

FLOURISHING WITHIN LIMITS TO GROWTH

Following nature's way

Sven Erik Jørgensen, Brian D. Fath,
Søren Nors Nielsen, Federico M. Pulselli,
Daniel A. Fiscus and Simone Bastianoni



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Decades of research and discussion have shown that human population growth and our increased consumption of natural resources cannot continue – there are limits to growth. This volume demonstrates how we might modify and revise our economic systems using nature as a model to sustain and flourish within these limits.

The book describes how nature uses three growth forms: biomass; information and networks, resulting in improved overall ecosystem functioning; and co-development. As biomass growth is limited by available resources, nature uses the two other growth forms to achieve higher resource use efficiency. Through a universal application of the three Rs – reduce, reuse, and recycle – nature shows us a way forward toward better solutions. However, our current approach, dominated by short-term economic thinking, inhibits full utilization of the three Rs and other successful approaches from nature.

Building on ecological principles, the authors present a global model and future scenario analysis that shows that implementation of the proposed changes will lead to a win-win situation. In other words, we can learn from nature how to develop a society that can flourish within the limits to growth with better conditions for prosperity and well-being.

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“The Club of Sienna has provided a helpful review, exposition, and extension of the Club of Rome’s systems modeling approach, demonstrating the increasing relevance of the 1972 book *The Limits to Growth* to problems that continue today. Especially recommended for environmental studies and economics courses.”

– *Herman E. Daly, University of Maryland, USA*

“This book creates the intellectual spine for the Club of Siena, walking in the footsteps of the famous *Limits to Growth*, but turns away from the fears of collapse towards showing that staying within the limits can offer agreeable, pleasant, even wonderful living conditions. An inspiring read for those who believe in the need to change course.”

– *Marina Fischer-Kowalski, Institute of Social Ecology, Vienna, Austria*

“A profound treatise of the fallacies of the growth paradigm. Plus good suggestions for flourishing within the limits. Good tax signals can make us more successful. Bravo!”

– *Ernst Ulrich von Weizsäcker, Co-President, The Club of Rome,
Emmendingen, Germany*

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First published 2015
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

and by Routledge
711 Third Avenue, New York, NY 10017

Routledge is an imprint of the Taylor & Francis Group, an informa business

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British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data

Jørgensen, Sven Erik, 1934–

Flourishing within limits to growth : following nature's way / Sven Erik Jørgensen, Brian D.
Fath, Simone Bastianoni, Daniel A. Fiscus, Søren Nors Nielsen and Federico M. Pulselli.
pages cm

Includes bibliographical references and index.

1. Sustainable development. 2. Conservation of natural resources. 3. Natural resources
management. 4. Nature—Effect of human beings on. 5. Consumption (Economics)
6. Population. I. Title.

HC79.E5J665 2015

338.9'27—dc23

2015003745

ISBN: 978-1-138-84252-6 (hbk)

ISBN: 978-1-138-84253-3 (pbk)

ISBN: 978-1-315-73144-5 (ebk)

Typeset in Bembo

by Apex CoVantage, LLC

The publication of this book has been supported by the Velux Foundation.

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PREFACE

In April 2010, at a symposium in Siena about sustainability and how to use ecological models to assess sustainability, the results of the Club of Rome and the general use of global economic-ecological models were discussed. The general agreement was that the Club of Rome results were very important contributions to the ongoing discussion about the unsustainable global development, which – as shown by the *Limits to Growth* books – inevitably will lead to a collapse due to our overexploitation of the Earth. However, economic priorities dominate almost all political decisions and the direction of development. The very clear messages from the *Limits to Growth* books have had hardly any effect on global development since the first *Limits to Growth* book was published and widely debated in 1972. In Siena, we discussed why the books had such little impact to change the direction of development; we concluded that it was probably because politicians and economists could not reconcile a long-term reduction of the growth of population, production, use of resources, and pollution to more straight forward, concrete initiatives with preferably visible short-term agendas. The controlling growth-oriented paradigm has the advantage of status quo and can work effectively during early periods of development but eventually, as resources become limiting, should naturally give way to more qualitative development. This turn-the-corner transition from growth to development was not agreeable with the current mindsets and approaches of the 1970s. The reality of resource shocks, such as the oil shortages and the recent financial crises, have only made the message more urgent, but an appropriate response has not come from the politicians. Nature has coped with the same problems of balancing growth and development, and therefore it is sensible to ask how nature deals with this situation. By imitating nature, we could launch a workable plan to manage overexploitation. Of course, the benefits from such a plan must be recognized by politicians, economists, and the general public. We do not have political power, but we could develop a very clear, easily applied, and understood plan based on the

principles that nature follows to achieve sustainable development without relying on overexploitation to fuel growth only-oriented policies. Our nature-inspired plan is tested on a global ecological-economic model similar to the models developed and applied by the *Limits to Growth* books. More importantly, we want to refocus the debate away from the fears that come with the concept of no growth toward the advantages of a system that focuses on qualitative development. The restrictions imposed by *Limits to Growth* do not entail stagnation and strife but rather give an opportunity for new priorities, greater equity, and higher well-being. Living within the limits can offer agreeable, pleasant, even thriving and wonderful living conditions. Therefore, the message of the Club of Siena, presented in this book, is the possibility and processes necessary on how to flourish within these limits.

The book consists of nine chapters. After an introduction and a presentation of the important *Limits to Growth* books in Chapters 1 and 2, Chapter 3 presents an overview of ecological principles describing the main drivers for nature, to the best of our understanding, to operate as a sustainable system. Nature avoids over-exploitation and uses a development strategy that considers limits to growth: trees are not growing into the sky, resources are used sustainably, and depletion is avoided by complete recirculation. Chapter 4 translates these principles into rules that we can implement in society, while Chapter 5 tests these rules on a global model to be able to answer the crucial questions: Can it work? Can the principles of nature be used to solve our sustainability problems and to avoid a major collapse with all the disastrous consequences? Chapter 6 discusses the eternal problem: is it better to introduce nature's principles through a top-down or bottom-up approach; the chapter also gives successful examples on how nature's principles have been applied locally and regionally to solve specific environmental problems. The results of employing nature's principles in our society presented using a global model in Chapter 5 are very clear, but it would be beneficial to elucidate the results further to supplement the investigation with two other angles: to apply the widely used ecological footprint and to use a sustainability analysis based on work energy as an indicator, which have given workable results in a number of cases. Therefore, Chapters 7 and 8 are devoted to an interpretation of the model results in Chapter 5 using ecological footprints and a sustainability analysis based on work energy. The last chapter has the title "Can we overcome the obstacles?" The conclusion is that the three chapters with the global results – Chapters 5, 7, and 8 – present the action items in such a clear language that the politicians and economists ought to understand it, but, if not the case, then the population in all democratic countries will be able to understand the clear headlines and provoke a change. Ironically, the changes are not a question about sacrificing our well-being – on the contrary, it will ensure it because the society will reorganize in a structure that is fairer, offer more well-being, have more logic and realism in the sense that the limits are considered, be longer lasting, and increase equality.

The six authors have many colleagues and scientific friends and know many people who are interested in the focal theme of the book, and we have therefore invited everybody who can approve the main lines of the book (but not necessarily

all the details) and its main messages to join the **Club of Siena**. Hopefully it could be a beginning to a movement of all that have acknowledged that a change close to what is formulated as the 12 recommendations in Chapter 9 is urgently needed. Millions have already accepted that changes are needed due to the limits to growth, but the Club of Siena idea is to make it concrete and easily applicable politically and economically to guide the development to cope with the limits. If you are interested in joining the Club of Siena, then please use the blog at www.clubofsiena.dk. We will include your name in our list of members that will be accessible on the blog, currently updated, and referred to in coming discussions. The blog is also open for exchange of opinions and ideas about the focus and the content of the book.

The publication has been supported by the Velux Foundation.

The authors are grateful for the support that will be applied to strengthen the dissemination of our message.

Sven Erik Jørgensen and Søren Nors Nielsen, *Copenhagen, January 2015*

Simone Bastianoni and Federico Pulselli, *Siena, January 2015*

Brian D. Fath, *Towson, January 2015*

Dan Fiscus, *Frostburg, January 2015*

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1

INTRODUCTION

Natural principles of chemistry, mechanics and biology are not merely limits. They're invitations to work along with them.

—Jane Jacobs, *The Nature of Economies*, 2000, p. 12

1.1 Uncontrolled growth

The worst economic crisis since the 1930s started in 2008, and the industrialized countries have hardly recovered by 2014. The crisis was blamed on a combination of lax Wall Street oversight, short-term profit taking (essentially gambling), risky loans, a naïve belief in continuously increasing real estate prices (and policies to encourage this bubble), and an irresponsible use of state money in some Southern European countries, to name the major culprits. Yet, rarely in the mainstream media did one read about the problem in terms of a fundamentally flawed economic structure or a real debate to use the crash to implement new, economic approaches. One notable exception was Thomas Friedman, reporter and author, who wrote in 2009 in the *New York Times* that the crisis may show something very fundamental being more than just a temporary recession in the normal business cycle. The crisis, in his opinion, revealed that the basic economic growth model used as a compass for our decisions during the last 60 years has failed and the next warning may be a major collapse. He was not the first to propose this vision, but it is one that needs much further attention, as we explore in this book. This is in contrast to most economists and politicians who claim that the crisis is provisional and momentary, not structural. In this mainstream worldview, the medicine politicians in industrialized countries prescribed to recover the ailing economy was growth, more growth, and “back to normal growth,” whatever that means. Not one world leader

2 Introduction

questioned the neoliberal, growth-oriented economy or proposed an alternative socioeconomic structure to avoid new crises or to meet the challenges of the future such as unemployment/underemployment, diminishing financial capital, human misery and alienation, loss of community and sense of place, resource shortages, climate change, and the general deterioration of nature and thereby the services that it provides to human societies. An apt description is given in the book *Enough is Enough* by Rob Dietz and Dan O'Neill (2013) (see Note 1). It is no secret that the dominant economic philosophy of modernity is *more* – more people and more production, more money and more consumption. Employers try to earn more income, business managers try to report more revenue on the balance sheet, and politicians try to ensure that the economy can provide steadily more goods and more services.

Physical growth cannot continue indefinitely because the Earth has only finite resources. Nature sets limits to growth. Natural laws that inexorably must be obeyed tell us that unlimited growth is impossible. Even the most conservative politician or economist has to admit that, but no structural changes to the economy or society are pursued and implemented. There were hopes in 2012 due to the Rio+20 Conference (United Nations Conference on Sustainable Development in Brazil on June 20–22, 2012) and the COP 18 (United Nations Framework Convention on Climate Change, 18th meeting of the Conference of the Parties held in Doha, Qatar, November 26 to December 7, 2012), but all hopes were crushed when the results of these global events were presented. Nations are more occupied with the ongoing financial crisis than with finding solutions to the far greater, long-term problems that we are facing in the coming decades: how do we stop our depredation of nature, which is the very basis for our life on Earth? Most discouraging is the lack of understanding regarding how the economic crises and environmental degradation are linked. The very solutions to the global environmental crisis will in fact set the course to a more sustainable economic system, such that one problem cannot be addressed in isolation. Rather than heed the advice of scientists and seek an approach that addresses environment, society, and economy as a complex, integrated whole, we focus on putting the economic machinery back the way that it was, knowing full well that similar crises will arise in the future. Thousands of pages have been written about the irrational, uncontrolled, and unintelligent misuse of our global resources, but any changes have been at the margins, tinkering with rates and efficiencies, not fundamentally addressing the systemic needs. Most economists and politicians are deaf or blind to the signals about them as well as the loud shouts for changes. A Nobel Symposium on Global Sustainability in Stockholm in May 2011 warned against the global predicament that we are facing, but politicians are not listening to natural scientists but rather let orthodox economists dominate the decision making. There seems to be a sound barrier between the world of economists and politicians on the one side and long-term reality and natural scientists on the other side. How do we break through the sound barrier?

Confronting crises and resource limitations is nothing new. In 1972, the Club of Rome published the well-known book *The Limits to Growth*, in which they used several global model scenarios to demonstrate that population growth and

the growth of our consumption of natural resources, both renewable and non-renewable, cannot continue without precipitating a collapse – there *are* limits to growth. Business as usual in 1972 regarding the growth rates of human population, of the withdrawal of renewable and nonrenewable resources, and of pollution emissions would inevitably lead to a collapse. But the global population and politicians have not followed the prudent advice of the Club of Rome because the controlling factors of society are obviously tethered to a short-term perspective, not wise long-term planning. One reason for inaction was the scenarios were painted as too dire and unwelcoming, not motivational and attractive enough to steer the global population toward them. The idea of limits was derided as pessimistic and not relevant to our modern conditions – yes, maybe Malthus had to worry about natural resources when the population was directly dependent on land for a living, but today's economy is service-based, and economists insisted that perfect substitutability could solve any resource constraints. Therefore, little action was taken.

The world has experience with systems that on the surface appear completely different, notably socialism in the former Soviet Union and communism in China; however, both were governed and dominated by a growth paradigm. The Soviet Union failed for some of the same reasons that caused the global crisis in 2008: human selfishness, misuse of resources, and shortsightedness. We have to acknowledge, in Mahatma Gandhi's words, that “there is enough for everyone's need, but not for everyone's greed.” Is being selfish, shortsighted, and therefore unfortunately also foolishly self-destructive embedded in our genes? Or are we like teenagers that never listen to parents' advice but instead only learn firsthand through their own experience? However, if we need a collapse before we perceive what we need to do, then it would be too late.

Perhaps being self-destructive is a characteristic of any technologically advanced society. Since the 1960s, we have built a chain of radio-telescopes that have been listening to radio signals that might emanate from other civilizations. Drake (Note 2) has calculated that if a technologically advanced society has a lifetime of 1,000 years, we should find 25 other societies in our galaxy with at least our level of technology. Of course, if a civilization's lifetime is more than 1,000 years, the probability is correspondingly higher – for instance, if the lifetime is 10,000 years, we should find 250 other technologically advanced societies on planets in our galaxy. We have now been listening to radio signals for about 50 years with no contact with other civilizations. It would be unfortunate to conclude that intelligent life is inevitably self-destructive, or expressed differently: intelligent life is self-destructive before it becomes sufficiently intelligent to understand how to cooperate meaningfully with each other and with nature. Maybe our species has the wrong name and should not be called *Homo sapiens* but *Homo not-yet-sapiens*. Drake's equation can, of course, be criticized for being too optimistic (Note 2), and other calculations indicate that there are maybe only two other technologically advanced planets if the lifetime for an advanced civilization is 10,000 years.

Similarly, China and the other emerging economies have not learned from the mistakes of North America, Europe, and Japan: that it pays better to integrate

environmental considerations into all projects from the very beginning. This was the clear experience learned from the mistakes in the 1950s, '60s, and '70s by the industrialized countries. China wanted, however, economic growth as fast as possible during the last 20 years, but now the Chinese leaders acknowledge that the fast growth has generated many environmental problems that China must solve. Air quality is so poor in many major cities that people are opting to wear masks, and the overall livability of these areas is being questioned. Solutions to the problems are much more expensive now than if they were integrated step-by-step during all phases of the projects.

The Limits to Growth and other books have clearly defined the problems and made the consequences of not shifting direction very apparent. The messages they promote, however, have not changed the direction of global development very much – maybe slightly if we use our very positive “glasses,” but very far from sufficiently. We are still directed toward a collapse. The present economic crisis is just a symptom of the disease: the idea of continuous, resource-based economic growth as the primary organizing factor for society. Another approach should be used as a compass for our development.

With this book, we would like to present a possible alternative pathway to avoid the threatening collapse based on changing the economy from an end goal in decision making to a means toward realizing sustainable communities. Primarily, this requires a reorientation from growth to development – from a quantitative concept to a qualitative one and from short-term to long-term considerations. We will be careful and mindful here to refer to quantitative change only as growth and qualitative change as development. When global annual car production increases, this is a quantitative growth, while the increasing efficiency of the produced vehicle motors constitutes development, for example. We will furthermore emphasize the need for systems thinking and holistic approaches and solutions. The economy provides roles in which individuals can productively contribute to the overall society. It is a fundamental and necessary aspect of our societies, but it should serve us as a useful tool. We should not be beholden to the economy but rather be its boss. The preconditions for a sustainable economy are clear: 1) it is a subsystem of the global ecology, 2) it has to reach for optima not maxima, and 3) it must be based on real physical-chemical-biological transactions, not on virtual or speculative exchanges. *Homo sapiens* are shortsighted but also ambitious to solve problems. How can we improve our quality of life, alleviate poverty, and provide meaningful employment to everyone willing? If one idea is not working, then we are open-minded to try to find another approach that is better. Humans strive for betterment and attempt to find solutions to urgent problems. We need to have goals and see the horizon. Therefore, development should not be stopped, but we can direct it from quantitative growth to qualitative development, which can continue in the face of physical limits. This shift is even a must, as constraints will render the present quantitative growth imperative unattainable and unsustainable. The constraints are clearly defined in the laws of nature. We know that, but how can we change the economy and the growth paradigm toward sustainable development? We could learn from nature, which has been constantly developing and sustaining for a period of almost four billion years. Catastrophes have massively destroyed nature from time to time,

but nature recovers and finds new ways to develop under changing conditions. Which properties of nature have ensured this steady, sustainable, and persisting development? How has nature been able to utilize qualitative development when quantitative growth is no longer possible due to limits? We could imitate how nature has been able to bypass the problems of continuous growth. This book proposes to learn from nature how to change the direction of human development to solve the gigantic problems that we are facing. This entails not only the economic crisis, because it is just a symptom caused by our irrational and unintelligent economic system, but also the real and very serious problem that we are destroying the conditions for sustaining our life on Earth.

1.2 Different types of quantitative growth

Growth can occur more or less rapidly, which implies that we approach the limits to growth at different rates. Four types of growth are important for our understanding of the global problems that we are facing. The four types will be used several times in Chapters 2–9. Therefore, they are defined and presented here in the Introduction:

- 1) Zero growth occurs when the focal variable is constant. The state is not zero or dead but not increasing or decreasing because there is a balance between inputs and outputs. The rate of change, as given by the first derivative of the state variable, is zero. For instance, it would be ideal if we could stop carbon dioxide growth in the atmosphere. This would level the atmospheric greenhouse gas concentration and stabilize the climate. Under conditions for this to occur, our emissions to the atmosphere must be balanced by sequestration out of the atmosphere. Figure 1.1 illustrates no growth.

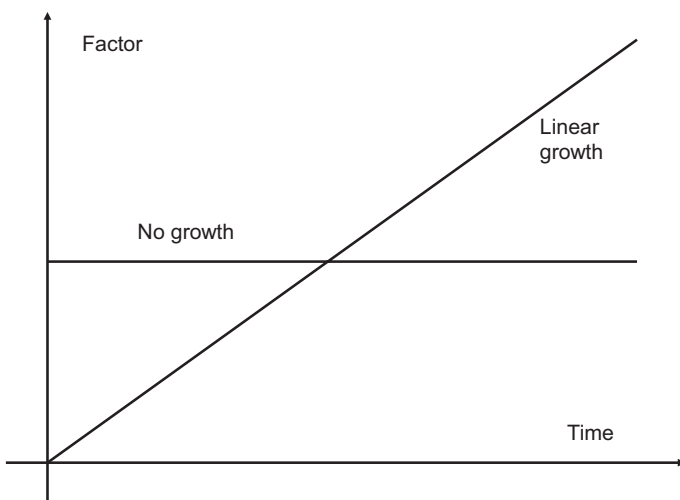


FIGURE 1.1 Illustration of a variable or factor without growth and a factor (variable) growing linearly.

- 2) Linear growth means that the considered variable is increasing (growing) with the same amount per unit of time. The growth (increase per unit of time) is therefore constant. The population of many towns has increased linearly over a certain phase of time. Figure 1.1 illustrates linear growth.
- 3) Exponential growth occurs when the growth of the variable increases at the same rate per unit of time. This type of growth corresponds to the growth of capital in an interest-bearing account as it compounds according to the interest and the interest on the interest, and so on. This is called first-order growth because the growth rate is directly proportional to the amount. Therefore, the acceleration (= increase in growth rate) is constant. A state variable with exponential growth experiences a constant doubling time – to go from two to four, from four to eight, or from eight to 16 and so on requires the same time. It is relentless and rewarding early, becoming instable and insidious late. If one of your ancestors would have deposited one cent in a bank with an annual interest rate of 5 percent 1,000 years ago, then today you would inherit 1,000 times all the capital in the world. Of course, this is impossible, meaning that exponential growth does not continue unabated. Our consumption of fossil fuel has increased exponentially, on average about 2.33 percent per year, for the last many years. Continuing such conditions going forward requires that the total consumption of fossil fuel doubles in about 30 years, and will be four times the present level 60 years from now, eight times the present level 90 years from now, and so on. Given the resource constraints imposed by nature, these doublings are unrealistic, so a lowering of the growth rate will be imminent. Therefore, without improved efficiency or implementation of sequestration technologies, the carbon dioxide emissions to the atmosphere will be twice as much 30 years from now, four times as much in 60 years, and so on. Figure 1.2 illustrates exponential growth. The British scholar Malthus claimed over 200 years ago that exponential growth of the population could not continue and it would lead to famine and disease and a collapse known as a Malthusian catastrophe.
- 4) Logistic growth starts as exponential growth but is regulated by a carrying capacity or a limit. The state variable increases with the same percentage per unit of time but at the same time is regulated (reduced) more and more as the value approaches the carrying capacity. Figure 1.2 compares exponential and logistic growth curves. The latter shows an s-shape. The amount of increase is greater and greater in the beginning and will then diminish due to regulation from the carrying capacity. Many factors in nature follow logistic growth. For instance, the size of an organism often grows according to logistic growth. A population exposed to new (and better) conditions follows logistic growth. When the regulation is not tight (due to time delays or indirect feedback), growth follows a path that exceeds the carrying capacity in a process known as overshoot. The system is then forced into decline either gradually or by collapse. Exceeding the carrying capacity may degrade the environment in such a way that the carrying capacity itself is lowered. Mathematical expressions for the four types of growth are presented in Box 1.1.

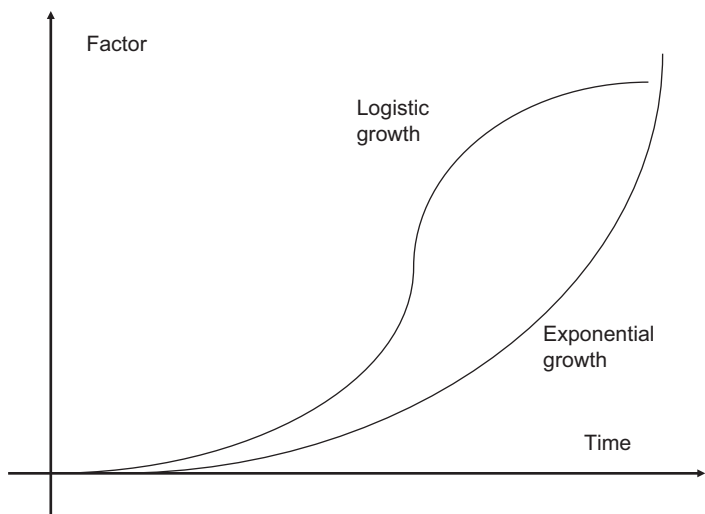


FIGURE 1.2 Exponential and logistic growth curves are illustrated by the graph.

Box 1.1 Four standard growth forms and the equations that describe them (for further details, see Note 3).

Assume we have a state variable such as number of fish in a lake at a certain time. Let us call that variable X to indicate the condition and the growth rate, and use K to notate the carrying capacity of the system. The state variable and rate of growth are governed by the following equations.

Growth form	State variable	Growth rate
Zero growth	Constant	0
Linear growth	Constant \times time	Constant
Exponential growth	Constant $\times e^{\text{time}}$	Constant \times time
Logistic growth	$\frac{K}{1 + e^{(\text{a-constant} \times \text{time})}}$	Constant \times time $\times (1 - X/K)$

These basic growth forms need to be understood in context with our economic and social systems as well. Exponential growth, for certain, cannot continue indefinitely, so a system that relies on borrowing and interest is inherently unsustainable. The conclusion is that we need to modify and revise the economic system and our economic goals. We need to understand there are better ways to achieve harmony

between humans and nature and that we have to redefine the economy and even the meaning of the word growth. But most importantly, we recognize clearly now that constraints are not only negative. They challenge us to find innovative and transformative solutions. Therefore, the message in this book is steered not toward the limits but the possibilities within the limits. Nature has managed quite successfully to construct and maintain complex, wonderful, diverse, creative systems in spite of the constraints. Therefore, just as in nature, our aim is to learn how we may flourish within the limits. The message of the Club of Siena is cast as an addition to the important message of the Club of Rome. The economic and environmental crises are two sides of the same coin. The problems causing both are the same and can only be eliminated by shifting to another economic structure.

1.3 The content of the book

Chapter 2 reviews the book, *The Limits to Growth*, and the six books that have been published to follow up on the original idea from 1972. The latest is the book by J. Randers, *2052*, which predicts world conditions in 2052, presuming humans follow different but very probable scenarios. A few other books focusing on the same theme are mentioned in this chapter. The crucial question is: will there be social and political will to shift direction? The books that we mention and discuss in this chapter show clearly that a collapse is waiting around the corner if we do not alter business as usual. In accordance with the books, we will have to radically slow down population growth, growth of industrial production, our consumption of resources, and our emissions of pollutants to the environment. The key problem is, however, that we know what to do, but we do not do it because humans are dominated in their decisions by the short-term economic benefits. The incredibly passive reactions by particular politicians to the limits to growth debate imply that the business-as-usual attitude is dominant. We address in this chapter why politicians have been passive and why practically nothing has changed, although the consequences of continuing the same procedure are made very clear in these books. We conclude that a change in the social-economic structure is needed to be able to control the economic growth better than we do today. We must dig deeper to understand why such clear messages as presented in the *Limits to Growth* books are not adopted politically and economically. It is obviously not sufficient to shout that the wolf is coming. Must we wait until the wolf has attacked before the population and the politicians awake? Must much of Florida be flooded before it is understood in the United States that global warming is threatening our life and it is associated with our over-reliance and exploitation of fossil fuels? Or, can we change some structural elements in our society that will facilitate our understanding of the problems and shift development in another direction? In this context, we could learn from nature, which is the focus of Chapter 3. The unfolding of the problems as they have been presented by the key environmental books during the last 40 years will hopefully give an understanding of how serious the problems are and that inaction cannot be accepted. Chapters 3–6 delve into the structural changes we have to

introduce in society to be able push the economy and policies in another direction so that the problems are considered much more seriously by decision makers in all fields.

Chapter 3 presents how nature deals with the problems of limited resources. We identify and discuss 14 very significant properties of ecosystems – the systems of nature. We articulate how ecosystems manage to avoid, to a large extent, the same obstacles as our societies. It is rooted in four billion years of experience and steady evolution within the 14 mentioned properties. Nature has, of course, experienced catastrophic events caused by external factors, but nature has been capable to recover after major catastrophes and to benefit from both quantitative growth, when the timing is right, and qualitative development. We should and could learn from nature how to change the social-economic structure and pathways to manage both quantitative growth and qualitative development.

Chapter 4 presents how we could adopt nature's 14 properties in our society. Specifically, we describe how our society could differ from today, particularly the "everyday" consequences of adopting these properties. A green society with a green economy would be heavily based on the simple, yet crucial, three Rs of resource management: reduce, reuse, and recycle. Reduction is the primary strategy, but, when not possible, finding reuse or then recycling will help our material flow balance in a limited world. The consequences of adopting nature's 14 properties are a changed economic structure based on the three Rs along with a massive investment in education, innovation, research, and better global cooperation among the countries and their people. It is particularly important in this context that the developed countries invest in better education in the developing countries, which will lead to a win-win situation. It is touched again and again in this chapter that economics cannot solve our problems because the economists simply do not have the answer to the problems. Their answer back to "normal" growth does not work in a world with limited resources.

Chapter 5 answers the crucial question: How will adopting nature's 14 properties change the future for humans? Can we cope with the gigantic problems that we otherwise are facing? We develop a model based on the original *The Limits to Growth* book and update it with our scenarios based on implementing nature's 14 properties. The model details are presented in the Appendix. Model scenario results are presented as graphs and tables in this chapter. These model scenarios give robust evidence that we could and should learn from nature to build a sustainable future. We should, however, examine the consequences of the implemented changes in more details and from different angles, which leads to the content of the next chapters.

Chapter 6 explores the view that part of our problem is improperly understanding the current human crisis and also seeing clearly that nature and living ecosystems provide pragmatic examples of how to solve the crisis. We need to revise our most basic ideas and mental models of life, environment, and the relationship between life and environment. Our current scientific paradigm of life science, and our current mainstream image of life in modern industrial culture, focuses on organisms