7 aligning with the negative impact at the Goal level (-0.26). However, Fish production has a negative impact (-0.65) on Target 14.5, consistent with the negative impact at the Goal level (-0.51) but has a positive impact (0.25) on Target 14.7, opposite to the Goal level estimate. Besides, Population density has the same negative impact (-0.18) on Target 14.5 and SDG 14, but the impact is positive (0.14) on Target 14.1. Tourist has a positive impact (0.48) on Target 14.7 (Table 3.1).

The same impacts (both positive or negative) among Targets and SDGs are considered synergies, meaning the variable contributes to achieving or preventing the Target and SDG progress at the same time. The same positive impacts are considered positive synergies (win-win), and the same negative impacts are considered negative synergies (lose-lose). For example, GDP per capita has both positive impacts on Targets 14.5 and 14.7, which is a positive synergic effect meaning that GDP per capita helps achieve both Targets 14.5 and 14.7. On the contrary, Fish production has both negative impacts on SDG 14 and Target 14.5, which is a negative synergic effect meaning that Fish production suppresses both SDG 14 and Target 14.5 progress. The opposite impacts (one positive, while other negative, vice versa) among Targets and SDGs are seen as trade-offs (win-lose), meaning the variable buttresses to fulfill one Target/SDG while

compromising the other (Zhao et al., 2021, Xing et al., 2024). Both synergies and trade-offs exist in SDGs 14 and 15 among their Targets. From the results above, many trade-offs have been detected among SDG 14 and their Targets.

Most variables in the SDG 15 Target regressions have consistent impacts (both positive or both negative) on SDG 15 and their Targets, so synergies are more prevailing (Table 3.2). Nevertheless, a few trade-offs are noticeable. For example, Forestry Import for non-hotspot countries has negative impacts on SDG 15 (-0.04), Targets 15.1 (-0.08), 15.4 (-0.12) and 15.5 (-0.08), but it has a positive impact (0.12) on Target 15.9. Forestry Import for biodiversity hotspot countries has positive impacts on SDG 15 (0.01) and Target 15.5 (0.04). Forestry Production for LB countries has negative impacts on SDG 15 (-0.08), Targets 15.1 (-0.3), 15.4 (-0.11), and 15.5 (-0.25), but a positive impact on Target 15.8 (0.1). Forestry Production for LN countries has negative impacts on SDG 15 (-0.14), Targets 15.1 (-0.3), 15.4 (-0.01), 15.8 (-0.06), and 15.9 (-0.17), but a positive impact on Target 15.5 (0.06). In addition, Forest Land Area has a negative impact (-0.13) on Targets 15.5, while it has all positive impacts on SDG 15 (0.23), Targets 15.1 (0.48), 15.4 (0.14), 15.6 (0.09), and 15.9 (0.2). The synergies and trade-offs among SDGs and their Targets could reveal insights into further actions and policy implications to achieve sustainable development holistically.

3.5 Discussion

Our LASSO regression approach and results identified the key variables and their impact on SDGs 14 and 15 progress among countries of different income levels and biodiversity hotspot status. Fish Production has the most profound negative impact on SDG 14, so does Forestry Production on SDG 15. Forest Area and Forest Rents in GDP Percentage have the most positive impact on SDG 15, while Fish Export, surprisingly, has the most positive correlation with SDG
14. The drivers for SDG progress and their significant levels largely vary among countries of different income and biodiversity hotspot status. Both synergies and trade-offs exist among SDGs and their Targets, highlighting potential challenges for future sustainable planning and opportunities to maximize the common benefits of multiple socioecological sustainability goals while minimizing the conflicting interests.

The mixed expected and unexpected variable estimates on SDG progress are not fully understood. Several variables have either positive or negative effects on SDG progress, aligning with theories and expectations of drivers for environmental change. For example, Fish harvest and human population pressures have negative impacts on SDG 14 progress, which is illustrated by the negative estimates of Fish production, Human population density, and Population growth rate. Economic factors such as GDP per capita have a positive impact on SDG progress. However, fish trade has an interestingly mixed impact when Fish export has a positive estimate and Fish import has a negative outcome, refuting the assumption that SDG 14 scores should be higher when countries import more fish and conserve their domestic fish stocks, and lower SDG 14 scores when countries export more fish and consume their own natural resources. Namely, countries such as Croatia (high-income) and Morocco (low-income) that made great SDG 14 progress report mixed impacts of Fish export (negative for both countries), Fish import (positive for Croatia, negative for Morocco), and Fish production (positive for both countries); other countries such as Finland (highincome) and Tonga (low-income) that had retrogress in SDG 14 also show mixed impacts of Fish export (positive for Finland, negative for Tonga), Fish import (negative for Finland, positive for Tonga), and Fish production (positive for both countries). Possibly, the increase in domestic aquaculture that is highly correlated with Fish production and Fish export reduced the negative exploitation impact and sufficed sustainable fish capture. This might also result from the potential

reverse causation when higher global sustainable fisheries standards are imposed, countries with better SDG 14 progress practice more sustainable fishing and hence are likely to have more fish exports. Meanwhile, political stability also has an unexpected negative impact on SDG 14 progress when separating countries by their income levels. This is contradictory to the literature and beyond established knowledge (Feng, 1997, Aisen and Veiga, 2013, Ali, 2019), likely resulting from the limitation of LASSO technique that causal inference was not fully established during the regularization and modeling process.

Due to data limitations, our study does not capture all variables of direct and indirect drivers for SDG progress. The data analyzed in this study include (1) as many variables as possible, (2) as many countries as available, and (3) as long-time span as possible. The panel data and regression analysis can reveal a significant part of the relationship in how different drivers impact SDG 14 and 15 progress as proxy of global socioecological change. However, it requires caution in examining the causal inference. The LASSO technique is useful as an exploratory approach to provide an initial understanding of significant variables that correlate with target-dependent variables while balancing the simplicity of regression models. However, limited causal inference, which is important for theory testing or policy making, is produced due to a lack of explicit pathways and mechanisms identified. For example, it is unlikely that the increased temperature or pollutants would improve SDG progress. These may not be the perfect indicators to choose based on data insufficiency. Other variables, such as fish trade, may involve dual directional causalities, meaning that those variables may have impacts on SDG progress at the same time being affected by SDG progress. Hence, further pathway studies are needed to discover the mechanisms for theory testing or policy recommendations.

For SDG 15 progress, the expected and unexpected impacts are also mixed across variables and vary among different country groups (income level, biodiversity hotspot). Specifically, both Forest land area and Agricultural land percentage have positive impacts on high-income countries, but Agricultural land percentage has a negative impact on low-income countries regardless of biodiversity hotspot difference. Forest land area is truly important for all countries to improve SDG 15 progress, with positive impacts across all country types. The expansion of Agricultural land percentage remains controversial, because agricultural land percentage has a positive impact on SDG 15 progress for high-income countries and a negative impact for low-income countries. Further investigation should focus on potential different mechanisms of how agricultural lands impact countries' SDG 15 progress while considering other hidden factors. For example, agroecosystems that provide habitats for wildlife and enhance biodiversity while achieving food supply goals in highly developed countries with limited land would require exhaustive study and careful design. Besides, Forestry import has positive impacts on both high- and low-income countries when they are biodiversity hotspots. This can be explained by the fact that countries show better sustainability progress by conserving domestic resources through import while transferring environmental costs to other countries (Chung and Liu, 2022, Xu et al., 2020). It is critical and efficient to conserve forest ecosystems in countries with rich biodiversity. But Forestry import has a negative impact on non-hotspot countries. This could be the fact that they rely more on domestic forest consumption and reduce forestry import when biodiversity is not a primary goal to protect local forests and thus countries are not motivated to plant trees. For those countries, it is unlikely that Forestry import will directly impact their SDG 15 progress, but instead, domestic forest consumption could be more significant, calling for closer scrutiny. Additional causal path diagrams with quantitative analysis would be beneficial to enhance the understanding. Forest rent

percentage of GDP plays a more important and positive role in non-hotspot countries than that in biodiversity hotspot countries. Considering the concept of forest rent (roundwood harvest times the product of regional prices and a regional rental rate) and determinants to this variable, it could be explained that non-biodiversity countries produce more quantities of forestry products with a lower cost. All these assumptions and explanations need further examination and empirical studies, particularly those that are inconsistent with existing theories or established knowledge.

The indirect drivers are more important than the direct drivers for all countries in SDG 14 progress and non-biodiversity hotspot countries in SDG 15 progress. However, direct drivers have a profound impact on SDG 15 progress for biodiversity hotspot countries. It is critical to examine the hidden factors and associated mechanisms that drive environmental and socioeconomic changes. The integrated metacoupling framework (Liu, 2017, Liu, 2023) has helped to identify important natural and social drivers domestically and internationally for SDG progress in this study, and it would be of great use to further demonstrate interactions among different endogenous (domestic land competition between forest and agriculture, population (Stern et al., 1992, Dietz and Rosa, 1994, Ehrlich and Holdren, 1971, da Silva et al., 2021) and exogenous (tourism, trade (Xu et al., 2020, Zhao et al., 2020)) factors and analyze system feedbacks within and beyond countries, placing the foundation for building complex system dynamics models. Furthermore, understanding the mechanisms that cause SDG 15 progress for biodiversity hotspot countries is urgently needed. Intense land competition between forest and agricultural activities significantly influences countries' SDG 15 progress. Further study could explore the possibility of releasing agricultural land use pressure of those hotspot countries by satisfying domestic agricultural needs through international trade or from countries with less land use competition.

Synergies and trade-offs among SDGs and their Targets should be carefully evaluated and incorporated into decision making. Drivers that promote synergic effects among SDGs and Targets should be emphasized and those creating conflicts should be given special attention. For example, Fish export creates the opportunity to improve Targets 14.5, 14.7 and SDG 14 simultaneously, which could be an effective leverage and promotion for future marine resources management and sustainable development, considering almost half a billion people depend at least partially on small-scale fisheries (Sachs et al., 2022). But key questions on Fish export including the portion of wild capture vs. aquaculture, direct export and re-export, should be cautiously examined prior to implementing policies at a global scale. The trade-offs should be realized to inform policymaking. For instance, Forest Land Area plays such an imperative role in contributing to SDG 15 and most of its Target progress, but attention must be drawn to investigate the mechanism of how it negatively impacts Target 15.5 as a measure of trends in overall extinction risk (Red List Index). The discussion of biodiversity habitat quality versus quantity should be adequately considered in future conservation planning and policy agenda.

3.6 Conclusions

Using a metacoupling framework, we explored the relationship between drivers for SDG progress within and among countries. In particular, we deployed the machine learning based statistical approach (LASSO) to learn the significant variables that impact countries' SDG progress. Our study highlights the expected and unexpected impacts of multiple factors that affect SDG progress for countries at different income levels and biodiversity hotspot statuses. Our results further illustrate the synergies and trade-offs between SDGs and their Targets, calling for careful decision making in the future to maximize the common benefits of multiple socioecological sustainability goals while minimizing the conflicting interests. Our study provides an exploratory

example of integrating the metacoupling framework and the LASSO statistical approach, paving the way for more pathway studies.

CHAPTER 4: SUSTAINING LIFE ON LAND THROUGH A METACOUPLING APPROACH: SIMULATING SPAIN'S SDG 15 PROGRESS

4.1 Abstract

Anthropogenic activities such as natural resources harvest, trade, and population growth have substantial impacts on the environment and become a major challenge to socioecological sustainability. Lack of understanding in achieving environmental and socioeconomic sustainability within and across boundaries is a bottleneck in conservation and sustainability science. The metacoupling framework that integrates interactions across multiple scales and borders, together with System Dynamics Model, is a powerful tool to analyze system interactions and simulate responses both qualitatively and quantitatively. We first applied the metacoupling framework to understand the interactions among environmental and socioeconomic variables and their impact on countries' SDG 15 progress. Then we used Spain as an example and developed a System Dynamics Model to explore how SDG 15 progress responded to forest and population change. Our results show that Net Forest Import has the dominant impact on SDG 15 progress, while other variables like Forestry Production, Forest Regeneration Rate, and Human Population also have impact on SDG 15 progress to different extents. SDG 15 progress, resonating with Forest Area variation, is likely to reach the peak in mid 2030s and depreciate in the long run with the increase of forest harvest. Future natural resources management and conservation planning should be aware of and set up the baseline for potential minimum sustainable forest regeneration and maximum sustainable harvest. The modeling outcome not only served such purposes for providing important information to natural resources management but can also be utilized by broader stakeholders for communication with different communities and learning feedback for model refinement.

4.2 Introduction

A major challenge for conservation science is to achieve environmental and socioeconomic sustainability within and across boundaries. Integrated studies of coupled human and natural systems (CHANS, Liu et al., 2007a, Liu et al., 2007b) have generated important findings on complex patterns and processes that studies through a single lens of physical or social sciences cannot obtain. The holistic metacoupling framework (human-nature interactions within a CHANS as well as between adjacent and distant CHANS, Liu, 2017) integrates interactions across multiple scales across borders. This framework could provide a useful conceptual platform for stakeholder coordination and decision-making to achieve conservation and sustainable goals beyond boundaries. However, quantification of the framework is needed to make coordination and decision-making more effective.

System dynamics modeling (SDM) is used to simulate and understand complex system patterns and processes with quantification features (Meadows, 2008). By identifying the stocks and flows, SDM represents the key feedback structures in the system. SDM can also show scenarios based on different policy interventions. For example, different extents of resource consumption would be the specific scenario analysis in the system dynamics model. Through the feedback loops in the system, potential problems and solutions could be found in terms of conservation and sustainable development goals. Besides, SDM could also help identify the delayed effect of policy intervention, which is significant and informative for future planning. Therefore, SDM is an appropriate approach used in this study to evaluate different policy scenarios and analyze potential strategies for achieving sustainable development goals.

We have identified significant variables that impact SDG progress for countries at different income levels and biodiversity hotspot statuses in the previous chapter. However, the mechanisms through which those variables impact SDG progress differ from country to country and therefore remain unknown. Intermediate converters among variable interactions were not fully understood. Here, we first apply the metacoupling framework to delineate the problem (system processes and interactions among forest, land use for anthropogenic activities, governance, economy, and SDG progress), and then use SDM to model the problem by identifying and quantifying the interactions among system components. The modeling outcomes aim to inform future conservation planning, natural resource management, and community sustainable development.

<u>Research questions:</u> (1) How does the change of forest area impact a country's SDG 15 progress? (2) What parameter has the largest impact on a country's SDG 15 progress?

4.3 Methodology

4.3.1 Metacoupling framework

To systematically understand the human-nature interactions within and across multiple scales and borders, metacoupling framework is used to understand the problem of this study. Three types of human-nature interactions (couplings) are delineated under the complete metacoupling framework: (1) within a coupled system (intracoupling), (2) between distant coupled systems (telecoupling), and (3) between adjacent coupled systems (pericoupling). Here, we adopted the metacoupling framework and followed the six general procedures for operationalizing this framework (Liu, 2017) including setting research goal, defining focal system, reviewing literature and conducting additional studies on flows, agents, causes, and effects, identifying couplings and sending, receiving, and spillover systems, conducting further studies on metacoupling components and interrelationship, and publishing and communicating final results. The preliminary system identification and definition (CHANS, metacoupling) can be found in Figure 4.1.



Figure 4.1. Simplified conceptual metacoupling framework: focal country (coupled human and natural system), adjacent country, distant country, and relationships between forest harvest, agricultural land transformation, population, economy development, SDG 15 performance, and international forest trade within the three coupled countries. Components are categorized under human system (brown rectangle) and natural system (green rectangle), including agricultural land, population, economy, forest, temperature, pollution, as causes and SDG 15 progress as effect. The interactions within a coupled human and natural system are shown in light blue arrows. The forestry trade is another component (i.e., flow) between the focal country and adjacent/distant countries. Each country was confined with a black line of rectangle. The interactions between different coupled human and natural systems (e.g., between focal system and distant system) are shown in black arrows (the solid line indicates a direct/observable interaction; the dash line indicates an indirect/unobservable or potential interaction).

4.3.2 Conceptual Framework based on Metacoupling

With the focus on only one country (system), the Casual Loop Diagram below shows the interactions among forest, agriculture, population, economy, governance, and trade. There are two balancing feedback loops (labelled as brown B in Figure 4.2) and five reinforcing feedback loops (labelled as green R in Figure 4.2). The first balancing loop (B1) is that the larger total forest size will provide more forest harvest, but more harvest will lead to a decreasing forest size. The second balancing loop (B2) is that more population will have more population deaths holding the death rate constant, and the more deaths will cause a smaller size of population. Therefore, the population is balanced out through this loop. On the other hand, the reinforcing feedback loops include: R1.

More domestic forest demand will require more forest product, and more forest product will meet more domestic demand; R2. More economic growth (development activities) will boost domestic forest demand, and more domestic demand will satisfy economic needs; R3. More population will create more economy (productivity), and more economy will support larger population; R4. More population will drive more agriculture (activity, products), and more agriculture will support more population; R5. More population will drive more population births holding the birth rate constant, and more population births will contribute to a larger population size.



Figure 4.2. Causal loop diagram with feedback loops for the forest system. The system components are in blue text, and the interactions among components are connected through pink arrows. The positive sign shows a positive effect, and the negative sign shows a negative effect. Feedback loops are labelled as unclosed ¹/₂ circles with arrows. The brown feedback loops with letter "B" are negative (balancing) feedback loops; the green feedback loops with letter "R" are positive (reinforcing) feedback loops.

4.3.3 System Dynamics Model (SDM)

4.3.3.1 Geographic foci, data sources, and assumptions

This study used Spain as an example, to illustrate the interactions among forest, population, and SDG 15 progress. Spain is one of countries that made tremendous progress in SDG 15 between 2010 and 2020, with scores increasing from 29.74 to 77.31 and ranks emerging from the 60th to the 15th worldwide over those ten years (Zhang et al., 2023). Understanding on how Spain achieved

their SDG 15 progress and what variables have large impacts is useful for future conservation and development planning and as a reference for other countries.

Multiple sources of data were used in this study. Population, Population Growth Rate, Forest Area, Forestry Production, and Net Forest Import data were collected through World Bank Group (World Bank Country and Lending Groups, 2021), while Forest Regeneration Rate, Carrying Capacity, and SDG 15 Progress were referred from literature review (Bolin et al., 2000, Instituto Nacional de Estadística, 2022, Zhang et al., 2023). The formula used to define relationships between components in the model were not all available. Several trials were made in calibration and validation processes to best match the real-world data, such as Forestry Production, Net Forest Import, and Population Growth Rate. The other assumption was also made especially for generating the graphical function for Effect of Carrying Capacity on the ratio of Population Growth Rate/Carrying Capacity (the effect increases with the ratio increase at a diminishing rate of return, range from 0 to 1). Namely, when the population approaches the carrying capacity, the effect is more profound leading to a lower population growth rate (Cohen, 1995, Vandermeer, 2010, Meadows et al., 2018).

4.3.3.2 Model description

To simplify the complex system, only limited components and their interactions were included in the model from the causal loop diagram (Figure 4.2). The model simulated the human and natural system interactions (e.g., population, land use change, forest change through production, trade, and regeneration, and SDG progress) from 2000 to 2050 with DT = 1 year. The model was developed with Stella Architect V2.1.5 (ISEE System 2022), with initial settings listed in Table 4.1. The complex system is a coupled human and natural system at a country scale, where there are two major sub-systems: population and forest.

The model has two stocks (Population, and Forest Area), and four flows (Net Growth, Forest Regeneration, Net Forest Harvest, and Land use change). The Net Growth is a bi-flow, meaning it can be an inflow towards or outflow from the stock of Population (contributing to the increase or decrease of the stock) depending on the positive or negative values of Net Growth. Namely, if the Net Growth is positive, there will be more population added towards the stock of Population; if the Net Growth is negative, there will be a removal from Population. The Net Growth is determined by the Population Growth Rate, which is dependent on Effect of Carrying Capacity. The Effect of Carrying Capacity relies on Population and Carrying Capacity. The Carrying Capacity is a user-defined value, and it varies from country to country (for Spain, it is set as 53 million people, Instituto Nacional de Estadística, 2022). Land Use Change is an outflow, meaning that the stock Forest Area may be taken away by Land Use Change depending on both Population and Carrying Capacity. Forest Regeneration is an inflow towards the stock of Forest Area, and it is the multiplication of Forest Area and Forest Regeneration Rate. Forest Harvest is an outflow of Forest Area, which is impacted by Forestry Production and Net Forest Import.

There is one balancing feedback loop (labelled as brown B), one reinforcing feedback loop (labelled as green R), and one mixed (reinforcing and balancing) feedback loop (labelled as yellow R/B in Figure 4.3) in the system. The mixed loop (R1/B1) between Population and Net Growth is dependent on whether Net Growth is positive or negative. If positive (inflow), it is a reinforcing loop because larger population will have more net population growth, which in turn contributes to a larger population size. If negative (outflow), it is a balancing loop because larger population will have less Net Growth, as a source of reducing population size. The balancing loop (B2) is that larger Population, stronger Effect of Carrying Capacity, lower Population Growth Rate, lower Net Growth, smaller Population, in this case, the Population is constrained through this loop. The

reinforcing loop (R2) is that more Forest Area, more Forest Regeneration holding the Forest Regeneration Rate constant, contributing to additional Forest Area, in this case, Forest Area is reinforced through the loop.



Figure 4.3. System dynamics model with feedback loops for the population and forest system. The system components are in blue text, and the interactions among components are connected through pink arrows. Feedback loops are labelled as unclosed ½ circles with arrows. The brown feedback loops with letter "B" are negative (balancing) feedback loops; the green feedback loops with letter "R" are positive (reinforcing) feedback loops; the yellow feedback loops with letters "R/B" are mixed (both reinforcing and balancing) feedback loops.

Component	Name	Initial values or formula [unit]					
Stock	Population	40,567,864 [person]					
	Forest Area	170,939.3 [km ²]					
Flow	Net Growth	Population_Growth_Rate/100*Population					
	Land Use Change	(Population/Carrying_Capacity)*1000 [km ²]					
	Forest Harvest	(Forestry_Production- Net_Forest_Import)/12000 [km ²]					
	Forest Regeneration	Forest_Area*Forest_Regeneration_Rate [km ²]					
Converter	Population Growth Rate	(1-Effect_of_Carrying_Capacity)*43					
	Effect of Carrying	Population/Carrying_Capacity (in graphical					
	Capacity	function)					
	Carrying Capacity	53000000 [person]					
	Forestry Production	98018*(TIME-2000) + 15921000 [m ³]					
	Net Forest Import	-266374*(TIME-2000) + 3354634 [m ³]					
	Forest Regeneration Rate	0.016					
	SDG 15 Progress	0.000528131*Forest_Area - 20.77720428					

Table 4.1. Summary of system components and initial values or formula.

4.3.3.3 Model calibration and validation

To calibrate the model, I ran the model for 10 years with initial settings (DT=1) and plotted the simulated Population, Forest Area, Forestry Production, and Net Forest Import results against the real-world data from 2000 to 2010. The parameters I changed to fit the model with reality were Forest Harvest, Land Use Change, Population Growth Rate, and Effect of Carrying Capacity in graphical function.

With the final calibrated model, I changed the runtime to 20 years from 2000 to 2020. After exporting simulated data from 2010 to 2020, I validated the model results by plotting them against real-world data. Because SDG 15 Progress data was not available before 2010 and the major data jumps between 2011 and 2012, 2015 and 2016 could mislead the prediction, only data from 2016 to 2020 were used for this variable in the iterative model calibration process to avoid noises.

4.3.3.4 Reference model prediction and sensitivity analysis

The reference model prediction was based on the existing variables and their relationships with no interventions after model validation, between 2020 and 2050. The key variables of interest are Forest Area and SDG 15 Progress. I changed the runtime to 50 years from 2000 to 2050.

The sensitivity analysis was also performed during the same period after model validation. The key variables of interest are Forest Area and SDG 15 Progress. To perform the five runs of sensitivity analysis, Forest Regeneration Rate, Initial Forest Area, Population, Forestry Production, and Net Forest Import were changed one at a time ranging from 10% lower and 10% higher than the baseline values or formula while holding other input variables constant. Sensitivity is estimated by the index of Sx, within the following formula.

$$S_{\chi} = \frac{\Delta X}{X} / \frac{\Delta P}{P}$$

Where X is the variable under the original condition, ΔX is either the difference of the variable at 10% lower value between the original variable value or the difference of the original variable and the variable at 10% higher value. For example, for Forest Regeneration Rate analysis, X is the Forest Regeneration Rate at the baseline of 0.016; ΔX is either the difference between 0.0144 (lower 10%) and 0.016 (baseline) or the difference between 0.016 (baseline) and 0.0176 (higher 10%).

P represents the value of either Forest Area or SDG 15 Progress under the original condition and ΔP is the difference in the data value of either Forest Area or SDG 15 Progress between the original and modified conditions. For example, for Forest Regeneration Rate analysis, *P* is either Forest Area or SDG 15 Progress (when Foerst Regeneration Rate is set at 0.016); ΔP is either the difference between Forest Area values (when Forest Regeneration Rate is 0.0144 and

0.016; or when Forest Regeneration Rate is 0.016 and 0.0176) or the difference between SDG 15 Progress values under the above conditions.

 S_x refers to the change in the Forest Area or SDG 15 Progress due to the change in the following variables at a time (Forest Regeneration Rate, Initial Forest Area, Population, Forestry Production, and Net Forest Import). The larger the value, the more sensitive Forest Area or SDG 15 Progress are to those variables of change.

For Initial Forest Area, the baseline is 170,939.3, lower bound is 153,845.37, and upper bound is 188,033.23. For Population, the baseline is 40,567,864, lower bound is 36,511,077.6, and upper bound is 44,624,650.4. For the formula of Forestry Production and Net Forest Import, a coefficient of 0.9 or 1.1 was multiplied to its original formula to represent the 90% or 110% of variable levels. I ran each of the five sensitivity analyses individually and then exported the changed Forest Area and SDG 15 Progress in separate Excel files. For each sensitivity analysis, two Sx values were produced – one showed the difference between the baseline value and its 10% lower value, the other showed the difference between the baseline value and its 10% higher value. Those Sx values would depict how input variable sensitivity affects the key output variables of interest and show which variable among those five changed variables is more significant to the output variable variation.

Component	Name	Lower/higher values or formula					
Converter	Forest Regeneration	0.0144.0.0176					
	Rate	0.0144, 0.0170					
	Forest Area	153,845.37, 188,033.23					
	Population	36,511,077.6, 44,624,650.4					
	-	0.9* (98018*(TIME-2000) +					
	Forestry Production	15921000), 1.1* (98018*(TIME-					
		2000) + 15921000)					
		0.9* (-266374*(TIME-2000) +					
	Net Forest Import	3354634), 1.1* (-266374*(TIME-					
		2000) + 3354634)					

Table 4.2. Summary of modified system component values for five runs of sensitivity analysis.

4.4 Results

4.4.1 Calibration

The model calibration indicated when Forest Harvest, Land Use Change, Population Growth Rate, and Effect of Carrying Capacity in graphical function were set as current formula summarized in Table 4.1, the model best fit the real-world data from 2000 to 2010 (Table 4.3), especially for the key stocks of interest (Forest Area and Population). Then I plotted the simulated data against the real-world data for Forest Area, Forestry Production, Net Forest Import, and Population, which generated the R^2 values of 0.998, 0.211, 0.606, and 0.987 (Figure 4.5).

Table 4.3. Real-world and modeled data for Forest Area, Population, Forestry Production, and Net Forest Import between 2000 and 2010.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Real-world Forest Area	170939.3	172390.71	173842.12	175293.5	176744.9	178196.4	179647.8	181099.2	182550.6	184002	185453.4
Modeled Forest Area	170939.3	171861.7002	172758.6346	173630.2	174476.6	175297.9	176094.2	176865.3	177611.2	178331.7	179026.7
Real-world Forestry Production	15921000	16986000	17828000	18135000	18345000	17711000	17323000	16510000	19627374	16060035	21209399
Modeled Forestry Production	15921000	16019018	16117036	16215054	16313072	16411090	16509108	16607126	16705144	16803162	16901180
Real-world Net Forest Import	3354634	3641000	3059000	2871000	2639000	3287000	3325000	3332098	1576000	944904	392626
Modeled Net Forest Import	3354634	3088260	2821886	2555512	2289138	2022764	1756390	1490016	1223642	957268	690894
Real-world Population	40567864	40850412	41431558	42187645	42921895	43653155	44397319	45226803	45954106	46362946	46576897
Modeled Population	40567864	41090352.04	41584035.81	42049673	42488118	42902337	43300841	43683868	44051685	44404589	44742902



Figure 4.4. Plots of modeled against real-world data for four variables between 2000 and 2010. (A) Forest Area, (B) Forestry Production, (C) Net Forest Import, and (D) Population.



Figure 4.4 (cont'd)



With the initial values or formula of stocks, flows and converters in Table 4.1, the simulation results from 2000 to 2010 are shown in Figure 4.5.

Forest Area constantly increased from 171 to 179 thousand square kilometers, while the three major flows all increased – Forest Regeneration increased from 2.74 to 2.86 thousand square kilometers, Forest Harvest increased from 1.05 to 1.35 thousand square kilometers, and Land Use Change slightly increased from 765 to 844 square kilometers. Forestry Production increased from 15.9 to 16.9 million cubic meters, while Net Forest Import decreased from 3.35 million to 691 thousand cubic meters. Population drastically increased from 40.6 to 44.7 million over 2000 and 2010.



Figure 4.5. Model calibration results. (A) Forest Area, (B) Forest Harvest, Forest Regeneration, Land Use Change, (C) Forestry Production, Net Forest Import, and (D) Population estimates between 2000 and 2010.

4.4.2 Validation

Keeping the initial values and formula set in calibration and increasing the runtime for another 10 years (till 2020), I found the model fit the real-world data well (Table 4.4). Then I plotted the modeled data against the real-world data, which generate the R^2 values of 0.902, 0.004, 0.640, and 0.280 (Figure 4.6).

Table 4.4. Real-world and modeled data for Forest Area, Population, Forestry Production, and Net Forest Import between 2010 and 2020.

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Real-world Forest Area	185465.1	185476.8	185488.4	185500.1	185511.8	185552.4	185593	185635.9	185678.8	185721.7
Modeled Forest Area	179696	180339.6	180957.3	181548.9	182114.2	182653.1359	183165.4254	183650.8929	184109.3261	184540.5019
Real-world Forestry Production	19327772	17686795	18994298	20104343	21950361	19171601	19179531	22469782	18635586	17881367
Modeled Forestry Production	16999198	17097216	17195234	17293252	17391270	17489288	17587306	17685324	17783342	17881360
Real-world Net Forest Import	23361	-116431	-625677	-1162310	-1456442	-1621376	-855882	-873275	-1586331	-1972841
Modeled Net Forest Import	424520	158146	-108228	-374602	-640976	-907350	-1173724	-1440098	-1706472	-1972846
Real-world Population	46742697	46773055	46620045	46480882	46444832	46484062	46593236	46797754	47134837	47365655
Modeled Population	45066968	45377147	45673817	45957366	46228191	46486695.51	46733288.81	46968381.02	47192382.69	47405702.71



Figure 4.6. Plots of modeled against real-world data for four variables between 2010 and 2020. (A) Forest Area, (B) Forestry Production, (C) Net Forest Import, and (D) Population.



Figure 4.6 (cont'd)

With the initial values or formula of stocks, flows and converters in Table 4.1, the simulation results from 2000 to 2020 are shown in Figure 4.7.

Forest Area kept increasing from 179 to 185 thousand square kilometers, with Forest Regeneration increasing from 2.86 to 2.95 thousand square kilometers. Land Use Change

increased from 844 to 894 square kilometers, but Forest Harvest increased at a slower rate from 1.35 to 1.65 thousand square kilometers. This is mainly due to the change in Net Forest Import from 16.9 to -1.97 million cubic meters, while Forest Production increasing from 16.9 to 17.9 million cubic meters. Population increased from 44.7 to 47.4 million between 2010 and 2020.



Figure 4.7. Model validation results. (A) Forest Area, (B) Forest Harvest, Forest Regeneration, Land Use Change, (C) Forestry Production, Net Forest Import, and (D) Population estimates between 2000 and 2020.

4.4.3 Reference model prediction and sensitivity analysis

4.4.3.1 Reference model prediction

With the initial values or formula of stocks, flows, and converters in Table 4.1, I ran the reference model between 2000 and 2050. Forest Area constantly increased and reached the peak of 187,549 km² in 2034, then slightly decreased to 183,071 km² in 2050. SDG 15 Progress followed the same

pattern: it reached the peak of 78.27 in 2034 and then slightly dropped to 75.91 by the end of 2050. Land Use Change gradually increased from 765 to 966 km² between 2000 and 2050. Forest Regeneration increased and reached the peak of about 3,000 km² in 2034 and then decreased to 2,929 km² in 2050, while Forest Harvest continuously increased from 1,047 to 2,565 km² over those 50 years. This is primarily because Net Forest Import dropped from 3,354,634 to -9,964,066 m³, which became a net export, while Forest Production kept increasing from 15,921,000 to 20,821,900 m³ between 2000 and 2050. Population increased from 40,567,864 to 51,196,843, but the growth rate became slower over the years (Figure 4.8).



Figure 4.8. Reference model results. (A) Forest Area, (B) SDG 15 Progress, (C) Forest Harvest, Forest Regeneration, Land Use Change, (D) Forestry Production, Net Forest Import, and (E) Population estimates between 2000 and 2050.



4.4.3.2 Sensitivity analysis of Forest Area

Among the five runs of sensitivity analysis by changing one variable at a time, Forest Area is most sensitive to Net Forest Import and least sensitive to Initial Forest Area. Both 10% lower and higher values of Net Forest Import had major impact on Forest Area, with S_x values over 200 at the first few years of study. Although the S_x values dropped down to 80 around 2015, they bounced and peaked over 1700 in 2028. The absolute value of S_x remained as high as 700 in 2029 and shrank to about 10 at the end of 2050. Population and Forestry Production also had a large impact on Forest Area, but their S_x values (absolute) were not as high as Net Forest Import and decreased over time. Forest Regeneration Rate had a smaller impact on Forest Area, with an initial S_x value of 60 and diminishing towards 0 in 2050. Initial Forest Area has the minimal impact on Forest Area, regardless of 10% lower or higher of its baseline.



Figure 4.9. Sensitivity estimates of Forest Area to five variables between 2000 and 2050. The lower 10% of baseline value (e.g., 90% of variable) estimate is orange, and the higher 10% of baseline value (e.g., 110% of variable) estimate is in green. (A) Forest Regeneration Rate, (B) Initial Forest Area, (C) Population, (D) Forestry Production, and (E) Net Forest Import.





4.4.3.3 Sensitivity analysis of SDG 15 Progress

SDG 15 Progress is also most sensitive to Net Forest Import and least sensitive to Initial Forest Area. SDG 15 Progress is highly sensitive to both 10% lower and higher values of Net Forest Import, with S_x values over 150 for the first four years of study. The S_x values decreased to 60 in 2015, but they immediately increased by 1000 in 2028. The absolute value of S_x stayed as high as 550 in 2029 and eliminated to 9 in 2050. Population and Forestry Production had smaller but still noticeable impact on SDG 15 Progress, with an initial S_x value over 100 and reducing to single digits by the end of 2050. Forest Regeneration Rate had an even smaller impact on SDG 15 Progress, with an initial S_x value of about 50 and dropping to 0 in 2050. Initial Forest Area has the smallest impact on SDG 15 Progress throughout the whole study period between 2000 and 2050.



Figure 4.10. Sensitivity estimates of SDG 15 Progress to five variables between 2000 and 2050. The lower 10% of baseline value (e.g., 90% of variable) estimate is orange, and the higher 10% of baseline value (e.g., 110% of variable) estimate is in green. (A) Forest Regeneration Rate, (B) Initial Forest Area, (C) Population, (D) Forestry Production, and (E) Net Forest Import.





4.5 Discussion

Our model results document how forest, SDG 15 progress, and population interacted within the couple human and natural system using Spain as an example. With the existing data from 2000 and 2010, the model is well calibrated by adjusting the initial values or formula for each parameter. The model fit well with the real-world Forest Area for those years. The calibration method is valid because only the endogenous factors in the model were changed which generates its own system behavior. Further, through the calibration and validation processes, the model well explains the trajectory of Forest Area (key stock of interest) patterns and sufficiently delineates Net Forest Import with real-world data from 2010 to 2020, despite that Forestry Production and Population variables are sparsely fit. The simulation result of SDG 15 Progress between 2020 and 2050 reflects the joint impact of forest and population systems. SDG 15 Progress, resonating with Forest Area dynamics, is likely to gain moderately by 2050 compared to 2000. However, it is noticeable that the peak of SDG 15 Progress would reach in 2034, and that SDG 15 Progress may collapse due to loss of Forest Area and overharvest in the long term.

Forest Area and SDG 15 Progress are sensitive to different parameters to various extents. The Net Forest Import, as a result, has the largest impact on SDG 15 Progress, because the sensitivity index (S_x) has the highest values compared to other variables of change (Population, Forestry Production, Forest Regeneration Rate, and Initial Forest Area) between 2000 and 2050. Many Targets (United Nations, n.d.) under SDG 15 are directly associated with Forest or Protected Area. Adding such Forest Area would have a direct impact on SDG 15 Progress, and such a linear relationship between Forest Area and SDG 15 Progress was defined in the model. The growth of Net Forest Import seems to have a profound impact on Forest stock in Spain. Besides, Forestry Production and Population can also have a large impact on SDG 15 Progress especially during early years when SDG 15 Progress was at a relatively low level. Forest Regeneration Rate has a smaller impact on SDG 15 Progress, but it should not be ignored. This provides potential insights for domestic sustainable forest harvest and international trade. For example, considering population growth and domestic demand for forestry, a baseline for sustainable forest harvest and trade should be set for Spain and the international community, to achieve both domestic and international forest conservation and sustainable development.

Challenges such as lack of data and bounded rationality of picturing system structure existed when building the model. Several assumptions have been made to indicate the limit of this model and under what conditions the model worked. It is difficult to overcome existing limitations in this study such as the underestimation of Forestry Production and simplification of Net Forest Import trend. Our goal is to train the model with best fit to as many variables as possible, but modeled Forest Area (key stock of interest) reliably fit real-world data at the cost of sparsely fit of Forestry Production with a simple time-dependent function defined in the model. The change of Forestry Production and Net Forest Import are highly dependent on the market (involving both domestic and international supply and demand) which is not necessarily correlated with time or maybe there is a delay in market response reflected in the change at specific years. External variables could also shape the dynamics of markets such as global economy, transportation delays, pandemic (Li et al., 2017, Amrouss et al., 2017, Golar et al., 2020). Another limitation is although Forest Area and Population (stocks) generally fit the real-world data during calibration and validation processes, Forestry Production and Net Forest Import could be under/overestimated, which could add uncertainty for prediction outcomes. To obtain a better and realistic estimate result and represent a more complete system patterns and processes, future study should consider more elements of both natural and human factors including the elasticity of the forestry market, differentiation between neighboring and distant trade partners, domestic and global economy, domestic and international policies' intersections and interactions, and socioecological shocks (e.g., pandemic, natural disaster, climate change) (Frieden and Martin, 2002, Michinaka et al., 2011, Xu et al., 2020, White and Wulfing, 2024). The modeling approach integrating human and natural systems can be generalized and applied to other countries and SDG Progress simulations at different scales.

Despite the limitations, the information offered by the System Dynamics Model in this study would still assist in better adaptive management for Forest management, natural resources policy-making, and sustainable development in the future. To disseminate the modeling results, future work should extend to stakeholder engagement. In this case, by sharing the findings with stakeholders (natural resources management, demographics, and development planning governments, research institutes, associate NGOs, and public communities), obtaining feedback on the model and additional real-world data could help include important parameters and refine the model. The modeling outcomes would also be utilized to facilitate communications among community members, governments and NGOs. Those findings would be informative to stakeholders such as the public and decision makers on land use and management. For instance, the public might have a better understanding of the policy impact – how it would regulate their agricultural and urban land, how it would enhance forest conservation and trade, and whether it would bring them more environmental and economic benefits in a sustainable way. Winning public support is a significant part of conducting sustainable development work. With the outcomes from the model, decision-makers would have more information of benefits and losses at specific time to make cost-effective policies for natural resources management and conservation planning.

CHAPTER 5: SYNTHESIS

This dissertation focuses on the current challenge for conservation science and the knowledge gap in the United Nations' SDGs 14 and 15 assessments on a global scale. Adding to the knowledge of SDG assessment, socioecological driver exploration, and mechanism disentanglement, this dissertation broadly contributes to public research and development. Analyzing environmental and social drivers for SDGs 14 and 15 variations offers helpful information for domestic and international development and decision-making. With operationalizing the metacoupling framework, this dissertation explores complex system dynamics (interactions and processes) and conducts scenario analysis to better inform future conservation planning and natural resources sustainable management. The main conclusions of each chapter are summarized below.

Chapter 2 evaluated countries' SDGs 14 and 15 performances between 2010 and 2020, based on the indicator selection and guidance from the United Nations. This delineates how countries did in SDGs 14 and 15 over the past decade, and that through comparisons, which countries did well or poorly. This evaluation step also provides significant data for the following chapters. Global biodiversity conservation and sustainable development made positive progress, but ocean sustainability progress surprisingly slowed after the United Nation Member States adopted SDGs in 2015. Low-income countries lagged in SDGs 14 and 15 progress, and the gap between low-income and high-income countries became wider over time.

Chapter 3 identified the important direct and indirect socioecological drivers for countries' SDG variation with multivariate regressions. This chapter further sheds light on the understanding of mechanisms that drive SDGs 14 and 15 variations and places the foundation for the following modeling work. Multiple drivers have mixed expected and unexpected impacts on SDG progress
for countries across different income and biodiversity hotspot groups. Fish production has the most profound negative impact on SDG 14 progress for all countries, while the positive and negative impact of drivers on SDG 15 progress varies for countries of different income levels and biodiversity statuses. Synergies and trade-offs between SDGs and their Targets call for special attention for policy making to maximize the common benefits of multiple socioecological sustainability goals while minimizing the conflicting interests.

Chapter 4 investigated the drivers for SDG 15 in Spain and framed the interactions among forest, land transformation, population, and SDG 15 with the metacoupling framework. System Dynamics modeling is exercised to simulate the stocks (e.g., forest, population) change over interactions and time. This chapter deepens understanding of drivers for SDG 15 and provides useful policy implications for decision-makers with scenario analysis. SDG 15 progress, associated with forest area, is likely to reach the peak in the mid-2030s and depreciate in the long run as forest harvest increases. Forestry trade and production as well as human population have a major impact on SDG 15 progress. Future natural resources management and conservation planning should be aware of and set up the baseline for potential minimum sustainable forest regeneration and maximum sustainable harvest.

In summary, achieving sustainable development everywhere is the goal that requires every country to actively participate and make enormous efforts. To know where countries stand in SDGs 14 and 15 is the first important step. By understanding the drivers for those SDGs variations, countries would make better-informed and collaborative decisions for future sustainable development and conservation planning. Following sustainable practices in natural resources management and holding socioecological baselines are the cornerstone for a prosperous society and a sustainable planet, now and into the future.

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APPENDIX A SUPPORTING INFORMATION FOR CHAPTER 2

Please see Supplementary Material section in: Zhang, Y., Li, Y., & Liu, J. (2023). Global

decadal assessment of life below water and on land. Iscience, 26(4).

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The supporting information includes 4 tables in Excel:

Table S1. SDG 14 scores & targets. This spreadsheet contains calculations for SDG 14 scores and target values for all countries between 2011 and 2019, and analysis by country's income level.

Table S2. SDG 15 scores & targets. This spreadsheet contains calculations for SDG 15 scores and target values for all countries between 2010 and 2020, and analysis by country's biodiversity-hotspot and income category.

Table S3. SDG data source. This spreadsheet has a detailed description of SDG, target, indicator, sub-indicator, data characteristics, and sources.

Table S4. Country class/category. This spreadsheet includes the categorized country (by income, and by biodiversity-hotspot and income) information used in SDGs 14 and 15 analyses.

APPENDIX B SUPPORTING INFORMATION FOR CHAPTER 3

Characteristic	Beta	95% CI [†]	p-value	$\mathbf{GVIF}^{^{\dagger}}$	Adjusted GVIF ^{2,1}
Log of Fish Export	0.58	0.40, 0.76	<0.001	4.3	2.1
Log of Fish import	-0.26	-0.45, -0.07	0.008	4.6	2.1
Log of Fish Production	-0.51	-0.70, -0.31	<0.001	4.7	2.2
GDP per Capita	0.23	0.06, 0.41	0.008	3.8	1.9
Political Stability	-0.25	-0.43, -0.07	0.007	4.1	2.0
Political Stability * High Income (0/1)	0.03	-0.13, 0.19	0.68	3.2	1.8
Log of Population Density	-0.18	-0.28, -0.08	<0.001	1.3	1.1
Population Growth Rate	-0.12	-0.24, -0.01	0.035	1.6	1.3
Temperature Change	0.15	0.03, 0.27	0.012	1.7	1.3
Log of Tourist	0.40	0.21, 0.59	<0.001	4.5	2.1
Voice and Accountability	0.09	-0.04, 0.23	0.18	2.4	1.6

Table A3.1. Full	regression res	ults for SDG 14.

[†] CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

Characteristic	Beta	95% CI [†]	p-value	GVIF [†]	Adjusted GVIF ^{2,1}
Log of Fish Export	-0.18	-0.43, 0.07	0.16	4.6	2.1
Log of Fish Import	0.10	-0.16, 0.35	0.45	4.8	2.2
Log of Fish Production	0.18	-0.08, 0.44	0.17	5.0	2.2
GDP per Capita	-0.06	- <mark>0.</mark> 29, 0.17	0.60	3.9	2.0
Political Stability	0.12	-0.12, 0.37	0.33	4.4	2.1
Political Stability * High Income (0/1)	-0.15	-0.39, 0.08	0.20	4.2	2.0
Log of Population Density	0.14	0.00, 0.27	0.042	1.3	1.1
Population Growth Rate	0.01	-0.24, 0.25	0.96	4.4	2.1
Population Growth Rate * High Income (0/1)	0.03	-0.19, 0.25	0.80	3.6	1.9
Temperature Change	0.16	- <mark>0.03</mark> , 0.35	0.092	2.6	1.6
Temperature Change * High Income (0/1)	-0.01	-0.26, 0.25	0.96	4.9	2.2
Log of Tourist	0.10	-0.15, 0.35	0.42	4.6	2.1
Voice and Accountability	-0.24	-0.43, -0.06	0.010	2.5	1.6
*	-				

Table A3.2. Full regression results for Target 14.1.

⁷ CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

Characteristic	Beta	95% CI ¹	p-value	$\mathbf{GVIF}^{^{\prime}}$	Adjusted GVIF ^{2,1}
Log of Fish Export	0.60	0.44, 0.77	<0.001	4.6	2.1
Log of Fish Import	-0.14	-0.30, 0.03	0.11	4.6	2.1
Log of Fish Production	-0.65	-0.82, -0.48	<0.001	5.0	2.2
GDP per Capita	0.23	0.08, 0.38	0.003	3.9	2.0
Political Stability	-0.25	-0.41, -0.09	0.003	4.4	2.1
Political Stability * High Income (0/1)	0.15	0.01, 0.29	0.031	3.2	1.8
Log of Population Density	-0.18	-0.27, -0.09	<0.001	1.3	1.1
Population Growth Rate	0.10	-0.06, 0.26	0.23	4.2	2.1
Population Growth Rate * High Income (0/1)	-0.24	-0.39, -0.10	<0.001	3.5	1.9
Temperature Change	0.05	-0.05, 0.15	0.36	1.8	1.3
Log of Tourist	0.48	0.32, 0.65	<0.001	4.6	2.1
Voice and Accountability	0.15	0.03, 0.27	0.017	2.5	1.6
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Table A3.3. Full regression results for Target 14.5.

['] CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

Characteristic	Beta	95% CI [†]	p-value	GVIF [†]	Adjusted GVIF ^{2,1}
Log of Fish Export	0.27	0.07, 0.47	0.008	4.6	2.1
Log of Fish import	-0.43	-0.63, -0.23	<0.001	4.6	2.1
Log of Fish Production	0.25	0.04, 0.46	0.019	5.0	2.2
GDP per Capita	0.22	0.04, 0.40	0.019	3.9	2.0
Political Stability	0.38	0.18, 0.57	<0.001	4.4	2.1
Political Stability * High Income (0/1)	-0.28	-0.45, -0.11	0.001	3.2	1.8
Log of Population Density	0.02	-0.08, 0.13	0.64	1.3	1.1
Population Growth Rate	0.23	0.04, 0.43	0.018	4.2	2.1
Population Growth Rate * High Income (0/1)	-0.29	-0.47, -0.12	0.001	3.5	1.9
Temperature Change	0.15	0.03, 0.28	0.016	1.8	1.3
Log of Tourist	-0.35	-0.55, -0.15	<0.001	4.6	2.1
Voice and Accountability	-0.30	-0.45, -0.16	<0.001	2.5	1.6

Table A3.4. Full regression results for Target 14.7.

 † CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

Characteristic	Beta	95% CI ¹	p-value	GVIF [†]	Adjusted GVIF
Agricultural Land Percentage	-0.07	-0.11, -0.03	<0.001	1.6	1.3
Agricultural Land Percentage * High Income (0/1)	0.19	0.14, 0.24	<0.001	2.5	1.6
Percentage of Forest Rents in GDP	0.26	0.20, 0.31	<0.001	2.7	1.6
Percentage of Forest Rents in GDP * Biodiversity Hotspot (0/1)	-0.17	-0.23, -0.11	<0.001	3.0	1.7
Percentage of Forest Rents in GDP * High Income (0/1)	-0.06	-0.10, -0.01	0.013	1.8	1.3
Forestry Import	-0.04	-0.09, 0.01	0.094	2.3	1.5
Forestry Import * Biodiversity Hotspot (0/1)	0.05	0.00, 0.10	0.038	2.0	1.4
Forestry Production	0.01	-0.04, 0.07	0.59	2.7	1.6
Forestry Production * Biodiversity Hotspot (0/1)	-0.09	-0.14, -0.05	<0.001	2.0	1.4
Forestry Production * High Income (0/1)	-0.15	-0.20, -0.11	<0.001	1.8	1.4
Log of Forest Land Area	0.23	0.18, 0.28	<0.001	2.4	1.5
Log of PM2.5	0.10	0.04, 0.16	0.001	3.2	1.8
Political Stability	0.13	0.07, 0.19	<0.001	3.3	1.8
Political Stability * Biodiversity Hotspot (0/1)	-0.11	-0.16, -0.06	<0.001	2.2	1.5
Political Stability * High Income (0/1)	0.17	0.11, 0.22	<0.001	2.5	1.6
Population Density	-0.03	-0.08, 0.02	0.22	2.4	1.6
Population Density * Biodiversity Hotspot (0/1)	-0.02	-0.07, 0.04	0.53	2.9	1.7
Population Density * High Income (0/1)	0.01	-0.05, 0.06	0.80	2.7	1.6
Population Growth Rate	-0.04	-0.10, 0.01	0.15	2.8	1.7
Population Growth Rate * Biodiversity Hotspot (0/1)	0.02	-0.04, 0.07	0.57	2.8	1.7
Population Growth Rate * High Income (0/1)	-0.13	-0.17, -0.08	<0.001	2.0	1.4
Regulatory Quality	0.13	0.06, 0.19	<0.001	3.6	1.9
Temperature Change	0.04	0.00, 0.08	0.029	1.5	1.2
Temperature Change * Biodiversity Hotspot (0/1)	0.03	-0.03, 0.08	0.30	2.7	1.7

Table A3.5. Full regression results for SDG 15.

⁷ CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

Characteristic	Beta	95% CI [†]	p-value	GVIF [†]	Adjusted GVIF ²
Agricultural Land Percentage	-0.15	-0.20, -0.10	<0.001	1.6	1.3
Agricultural Land Percentage * High Income (0/1)	0.21	0.14, 0.27	<0.001	2.5	1.6
Forest Rents in GDP Percentage	0.40	0.33, 0.47	<0.001	2.7	1.6
Forest Rents in GDP Percentage * Biodiversity Hotspot (0/1)	-0.27	-0.34, -0.20	<0.001	3.0	1.7
Forest Rents in GDP Percentage * High Income (0/1)	-0.09	-0.15, -0.04	<0.001	1.7	1.3
Log of Forest Area	0.48	0.42, 0.55	<0.001	2.4	1.5
Forestry Import	-0.08	-0.14, -0.02	0.015	2.4	1.5
Forestry Import * Biodiversity Hotspot (0/1)	0.00	-0.06, 0.06	0.96	2.0	1.4
Forestry Production	-0.19	-0.25, -0.12	<0.001	2.8	1.7
Forestry Production * Biodiversity Hotspot (0/1)	-0.11	-0.17, -0.06	<0.001	2.0	1.4
Forestry Production * High Income (0/1)	-0.11	-0.17, -0.06	<0.001	1.8	1.4
Political Stability	0.22	0.14, 0.29	<0.001	3.3	1.8
Political Stability * Biodiversity Hotspot (0/1)	0.01	-0.05, 0.07	0.70	2.2	1.5
Political Stability * High Income (0/1)	0.07	0.01, 0.14	0.025	2.4	1.6
Log of PM2.5	0.14	0.07, 0.21	<0.001	3.2	1.8
Population Density	-0.02	-0.08, 0.05	0.62	2.5	1.6
Population Density * Biodiversity Hotspot (0/1)	0.07	0.00, 0.14	0.053	2.9	1.7
Population Density * High Income (0/1)	0.02	-0.04, 0.09	0.46	2.6	1.6
Population Growth Rate	-0.31	-0.37, -0.24	<0.001	2.8	1.7
Population Growth Rate * Biodiversity Hotspot (0/1)	0.14	0.07, 0.21	<0.001	2.8	1.7
Population Growth Rate * High Income (0/1)	-0.07	-0.13, -0.02	0.011	2.0	1.4
Temperature Change	0.00	-0.04, 0.05	0.85	1.5	1.2
Temperature Change * Biodiversity Hotspot (0/1)	0.01	-0.06, 0.07	0.88	2.8	1.7
Voice and Accountability	0.19	0.12, 0.25	<0.001	2.5	1.6

Table A3.6. Full regression results for Target 15.1.

¹ CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

Table A3.7.	Full	regression	results for	· Target	15.4.
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Characteristic	Beta	95% CI [†]	p-value	GVIF [†]	Adjusted GVIF ²
Agricultural Land Percentage	-0.03	-0.09, 0.03	0.39	1.6	1.3
Agricultural Land Percentage * High Income (0/1)	0.20	0.13, 0.28	<0.001	2.6	1.6
Forest Rents in GDP Percentage	0.43	0.36, 0.51	<0.001	2.7	1.6
Forest Rents in GDP Percentage * Biodiversity Hotspot (0/1)	-0.37	-0.45, -0.28	<0.001	3.0	1.7
Forest Rents in GDP Percentage * High Income (0/1)	-0.01	-0.07, 0.06	0.80	1.7	1.3
Log of Forest Area	0.14	0.06, 0.21	<0.001	2.5	1.6
Forestry Import	-0.12	-0.20, -0.03	0.008	3.2	1.8
Forestry Import * Biodiversity Hotspot (0/1)	0.05	-0.02, 0.12	0.18	2.0	1.4
Forestry Production	0.00	-0.08, 0.08	0.92	2.8	1.7
Forestry Production * Biodiversity Hotspot (0/1)	-0.11	-0.18, -0.04	0.001	2.0	1.4
Forestry Production * High Income (0/1)	-0.14	-0.22, -0.05	0.001	3.0	1.7
Political Stability	0.06	-0.03, 0.14	0.21	3.3	1.8
Political Stability * Biodiversity Hotspot (0/1)	-0.05	-0.12, 0.02	0.20	2.2	1.5
Political Stability * High Income (0/1)	0.11	0.03, 0.18	0.005	2.5	1.6
Log of PM2.5	0.04	-0.04, 0.13	0.32	3.3	1.8
Population Density	-0.14	-0.22, -0.07	<0.001	2.5	1.6
Population Density * Biodiversity Hotspot (0/1)	0.06	-0.02, 0.14	0.14	2.9	1.7
Population Density * High Income (0/1)	0.02	-0.06, 0.10	0.64	2.6	1.6
Population Growth Rate	-0.19	-0.27, -0.11	<0.001	2.8	1.7
Population Growth Rate * Biodiversity Hotspot (0/1)	0.11	0.03, 0.19	0.006	2.8	1.7
Population Growth Rate * High Income (0/1)	-0.05	-0.12, 0.01	0.11	2.0	1.4
Temperature Change	0.00	-0.06, 0.06	0.94	1.5	1.2
Temperature Change * Biodiversity Hotspot (0/1)	0.04	-0.04, 0.12	0.30	2.8	1.7
Voice and Accountability	0.16	0.08, 0.24	<0.001	2.5	1.6
1					

¹ CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

Table A5.8. Full regression results for Target 15.3	Table A3.8.	Full	regression	results for	Target 1	15.5
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Characteristic	Beta	95% CI ¹	p-value	GVIF [†]	Adjusted GVIF ^{2,1}
Agricultural Land Percentage	-0.05	-0.10, 0.00	0.071	1.6	1.3
Agricultural Land Percentage * High Income (0/1)	0.11	0.05, 0.18	<0.001	2.5	1.6
Forest Rents in GDP Percentage	-0.01	-0.08, 0.05	0.67	2.7	1.6
Forest Rents in GDP Percentage * Biodiversity Hotspot (0/1)	0.05	-0.02, 0.12	0.14	3.0	1.7
Forest Rents in GDP Percentage * High Income (0/1)	-0.07	-0.12, -0.02	0.011	1.7	1.3
Log of Forest Area	-0.13	-0.19, -0.07	<0.001	2.4	1.5
Forestry Import	-0.08	-0.14, -0.01	0.016	2.4	1.5
Forestry Import * Biodiversity Hotspot (0/1)	0.12	0.06, 0.18	<0.001	2.0	1.4
Forestry Production	-0.10	-0.17, -0.04	0.003	2.8	1.7
Forestry Production * Biodiversity Hotspot (0/1)	-0.15	-0.20, -0.09	<0.001	2.0	1.4
Forestry Production * High Income (0/1)	0.16	0.10, 0.21	<0.001	1.8	1.4
Political Stability	0.15	0.07, 0.22	<0.001	3.3	1.8
Political Stability * Biodiversity Hotspot (0/1)	-0.35	-0.41, -0.29	<0.001	2.2	1.5
Political Stability * High Income (0/1)	0.23	0.16, 0.29	<0.001	2.4	1.6
Log of PM2.5	0.26	0.19, 0.33	<0.001	3.2	1.8
Population Density	-0.24	-0.30, -0.17	<0.001	2.5	1.6
Population Density * Biodiversity Hotspot (0/1)	-0.27	-0.33, -0.20	<0.001	2.9	1.7
Population Density * High Income (0/1)	0.00	-0.06, 0.07	0.94	2.6	1.6
Population Growth Rate	0.01	-0.06, 0.08	0.79	2.8	1.7
Population Growth Rate * Biodiversity Hotspot (0/1)	-0.08	-0.14, -0.01	0.025	2.8	1.7
Population Growth Rate * High Income (0/1)	-0.11	-0.16, -0.05	<0.001	2.0	1.4
Temperature Change	0.19	0.15, 0.24	<0.001	1.5	1.2
Temperature Change * Biodiversity Hotspot (0/1)	-0.14	-0.21, -0.08	<0.001	2.8	1.7
Voice and Accountability	0.03	-0.04, 0.09	0.42	2.5	1.6

¹ CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

Beta 0.07 0.08 0.15 0.17	95% Cl ¹ -0.12, -0.02 0.02, 0.15 0.09, 0.21 0.11, 0.24	p-value 0.010 0.014 <0.001	GVIF ¹ 1.7 2.6	Adjusted GVIF ² 1.3
0.07 0.08 0.15 0.17	-0.12, -0.02 0.02, 0.15 0.09, 0.21 0.11, 0.24	0.010 0.014 <0.001	1.7 2.6	1.3
0.08 0.15 0.17 0.07	0.02, 0.15 0.09, 0.21 0.11, 0.24	0.014 <0.001	2.6	
0.15 0.17 0.07	0.09, 0.21	<0.001		1.6
0.17	0.11, 0.24		2.5	1.6
0.07		<0.001	2.7	1.6
0.01	-0.14, 0.00	0.054	3.0	1.7
0.10	-0.15, -0.05	<0.001	1.8	1.3
0.09	0.03, 0.15	0.004	2.3	1.5
0.04	-0.10, 0.03	0.25	2.5	1.6
0.01	-0.07, 0.04	0.67	1.8	1.4
0.12	0.05, 0.18	<0.001	2.7	1.7
0.03	-0.03, 0.08	0.32	2.0	1.4
0.13	-0.18, -0.07	<0.001	1.8	1.3
0.21	0.15, 0.28	<0.001	3.0	1.7
0.12	-0.18, -0.06	<0.001	2.2	1.5
0.08	0.01, 0.16	0.030	3.4	1.8
0.03	-0.02, 0.08	0.21	1.7	1.3
0.05	-0.01, 0.11	0.12	2.4	1.6
D.16	0.10, 0.23	<0.001	2.9	1.7
0.09	-0.15, -0.02	0.011	2.8	1.7
0.11	-0.17, -0.05	<0.001	2.1	1.5
0.04	0.00, 0.09	0.067	1.4	1.2
0.01	-0.06, 0.09	0.69	3.3	1.8
0.14				1.0
	.08 .03 .05 .16 .09 .11 .04	0.12 -0.18, -0.06 0.12 -0.18, -0.06 0.08 0.01, 0.16 1.03 -0.02, 0.08 1.05 -0.01, 0.11 1.16 0.10, 0.23 0.09 -0.15, -0.02 0.11 -0.17, -0.05 0.04 0.00, 0.09 0.01 -0.06, 0.09	0.12 -0.18, -0.06 <0.001 .0.8 0.01, 0.16 0.030 .03 -0.02, 0.08 0.21 .05 -0.01, 0.11 0.12 .16 0.10, 0.23 <0.001	0.12 -0.18, -0.06 <0.001

Table A3.9. Full regression results for Target 15.6.

Table A3.10.	Full	regression	results	for	Target	15.8	s.
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Characteristic	Beta	95% CI ¹	p-value	GVIF [†]	Adjusted GVIF ^{2,1}
Forest Rents in GDP Percentage	0.03	0.00, 0.07	0.080	1.3	1.1
Forest Rents in GDP Percentage * High Income (0/1)	0.10	0.06, 0.14	<0.001	1.6	1.3
Forestry Export	-0.03	-0.09, 0.03	0.32	4.0	2.0
Forestry Export * Biodiversity Hotspot (0/1)	-0.13	-0.17, -0.08	<0.001	2.3	1.5
Forestry Production	0.05	0.01, 0.10	0.020	2.3	1.5
Forestry Production * Biodiversity Hotspot (0/1)	0.05	0.01, 0.10	0.027	2.3	1.5
Forestry Production * High Income (0/1)	-0.11	-0.16, -0.05	<0.001	2.9	1.7
Political Stability	-0.01	-0.07, 0.05	0.76	3.7	1.9
Political Stability * Biodiversity Hotspot (0/1)	0.04	0.00, 0.08	0.077	2.0	1.4
Political Stability * High Income (0/1)	0.10	0.05, 0.14	<0.001	2.4	1.5
Log of PM2.5	-0.03	-0.08, 0.02	0.23	2.7	1.6
Log of PM2.5 * High Income (0/1)	-0.05	-0.10, -0.01	0.012	1.9	1.4
Log of Population aged between 0 and 14	0.12	0.06, 0.17	<0.001	3.0	1.7
Temperature Change	0.02	-0.01, 0.06	0.24	1.4	1.2
Temperature Change * Biodiversity Hotspot (0/1)	0.03	0.00, 0.07	0.080	1.6	1.3
Voice and Accountability	0.09	0.05, 0.14	<0.001	2.1	1.5

[†] CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

Characteristic	Beta	95% CI [†]	p-value	GVIF [†]	Adjusted GVIF ^{2,1}
Agricultural Land Percentage	-0.04	-0.08, 0.01	0.11	1.5	1.2
Agricultural Land Percentage * High Income (0/1)	0.09	0.03, 0.15	0.004	2.5	1.6
Forest Rents in GDP Percentage	0.01	-0.05, 0.07	0.80	2.7	1.6
Forest Rents in GDP Percentage * Biodiversity Hotspot (0/1)	-0.04	-0.11, 0.02	0.20	2.9	1.7
Forest Rents in GDP Percentage * High Income (0/1)	-0.03	-0.08, 0.02	0.26	1.7	1.3
Log of Forest Area	0.20	0.14, 0.25	<0.001	2.2	1.5
Forestry Import	0.12	0.06, 0.18	<0.001	2.4	1.6
Forestry Import * Biodiversity Hotspot (0/1)	0.02	-0.03, 0.07	0.38	1.6	1.2
Forestry Production	-0.03	-0.09, 0.03	0.40	2.6	1.6
Forestry Production * High Income (0/1)	-0.14	-0.19, -0.09	<0.001	1.7	1.3
Political Stability	0.03	-0.04, 0.09	0.41	3.0	1.7
Political Stability * Biodiversity Hotspot (0/1)	-0.04	-0.09, 0.02	0.19	1.9	1.4
Log of PM2.5	0.07	0.00, 0.14	0.050	3.4	1.8
Population Density	0.04	0.00, 0.09	0.072	1.7	1.3
Population Density * High Income (0/1)	-0.03	-0.09, 0.03	0.36	2.4	1.6
Population Growth Rate	0.05	-0.01, 0.12	0.10	2.9	1.7
Population Growth Rate * Biodiversity Hotspot (0/1)	-0.06	-0.12, 0.01	0.082	2.8	1.7
Population Growth Rate * High Income (0/1)	-0.02	-0.07, 0.04	0.58	2.1	1.5
Temperature Change	0.01	-0.03, 0.06	0.65	1.4	1.2
Temperature Change * Biodiversity Hotspot (0/1)	0.11	0.05, 0.17	<0.001	2.4	1.6
Voice and Accountability	0.06	0.00, 0.13	0.064	3.2	1.8
Voice and Accountability * High Income (0/1)	0.04	-0.02, 0.11	0.21	3.4	1.8
1					

¹ CI = Confidence Interval, GVIF = Generalized Variance Inflation Factor

² GVIF^[1/(2*df)]

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Supplementary Methods: Raw Data Analysis

- 1. Raw data preliminary analysis for SDG 14
- (1) Drivers' correlation (including all variables)



Figure A3.1. Correlation among independent variables for SDG 14.

(2) Form specification analysis

Below, From left to right, there are four plots for SDG 14, and five plots for SDG 15. The first plot is (1) original form vs. SDG, and the second plot (2) uses a nonlinear detection package (nlcor) provided by R (Ranjan and Najari, 2020). Although the second plots produced several piecewise lines that were not convenient to incorporate into one regression, they confirmed whether both plot (1) and plot (2) were the same, then a linear relationship between that independent variable and SDG should be used in the regression. The third plot (3) is log form vs. SDG, which is only shown if the original form plot was non-linear, or the distribution of independent variables is obviously skewed (close to zero because the numeric scale range is large).

The fourth plot (4) is original or log form (depending on whether plot (1) or (3) is a better fit) of independent variable vs. SDG separated by income level. For SDG 15, plot (4) was separated by biodiversity hotspot, and plot (5) was separated by income level. In total, according to the number of independent variables, there are 21 subplots for SDG 14 and 25 subplots for SDG 15.

After this step, we added interaction terms of high-income * independent variable (for SDG 14 and 15) and biodiversity-hotspot * independent variable (for SDG 15 only, because biodiversity hotspot was based on terrestrial lands, Zhang et al., 2023). The high-income and biodiversity-hotspot were dummy variables, meaning that when a country was a high-income country, the high-income value would be 1 and there would be a coefficient estimate for that independent variable; otherwise, when a country was a low-income country, the high-income value would be 0 and there would not be a coefficient estimate for that independent variable. We only included interaction terms when a major difference between lines was observed in the plots (4) and (5). For instance, if in plot (4) or (5) the lines were significantly different from each other, we generated the interaction terms. For example, when one coefficient is positive, while the other coefficient is negative, we used the interaction terms; if the two lines were paralleled, we considered there was no need to include such interaction terms.



Figure A3.2. Plots of each independent variable vs. SDG 14. From the left to right, the independent variables are in the form of (1) original, (2) with nonlinear detecting result, (3) log, and (4) separated original or log form depending on (1) or (2) by income level. (a) Decision on variable form: Corrupt vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (b) Decision on variable form: log.Crop_ani_exp vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (c) Decision on variable form: log.Crop ani imp vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (d) Decision on variable form: log.Fish_exp vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (e) Decision on variable form: log.Fish imp vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (f) Decision on variable form: log.Fish_prod vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (g) Decision on variable form: log.GDP vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (h) Decision on variable form: GDP Capita vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (i) Decision on variable form: Gov effec vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (j) Decision on variable form: Pol_stab vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (k) Decision on variable form: log.Pop 0 14 vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (1) Decision on variable form: log.Pop 15 64 vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (m) Decision on variable form: log.Pop_65 vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (n) Decision on variable form: log.Pop den vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (o) Decision on variable form: Pop_grow_rate vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (p) Decision on variable form: log.Pop_total vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (q) Decision on variable form: Reg quali vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (r) Decision on variable form: Rule law vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (s) Decision on variable form: Temp_change vs. SDG 14 SCORE,

Figure A3.2 (cont'd)

linear form is the best fit based on the plots above and will be used in the overall regression. (t) Decision on variable form: log.Tourist vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (u) Decision on variable form: Voic_acc vs. SDG 14 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression.

















- 2. Raw data preliminary analysis for SDG 15
- (1) Drivers' correlation (including all variables)



Figure A3.3. Correlation among independent variables for SDG 15.

(2) Form specification analysis



Figure A3.4. Plots of each independent variable vs. SDG 15. From the left to right, the independent variables are in the form of (1) original, (2) with nonlinear detecting result, (3) log, (4) separated original or log form depending on (1) or (2) by biodiversity hotspot status, and (5) separated original or log form depending on (1) or (2) by income level. (a) Decision on variable form: Separate Agri_perc vs. SDG 15 SCORE, linear form is the best fit based on the plots above and

Figure A3.4 (cont'd)

will be used in the overall regression. (b) Decision on variable form: Separate log.Agri_skm vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (c) Decision on variable form: Separate Corrup vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (d) Decision on variable form: Separate log.Crop_ani_exp vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (e) Decision on variable form: Separate log.Crop_ani_imp vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (f) Decision on variable form: Separate Fore_rents_perc_GDP vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (g) Decision on variable form: Separate log.Fore_skm vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (h) Decision on variable form: Separate Forest_exp vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (i) Decision on variable form: Separate Forest imp vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (j) Decision on variable form: Separate Forestry_prod vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (k) Decision on variable form: Separate log.GDP vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (1) Decision on variable form: Separate GDP capita vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (m) Decision on variable form: Separate Gov_effec vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (n) Decision on variable form: Separate Pol stab vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (o) Decision on variable form: Separate log.Pollution vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (p) Decision on variable form: Separate log.Pop 0 14 vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (q) Decision on variable form: Separate log.Pop 15 64 vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (r) Decision on variable form: Separate log.Pop_65 vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (s) Decision on variable form: Separate Pop_den vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (t) Decision on variable form: Separate Pop_grow_rate vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (u) Decision on variable form: Separate log.Pop_total vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (v) Decision on variable form: Separate Reg quali vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (w) Decision on variable form: Separate Rule_law vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (x) Decision on variable form: Separate Temp_change vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression. (y) Decision on variable form: Separate Voic acc vs. SDG 15 SCORE, linear form is the best fit based on the plots above and will be used in the overall regression.














Figure A3.5. LASSO process for SDG 14.

Figure A3.5 (cont'd)



Log Lambda



Figure A3.6. LASSO process for SDG 15.

Figure A3.6 (cont'd)



Log Lambda

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APPENDIX C SUPPORTING INFORMATION FOR CHAPTER 4

Instruction Freest Area Sol 15 Progress Forest Area SOL 15 Progress Forest Area SOL 15 Progress 2000 171083.0 05.01317 117083.0 05.01317 117083.0 05.01317 117083.0 2001 1778.68.07 11080818 172206.2.14 07.0122328 7.1358852 24.7390254 2001 1778.65.77 1.02301891 1737345.800 7.0.4403775 21.72737.5408 7.1358857 18.843580 14.8339408 2001 17697.9402 71.80007217 173875.007 7.1.80007217 173875.007 7.3.8008234 177673.04682 7.3.140857 8.8343908 2000 17690.4027 12.2208778 17.40007217 173875.007 7.1.8008234 177673.04682 7.3.1004577 7.3.7305878 6.2.2384464 121025.515 17881.4175 7.3.7305878 6.2.2384465 121025.515 7.8.8008781 1.0.9008588 5.2.2384465 121025.317 7.3.7305878 6.3.900843398 1.0.201857 7.3.7305878 6.3.90084334 1.0.201857 7.3.7305878 6.3.90084334 1.0.20185774	Voar	Forest Area	SDG 15 Progress	Estimates under 90% of F	orest Regeneration Rate		Sx_90	Estimates under 110% o	f Forest Regeneration Rate	S	x_110
2000 170833.3 68.50113917 107001 170833.3 69.50113917 107001 2001 17286.546 70.46186618 172206.2146 70.1023003 31.273057 24.15140244 173311.9299 70.75419857 84.7998982 22.102716 2001 17265.6346 71.36854757 17.38031689 17.3731.9299 70.75419857 18.43334900 2001 17267.6578 71.36831689 17.2349.909 70.7429977 15.4883455 11.96449754 17.5685485 12.9237496 72.5588585 12.7237496 11.96449757 73.1468573 72.558858 12.7237496 73.1468573 73.4468503 9.0628445 7.34994222 2000 17691.1811 73.0427641 17520.6222 77.580100 5.94543032 5.9444593 12.237746 73.7326877 74.25746831 1.0209756 17.988.4175 73.106877 73.711244 71.36836 1.72506422 77.726874 1.76697012 7.200877 7.2358677 7.37226877 1.76683.41027744 1.76697012 7.2008775 1.9914.4175 7.20764712 5.468149404	Tear	FUIESCAIEd	SDO IS FIOSIESS	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress
2001 17168.1702 69.9828733 17158.1974 69.434419 62.372543 44.432069 17231.1529 70.1227268 57.1586573 44.1392054 2002 17268.466 70.42230755 172783.4904 70.4480735 20.7489161 16.0446765 17.3907785 18.844309 14.6334085 2006 17697.4027 1.133749.9907 71.0520527 12.827746 9.560742822 177270.0563 72.5588888 11.2283778 8.72330822 2006 176974.402 72.2307764 71.5589856 7.1459391 12.202515 178991.44175 73.71304597 7.3974942 72.3498435 7.2404422 2006 176904.022 7.22074941 175570.02 71.75509.422 7.73989234 17780.19827 7.21345977 1.39834885 7.2404422 2000 17781.111 7.04277441 17567.0422 7.2157006 6.00048189 4.62272187 1780506.473 7.414976 7.39898234 1780506.413 7.71304597 7.114944 2.28839721 211 17986.027 7.4253797 16905720 <td< td=""><td>2000</td><td>170939.3</td><td>69.50113917</td><td>170939.3</td><td>69.50113917</td><td>#DIV/0!</td><td>#DIV/0!</td><td>170939.3</td><td>69.50113917</td><td>#DIV/0!</td><td>#DIV/0!</td></td<>	2000	170939.3	69.50113917	170939.3	69.50113917	#DIV/0!	#DIV/0!	170939.3	69.50113917	#DIV/0!	#DIV/0!
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2006 17604.202 72.22860273 174371.2149 71.3136398 10.2202852 7.39982934 177830.9824 73.140853 9.30828435 7.249044222 2007 17685.3181 72.62608355 17485.7702 71.95888268 8.7453032 5.09454399 17979.3262 74.2745616 6.09095656 5.39865138 2009 17731.1811 73.0476641 17529.722 72.1765065 6.00958995 14025.6754 74.8206667 6.1075565 4.78114425 2001 17905.0627 74.12563862 17683.338 72.37630439 5.42447473 3.8651995 184052.8474 74.25646144 2.889110306 2011 17905.0627 74.12563862 177823.72674 4.34877 18791672 4.34480648 3.8651995 184052.4477 74.9379171 3.8907028 4.34300648 3.86519936 130957.292 77.4430747 3.85018405 18502.4477 74.9399254 4.135700653 3.259454307 2014 11548.886 75.104201 77.4430747 3.50508863 3.044939785 1866810.8762 77.9362267	2005	175297 9402	71 80307217	173875 907	71 05205237	12 32727496	9 560742822	176729 0563	72 55888893	11 22639758	8 727330522
1000 1700 1710 <th< td=""><td>2000</td><td>176094 202</td><td>72 22360273</td><td>17/371 21/9</td><td>71 3136398</td><td>10 2202852</td><td>7 936982934</td><td>177830 9824</td><td>73 1408503</td><td>9 308288435</td><td>7 249044222</td></th<>	2000	176094 202	72 22360273	17/371 21/9	71 3136398	10 2202852	7 936982934	177830 9824	73 1408503	9 308288435	7 249044222
1006 1705111811 73.02476641 175284.4222 71.78801083 75.84520322 5.94543586 179973.322 74.27545831 5.906969566 5.380685118 2000 177811.1811 73.02476641 175284.4222 71.78801083 75.84520322 5.24584645 181025.6754 74.42260667 108705566 4.78114425 2011 179066.6217 71.2723667 176.076 5.00085189 4.68222197 1823052.4099 75.90377204 4.4434042 3.881103006 2012 180305.2083 74.42583662 176063.3177 72.6852419 4.53640743 3.86512925 164052.8474 76.42651007 4.5067124 3.42590666 2013 180557.2832 74.9155193 176063.317 72.68524017 5.5084772 77.4362377 177425.357 72.82662065 3.83896963 3.04439756 168910.8762 77.93822367 3.84250682 2.798653417 2.0461748 3.01151024 2.609708508 3.04439756 168910.8762 77.93822367 3.84250682 2.7986534 77.93822367 3.84250682 2.7986534 7.3337 <	2000	176865 3101	72.22000275	174371.2145	71 55898586	8 71/513802	6 776102515	17891/ /175	73,7130/597	7 937611268	6 192231505
2006 17/311.671 73.0287/041 17.0303.7.030237.03 17.0302307.03 17.0302307.03 17.0300237.03 17.0302237.03 17.030237.03 17.030237.03 17.030237.03 17.030237.03 17.030237.03 17.030237.03	2007	177611 1011	72.03003533	175260 4222	71.330303000	7 594520222	5 00/5/2509	170070 2202	74.27545921	6 000006506	5 209962129
2000 1/533161 7.3405/2444 1/36/2.0128 6.200049518 6.20070495 1.8102.5013 7.37024712 7.4.8200604 6.106/70284 3.82036414 7.8203871 7.3.7014712 5.460014494 4.266398721 2010 179056.0279 7.4.12553862 17633.338 72.37504373 3.36512295 184052.447 76.4261100 5.00075124 3.542340686 2011 130057.2332 7.4<79195133	2000	170001.1011	73.02470041	175209.4222	71.76601093	7.364320332	5.904545596	1/99/9.3262	74.27545851	0.909090590	4 7011 44005
2010 179/26.0691 7.7/25.069 17004.3.762 72.197/0403 6.00095012 71.0203.4137 75.3/070712 5.4004712	2009	178331.671	73.40527944	1/06/2.0128	72.00063153	6.705059898	5.225884645	181025.6754	74.82800007	6.108/05565	4.781144625
2011 17/995/0.279 74.12533662 17/836.3.38 72.376304.39 5.42474783 4.23688983 18306.24809 7.53037/208 4.94440622 3.881103000 2012 10305 AC1 74.4657401 176666.3137 72.6852419 4.556439745 3.55018405 18502.41157 76.39392543 4.135700653 3.225634087 2014 18156.8846 75.10438968 17712.921 72.4434375 4.127058899 3.279737957 1185977.1202 77.4407173 3.81010100 2.301353823 2015 182114.2254 75.40296372 177455.357 72.29626956 3.88399063 3.04493975 186910.8762 77.33622367 3.54245048 2.796835447 2011 18105.4284 75.59581350 1777757.716 7.30951434 3.33991122 2.483117189 187825.5904 78.41832665 2.99773.380504888 2.89495067 2.287045337 2010 18450.5019 76.6463552 177967.1815 73.328103312 2.445164.078 79.3077255 2.287043337 2.89495067 2.227064337 2020 184540.5019 7	2010	179026.6641	73.77232687	1/6043.3/62	72.19676005	6.000985189	4.682272197	182053.4137	75.37084712	5.468014494	4.286398721
2012 180339.627 7.4.495/401 1.76991.744 7.2.83916/72 4.3484733 3.88512245 1.18405.8474 7.6.42081007 4.3.3220889 2013 18057.2932 7.7.4307817 3.18001682 3.1010358233 2015 18214.2254 7.5.40296372 1.77425.357 7.2.8626499 3.27973957 18597.1202 7.7.4307817 3.181001682 3.1010358233 2015 18214.2254 7.5.6075702 1.77465.365 7.3.20466295 3.88399663 3.044939795 186910.8762 7.7.93622367 3.542450488 2.79968508 2011 18365.4224 7.5.9813501 1.77752.7216 7.3.09951343 3.31891129 2.657164065 188721.1602 7.8.9229077 3.88064817 2.44432865 2011 18365.0297 7.6.45663824 1.77946.4878 7.3.20290655 2.88831083 2.349815306 190454.4078 7.9.8076755 2.72873339 2.165075702 2020 184494.4185 7.8.89755336 1.7010.566 7.3.2356866 1.9207.5713 81.1032642 2.43732824 4.33732824 4.33732824	2011	1/9696.02/9	/4.12583862	1/6383.338	/2.3/630439	5.424474783	4.236889883	183062.4909	/5.903//208	4.943480642	3.881103006
2013 110997.292 74.7919133 176988.3137 72.68524319 4.38204745 3.50184405 1185024.4157 76.93992243 4.1357001682 3.125643407 2014 18154.8846 75.10143986 177212.3321 72.214434375 4.187058893 3.279573757 185977.1202 77.44301761 3.81001682 2.01016353823 2015 18154.254 75.6575902 177605.365 73.02169473 3.8399132 2.657164006 188721.1602 78.922077 3.08064317 2.444323685 2011 18156.4254 75.6575902 177867.1815 73.15996813 3.17512174 2.469118719 189597.4733 79.3550988 2.89845067 2.279764357 2011 184169.3261 76.5455534 177896.3726 73.22290852 2.49815306 190454.4078 79.80767255 2.72873359 2.165075702 2021 184450.5019 76.8435552 177996.3726 73.22560865 2.673845025 1.99169037 80.6183244 2.43733285 1.938205773 2022 18560.011 77.2985534 177900.7466 73.2252650.	2012	180339.621	74.4657401	176691.7147	72.53916772	4.94364733	3.86519295	184052.8474	76.42681007	4.506075124	3.542908696
2014 181548.8846 75.10438968 177212.9321 72.81443975 1185708.8949 3.279737957 185977.1022 77.44307817 3.818001682 3.01033823 2015 18214.2254 75.40269572 177465.355 73.02169473 3.814901012 2.889117189 187625.5904 78.41331262 3.01151024 2.609708508 2016 183650.4254 75.95813501 177767.1815 73.19996183 3.17531214 2.489117189 187625.5904 78.489239077 3.088049817 2.444323865 2016 183650.8929 67.645653824 177967.1815 73.19996183 3.17531214 2.49815306 199454.4078 79.80767255 2.728733539 2.166075702 2020 184540.5019 76.8456552 177966.3726 73.2281977 2.8199732 2.21874883 1912918.8119 80.24994218 2.575813439 2.166075702 2021 184532.117 77.9663726 73.22819797 2.819939732 2.21874883 1912918.8119 80.6618224 2.43732886 1.93626057 3.13427624 2.31126255 81.389269176 2.4462344 <td>2013</td> <td>180957.2932</td> <td>74.79195193</td> <td>176968.3137</td> <td>72.68524819</td> <td>4.536430745</td> <td>3.550188405</td> <td>185024.4157</td> <td>76.93992543</td> <td>4.135700653</td> <td>3.256343087</td>	2013	180957.2932	74.79195193	176968.3137	72.68524819	4.536430745	3.550188405	185024.4157	76.93992543	4.135700653	3.256343087
2015 182114.2254 75.40296372 177425.357 72.92662695 3.044939795 186910.8762 77.93622367 3.424450498 2.766935467 2016 18265.1359 75.68757902 177665.365 70.07165.365 3.1513117189 187825.5904 77.4153157 2.449323685 2017 183165.4254 75.95813501 177752.7216 73.09951834 3.383991292 2.657164065 188721.1602 78.89229077 3.088064817 2.444323685 2018 18365.8292 76.21452543 177967.1815 73.15996818 2.4495108719 189957.4733 79.3550988 2.898495067 2.2165075672 2020 184540.5019 76.64633552 177996.3726 73.22819797 2.819939732 2.218774883 191291.8319 80.24994218 2.575813439 2.046072633 2021 185404.550 177.996.3726 73.22819797 2.819939732 2.218774883 191291.8319 80.24994218 2.575813439 2.046072633 2022 18520.1311 77.996104 177.996.3726 73.22816966 19201.57513 81.10326442	2014	181548.8846	75.10438968	177212.9321	72.81443875	4.187058899	3.279737957	185977.1202	77.44307817	3.818001682	3.010353823
2016 122653.1359 75.6875702 177605.365 73.02169473 3.812491012 2.839117189 18725.5904 76.41931262 3.001151024 2.6090506 2017 183165.4254 75.95813501 177765.7216 73.09961813 3.157312174 2.495108719 189997,473 79.35509888 2.898495067 2.227064853 2018 183650.8229 76.21452543 177948.4876 73.22090555 2.498915306 190454.4078 79.35509888 2.898494503 2.2470733 99.3509888 2.898495037 2.218774883 191291.8319 80.24994218 2.575813439 2.165075702 2021 184944.1865 76.68435552 177990.3766 73.22522669 2.24814206 1.99160607 180.018132242 2.437332825 1.839901392 2021 18568.0811 77.2986504 177947.466 73.22522669 2.2444060 1.991696027 192097.5713 81.1032428 2.31132652 1.839901392 2021 18568.0811 77.2986504 177784.7813 73.19671942 2.248496006 1.8015129 194443.4011 81.91451051	2015	182114.2254	75.40296372	177425.357	72.92662695	3.88396963	3.044939795	186910.8762	77.93622367	3.542450498	2.796835447
2017 183165.4254 75.95813501 177752.7216 73.09951843 3.833991292 2.657164065 188721.1602 78.89229077 3.088064917 2.444323685 2018 183650.8929 76.21452543 177667.1815 73.15996813 3.175312174 2.49515306 190454.4078 79.3550988 2.989435067 2.2987064537 2020 184540.5019 76.64635552 177996.3726 73.2281979 2.19374883 191291.8319 80.24994218 2.57813439 2.04077633 2021 184540.1855 76.89755336 178010.556 73.2252669 2.528454206 1.991696927 192907.5713 81.10326428 2.43733288 1.938205703 2021 18566.8011 77.79961047 17799.7466 73.2252669 2.528454206 1.991696927 192907.5713 81.10326428 2.43733288 1.938205703 2024 185687.7329 77.44883306 17784.78913 73.1967184 1.892623688 193685.5725 81.51415081 1.966154654 2024 186567.7597 77.74888307 177784.8913 73.0844077	2016	182653.1359	75.68757902	177605.365	73.02169473	3.618491012	2.839117189	187825.5904	78.41931262	3.301151024	2.609708508
2018 183650.8929 76.21482543 177867.1815 73.15996813 3.175312174 2.495108719 189597.4733 79.35509888 2.89849507 2.297064537 2019 184109.3261 76.68435552 177996.3726 73.2291977 2.81939732 2.218774883 191251.8319 80.2494218 2.57813439 2.164077033 2021 184341.855 76.8975536 176010.556 73.22582669 2.528454206 1.991696927 192907.5713 81.0326428 2.31326552 1.839610807 2021 185660.0811 77.2966504 177936.6412 73.19665189 2.201408348 1.892623868 193685.5725 81.5115081 1.0617064 1.750080907 2021 185627.7329 77.44588306 177847.8913 73.14978042 2.284906067 1.801591929 194443.4011 81.91438357 2.090511643 1.667546254 2025 186278.445 77.6075988 177564.9014 73.0044075 1.77754876 1.7176388 195180.8138 82.3038409 1.993212103 1.95145652 2020 186773.4464 77.80759	2017	183165.4254	75.95813501	177752.7216	73.09951834	3.383991292	2.657164065	188721.1602	78.89229077	3.088064817	2.444323685
2019 184109.3261 76.45663824 177948.4878 73.20200855 2.988381030 2.349815306 190454.4078 79.80767255 2.728733539 2.16507702 2020 184540.5019 76.68435552 177996.3726 73.22810797 2.819939732 2.218774883 191291.8319 80.24994218 2.473732884 2.046072633 2021 18530.111 77.09610187 177990.7466 73.2252669 2.528454206 1.991696927 192907.5713 81.10326428 2.31326525 1.839961365 2023 185668.0811 77.27986504 177936.6412 73.106470842 2.284906067 1.801591929 194443.4011 81.91333837 209151643 1.667546254 2025 186578.7455 77.60237584 177784.9813 73.108440757 2.177518176 1.7176388 195180.8138 82.0333409 1.99321213 1.99321943 1.65746254 2026 186576.4156 77.74075898 177564.9014 73.0032465 2.078247611 1.639950129 195897.505 82.68237023 1.993309548 1.5210766 2020 1	2018	183650.8929	76.21452543	177867.1815	73.15996813	3.175312174	2.495108719	189597.4733	79.35509888	2.898495067	2.297064537
2020 184540,5019 76.68435552 177996.3726 73.22819797 2.81974883 191291.8319 80.24994218 2.57813439 2.046072633 2021 184944,1855 76.89755336 177801.0556 73.22582685 2.69735025 2.099956156 19210.96037 80.6818242 2.43732828 1.838205703 2021 18568.0811 77.2986504 177936.6412 73.19665198 2.401468348 1.889262868 193685.5725 81.51415081 2.196170646 1.750089097 2022 185687.3725 77.44868306 177747.81913 73.149760472 2.2181768 195180.8138 82.3038409 1.99310143 1.65746254 2025 186278.7455 77.60237584 177747.41098 73.04940072 2.17518176 1.7176388 195180.8138 82.3038409 1.99310548 1.5210786 2027 18677.44444 7.86364378 177369.8623 72.69731445 1.966198346 1.50690008 19768.0138 83.04985612 1.495840523 1.455740523 2029 18676.4156 77.907083708 177369.8623 72.43	2019	184109.3261	76.45663824	177948.4878	73.20290855	2.988381083	2.349815306	190454.4078	79.80767255	2.728733539	2.165075702
202118494.185576.89755336178010.55673.235688652.6673502552.099956156192109.603780.681832842.4373328851.9382057032022185201.31177.09610187177990.746673.225226692.5284542061.99169692719290.7.57181.103264282.3113265251.8399613652023185668.081177.27986504177936.641273.196651982.4014683481.892623868193685.751581.514150812.1961706461.750089072024185987.732977.44686306177747.9138173.149780422.284906071.80159129194443.401181.914383572.0095116431.6675462542025186540.769777.74075898177764.901473.00840752.1775181761.7176388195180.813882.303834091.9932121031.5914565942026186540.769777.74075898177764.901473.00924652.0782476111.639950129195897.560582.662370231.9033095481.52107862027186773.448477.863643781777369.862372.807318451.986138461.56782122196593.38883.049861221.8199840361.452753772029187149.297378.06214126176870.63572.472560861.7461282931.37935049219952.63384.064596481.602904571.2853107032031187291.710678.1373415176625.596772.472560861.7461282931.37935049219852.63384.0646694641.539754871.2258425203218743.254778.26467419175	2020	184540.5019	76.68435552	177996.3726	73.22819797	2.819939732	2.218774883	191291.8319	80.24994218	2.575813439	2.046072633
202218520.131177.09610187177990.746673.225226692.5284542061.991696927192907.571381.103264282.3113265251.8399613652023185686.081177.27986504177936.641273.196651982.401463481.892623868193685.572581.514150812.1961706461.7500890972024185987.732977.448683061777847.891373.149780422.2849060671.801591929194443.401181.914333572.0905116431.667462542025186540.769777.740758981777547.109873.094407572.177518161.7176388195180.813882.3082370231.903305481.52107862027186773.448477.86364378177369.862372.897318451.9861938461.567832122196593.338883.049856121.8199840361.4557805232028186976.415677.97083708177138.580472.775171311.9005849441.50069000819728.019583.406152121.7425327051.338324372030187291.710678.1373541517665.656772.472560641.461282931.37935049219852.63384.094596441.620904571.285107032031187403.26478.19626895176223.027372.291639341.6762012151.324321323199162.045684.406446041.5397548071.2356029732033187532.180478.27306637174965.616471.667261251.324321323199162.045684.406446041.5397548071.2356029732033187548.715578.238661175423.4977	2021	184944.1855	76.89755336	178010.556	73.23568865	2.667350255	2.099956156	192109.6037	80.68183284	2.437332885	1.938205703
2023 185668.0811 77.27986504 177936.6412 73.19665198 2.401468348 1.892623868 193685.5725 81.51415081 2.196170646 1.750089097 2024 185987.7329 77.44868306 177847.8913 73.14978042 2.284900067 1.80159129 194443.4011 81.91438357 2.090511643 1.667546254 2025 186247.679 77.70237588 177764.098 73.08440757 2.177518176 1.7176388 195180.138 82.30383409 1.993212103 1.591456594 2026 186540.7697 77.707588 177369.8623 72.89731845 1.986193846 1.56783212 196593.3838 83.04985612 1.819984036 1.455780523 2028 186976.4156 77.97083708 177138.5804 72.77517131 1.900584944 1.500690008 197268.0195 83.40615212 1.742532705 1.33832437 2030 18749.2973 78.06214126 176870.635 72.47256086 1.74622923 1.97350492 19852.633 84.84064640 1.539754807 1.228502973 2031 187403.264 78.	2022	185320.1311	77.09610187	177990.7466	73.22522669	2.528454206	1.991696927	192907.5713	81.10326428	2.311326525	1.839961365
2024185987.732977.44868306177847.891373.149780422.2849060671.801591929194443.401181.914383572.0905116431.6675462542025186278.745577.60237584177724.109873.084407572.1775181761.7176388195180.813882.303834091.9932121031.5914565942026186670.769777.74075898177564.901473.000324652.0782476111.639950129195897.560582.682370231.9033095481.52107862027186773.448477.8664378177369.862372.897318451.9861938461.567832122196593.383883.049856121.8199840361.452708522028186976.415677.97083708177138.580472.775171311.9005849441.50069008197268.019583.406152121.7425327051.3950207882029187149.297378.06214126176870.63572.403661041.8207553771.438010973197926.019583.751114711.6703495881.338324372030187291.710678.13735415176565.596772.472560861.7461282931.379350492198552.633384.084596481.6029094571.2853107032031187403.26478.19626895176223.027372.291639341.6762012151.324321323199162.045684.406440441.5397548071.235602973203218743.57778.2366741917542.497772.090660331.615344131.227845261.99749.138484.716507951.480485271.1889064222033187532.180478.2336614 <td>2023</td> <td>185668.0811</td> <td>77.27986504</td> <td>177936.6412</td> <td>73.19665198</td> <td>2.401468348</td> <td>1.892623868</td> <td>193685.5725</td> <td>81.51415081</td> <td>2.196170646</td> <td>1.750089097</td>	2023	185668.0811	77.27986504	177936.6412	73.19665198	2.401468348	1.892623868	193685.5725	81.51415081	2.196170646	1.750089097
2025186278.745577.60237584177724.109873.084407572.1775181761.7176388195180.813882.303834091.9932121031.5914565942026186540.769777.74075898177564.901473.000324652.0782476111.639950129195897.560582.682370231.9033095481.52107862027186773.448477.86364378177369.862372.897318451.9861938461.567832122196593.383883.049856121.8199840361.4557805232028186976.415677.97083708177138.580472.775171311.9005849441.500690008197268.019583.406152121.7425327051.3950207882029187149.297378.06214126176870.63572.637661041.820753771.438010973197921.195783.751114711.670395881.3383324372030187291.710678.13735415176625.596772.472560861.7461282931.379350492198552.633384.084546441.5997548071.225602973203118743.26478.1962895176223.027372.291639341.6762012151.324321323199162.045684.406464041.597548071.235602973203218748.355778.23867419175842.479772.290660351.6105344131.22728455199749.138484.4716507951.480485271.1889006422033187532.180478.2643566175423.497871.869383031.5487414031.223842268200313.609785.014622711.4247489621.1449324482034187548.715578.27308637 </td <td>2024</td> <td>185987.7329</td> <td>77.44868306</td> <td>177847.8913</td> <td>73.14978042</td> <td>2.284906067</td> <td>1.801591929</td> <td>194443.4011</td> <td>81.91438357</td> <td>2.090511643</td> <td>1.667546254</td>	2024	185987.7329	77.44868306	177847.8913	73.14978042	2.284906067	1.801591929	194443.4011	81.91438357	2.090511643	1.667546254
2026186540.769777.74075898177564.901473.000324652.0782476111.639950129195897.560582.682370231.9033095481.52107862027186773.448477.86364378177369.862372.897318451.9861938461.567832122196593.383883.049856121.8199840361.4557805232028186976.415677.97083708177138.580472.775171311.9005849441.500690008197268.019583.406152121.7425327051.3950207882029187149.297378.06214126176870.63572.633661041.8207553771.438010973197921.195783.751114711.6703495881.383324372030187291.710678.13735415176565.596772.472560861.7461282931.379350492198552.633384.084564841.602904571.2853107032031187483.55778.23867419175824.379772.291639341.6762012151.324321323199162.045684.40646441.5397548071.2356029732032187483.55778.2386741917542.479772.090660351.6105344131.27258455199749.13609785.17650751.480468271.188900642203318752.180478.2645366177423.479772.69066331.5487414031.223842268200315.009785.574351891.322353481.103458982034187548.715578.27308637174965.616471.627561661.4904811131.177831546200855.149485.30062641.3722353481.103458982035187532.734778.26464644	2025	186278.7455	77.60237584	177724.1098	73.08440757	2.177518176	1.7176388	195180.8138	82.30383409	1.993212103	1.591456594
2027186773.448477.86364378177369.862372.897318451.9861938461.567832122196593.383883.049856121.8199840361.4557805232028186976.415677.97083708177138.580472.775171311.9005849441.500690008197268.019583.406152121.7425327051.3950207882029187149.297378.06214126176870.63572.633661041.8207553771.438010973197921.195783.751114711.6703495881.3383324372030187291.710678.13735415176565.596772.472560861.7461282931.379350492198552.633384.084596481.6029094571.285107032031187403.26478.19626895176223.027372.291639341.676211251.324321323199162.045684.406446041.5397548071.235602973203218743.55778.23867419175424.479772.090660351.6105344131.27258455199749.138444.716507951.480485271.188906422033187532.180478.2645366175423.497871.89838031.5487414031.223842268200315.009785.014622711.44247489621.1449324482034187548.715578.27308637174965.616471.627561661.4904811131.177831546200855.149485.30062641.3722353481.103458982035187532.734778.26464644173468.361171.364945711.43545141.134319437201373.439985.574351891.3226693411.0642681282036187483.801178.2388031 <td>2026</td> <td>186540.7697</td> <td>77,74075898</td> <td>177564.9014</td> <td>73.00032465</td> <td>2.078247611</td> <td>1.639950129</td> <td>195897,5605</td> <td>82.68237023</td> <td>1.903309548</td> <td>1.5210786</td>	2026	186540.7697	77,74075898	177564.9014	73.00032465	2.078247611	1.639950129	195897,5605	82.68237023	1.903309548	1.5210786
2028186976.415677.97083708177138.580472.775171311.9005849441.500690008197268.019583.406152121.7425327051.3950207882029187149.297378.06214126176870.63572.633661041.8207553771.438010973197921.195783.751114711.6703495881.3383324372030187291.710678.13735415176665.596772.472560861.7461282931.379350492198552.633384.084596481.6029094571.2853107032031187403.26478.19626895176223.027372.291639341.6762012151.324321323199162.045684.40646041.5397548071.2356029732032187483.55778.23867419175842.479772.090660351.6105344131.27258455199749.138484.716462751.480485271.1889006422033187532.180478.26453661.75423.497871.86938031.5487414031.223842268200313.609785.01662641.3722353481.1449324482034187548.715578.273086371.74965.616471.627561661.4904811131.177831546200855.149485.00626641.3722353481.1449324482035187532.734778.26464644174468.361171.364945711.43545141.134319437201373.439985.574351891.3226693411.0642681282036187483.801178.23880311.73931.248171.081279721.3833836391.093098813201868.155185.835626321.2758063761.0271712962037187401.468378.195205	2027	186773.4484	77.86364378	177369.8623	72.89731845	1.986193846	1.567832122	196593.3838	83.04985612	1.819984036	1.455780523
2020 187149.2973 78.06214126 176870.635 72.63366104 1.820755377 1.438010973 197921.1957 83.75111471 1.670349588 1.338332437 2030 187291.7106 78.13735415 176870.635 72.47256086 1.746128293 1.379350492 198552.6333 84.08459648 1.602909457 1.285310703 2031 187403.264 78.19626895 176223.0273 72.29163934 1.676201215 1.324321323 199162.0456 84.40644604 1.539754807 1.235602973 2032 187483.557 78.23867419 175842.4797 72.09066005 1.610534413 1.27258455 199749.1384 84.71650795 1.48048527 1.188900642 2033 187532.1804 78.26435366 175423.4978 71.86938303 1.548741403 1.22384268 200316.5079 85.01462271 1.4424748962 1.14432448 2034 187548.7155 78.27308637 174965.6164 71.62756166 1.490481113 1.177831546 20085.1494 85.57435189 1.322669341 1.064268128 2035 187542.7347	2028	186976 4156	77 97083708	177138 5804	72 77517131	1 900584944	1 500690008	197268 0195	83 40615212	1 742532705	1 395020788
2030187291.71678.13735415176565.596772.472560861.7461282931.37935049219852.633384.084596481.6029094571.2853107032031187403.26478.19626895176223.027372.291639341.6762012151.324321323199162.045684.406446041.5397548071.2356029732032187483.55778.23867419175842.479772.090660351.6105344131.27258455199749.138484.716507951.480485271.1889006422033187532.180478.26435366175423.497871.869383031.5487414031.223842268200313.609785.014622711.4247489621.1449324482034187548.715578.27308637174965.616471.627561661.4904811131.177831546200855.149485.300626641.3722353481.103458982035187532.734778.26464644174468.361171.364945711.43545141.134319437201373.439985.574351891.3226693411.0642681282036187483.801178.2388031173931.248171.08127721.383386391.093098813201868.155185.835626321.2758063761.0271712962037187401.468378.19532057173353.784470.776303251.334038151.053984876202338.960986.08217251.231428280.9920002312038187285.280378.13395807172735.467470.449750851.2872006121.016812221202785515186.320112611.1893398300.9886043032038187285.280378.13395807 <td>2029</td> <td>187149 2973</td> <td>78 06214126</td> <td>176870 635</td> <td>72 63366104</td> <td>1 820755377</td> <td>1 438010973</td> <td>197921 1957</td> <td>83 75111471</td> <td>1 670349588</td> <td>1 338332437</td>	2029	187149 2973	78 06214126	176870 635	72 63366104	1 820755377	1 438010973	197921 1957	83 75111471	1 670349588	1 338332437
203 10/10/10/10 17/00/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10 17/00/10/10/10/10/10/10/10/10/10 <th< td=""><td>2020</td><td>187291 7106</td><td>78 13735415</td><td>176565 5967</td><td>72.00000104</td><td>1 746128293</td><td>1.379350492</td><td>198552 6333</td><td>84 08459648</td><td>1 602909457</td><td>1 285310703</td></th<>	2020	187291 7106	78 13735415	176565 5967	72.00000104	1 746128293	1.379350492	198552 6333	84 08459648	1 602909457	1 285310703
2031 10/10/00/01 10/21/3/25 12/21/3/25 10/22/3/25 10/2/3/25 10/2/3/25 10/2/3/25 10/2/3/25 10/2/3/25 10/2/3/25 10/2/3/25 10/2/3/25 10/2/3/25 1.4804054 1.4804052 1.148000642 1.4804054 1.48040564 1.48040564 1	2000	187403 264	78 19626895	176223 0273	72.47200000	1.676201215	1 32/321323	199162.0000	84,40644604	1 53975/807	1 235602973
2032 16748.354 78.25807419 173842.479 72.5960635 1.610354413 1.2228435 199749.13647 64.71040527 1.4640527 1.1689044327 2033 187532.1804 78.26435366 17542.4797 71.86998303 1.548741403 1.22384268 20031.6007 85.01462271 1.424748962 1.1449032448 2034 187548.715 78.27308637 174965.6164 71.62756166 1.49048113 1.177831546 200855.1494 85.03062664 1.372235348 1.10435898 2035 187532.7347 78.26464644 174468.3611 71.36494571 1.4354514 1.134319437 201373.4399 85.57435189 1.322669341 1.064268128 2036 187483.8011 78.2388031 173931.2481 71.08127972 1.383383639 1.093098813 201868.1551 85.83562632 1.2275806376 1.027171296 2037 187401.4683 78.1952057 173353.7844 70.77630325 1.334038195 1.053984876 202338.9609 86.0842735 1.21428288 0.99200221 2038 187285.2803 78.	2001	107403.204	70.13020033	176223.0273	72.20100004	1.610524412	1.024021020	100740 1294	84 71650705	1 49049527	1.199000640
2033 1073423.4976 71.6023603 1.349/41435 2003103007 63.5140271 1.42244352 1.143344352 2034 187548.7155 78.27308637 174465.6164 71.62756166 1.49048113 1.172842166 200315.51494 85.514094 85.514094 85.5046264 1.322642348 1.10345898 2035 187548.7155 78.27308637 174468.3611 71.134944571 1.4354514 1.134319437 201373.4399 85.57435189 1.322669341 1.064268128 2036 18748.38011 78.2388031 173931.2481 71.08127972 1.383383639 1.093098813 201868.1551 85.83562632 1.2275806376 1.027171296 2037 187401.4683 78.19532057 173353.7844 70.77630325 1.334038195 1.053984876 202338.9609 86.0842735 1.23142828 0.99200221 2038 187245.7714 78.13395807 7172735.4674 70.44975085 1.287200612 1.01681221 202785.511 86.32011261 1.18933883 0.985804323 2038 187143.7714 78.04469999 1	2032	107522 1004	70.23007419	17542.4797	72.09000033	1.549741402	1 222042260	200212 6007	95 01/62271	1 40040527	1.188500042
2034 187348.7155 78.2730837 174955.8164 71.62756166 1.49481113 1.177831346 200855.1494 85.3006204 1.32233348 1.1043898 2035 187532.7347 78.26464644 174468.3611 71.36494571 1.4354514 1.134319437 201373.4399 85.573556189 1.32269341 1.064268128 2036 187483.8011 78.2388031 173931.2481 71.08127972 1.383383639 1.093098813 201868.1551 85.83562632 1.275806376 1.027171296 2037 187401.4683 78.19532057 173353.7844 70.77630325 1.334038195 1.053984876 202338.9609 86.32011261 1.189339839 0.992000221 2038 187285.2803 78.13395807 172735.4674 70.44975085 1.287200612 1.016812221 202785.5151 86.32011261 1.189339839 0.958604303 2039 187134.7714 78.05446999 172075.7848 70.1135203 1.24267883 0.981432352 20372.4669 86.54295841 1.499585777 0.92684834	2000	107540 7155	78.20433300	173423.4378	71.00350505	1.040741403	1.223042208	200313.0097	05.01402271	1.424746902	1.144932448
2035 18/52/34/ 78.26464644 1/4468.3611 71.36449471 1.334319437 2013/3.4399 85.5/43169 1.322669341 1.06426128 2036 187483.8011 78.284604644 1/73931.2481 71.08127972 1.383383639 1.093098813 201868.1551 85.83662623 1.275806376 1.027171296 2037 187401.4683 78.19532057 173353.7844 70.77630325 1.334038195 1.053984876 202338.9609 86.0826235 1.221428288 0.992000221 2038 187285.2803 78.13395807 172735.4674 70.44975085 1.287200612 1.016812221 202785.5151 86.32011261 1.189339839 0.958604303 2039 187134.7714 78.0546999 172075.7848 70.14975085 1.24267883 0.981432352 20370.74669 86.54219261 1.149365777 0.92684834	2034	18/548./155	78.27308637	174905.0104	71.02/00100	1.490481113	1.1//831546	200855.1494	85.30062664	1.372235348	1.10345898
2036 187483.8011 78.2388031 173931.2481 71.0817/92 1.88383639 1.093098813 201868.1551 85.8356262 1.275806376 1.027171296 2037 187401.4683 78.19532057 173353.7844 70.77630325 1.334038195 1.053984876 202338.9609 86.0842735 1.221428288 0.992000221 2038 187285.2803 78.13395807 172735.4674 70.44975085 1.287200612 1.016812221 202785.5151 86.32011261 1.189339839 0.958604303 2039 187134 7714 78.05446999 172705.7848 70.14135203 1.242672883 0.981432352 202378.5151 86.32011261 1.189339839 0.958604303 2039 187134 7714 78.05446999 172705.7848 70.14135203 1.24267883 0.981432352 202377.2669 86.54295841 1.49356777 0.92684834	2035	18/532./34/	78.26464644	174408.3011	/1.364945/1	1.4354514	1.134319437	2013/3.4399	85.5/435189	1.322669341	1.064268128
2037 18/401.4683 78.1952057 17/335.7844 70.7/630325 1.334038195 1.053984876 202338.9609 86.0821275 1.231428288 0.992000221 2038 187285.2803 78.13395807 172735.4674 70.44975085 1.287200612 1.016812221 202785.5151 86.32011261 1.189339839 0.958604303 2039 18714 7714 78.05464999 1770757848 70.14975085 1.247200612 1.016812221 202785.5151 86.32011261 1.189339839 0.958604303 2039 18714 7714 78.05464999 1770757848 70.149750883 0.981432352 203072 4669 86.54099841 1.409365777 0.92684834	2036	187483.8011	/8.2388031	173931.2481	/1.0812/9/2	1.383383639	1.093098813	201868.1551	85.83562632	1.2/58063/6	1.02/1/1296
2038 187285.2803 78.13395807 172735.4674 70.44975085 1.287200612 1.016812221 202785.5151 86.32011261 1.189339839 0.958604303 2039 187134 7714 78.054469699 172075.7848 70.10135203 1.242678383 0.981432352 203207.4669 86.54295841 1.49365777 0.958604303	2037	18/401.4683	/8.19532057	1/3353./844	/0.//630325	1.334038195	1.053984876	202338.9609	86.0842/35	1.231428288	0.992000221
2039 187134 7714 78 05446969 172075 7848 70 10135203 1 242678383 0 981432352 203207 4669 86 54295841 1 149365777 0 92684834	2038	187285.2803	78.13395807	172735.4674	70.44975085	1.287200612	1.016812221	202785.5151	86.32011261	1.189339839	0.958604303
	2039	187134.7714	78.05446969	172075.7848	70.10135203	1.242678383	0.981432352	203207.4669	86.54295841	1.149365777	0.92684834
2040 186949.4665 77.95660439 171374.2148 69.73083116 1.200298208 0.947711567 203604.457 86.75262119 1.111348342 0.896610603	2040	186949.4665	77.95660439	171374.2148	69.73083116	1.200298208	0.947711567	203604.457	86.75262119	1.111348342	0.896610603
2041 186728.8801 77.8401059 170630.2257 69.33790744 1.159903649 0.915529157 203976.1176 86.94890669 1.075145131 0.867781198	2041	186728.8801	77.8401059	170630.2257	69.33790744	1.159903649	0.915529157	203976.1176	86.94890669	1.075145131	0.867781198
2042 186472.5172 77.70471268 169843.2759 68.92229487 1.121353129 0.884775859 204322.0723 87.1316100 1.040627273 0.840260655	2042	186472.5172	77.70471268	169843.2759	68.92229487	1.121353129	0.884775859	204322.0723	87.13161606	1.040627273	0.840260655
2043 186179.8723 77.55015786 169012.8139 68.48370216 1.0845182 0.855352526 204641.9356 87.3005458 1.007677855 0.813958716	2043	186179.8723	77.55015786	169012.8139	68.48370216	1.0845182	0.855352526	204641.9356	87.3005458	1.007677855	0.813958716
2044 185850.43 77.37616917 168138.2782 68.02183273 1.049282053 0.827168978 204935.3134 87.45548772 0.976190562 0.788793294	2044	185850.43	77.37616917	168138.2782	68.02183273	1.049282053	0.827168978	204935.3134	87.45548772	0.976190562	0.788793294
2045 185483.6644 77.18246889 167219.0969 67.53638461 1.015538226 0.800143007 205201.8024 87.59622885 0.946068502 0.764689561	2045	185483.6644	77.18246889	167219.0969	67.53638461	1.015538226	0.800143007	205201.8024	87.59622885	0.946068502	0.764689561
2046 185079.0392 76.96877378 166254.6881 67.02705041 0.983189477 0.774199511 205440.9903 87.72255139 0.917223185 0.741579163	2046	185079.0392	76.96877378	166254.6881	67.02705041	0.983189477	0.774199511	205440.9903	87.72255139	0.917223185	0.741579163
2047 184636.0075 76.73479502 165244.4593 66.49351726 0.952146808 0.749269738 205652.4555 87.83423267 0.889573625 0.719399531	2047	184636.0075	76.73479502	165244.4593	66.49351726	0.952146808	0.749269738	205652.4555	87.83423267	0.889573625	0.719399531
2048 184154.0118 76.48023814 164187.8077 65.93546679 0.922328604 0.725290626 205835.7668 87.9310451 0.863045562 0.698093279	2048	184154.0118	76.48023814	164187.8077	65.93546679	0.922328604	0.725290626	205835.7668	87.9310451	0.863045562	0.698093279
2049 183632.4837 76.20480299 163084.1198 65.35257502 0.893659878 0.702204222 205990.4841 88.01275605 0.837570774 0.677607676	2049	183632.4837	76.20480299	163084.1198	65.35257502	0.893659878	0.702204222	205990.4841	88.01275605	0.837570774	0.677607676
2050 183070.8439 75.9081836 161932.7716 64.74451234 0.866071614 0.679957174 206116.157 88.07912786 0.813086478 0.657894184	2050	183070.8439	75.9081836	161932.7716	64.74451234	0.866071614	0.679957174	206116.157	88.07912786	0.813086478	0.657894184

Table A4.1. Sensitivity Analysis of Forest Area and SDG 15 Progress to Forest Regeneration Rate between 2000 and 2050.

Year Forest Area		SDG 15 Progress	Estimates under 90% of Initial Forest Area		Sx_90		Estimates under 110% of Initial Forest Area		Sx_110	
real	I VICSLAID	SDO IS FIOgress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress
2000	170939.3	69.50113917	153845.37	60.47330482	1	0.769853949	188033.23	78.52897351	1	0.790776317
2001	171861.7002	69.98828733	154494.2674	60.81600763	0.98956306	0.763041356	189229.1331	79.16056702	0.990511873	0.784583051
2002	172758.6346	70.46198618	155113.3228	61.14295001	0.979062521	0.756108088	190403.9464	79.78102235	0.980965928	0.77828008
2003	173630.2392	70.92230755	155702.6024	61.4541668	0.968506006	0.749062666	191557.8759	80.3904483	0.971369097	0.771875151
2004	174476.6378	71.36931689	156262.1588	61.74968589	0.957900788	0.741913249	192691.1167	80.98894789	0.961727989	0.765375681
2005	175297.9402	71.80307217	156792.0296	62.02952708	0.947253791	0.734667631	193803.8508	81.57661727	0.952048901	0.758788755
2006	176094.202	72.22360273	157292.1968	62.29368091	0.936571392	0.727333045	194896.2072	82.15352455	0.942337629	0.75212095
2007	176865.3191	72.63085355	157762.4818	62.54205299	0.925858899	0.719915644	195968.1564	82.71965412	0.932598999	0.745377858
2008	177611.1811	73.02476641	158202.6984	62.77454503	0.915121413	0.712421359	197019.6638	83.27498778	0.922837648	0.738564872
2009	178331.671	73.40527944	158612.6526	62.99105453	0.904363834	0.704855906	198050.6894	83.81950436	0.913058031	0.731687188
2010	179026.6641	73.77232687	158992.1414	63.19147435	0.893590861	0.697224791	199061.1868	84.35317938	0.903264419	0.72474981
2011	179696.0279	74.12583862	159340.9528	63.37569246	0.882807001	0.68953331	200051.103	84.87598478	0.89346091	0.717757554
2012	180339.621	74.4657401	159658.8647	63.54359161	0.872016567	0.681786556	201020.3773	85.3878886	0.883651425	0.710715051
2013	180957.2932	74.79195193	159945.6448	63.69504906	0.861223688	0.673989426	201968.9416	85.8888548	0.873839717	0.703626751
2014	181548.8846	75.10438968	160201.0498	63.82993636	0.850432312	0.66614662	202896.7193	86.37884299	0.864029374	0.696496927
2015	182114.2254	75.40296372	160424.8253	63.94811915	0.839646207	0.658262653	203803.6256	86.85780829	0.854223825	0.689329684
2016	182653.1359	75.68757902	160616.7054	64.04945694	0.828868976	0.650341855	204689.5664	87.3257011	0.844426341	0.682128959
2017	183165.4254	75.95813501	160776.412	64.13380297	0.81810405	0.64238838	205554.4388	87.78246705	0.834640046	0.674898527
2018	183650.8929	76.21452543	160903.6553	64.20100408	0.807354704	0.63440621	206398.1305	88.22804678	0.824867913	0.667642009
2019	184109.3261	76.45663824	160998.1327	64.25090055	0.796624055	0.626399159	207220.5196	88.66237593	0.815112777	0.660362872
2020	184540.5019	76.68435552	161059.5294	64.28332602	0.785915071	0.618370882	208021.4744	89.08538501	0.805377338	0.653064439
2021	184944.1855	76.89755336	161087.5174	64.2981074	0.775230577	0.610324879	208800.8536	89.49699933	0.795664161	0.64574989
2022	185320.1311	77.09610187	161081.7563	64.29506477	0.764573256	0.602264498	209558.5058	89.89713897	0.785975687	0.638422271
2023	185668.0811	77.27986504	161041.8923	64.27401135	0.753945659	0.594192945	210294.2698	90.28571874	0.776314235	0.631084495
2024	185987.7329	77.44868306	160967.5251	64.23473571	0.743350073	0.58611315	211007.9406	90.66263042	0.766681885	0.623739227
2025	186278.7455	77.60237584	160858.2144	64.17700532	0.732788566	0.578027815	211699.2766	91.02774635	0.757080515	0.616388923
2026	186540.7697	77.74075898	160713.5101	64.10058254	0.722263115	0.569939541	212368.0293	91.38093542	0.747511923	0.609035946
2027	186773.4484	77.86364378	160532.9526	64.00522451	0.711775609	0.561850831	213013.9441	91.72206304	0.737977826	0.601682574
2028	186976.4156	77.97083708	160316.0719	63.89068311	0.701327852	0.553764094	213636.7593	92.05099105	0.728479865	0.594330995
2029	187149.2973	78.06214126	160062.3881	63.75670483	0.690921567	0.545681648	214236.2065	92.3675777	0.719019606	0.586983316
2030	187291.7106	78.13735415	159771.4109	63.60303073	0.680558397	0.537605721	214812.0104	92.67167757	0.709598542	0.579641564
2031	187403.264	78.19626895	159442.6395	63.42939635	0.670239908	0.529538455	215363.8885	92.96314154	0.700218098	0.572307686
2032	187483.557	78.23867419	159075.5625	63.23553163	0.659967591	0.521481909	215891.5516	93.24181674	0.690879628	0.564983554
2033	187532.1804	78.26435366	158669.6579	63.02116083	0.649742866	0.513438061	216394.7028	93.5075465	0.681584423	0.557670964
2034	187548.7155	78.27308637	158224.3927	62.78600245	0.639567082	0.505408809	216873.0383	93.76017029	0.672333711	0.550371644
2035	187532.7347	78.26464644	157739.2228	62.52976918	0.629441521	0.497395977	217326.2467	93.99952371	0.663128655	0.543087252
2036	187483.8011	78.2388031	157213.593	62.2521678	0.6193674	0.489401313	217754.0093	94.2254384	0.653970364	0.535819376
2037	187401.4683	78.19532057	156646.9368	61.95289911	0.609345873	0.481426496	218155.9998	94.43774204	0.644859884	0.528569542
2038	187285.2803	78.13395807	156038.6763	61.63165786	0.599378033	0.473473135	218531.8842	94.63625828	0.635798212	0.521339213
2039	187134.7714	78.05446969	155388.2218	61.28813268	0.589464914	0.46554277	218881.3211	94.82080671	0.626786285	0.514129791
2040	186949.4665	77.95660439	154694.972	60.92200599	0.579607493	0.457636878	219203.9609	94.9912028	0.617824993	0.506942617
2041	186728.8801	77.8401059	153958.3138	60.53295393	0.569806692	0.449756875	219499.4465	95.14725788	0.608915175	0.499778977
2042	186472.5172	77.70471268	153177.6218	60.12064627	0.560063382	0.441904113	219767.4126	95.28877909	0.60005762	0.492640103
2043	186179.8723	77.55015786	152352.2586	59.68474639	0.550378379	0.434079887	220007.486	95.41556933	0.591253072	0.48552717
2044	185850.43	77.37616917	151481.5745	59.22491112	0.540752454	0.426285434	220219.2856	95.52742723	0.582502231	0.478441304
2045	185483.6644	77.18246889	150564.9072	58.74079071	0.531186328	0.418521938	220402.4217	95.62414707	0.573805753	0.47138358
2046	185079.0392	76.96877378	149601.5819	58.23202874	0.521680675	0.410790528	220556.4966	95.70551881	0.56516425	0.464355025
2047	184636.0075	76.73479502	148590.9109	57.69826206	0.512236128	0.403092282	220681.1042	95.77132797	0.556578298	0.45735662
2048	184154.0118	76.48023814	147532.1936	57.13912066	0.502853274	0.395428228	220775.8301	95.82135563	0.548048431	0.450389298
2049	183632.4837	76.20480299	146424.7164	56.55422762	0.49353266	0.387799347	220840.2511	95.85537835	0.539575145	0.443453952
2050	183070.8439	75.9081836	145267.7523	55.94319903	0.484274794	0.380206573	220873.9355	95.87316817	0.531158904	0.43655143

Table A4.2. Sensitivity Analysis of Forest Area and SDG 15 Progress to Initial Forest Area between 2000 and 2050.

Instruction Stock 19 Progets Forest Area SDG 19 Progets Forest Area SDG 19 Progets Forest Area SDG 19 Progets 2001 172883.0 66.5011387 40/101 170183.0 69.501137 40/101 FDI/SDI 19 FDI/SDI/SDI 19 FDI/SDI 19 FDI/SDI 1	Voar	Forest Area	SDC 15 Prograss	Estimates under 9	0% of Population	S	5x_90	Estimates under	110% of Population	S	x_110
2000 170839.3 69.50113917 170839.3 69.50113917 107001.0 170783.3 69.50113917 107001.0 107001.0 170783.53 69.50113917 107001.0 107001.0 107001.00 1070000.00 107001.00 10	Tear	FUIESLAIEd	3DO 13 FIUgress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress
2010 171838.2444 70.0287120 -224.522 173.132049 1778.1571 69.4786252 60.40.02654 -15.73.0165 2012 7258.0584 70.4932075 70.3341481 11.412744 80.54871 71.0320.1378 70.3047481 70.4047481 71.4174454 4.4071611 70.4174444 70.4017444 70.4047481 70.4047481 71.4174454 71.41744454 71.41744454 71.41744454 71.41744454 71.41744454 71.4174444 71.4174444 71.4174444 71.4174444 71.4174444 71.41744444 71.41744444 71.41744454 71.41744454 71.41744454 71.41744444 71.41712.4331 71.41744455 71.41744444	2000	170939.3	69.50113917	170939.3	69.50113917	#DIV/0!	#DIV/0!	170939.3	69.50113917	#DIV/0!	#DIV/0!
2002 127268.634 70.46136818 112609.8735 70.5413641 114.912794 486.76450736 172607.373 70.32841708 10.415473 40.4151473 2004 174476.5378 71.39831888 17477.73112 71.5223307 40.024678 47.4567394 71.2147861 41.212285 41.897470 2005 175257.9402 71.2300711 175655.1816 71.919712677 72.747399 22.895351 2006 175657.9474 172804.202 72.22280273 176555.6877 72.4462076 72.73078645 28.916004 -22.492558 2008 177811.911 70.02476841 171853.887 73.1220707 32.4640603 177712.6383 72.73078645 28.980301 45.54122767 2011 179056.641 73.7322467 17.9868.713 74.1318476 72.3403808 72.24077431 179856.266 73.73513715 21.9112413 11.15680818 2011 19056.641 73.71331375 21.9112413 74.3414715 1.5808999 1.301411 7.10181913 1.116804 74.413144715 1.58089999	2001	171861.7002	69.98828733	171938.2434	70.02871213	-224.5292	-173.1320349	171785.1571	69.94786252	-204.026546	-157.3018503
2001 27380 2202 70 92203 173851.953 71.0340111 78.2127614 400.5587 17480.654 71.14761 54.122265 41.0897400 2005 175807.9402 71.9030717 176555.1816 71.99174044 40.096882 38.0574397 1765155.1816 71.99174044 44.096786 41.447452 176866.010 71.977777 73.773739 72.852595 36.5673004 -28.4345966 178372.475 77.2.37076672 32.533343 -25.278566 2006 177611.1611 73.042476641 171613.886 77.2.239331 -28.49733 -20.0000038 17712.4838 77.2.37076645 -28.198106 -24.496550 2010 17302.6661 73.77232687 179666.711 74.125838 179104.538 77.37731407 -24.491570 11.516119 14.519224 14.519244 14.519244 14.519244 14.519244 14.519244 14.519244 14.519244 14.519244 14.519244 14.519244 14.519244 14.519244 14.519244 14.519774 15.8111974 14.819379411311 14.5197574 14.5	2002	172758.6346	70.46198618	172908.9735	70.54138481	-114.912794	-88.74458073	172607.973	70.38241708	-104.151473	-80.41315138
2004 1/4476.5378 71.36931689 1/2477.5112 71.5223007 40.0249578 446.49052855 1/248.4 1/2	2003	173630.2392	70.92230755	173851.953	71.03940151	-78.3127614	-60.56871668	173407.6434	70.80474781	-70.8204365	-54.75339885
2005 175297-9402 71, 160307217 175655, 1516 77, 21, 24620765 -176644, 244474632 175656, 6674 71, 16129454 -4.40, 715117 -34, 1694075 2007 176645, 3319 72, 63085355 177344, 9889 72, 8802695 -56, 67, 6704 -24, 434356 176, 72, 72, 73078440 -28, 916064 -20, 910753 -27, 8707846 -28, 916064 -22, 72, 70, 7845 -28, 916064 -20, 20, 793 -21, 17712, 5338 73, 07334068 -20, 802086 -20, 20, 793 2101 179606, 6641 73, 773, 773, 773, 773, 773, 773, 773,	2004	174476.6378	71.36931689	174767.3112	71.52283057	-60.0249578	-46.49052585	174184.0554	71.2147951	-54.1212265	-41.89747032
2006 176964.020 72.22360273 176515.6977 72.44620765 -41.77841.33 -32.44474825 72.3787389 -28.983031 2001 176856.3014 72.3026724 177345.538 72.3705672 -25.333341 -22.8233341 -22.8233341 -22.8433506 176737.475 72.73078645 -22.8400331 -17.855115 -22.8400331 -22.8400331 -72.840741 -11.1111.110.65 74.4571411 -21.9122445 -74.42014524 -74.40244743 -11.95669994 -21.9122445 -74.422473 -22.440273 -11.9168335 -14.9579747 -13.845245 -75.8013856 -22.4401457 -12.80164 -14.924974 -11.915843245 -75.402264273 17.9049138 -14.45973474 -11.556757 -11.81584484	2005	175297.9402	71.80307217	175655.1816	71.99174244	-49.0698822	-38.05743974	174937.0872	71.61249454	-44.0716117	-34.16049721
0001 T78865.3191 72.63083355 177348.888 72.862905 -36.573004 -28.433465 178372.475 1773754.539 72.37067645 28.9160064 -22.409633 0001 T7311.617 73.4627944 178954.389 73.27387645 28.916703 -23.109066033 177712.638 73.0736645 28.916004 -22.409633 0101 T99026.6441 73.7732687 179686.7111 74.1091919 -27.1323395 -21.1829324 178384.6014 73.41316467 23.8409301 18.81922 011 T99026.6441 73.7732687 17.9856.3266 T73.3515715 2.91924345 17.168118 T74.4657401 18.1111.0555 74.7315717 -23.877483 1-17.449156 10010.8010 74.4657401 19.309862 16.987297 12.9104345 14.959777 14.9136863 14.957977 13.9147.5402 16.9774923 14.957977 14.9136864 14.957977 14.913644 19.308561 14.92047071 15.947692 19.33748 15.32187330 19.9117.5433 15.267657802 19.327847 11.500757702 18.3206.9091 75.1493226	2006	176094.202	72.22360273	176515.6977	72.44620765	-41.7784143	-32,44474632	175666.6074	71.99777677	-37.3477399	-28.98361397
2008 177611.1811 73.02476641 178155.1819 73.3120707 -28.407633 177704.538 73.078646 28.040056 22.0409533 2009 178331.671 73.4052784 178666.7131 74.1203919 -27.1232395 17712.6383 73.07834080 28.0402886 20.320792 2011 179666.0279 74.12563862 180412.2445 74.4004944 20.080188 19.5972712 178864.6014 74.3151467 73.94029301 -11.556189 2011 190596.2027 74.12563862 180412.2445 74.4004944 -23.074431 1178964.0019 74.43014047 +1.9126433 -14.59774418 179841.3811 74.0204024 18.0139363 -14.99797 2011 180596.80866 16.2428.0988 75.58672960 -10.5479788 -15.21474201 180010.0019 74.3404407 +1.336533 -14.0977444 12.6712233 14.30045021 14.30045021 12.6707336 18200.1357 75.9487304 12.671274 12.6707233 14.30045021 15.944642 14.105259 -11.071781 2011 184456.501 76.45663	2007	176865.3191	72.63085355	177348.9898	72.88629505	-36.5673004	-28,43345966	176372.475	72.37056732	-32.5333343	-25.27656668
2009 178331.671 73.40527944 178834.386 73.72359331 -23.6066038 177712.6383 73.0783408 26.098286 -20.320789 2010 179026.644 73.7723687 179666.7131 74.1091919 -27.1232367 -21.1629244 17846.614 73.4131647 23.409301 -18.551922 2011 179606.727 74.1258862 1504122445 74.501911 23.3771483 18.95972712 17.9666.146 73.4341715 21.919335 14.9579972 2013 18057.230217 75.951933 181738.053 75.52806129 -21.810435 15.32187338 74.462244502 18.01399035 14.009724 2013 181548.846 75.10438968 15.24287398 15.32187339 13.0045744 18.039035 14.009724 2017 183165.425 75.95813501 18.4208.000701 76.50456296 17.7032193 13.304564 18.203.3061 15.409724 14.009724 2017 18365.4250 15.7270702 18.3056424 15.2187338 13.30145646 13.0345646 13.03456464 14.0224476 15.	2008	177611 1811	73 02476641	178155 1819	73 31207007	-32 6490691	-25 41727673	177054 539	72 73078645	-28 9160064	-22 49095363
2010 179026.6641 73.77232887 179686.7131 74.12091919 -27.1232395 -21.16292348 178346.6014 73.41316467 -23.8409301 -18.581922 2011 179686.0279 74.12583662 180412.2445 74.6040944 -20.0980188 19.9972121 179862.2465 73.7513715 -21.912943 -17.1568102 2013 180657.2392 74.7915513 181733.053 75.22206129 -21.9140345 -17.1481156 180010.8019 74.34144645 -20.449932 -14.59774318 180637.2397 74.6224602 18.00972.3937 74.6224602 18.00972.3937 74.6224602 18.00972.3937 74.62240028 -13.335762 2016 182653.1350 75.68757902 183046.0516 75.8879699 -15.3417386 1811632.2779 75.1484328 16.1746454 -20.4717221 2018 182650.329 75.268757902 18.3693764 -14.5967834 182523.3854 75.687597084 12.6712721 2018 184563.78687 76.5975683 16.37784779 75.64857992 75.448228 16.17467479 12.6712721	2009	178331 671	73 40527944	178934 3886	73 72359331	-29 58793	-23 06066038	177712 6383	73 07834908	-26 0982886	-20.32079912
2011 179696.0279 74.12583862 180412.2445 74.50499484 -25.0896188 -19.59672712 179856.2465 73.73513715 -21.9192943 -17.156818 2012 18039.621 74.4657401 181111.0656 74.87315911 -23.3771483 -17.34981655 151011.81911 74.4014047 151.35855 -14.459787 2014 181548.8446 75.1043866 182420.08988 75.58672996 -20.4449201 180012.0371 74.62294502 18.0139935 14.089724 2015 18214.224 75.40028672 18.3046.0516 75.8980999 -16.3744201 180632.2779 75.1484322 16.1746543 -12.671272 2015 18214.6254 75.68757902 183636.7614 76.69767904 18.2523.98614 75.6390768 +12.2071272 2018 18400.0517 6.68755306 16.7575004 16.9276339 +13.30145964 182523.9864 76.5397086 +12.607272 2018 18405.0197 76.4568352 16.5272.8709 77.54801131 +5.016302 +11.62206372 183626.388 76.20255663 +13.025	2010	179026 6641	73 77232687	179686 7131	74 12091919	-27 1232395	-21 16292348	178346 6014	73 41316467	-23 8409301	-18 58192237
2012 18039.621 74.4657401 181111.056 74.87315911 -23.3771483 18.27743418 179541.3811 74.04416485 -20.4474157 -15.9669894 2013 180967.2932 74.79196193 18178.033 75.22006129 -21.9140345 17.1481565 180101.8019 74.40416485 -20.447957 2014 18154.8486 75.10439968 1152228.098 -26.349998 15.5437988 15.22187336 181147.5402 74.8282473 17.0354933 -13.337542 2016 182653.3957 75.6279702 183656.4254 75.569801001 -15.4068748 -12.0607530 2017 183165.4254 75.65813501 184200.0701 76.54456296 -17.7032193 -13.30045082 182203.9364 75.61837068 -14.724476 -11.550757 18450.0519 76.4645552 18573.8709 77.3593236 15.594502 -12.200134 18293.3311 75.64320477 -12.1017813 -10.320748 18290.3011 76.54324977 -12.1017813 -10.320748 18292.388 76.23229632 -12.5505447 -11.0717813 -10.3207481	2011	179696 0279	74 12583862	180412 2445	74 50409484	-25 0896188	-19 59672712	178956 2465	73 73513715	-21 9912943	-17 15681864
Line Local-Socie Line Local-Socie Line Line <thline< th=""> <thlin< th=""> Line</thlin<></thline<>	2011	180339 621	74.12505002	181111 0565	74.30403404	-23.0000100	-18 277/3/18	1705/1 3811	74.04416485	-21.3312343	-15 96698961
2111 1010307.323 11.2400.03 11.2400.03 11.2400.03 11.2400.03 12.1400.03 12.1400.03 12.1400.03 12.1400.03 12.1400.03 12.1400.03 12.1400.03 12.1400.03 12.1400.03 12.1400.03 12.1400.03 12.010.003 12.010.03 <td>2012</td> <td>190057 2022</td> <td>74.4037401</td> <td>101111.0303</td> <td>75.22906120</td> <td>21 01/02/5</td> <td>17 1/091565</td> <td>190101 9010</td> <td>74.04410403</td> <td>10 1205025</td> <td>14 05700722</td>	2012	190057 2022	74.4037401	101111.0303	75.22906120	21 01/02/5	17 1/091565	190101 9010	74.04410403	10 1205025	14 05700722
2114 101345.08400 73.067/396 20.0403932 74.067/3263 74.0228302 74.010428302 14.0017/2633 75.86757002 13330782 13.33782 1015 18214224 75.068757002 138368.7614 76.20706218 143.6937444 181632.2779 75.14842226 16.146543 12.671271 118165 144200.070 76.5046296 17.7032133 13.3015962 182903.311 75.38397444 14.1025264 1184109.3261 76.45663824 18523.3700 77.0579233 16.2268196 12.27007638 182533.9844 75.61937068 14.1052564 11.0035591 10211 1404643552 17.70579233 16.2268196 12.27007638 12290.3311 75.83397442 13.0255113 11.0035591 1021 184544.1655 76.892753 11.8206372 18.366.238 76.3205636 13.0255113 11.0335512 1022 18523.1017 70.697118 18669377 13.9981196 11.03207348 184284.6832 76.54924977 12.110144 9.5247985 10221 185267.755 77.446863	2013	101540 0046	74.79193193	101/03.033	75.22000129	-21.9140343	-17.14901303	100607 0007	74.34014047	19.1303035	-14.93799732
1211 12114 1213 <t< td=""><td>2014</td><td>102114 2254</td><td>75.10438908</td><td>1920/6 0516</td><td>75.90509000</td><td>10 5/27099</td><td>15 22107226</td><td>101147 5402</td><td>74.02294302</td><td>17 025/022</td><td>12 22570210</td></t<>	2014	102114 2254	75.10438908	1920/6 0516	75.90509000	10 5/27099	15 22107226	101147 5402	74.02294302	17 025/022	12 22570210
2110 162053.1533 7.3.057.3.902 16.3003.0614 7.6.2.097.648 16.1052.2773 7.3.14495220 10.1.449524 7.5.8671501 17.2.120125 1183650.8929 76.21452543 18420.0017 76.50465206 17.032113 1.3.0005082 182203.0311 75.8397442 14.1052589 -11.0717811 2011 184109.3261 76.66435552 185723.8709 77.30932956 15.5044022 12.2700104 183309.9091 76.0344113 -13.51478 10.0355911 2021 184340.5019 76.68435552 185723.8709 77.3093296 -15.5044022 -11.22700104 183309.9091 76.0344113 -13.51478 -0.0355911 2021 185830.111 77.0972983 14.4862937 -11.4104578 183987.4285 76.39226032 12.505345 -9.8669237 2021 185837.729 77.4073680 17.7717288 -10.607394 184254.682 76.51277 -11.017811 -0.027572 78.31738410 -10.3536222 184794.4056 76.813377 -11.2110144 -9.2544798 2022 186278.7329 77.407	2015	102114.2234	75.40290372	103040.0310	75.69506999	-19.3437966	-13.32107330	101147.0402	74.0924273	-17.0334923	-13.33376216
2117 163:163:429 75:396:1301 164:00:701 75:306:010 12:409:740 12:409:740 12:409:740 12:409:740 12:409:740 12:409:740 12:409:740 12:509:740 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:507572 11:5015702 11:5015702 11:5075775 11:5015702 11:50157502 11:50157502 11:501	2016	182653.1359	75.68757902	183636.7614	76.20706218	-18.5693764	-14.56978494	181632.2779	75.14843226	-16.1746543	-12.6/12/282
2018 18365.8229 76.245293 18473.8106 76.7873049 -16.9276339 -13.3014566 18223.9854 75.6137046 -14.724476 -11.50757 2019 18440.5019 76.6683552 185723.8709 77.3082396 -15.594502 -12.2700104 183309.9091 76.03444133 -13.61876 -10.635591 2021 18440.5019 76.68435552 185723.8709 77.3082396 -11.82206372 182380.74285 76.39226032 -12.5505345 -0.835724 2021 18566.0811 77.27966108 186994.4598 77.80037667 -13.981106 -11.03207348 184384.6832 76.69326032 -12.5505345 -9.6662377 2021 18567.455 77.0237584 18769.7927 78.3191375 -11.3020748 18455.766 76.691377 -11.01035 -9.2062425 2025 18627.455 77.00237584 18769.7927 78.3191375 -11.33304326 76.691377 -10.305005 -8.908360077 -8.9083607 2025 18667.415 77.9023768 188095.433 78.51456224 -12.311549 -	2017	183165.4254	75.95813501	184200.0701	76.50456296	-17.7032193	-13.90085082	182091.1957	75.39080101	-15.4098748	-12.0805542
2019 144109.32b1 76.456638244 1185243.8062 77.05579425 -16.228196 -12.76076336 122930.3311 77.839397442 -14.105259 -11.1077481 2020 184540.5019 76.68435552 188723.8709 77.730923936 -15.5945022 -12.2700104 183309.042 -13.0525113 -10.235724 2021 184568.0511 77.27096504 186599.4102 77.7121283 14.4625397 -11.41104578 1838987.4285 76.39226032 -12.5505345 -9.86692377 2021 185660.8011 77.272986504 186909.4498 77.98036677 -13.9981196 -10.68079394 184553.7968 76.691377 -11.700395 -9.20624255 2025 186570.7697 77.60237584 187697.9727 78.3519137 -13.256149 -10.35336232 144794.4056 76.613477 -11.3178205 -8.09836203 2025 186540.7697 77.74075898 188005.9433 78.5145624 -12.3716502 -10.04657546 185006.1377 76.93027225 -10.5954612 -8.2896433 2021 186773.4484 77.8073878 188253.9927 78.7291369 -12.3615149 -9.757445557 185186.6128	2018	183650.8929	76.21452543	184/35.8106	/6./8/50409	-16.92/6339	-13.30145968	182523.9854	/5.6193/068	-14./2444/6	-11.55075749
2020 184343.5019 77.5093293 15.592.87/9 77.540113 15.1063062 11.8220734 18.309.5091 76.03444135 76.03444135 76.03444135 76.0395336 13.025724 2021 18494.4185 77.68075333 186175.8079 77.5401131 15.1063062 11.82207348 184284.6832 76.54924977 12.101444 -9.5242798 2021 18494.4185 77.6303754 187607.9727 78.17380409 13.5461369 -10.68079394 184553.7968 76.691377 -11.170395 -9.20624255 2025 18678.7455 77.60237584 187607.9727 78.35191375 -13.1253641 -10.35332622 184794.4056 76.8184497 -11.3178205 -8.0983620 2025 186773.4464 77.6037584 18805.9297 78.3519135 -12.10424 -9.7774857 18158.6128 77.0264298 -10.627603 -8.3660877 2029 18749.2973 78.60214126 18875.5079 78.9083183 -11.6046931 -9.25272653 185464.2278 77.1073686 -10.305665 -8.1803100 2029	2019	184109.3261	76.45663824	185243.8062	77.05579235	-16.2285196	-12./60/6336	182930.3311	75.83397442	-14.1052589	-11.0/1/8133
2021 184944.1855 76.89/55336 186175.80/9 77.54801131 15.103062 11.82206372 183662.388 76.2205986 -13.029113 -10.235724 2022 185508.0111 77.09610187 186699.4102 77.717288 14.4462337 11.4410478 18.9897.4285 76.39226032 12.5505345 9.86692377 2023 185668.0811 77.27986504 186994.4598 77.98036677 -13.3981196 -11.03207348 184284.6832 76.6491377 -11.700355 9.20824255 2025 186278.7455 77.60237584 187697.9727 78.35191375 -13.1253641 -10.35336232 184794.4056 76.81844997 -11.3178205 -8.90836207 2026 186670.7681 188005.9433 78.5146524 -12.3615149 -9.7574556 185188.6128 77.02664298 -10.6227603 8.3660977 2028 186976.4156 77.97083708 188532.9927 78.9921369 -12.010424 -9.48461311 185341.422 77.1073688 -10.305505 -8.118010 2029 18749.2973 78.06214126 18877.9297	2020	184540.5019	76.68435552	185/23.8/09	77.30932936	-15.5945022	-12.2/00104	183309.9091	76.03444133	-13.541878	-10.63559166
2022 185320.1311 77.09610187 186599.4102 77.7772883 14.4862937 -11.41104578 183987.4285 76.3922002 12.550534 -9.8669237 2023 185668.0811 77.29786504 186997.729 78.37830409 -13.6461369 -10.68073344 184284.6832 76.54924977 -12.1101484 -9.5248785 2024 185967.7329 77.44568306 187360.7275 78.17380409 -13.5451364 -10.05336232 184794.4056 76.81844997 -11.1178205 -8.9083620 2026 186547.7589 77.74075888 188005.9433 78.51456254 12.2315502 -10.04657546 185108.6128 77.02664298 -10.6260737 41.8518.86128 77.02664298 -10.255005 -8.1803102 2027 18673.4484 77.86364378 188253.9927 78.9291369 -12.012024 -9.48619311 185314.422 77.1073568 10.0205703 -7.833125- 2031 18740.3264 78.1375515 188939.6109 79.907452 -11.6460633 -8.978134898 185556.5643 77.220364 -10.0057503 -7.8343125-	2021	184944.1855	76.89755336	186175.8079	77.54801131	-15.0163062	-11.82206372	183662.388	76.22059636	-13.0259113	-10.23572412
2023 18568.0811 77.2798504 186994.4998 77.98036677 13.9981196 -11.03207348 184284.6832 76.5492497 -12.1101484 -9.5248798 2024 185987.7329 77.44688306 18769.7275 78.17380409 -13.5461369 -10.68073934 184553.7968 76.691377 -11.70395 -9.20624253 2025 186278.7455 77.60237584 187697.9727 78.35191375 -13.1253641 -10.35336232 184794.4056 76.691377 -11.378205 -8.0893620 2026 186540.7697 77.74075898 188005.9433 78.5145625 -12.7316502 -10.04657546 18506.1377 76.93027225 -10.9594612 -8.62896434 2027 18676.4156 77.97036708 188284.3752 78.6661109 -12.3615149 -9.757748557 18518.6128 77.1073684 -10.0057603 -8.830150 2029 18749.2973 78.06214126 188751.5079 78.9294394 -10.057362 -8.78134898 18556.6543 77.2209696 -9.72181924 -7.66063564 2031 187403.264 78.19626895 189096.9278 79.09074532 -11.0649623 -8.742127957 1	2022	185320.1311	77.09610187	186599.4102	77.77172883	-14.4862937	-11.41104578	183987.4285	76.39226032	-12.5505345	-9.866923778
2024 185987.7329 77.44868306 187360.7275 78.17380409 -13.681369 -10.68079394 184553.7968 76.691377 -11.700395 -9.20624255 2025 186540.7697 77.60237584 187097.9727 78.35191375 -13.1253641 -10.35336222 184794.4056 76.8184997 -11.3178005 -8.0886202 2026 186540.7697 77.74075898 18805.9433 78.51456254 -12.7316502 -10.04657546 185006.1377 76.93027225 -10.6227603 -8.2896430 2027 186773.4484 77.86364378 188284.3752 78.66161109 -12.3615149 -9.757748557 185188.6128 77.02064298 -10.6227603 -8.3660877 2028 18674.5156 77.97083708 188532.9927 78.9031833 -11.0604931 -9.25227263 185464.278 77.1720384 -10.0055703 -8.1803105 2030 187291.7106 78.13735415 188939.6109 79.00766135 -11.3654763 -8.97813498 185565.643 77.220384 -10.055703 -7.2408959 2031 187403.264 78.19268695 18909.9278 79.09074532 -11.0649623 -8.742127957	2023	185668.0811	77.27986504	186994.4598	77.98036677	-13.9981196	-11.03207348	184284.6832	76.54924977	-12.1101484	-9.524879816
2025 186278.7455 77.60237584 187697.9727 78.35191375 -13.1253641 -10.35336222 184794.4056 76.81844997 -11.3178205 -8.9083620 2026 186504.07697 77.74075898 188005.9433 78.51456254 -12.7316502 -10.04657546 185006.1377 76.93027225 -10.9264298 -10.6227603 -8.36896437 2027 186773.4484 77.7803708 188532.9927 78.7921309 -12.012024 -9.484619311 185341.442 77.1073568 +0.025703 -7.88331254 2028 186976.4156 77.97083708 188532.9927 78.90831833 -11.6806931 -9.225272653 185464.2278 77.1720384 -10.0057503 -7.88331254 2030 187403.264 78.19626895 189096.9278 79.0076135 -11.3654763 -8.97813488 18556.5643 77.2093761 -9.1956063 -7.24696597 2032 18743.557 78.23867419 189223.0764 79.15736826 -10.7778946 -8.51622492 185648.2208 77.25037613 -9.1956063 -7.24696597 -7.246966593 -7.250767	2024	185987.7329	77.44868306	187360.7275	78.17380409	-13.5461369	-10.68079394	184553.7968	76.691377	-11.700395	-9.206242599
2026 186540.7697 77.74075898 188005.9433 78.5145624 -12.7316502 -10.04657546 185006.1377 76.33027225 -10.9594612 -8.62896433 2027 186773.4484 77.86364378 188284.3752 78.66161199 -12.3615149 -9.757748557 18518.6128 77.02664298 -10.6227603 -8.3660871 2028 186976.4156 77.97083708 188529.927 78.79291369 -12.0120242 -9.484619311 185341.442 77.17220384 -10.0057503 -7.88331254 2030 187291.7106 78.13735415 188939.6109 79.00766135 -11.3654763 -8.978134898 185556.5643 77.2209696 -9.72181924 -7.66063566 2031 187403.264 78.136266 19.923.0764 79.15736822 -10.049623 -8.742127957 185648.208 77.2209696 -9.72181924 -7.24698592 2033 187532.1804 78.23867419 189223.0764 79.15736822 -10.591518 8.29977244 185646.822 77.2656472 -8.5194465 -7.04645472 2034 187532.1804 <t< td=""><td>2025</td><td>186278.7455</td><td>77.60237584</td><td>187697.9727</td><td>78.35191375</td><td>-13.1253641</td><td>-10.35336232</td><td>184794.4056</td><td>76.81844997</td><td>-11.3178205</td><td>-8.908362074</td></t<>	2025	186278.7455	77.60237584	187697.9727	78.35191375	-13.1253641	-10.35336232	184794.4056	76.81844997	-11.3178205	-8.908362074
2027 186773.4484 77.86364378 188284.3752 78.66161109 -12.3615149 -9.757748557 185188.6128 77.02664298 -10.6227603 -8.3660877 2028 186976.4156 77.97083708 188329.9927 78.9921369 -12.012024 -9.484619311 185341.442 77.1073568 -10.3055005 -8.11803101 2029 18719.2973 78.06214126 188751.5079 78.90831833 -11.6806931 -9.25272653 185464.2278 77.1720384 -10.0057503 -7.88331254 2030 187291.7106 78.13735415 188996.69278 79.09074532 -11.0649623 -8.742127957 185618.0366 77.253435 -9.4522253 -7.44886154 2031 18743.557 78.23867419 189223.0764 79.15736826 -10.7778946 -8.516292492 185648.642 77.253454 -9.19565063 -7.24698592 2033 187532.7347 78.2644644 189317.6652 79.2073235 -10.5031518 -8.299772344 185646.6242 77.2576718 8.71707568 -6.669947566 2035 187532.7347 <t< td=""><td>2026</td><td>186540.7697</td><td>77.74075898</td><td>188005.9433</td><td>78.51456254</td><td>-12.7316502</td><td>-10.04657546</td><td>185006.1377</td><td>76.93027225</td><td>-10.9594612</td><td>-8.628964365</td></t<>	2026	186540.7697	77.74075898	188005.9433	78.51456254	-12.7316502	-10.04657546	185006.1377	76.93027225	-10.9594612	-8.628964365
2028 186976.4156 77.97083708 188532.9927 78.79291369 -12.0120242 -9.484619311 185341.442 77.1073568 -10.3055005 -8.1103101 2029 187149.2973 78.06214126 188751.5079 78.9081383 -11.6660931 -9.225272653 185464.2278 77.17220384 -10.0057005 -7.8833125- 2030 187291.7106 78.13735415 188939.6109 79.00766135 -11.3654763 -8.978134898 185556.5633 77.2209696 -9.72181924 -7.66063564 2031 18743.557 78.23867419 18922.30764 79.15736826 -10.7778946 -8.516292492 185648.208 77.26937621 -9.15565063 -7.24698592 2033 187532.1804 78.26435366 189317.6652 79.20732355 -10.5031518 -8.299772344 185646.6842 77.25076718 -8.71707568 -6.86947586 2034 18743.8011 78.208637 18930.2942 79.24039986 -10.2397301 -8.09180134 18541.29851 77.25076718 -8.71707568 -6.86947586 2035 18743.8011	2027	186773.4484	77.86364378	188284.3752	78.66161109	-12.3615149	-9.757748557	185188.6128	77.02664298	-10.6227603	-8.366087703
2029 187149.2973 78.06214126 188751.5079 78.90831833 -11.6606931 -9.225272653 185464.2278 77.17220384 -10.0057803 -7.8633125- 2030 187291.7106 78.13735415 18899.6109 79.0076135 -11.3654763 -8.978134898 185556.5643 77.220384 -10.0057802 -7.66063561 2031 18743.3557 78.23867419 18922.30764 79.15738626 -10.7778946 -8.516292492 185648.2208 77.26393621 -9.1556063 -7.24698552 2033 187532.1804 78.26435366 189317.6652 79.20732355 -10.5031518 -8.299772344 185646.6842 77.25076718 -8.71707568 -6.86947584 2034 18743.801 78.2644644 189410.5542 79.26531311 -9.9867269 -7.891692091 185546.6725 77.21574542 -8.4931274 -6.62923047 2035 18743.8011 78.238631 189408.0268 79.25504634 -9.74387364 185447.2861 77.6035264 8.07180475 -6.52211706 2037 187401.4683 78.19532057 <	2028	186976.4156	77.97083708	188532.9927	78.79291369	-12.0120242	-9.484619311	185341.442	77.1073568	-10.3055005	-8.118031052
2030 187291.7106 78.13735415 18893.6109 79.00766135 -11.3654763 -8.978134898 185556.5643 77.2209696 -9.72181924 -7.66063564 2031 187403.264 78.19626895 189096.9278 79.09074532 -11.0649623 -8.742127957 185618.0366 77.253435 -9.45222253 -7.4488615 2032 18748.3557 78.23867419 189223.0764 79.15736286 -10.7778946 -8.516292492 185648.208 77.26937621 -9.195650465 -7.24698592 2033 187532.1804 78.26435366 189317.6652 79.2073255 -10.5031518 -8.299772344 18564.6842 77.25076718 -8.9509465 -7.05412026 2034 187532.7347 78.26464644 189410.5542 79.25638111 -9.98672669 -7.891692091 18554.6725 77.21574542 -8.4931274 -6.69235047 2036 187483.8011 78.2388031 189408.0268 79.25504634 -9.7333736 -7.69826413 18547.2861 77.1632564 -8.27828139 -6.52211706 2037 187401.4683 <	2029	187149.2973	78.06214126	188751.5079	78.90831833	-11.6806931	-9.225272653	185464.2278	77.17220384	-10.0057503	-7.883312549
2031 187403.264 78.19626895 189096.9278 79.09074532 -11.0649623 -8.742127957 185618.0366 77.253435 -9.45222233 -7.4488615- 2032 187483.557 78.23867419 18922.0764 79.15738826 -10.7778946 -8.516292492 185648.2208 77.26337621 -9.19565063 -7.24698593 2033 187532.1804 78.26435366 189317.6652 79.2073235 -10.2397301 -8.299772344 185646.6842 77.26076718 -8.5102026 2033 187532.7347 78.26464644 189410.5542 79.25534634 -9.74333736 -7.698826413 18542.7851 77.21574542 -8.4931274 -6.69235047 2035 187532.7347 78.26464644 189400.568 79.25504634 -9.74333736 -7.698826413 18547.2861 77.1632564 -8.27828139 -6.52211706 2035 187401.4683 78.19532057 189372.2845 79.23616968 -9.50882544 -7.512647119 185147.4043 77.0487948 -7.87303949 -6.20113844 2035 187285.2803 78.13395807	2030	187291.7106	78.13735415	188939.6109	79.00766135	-11.3654763	-8.978134898	185556.5643	77.2209696	-9.72181924	-7.660635686
2032 187483.557 78.23867419 189223.0764 79.15736826 -10.7778946 -8.516292492 185648.2208 77.26937621 -9.19565063 -7.24698592 2033 187532.1804 78.26435366 189317.6652 79.20732355 -10.5031518 8-8.299772344 185646.6842 77.26856472 8-8.95094665 -7.06412024 2034 187532.1804 78.27308637 189380.2942 79.20393906 -10.2397301 -8.09180134 185612.9851 77.2576718 8-8.7107568 6-6.69494586 2035 187433.8011 78.2388031 189408.0268 79.25504634 -9.7433767 -7.59826413 18544.7261 77.1632564 8.2782813 6-6.5221170 2037 187401.4683 78.19532057 189372.2845 79.23616968 -9.5082544 -7.512647119 185314.3564 77.043708 8.07180475 -6.35821430 2038 187285.2803 78.13395807 189302.8899 79.19952029 -9.2825328 -7.3132650949 185147.4043 77.0487948 -7.87130349 -6.20113644 2039 187134.7714	2031	187403.264	78.19626895	189096.9278	79.09074532	-11.0649623	-8.742127957	185618.0366	77.253435	-9.45222253	-7.448861545
2033 187532.1804 78.26435366 189317.6652 79.20732355 -10.5031518 -8.299772344 185646.6842 77.26856472 -8.95094465 -7.05412024 2034 187548.7155 78.27308637 18930.2942 79.203397301 -8.09180134 185512.9851 77.25076718 -8.7107568 -6.68947584 2035 187532.7347 78.2646464 189410.5542 79.25530431 -9.9867269 -7.891692091 185546.6725 77.21574542 -8.4931274 -6.69235047 2036 187483.8011 78.2388031 188408.0268 79.25504634 -9.74333736 -7.698826413 18544.72661 77.1632564 -8.2782179 -6.52211706 2037 187401.4683 78.19532057 189372.2845 79.23616968 -9.5082544 -7.512647119 18514.3564 77.09305208 -8.07180478 -6.352214706 2038 187401.4683 78.19532057 189372.2845 79.23616968 -7.512647119 185147.4043 77.00487948 -7.87303949 -6.20113844 2038 187134.7714 78.05446969 18919.3966	2032	187483.557	78.23867419	189223.0764	79.15736826	-10.7778946	-8.516292492	185648.2208	77.26937621	-9.19565063	-7.246985914
2034 187548.7155 78.27308637 189380.2942 79.24039986 -10.2397301 -8.09180134 185612.9851 77.25076718 -8.71707568 -6.86947584 2035 187532.7347 78.26464644 189410.5542 79.255046311 -9.98672869 -7.891692091 185546.6725 77.21574542 -8.4931274 -6.66923804 2036 187403.8011 78.2388031 189408.0268 79.25504634 -9.74333736 -7.69826413 185447.2861 77.1632564 -8.27828139 -6.52211706 2037 187401.4683 78.19532057 189372.2845 79.23616968 -9.5082544 -7.512647119 185417.364 47.09305208 8.07180475 -6.5821437 2038 187401.4683 78.19532057 189372.2845 79.19952029 -9.2825328 -7.31265049 185147.4043 77.00487948 -7.87303949 -6.20013844 2039 187134.7714 78.05446969 189199.3966 79.1448625 -9.06386175 -7.158382465 184495.9411 76.8948052 -7.68139347 -6.04743634 2040 186949.4665	2033	187532.1804	78.26435366	189317.6652	79.20732355	-10.5031518	-8.299772344	185646.6842	77.26856472	-8.95094465	-7.054120262
2035 187532.7347 78.26464644 189410.5542 79.25638111 -9.98672869 -7.891692091 185546.6725 77.21574542 -8.4931274 -6.69235041 2036 187483.8011 78.2388031 189408.0268 79.25504634 -9.74333736 -7.698826413 185447.2861 77.1632564 -8.27828139 -6.52211700 2037 187401.4883 78.19532057 189372.2845 79.23616968 -9.50882544 -7.512647119 185314.3564 77.09305208 -8.07180475 -6.38221430 2038 187285.2803 78.1395807 189392.8899 79.1992029 -9.2825328 -7.332650949 18514.3564 77.0487948 -7.87303949 -6.2011844 2039 187134.7714 78.05446969 189199.3966 79.1448625 -9.06386175 -7.158382465 184945.9411 76.8948052 -7.84033374 -6.04743634 2040 186949.4665 77.9560439 189061.3481 79.079475556 -8.85227014 -6.89242875 184709.4685 76.7359203 -7.49633247 -5.89699513 2041 186728.801	2034	187548.7155	78.27308637	189380.2942	79.24039986	-10.2397301	-8.09180134	185612.9851	77.25076718	-8.71707568	-6.869475863
2036 187483.8011 78.2388031 189408.0268 79.25504634 -9.74333736 -7.698826413 185447.2861 77.1632564 -8.27828139 -6.52211700 2037 187401.4683 78.19532057 189372.2845 79.23616968 -9.50882544 -7.512647119 185314.3564 77.09305208 -8.07180475 -6.35821430 2038 187285.2803 78.13395807 189302.8899 79.19952029 -9.2825328 -7.332650949 185147.4043 77.00487948 -7.87303949 -6.20013844 2039 18714.7714 78.05446969 189199.3966 79.1945225 -9.06386175 -7.158382465 18417.4043 77.0487948 -7.87303949 -6.04748634 2040 18692.4665 77.9560439 189061.3481 79.0194555 -8.85227014 -6.892437 18470.4685 76.7359203 -7.49633247 -5.89969513 2041 186728.8801 77.8401059 18888.2782 78.8055066 -8.64726532 -6.625414794 184437.4785 76.62994568 -7.3173744 -5.617680086 2042 186472.5172 <t< td=""><td>2035</td><td>187532.7347</td><td>78.26464644</td><td>189410.5542</td><td>79.25638111</td><td>-9.98672869</td><td>-7.891692091</td><td>185546.6725</td><td>77.21574542</td><td>-8.4931274</td><td>-6.692350471</td></t<>	2035	187532.7347	78.26464644	189410.5542	79.25638111	-9.98672869	-7.891692091	185546.6725	77.21574542	-8.4931274	-6.692350471
2037 187401.4683 78.19532057 189372.2845 79.23616968 -9.50882544 -7.512647119 185314.3564 77.09305208 -8.07180475 -6.35821434 2038 187285.2803 78.13395807 189302.8899 79.19952029 -9.2825328 -7.332650949 185147.4043 77.00487948 -7.87303949 -6.2011844 2039 187134.7714 78.05446969 189199.3966 79.1498225 -9.06386175 -7.158382465 184945.9411 76.89848052 -7.61139347 -6.04743634 2040 18694.665 77.9560439 189061.3481 79.0719555 -8.85227014 -6.89942875 184709.4685 76.7359203 -7.4963324 -5.89969513 2041 186728.8801 77.8041059 18888.2782 78.8055066 -8.64726532 -6.6252414794 184437.4785 76.62994568 -7.3173744 -5.517665000 2042 186472.5172 77.70471268 188697.107 78.87040003 -8.44839886 -6.659947 184129.4531 76.426726792 -7.14408174 -5.617660808 2043 186179.8723	2036	187483.8011	78.2388031	189408.0268	79.25504634	-9.74333736	-7.698826413	185447.2861	77.1632564	-8.27828139	-6.522117061
2038 187285.2803 78.13395807 189302.8899 79.19952029 -9.2825328 -7.332650949 185147.4043 77.00487948 -7.87303949 -6.2013844 2039 187134.7714 78.05446969 18919.3966 79.14486225 -9.06386175 -7.153826456 184945.9411 76.89848052 -7.68139347 -6.04743634 2040 186949.4665 77.95600439 18901.3481 79.0195506 -8.85227014 -6.99942875 184709.4685 76.77359203 -7.49633267 -5.89969952 2041 186728.8801 77.8401059 18888.2782 78.9805506 -8.64726532 -6.625414794 184437.4785 76.62994568 -7.31737444 -5.5617660842 2042 186472.5172 77.70471268 188679.7107 78.87040003 -8.4839886 -6.6519872006 183784.8643 76.46726792 -7.14408174 -5.617660842 2043 186179.8723 77.5015786 188435.1596 78.7124498 -8.2552618 -6.510872006 183784.8643 76.26927898 -6.96058089 -5.48276244 2043 186179.8723	2037	187401.4683	78.19532057	189372.2845	79.23616968	-9.50882544	-7.512647119	185314.3564	77.09305208	-8.07180475	-6.358214307
2039 187134.7714 78.05446969 189199.3966 79.1448625 -9.06386175 -7.158382465 184945.9411 76.89848052 -7.68139347 -6.04743634 2040 186949.4665 77.95660439 189061.3481 79.07195455 -8.85227014 -6.98942875 184709.4685 76.77359203 -7.49633274 -5.89969955 2041 186728.8801 77.8401059 18888.2782 78.980506 -8.64726532 -6.825414794 184437.4785 76.62994568 -7.3173744 -5.75655900 2042 186472.5172 77.70471268 188679.7107 78.87040003 -8.4839886 -6.66599947 184129.4531 76.46726792 -7.14408174 -5.10872006 2043 186179.8723 77.5015786 188433.1596 78.7124498 -8.2552618 -6.10872006 183784.8643 76.28527989 -6.97605809 -5.48766244	2038	187285.2803	78.13395807	189302.8899	79.19952029	-9.2825328	-7.332650949	185147.4043	77.00487948	-7.87303949	-6.200138447
2040186949.466577.95660439189061.348179.07195455-8.85227014-6.98942875184709.468576.77359203-7.49633267-5.8996995:2041186728.880177.840105918888.278278.98055096-8.64726532-6.825414794184437.478576.62994568-7.31737444-5.756559002042186472.517277.70471268188679.710778.87040003-8.44839886-6.66599947184129.453176.46726792-7.14408174-5.617680882043186179.872377.55015786188435.159678.74124498-8.25526198-6.510872006183784.864376.28527989-6.97050809-5.482762455	2039	187134.7714	78.05446969	189199.3966	79.14486225	-9.06386175	-7.158382465	184945.9411	76.89848052	-7.68139347	-6.047436345
2041 186728.8801 77.8401059 18888.2782 78.98055096 -8.64726532 -6.825414794 184437.4785 76.62994568 -7.31737444 -5.75655900 2042 186472.5172 77.70471268 188679.7107 78.87040003 -8.44839886 -6.66599947 184129.4531 76.46726792 -7.14408174 -5.61768088 2043 186179.8723 77.55015786 188435.1596 78.71214498 -8.25526198 -6.510872006 183784.8643 76.28527989 -6.97050809 -5.482762454	2040	186949.4665	77.95660439	189061.3481	79.07195455	-8.85227014	-6.98942875	184709.4685	76.77359203	-7.49633267	-5.899699519
2042 186472.5172 77.70471268 188679.7107 78.87040003 -8.44839886 -6.66599947 184129.4531 76.46726792 -7.14408174 -5.61768086 2043 186179.8723 77.55015786 188435.1596 78.74124498 -8.25526198 -6.510872006 183784.8643 76.28527989 -6.97050509 -5.48276245	2041	186728.8801	77.8401059	188888.2782	78.98055096	-8.64726532	-6.825414794	184437.4785	76.62994568	-7.31737444	-5.756559003
2043 186179.8723 77.55015786 188435.1596 78.74124498 -8.25526198 -6.510872006 183784.8643 76.28527989 -6.97605809 -5.48276245	2042	186472.5172	77.70471268	188679.7107	78.87040003	-8.44839886	-6.66599947	184129.4531	76.46726792	-7.14408174	-5.617680886
	2043	186179.8723	77.55015786	188435.1596	78.74124498	-8.25526198	-6.510872006	183784.8643	76.28527989	-6.97605809	-5.482762457
2044 185850.43 77.37616917 188154.1283 78.59282364 -8.06748142 -6.359748884 183403.174 76.08369743 -6.81294318 -5.35152882	2044	185850.43	77.37616917	188154.1283	78.59282364	-8.06748142	-6.359748884	183403.174	76.08369743	-6.81294318	-5.351528825
2045 185483.6644 77.18246889 187836.1102 78.42486841 -7.88471595 -6.212371109 182983.834 75.86223096 -6.65440904 -5.22372996	2045	185483.6644	77.18246889	187836.1102	78.42486841	-7.88471595	-6.212371109	182983.834	75.86223096	-6.65440904	-5.223729983
2046 185079.0392 76.96877378 187480.5881 78.23710617 -7.70665316 -6.068501795 182526.2856 75.62058544 -6.50015668 -5.0991382:	2046	185079.0392	76.96877378	187480.5881	78.23710617	-7.70665316	-6.068501795	182526.2856	75.62058544	-6.50015668	-5.099138219
2047 184636.0075 76.73479502 187087.0343 78.02925822 -7.53300669 -5.92792403 182029.9596 75.35846031 -6.34991315 -4.97754584	2047	184636.0075	76.73479502	187087.0343	78.02925822	-7.53300669	-5.92792403	182029.9596	75.35846031	-6.34991315	-4.977545845
2048 184154.0118 76.48023814 186654.9104 77.80104022 -7.36351375 -5.790438971 181494.2764 75.0755494 -6.20342889 -4.85876319	2048	184154.0118	76.48023814	186654.9104	77.80104022	-7.36351375	-5.790438971	181494.2764	75.0755494	-6.20342889	-4.858763197
2049 183632.4837 76.20480299 186183.6673 77.55216213 -7.1979329 -5.655864158 180918.6456 74.77154092 -6.06047548 -4.7426166	2049	183632.4837	76.20480299	186183.6673	77.55216213	-7.1979329	-5.655864158	180918.6456	74.77154092	-6.06047548	-4.74261686
2050 183070.8439 75.9081836 185672.7449 77.28232813 -7.03604211 -5.524032 180302.4659 74.44611734 -5.92084355 -4.62894805	2050	183070.8439	75.9081836	185672.7449	77.28232813	-7.03604211	-5.524032	180302.4659	74.44611734	-5.92084355	-4.628948099

Table A4.3. Sensitivity Analysis of Forest Area and SDG 15 Progress to Population between 2000 and 2050.

Voar	Forest Area	SDC 15 Prograss	Estimates under 90% of	of Forestry Production	S	5x_90	Estimates under 110% of	of Forestry Production	S	(_110
real	FUIESLAIEd	SDG 15 Plogless	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress
2000	170939.3	69.50113917	170939.3	69.50113917	#DIV/0!	NA	170939.3	69.50113917	#DIV/0!	NA
2001	171861.7002	69.98828733	171994.3752	70.05835711	-129.5358223	-99.88370026	171729.0252	69.91821755	-117.6689951	-90.71244934
2002	172758.6346	70.46198618	173026.9242	70.60367824	-64.39258744	-49.72895869	172490.345	70.32029411	-58.44781244	-45.11723316
2003	173630.2392	70.92230755	174037.13	71.13719924	-42.67243798	-33.00374563	173223.3483	70.70741586	-38.702207	-29.91249687
2004	174476.6378	71.36931689	175025.1643	71.65901079	-31.80823973	-24.63611315	173928.1112	71.079623	-28.82566774	-22.30555805
2005	175297.9402	71.80307217	175991,1855	72,1691965	-25,28656823	-19.61166379	174604.6949	71,43694785	-22.89688007	-17,73787662
2006	176094 202	72 22360273	176935 2983	72 66781175	-20.9362708	-16 25892291	175253 1057	71 77939371	-18 94206554	-14 68992993
2007	176865.3191	72.63085355	177857.4488	73.15482802	-17.82683418	-13.86152527	175873.1894	72,10687909	-16.11530335	-12.51047772
2008	177611 1811	73 02476641	178757 5776	73 63021395	-15 49299716	-12 06128719	176464 7846	72 41931887	-13 99363388	-10 87389736
2009	178331 671	73 40527944	179635 6194	74 09393502	-13 6762831	-10 65921516	177027 7226	72 71662387	-12 34207506	-9 599286603
2010	179026 6641	73 77232687	180491 502	74.54595318	-12 22160209	-9 535912318	177561 8262	72,99870055	-11 01963849	-8 578102015
2011	179696 0279	74 12583862	181325 1464	74 9862266	-11 03026151	-8 615396821	178066 9094	73 26545064	-9 936601091	-7 741269814
2011	180339 621	74.4657401	182136 4654	75 /1/70932	-10 03646295	-7 8/7013209	178542 7766	73 51677089	-9.0331/8239	-7 0/2739338
2012	180957 2932	74,70105103	182925 3639	75 83135107	-10.03040235	-7.195691171	178989 2225	73 75255279	-8 267867359	-6.450628308
2013	101540 0046	75 10/20069	102020.0000	76 226007	9 472206069	6 626270226	170305.2223	73.73233273	7 611179024	5.942162805
2014	101140.0040	75.10436508	104425 475	70.230037	7 945525459	-0.030379220 6 160706464	179400.0311	73.37200233	7.041297025	-J.542102095
2015	102114.2234	75.40290372	104433.473	70.02000700	7.0643323436	-0.130703434 E 724990007	1/9/92.9/59	74.17703969	-7.041367035	-3.30004129
2010	102000.1009	75.06757902	105150.4520	77.00903621	-7.290445295	-3.724009997	100149.0191	74.30349963	-0.342222020	-3.113330330
2017	183165.4254	75.95813501	185854.5393	77.37833942	-6.81136729	-5.348394527	180476.3115	74.5379306	-6.101243053	-4.//126//45
2018	183650.8929	76.21452543	186529.5935	//./3485646	-6.379645504	-5.013021/64	180772.1923	74.6941944	-5./08/6859	-4.46638343
2019	184109.3261	76.45663824	18/181.463/	78.0791293	-5.9928/3/88	-4./1229950/	181037.1886	74.83414719	-5.35/158124	-4.192999567
2020	184540.5019	/6.68435552	18/809.9881	/8.4110/255	-5.644327282	-4.441049359	1812/1.0156	/4.95/63848	-5.04029745	-3.946408488
2021	184944.1855	76.89755336	188414.9949	78.73059537	-5.328560754	-4.195078612	181473.3762	75.06451135	-4.753237099	-3.722798745
2022	185320.1311	77.09610187	188996.3015	79.03760144	-5.041119149	-3.970956424	181643.9606	75.15460229	-4.491926446	-3.519051283
2023	185668.0811	77.27986504	189553.7152	79.33198889	-4.778321274	-3.765848012	181782.4469	75.2277412	-4.25301927	-3.332589112
2024	185987.7329	77.44868306	190086.9989	79.61363255	-4.537098387	-3.577389836	181888.4668	75.28373358	-4.03372573	-3.1612635
2025	186278.7455	77.60237584	190595.8784	79.88238756	-4.314871716	-3.403595475	181961.6125	75.32236411	-3.831701477	-3.0032686
2026	186540.7697	77.74075898	191080.0722	80.13810533	-4.109458879	-3.242783793	182001.4673	75.34341263	-3.644962674	-2.857076178
2027	186773.4484	77.86364378	191539.2919	80.38063349	-3.919000872	-3.093522529	182007.6048	75.34665406	-3.471818917	-2.72138411
2028	186976.4156	77.97083708	191973.2417	80.60981584	-3.741903589	-2.954583732	181979.5895	75.33185832	-3.310821478	-2.59507612
2029	187149.2973	78.06214126	192381.6185	80.82549228	-3.576792984	-2.824908628	181916.9762	75.29879025	-3.160720921	-2.477189668
2030	187291.7106	78.13735415	192764.1116	81.02749876	-3.422477805	-2.703579396	181819.3096	75.24720954	-3.020434408	-2.366890359
2031	187403.264	78.19626895	193120.4029	81.21566724	-3.277920417	-2.589796428	181686.1251	75.17687066	-2.889018575	-2.263451293
2032	187483.557	78.23867419	193450.1665	81.3898256	-3.142212628	-2.482859882	181516.9476	75.08752277	-2.765647888	-2.166236251
2033	187532.1804	78.26435366	193753.0687	81.54979764	-3.014556311	-2.382154564	181311.292	74.97890969	-2.649596605	-2.07468597
2034	187548.7155	78.27308637	194028.768	81.69540297	-2.894246868	-2.287137499	181068.663	74.85076976	-2.5402244	-1.988306816
2035	187532.7347	78.26464644	194276.9148	81.82645702	-2.780660231	-2.197327584	180788.5546	74.70283586	-2.436963864	-1.906661442
2036	187483.8011	78.2388031	194497.1517	81.94277095	-2.673241532	-2.112297038	180470.4506	74.53483525	-2.339310509	-1.829360941
2037	187401.4683	78.19532057	194689.1129	82.04415159	-2.57149572	-2.031664163	180113.8237	74.34648956	-2.24681429	-1.756058334
2038	187285.2803	78.13395807	194852.4244	82.13040146	-2.474979709	-1.955087325	179718.1362	74.13751469	-2.159072442	-1.686443024
2039	187134.7714	78.05446969	194986.7039	82.20131863	-2.383295727	-1.882259779	179282.839	73.90762076	-2.07572341	-1.620236167
2040	186949.4665	77.95660439	195091.5607	82.25669675	-2.296085778	-1.812905347	178807.3723	73.65651203	-1.996441598	-1.557186682
2041	186728.8801	77.8401059	195166.5955	82.29632497	-2.213026527	-1.746774669	178291.1647	73.38388684	-1.920933212	-1.497067883
2042	186472.5172	77.70471268	195211.4005	82.31998787	-2.133825469	-1.683642026	177733.6338	73.0894375	-1.848932229	-1.439674571
2043	186179.8723	77.55015786	195225.5591	82.32746545	-2.058217107	-1.62330259	177134.1856	72.77285027	-1.780197373	-1.384820537
2044	185850.43	77.37616917	195208.6459	82.31853307	-1.985960066	-1.565570054	176492.2142	72.43380527	-1.714509155	-1.332336414
2045	185483.6644	77.18246889	195160.2267	82.29296139	-1.9168343	-1.510274577	175807.1022	72.0719764	-1.651667551	-1.282067797
2046	185079.0392	76.96877378	195079.8582	82.25051631	-1.850638824	-1.457260995	175078.2202	71.68703125	-1.591489845	-1.233873631
2047	184636.0075	76.73479502	194967.0882	82.19095898	-1.787189675	-1.406387264	174304.9269	71.27863106	-1.533808807	-1.187624785
2048	184154.0118	76.48023814	194821.4552	82.11404566	-1.726318158	-1.357523094	173486.5685	70.84643063	-1.478471062	-1.143202814
2049	183632.4837	76.20480299	194642.4884	82.01952774	-1.667869265	-1.310548758	172622.4791	70.39007823	-1.425335703	-1.100498869
2050	183070.8439	75.9081836	194429.7077	81.90715165	-1.611700323	-1.265354023	171711.9802	69.90921555	-1.374273031	-1.059412748

Table A4.4. Sensitivity Analysis of Forest Area and SDG 15 Progress to Forestry Production between 2000 and 2050.

Voar	Forost Aroa	SDC 15 Prograss	Estimates under 90%	of Net Forest Import	S	x_90	Estimates under 110	% of Net Forest Import	S	_110
Tear	FUIESLAIEd	3D0 13 Flogless	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress	Forest Area	SDG 15 Progress
2000	170939.3	69.50113917	170939.3	69.50113917	170939.3	NA	170939.3	69.50113917	170939.3	NA
2001	171861.7002	69.98828733	171833.745	69.97352328	171833.745	474.045193	171889.6555	70.00305138	171889.6555	431.0412042
2002	172758.6346	70.46198618	172704.4965	70.43339418	172704.4965	246.4395574	172812.7727	70.49057817	172812.7727	224.1269197
2003	173630.2392	70.92230755	173551.7192	70.88083871	173551.7192	171.0255413	173708.7591	70.9637764	173708.7591	155.568651
2004	174476.6378	71.36931689	174375.5655	71.31593751	174375.5655	133.7020274	174577.71	71.42269628	174577.71	121.6381881
2005	175297.9402	71.80307217	175176.1746	71.73876401	175176.1746	111.6546854	175419.7058	71.86738034	175419.7058	101.595154
2006	176094.202	72.22360273	175953.6319	72.14936327	175953.6319	97.28465068	176234.7722	72.29784219	176234.7722	88.53150038
2007	176865.3191	72.63085355	176707.8632	72,54769623	176707.8632	87.34149929	177022.775	72,71401088	177022.775	79,49226377
2008	177611.1811	73.02476641	177438.7891	72,93372087	177438.7891	80.20685305	177783.5731	73.11581195	177783.5731	73.00623373
2009	178331 671	73 40527944	178146 3237	73 30739181	178146 3237	74 98933273	178517 0182	73 50316708	178517 0182	68 26302502
2010	179026 6641	73 77232687	178830 3741	73 66866001	178830 3741	71 16288191	179222 9542	73 87599372	179222 9542	64 78444328
2010	179696 0279	74 12583862	179490 8397	74 0174724	179490 8397	68 40308779	179901 216	74 23420483	179901 216	62 27553585
2011	180339 621	74.12000002	180127 6122	7/ 35377168	180127 6122	66 50601855	180551 6298	74.57770853	180551 6298	60 55092185
2012	190057 2022	74,70105102	190740 5742	74.53377100	100127.0122	65 24562792	100001.0200	74.00640796	101174 012	50.000270
2013	101570 0076	75 10/20060	101220 6001	74.07745555	101220 6001	64 95097206	101174.012	74.30040780	1011760 160	59.49002779
2014	102114 2254	75.10438908	101323.0001	74.90037877	101004 5541	64 00402144	102222 0067	75.51007004	101700.103	50 17629650
2015	102114.2234	75.40290372	101094.0041	75.20094049	101094.0010	04.99402144	102030.0907	73.31697694	102030.0907	59.17030059
2016	182653.1359	75.68757902	182435.2913	75.57252854	182435.2913	65.78641033	182870.9805	75.8026295	182870.9805	59.89673734
2017	183165.4254	75.95813501	182951.6566	75.84523706	182951.6566	67.28034641	183379.1943	76.07103296	183379.1943	61.25486151
2018	183650.8929	76.21452543	183443.4848	76.10498678	183443.4848	69.57774596	183858.301	76.32406409	183858.301	63.34340386
2019	184109.3261	/6.45663824	183910.6003	/6.3516849/	183910.6003	/2.84826946	184308.052	/6.56159151	184308.052	66.31660507
2020	184540.5019	76.68435552	184352.817	76.58523333	184352.817	77.36346291	184728.1867	76.7834777	184728.1867	70.42133587
2021	184944.1855	76.89755336	184769.9381	76.8055279	184769.9381	83.56117348	185118.4329	76.98957882	185118.4329	76.05560962
2022	185320.1311	77.09610187	185161.7559	77.01245901	185161.7559	92.1729638	185478.5063	77.17974472	185478.5063	83.88451906
2023	185668.0811	77.27986504	185528.0518	77.20591125	185528.0518	104.4975055	185808.1103	77.35381884	185808.1103	95.08863378
2024	185987.7329	77.44868306	185868.5629	77.3857457	185868.5629	123.0567645	186106.9029	77.51162043	186106.9029	111.9606799
2025	186278.7455	77.60237584	186182.9883	77.55180349	186182.9883	153.4482337	186374.5027	77.65294818	186374.5027	139.5893302
2026	186540.7697	77.74075898	186471.0197	77.70392184	186471.0197	211.0390592	186610.5197	77.77759612	186610.5197	191.944591
2027	186773.4484	77.86364378	186732.3414	77.84193393	186732.3414	358.6558928	186814.5553	77.88535362	186814.5553	326.1418213
2028	186976.4156	77.97083708	186966.6299	77.96566891	186966.6299	1508.674059	186986.2014	77.97600525	186986.2014	1371.612754
2029	187149.2973	78.06214126	187173.5536	78.07495177	187173.5536	-609.3601273	187125.041	78.04933076	187125.041	-553.87315
2030	187291.7106	78.13735415	187352.7735	78.16960333	187352.7735	-242.2925459	187230.6478	78.10510497	187230.6478	-220.1750349
2031	187403.264	78.19626895	187503.9421	78.24944015	187503.9421	-147.0650777	187302.586	78.14309774	187302.586	-133.6045977
2032	187483.557	78.23867419	187626.704	78.31427451	187626.704	-103.4898758	187340.4101	78.16307387	187340.4101	-93.9907865
2033	187532.1804	78.26435366	187720.6954	78.3639143	187720.6954	-78.6097326	187343.6653	78.16479302	187343.6653	-71.37248726
2034	187548.7155	78.27308637	187785.5443	78.39816303	187785.5443	-62.58009128	187311.8866	78.14800971	187311.8866	-56.80008221
2035	187532.7347	78.26464644	187820.8702	78.41681971	187820.8702	-51.4312698	187244.5993	78.11247317	187244.5993	-46.66479217
2036	187483.8011	78.2388031	187826.2839	78.41967886	187826.2839	-43.25554846	187141.3184	78.05792733	187141.3184	-39.23231585
2037	187401.4683	78.19532057	187801.3877	78.40653041	187801.3877	-37.02257474	187001.5489	77.98411074	187001.5489	-33.56597829
2038	187285.2803	78.13395807	187745.7751	78.37715966	187745.7751	-32.12723999	186824.7854	77.89075648	186824.7854	-29.11567305
2039	187134.7714	78.05446969	187659.0307	78.33134724	187659.0307	-28.19097108	186610.5122	77.77759215	186610.5122	-25.53724733
2040	186949.4665	77.95660439	187540.7301	78.26886905	187540.7301	-24.96491453	186358.2028	77.64433974	186358.2028	-22.60446827
2041	186728.8801	77.8401059	187390.44	78.18949619	187390.44	-22.27884043	186067.3202	77.49071561	186067.3202	-20.16258252
2042	186472.5172	77.70471268	187207.7179	78.09299496	187207.7179	-20.01242832	185737.3165	77.31643041	185737.3165	-18.10220786
2043	186179.8723	77,55015786	186992.1118	77,97912673	186992.1118	-18.07827169	185367.6328	77,12118899	185367.6328	-16.3438835
2044	185850.43	77.37616917	186743.1608	77.84764796	186743.1608	-16.41137873	184957.6993	76,90469039	184957.6993	-14.82852626
2045	185483 6644	77.18246889	186460 394	77 69831008	186460 394	-14,96244768	184506 9348	76 6666277	184506 9348	-13.51131614
2046	185079 0392	76 96877378	186143 3315	77 53085952	186143 3315	-13 6934223	184014 7469	76 40668804	184014 7469	-12 35765661
2047	184636 0075	76 73479502	185791 4832	77 34503755	185791 4832	-12 5744751	183480 5318	76 12455248	183480 5318	-11 34043182
2048	184154 0118	76 48023814	185404 3497	77 14058031	185404 3497	-11 58191027	182903 674	75 81989507	182903 674	-10 43810034
2040	183632 4837	76 2048020014	184981 //212	76 91721973	184981 4213	-10 69667598	182283 5462	75 49238724	182283 5/62	-9 633341665
2049	183070 8420	75 9081926	18/522 1706	76 67/670/2	18/522 1706	-9 903287157	181610 5002	75 1/160070	181619 5002	-8 912079244
2000	1000/0.0409	/5.5001030	104022.1700	/0.0/40/043	104022.1700	-5.505207157	101010.0093	/0.141000/0	101010.0090	0.0120/0244

Table A4.5. Sensitivity Analysis of Forest Area and SDG 15 Progress to Net Forest Import between 2000 and 2050.