1. Introduction

The field of environmental and resource economics (E&RE) is developing rapidly, as is reflected by a large number of conferences, workshops, journals, monographs, edited books, and textbooks.¹ The variety of contributions is also increasing. To some extent this is due to economists from various sub-disciplines of economics showing an interest in environmental and resource economics and contributing to its progress. In addition, the multidisciplinary nature of some of the questions raised in environmental economics research has caused an increase in the interaction between economists and scientists from various other disciplines, for the purposes of either communication or integration of insights and tools. All these developments are reflected in the appearance of various new journals in the last decade, the main ones of interest for economists being *Environmental and Resource Economics*, *Ecological Economics*, and *Environment and Development Economics*. A consequence of these developments is that it is becoming increasingly difficult to stay well informed about the range of issues dealt with in E&RE. Established textbooks do not cover all of these, since many issues concern too recent or too advanced material. Moreover, the number of monographs comprising a thorough and complete discussion of specific topics within E&RE remains relatively small, as opposed to the number of edited books with less internal cohesion. Survey articles on environmental or resource economics are rare, the main ones being Fisher and Peterson (1976), Peterson and Fisher (1977), Cropper and Oates (1992) and Krautkramer (1998). There now exist various collections of reprints of 'classic articles' in E&RE that, although individually necessarily biased and incomplete, together provide a most diverse and comprehensive picture of important insights in E&RE (Costanza et al., 1997a; Dorfman and Dorfman, 1993; Heal, 1993; Krishnan et al., 1995; Daly and Townsend, 1993; Markandya and Richardson, 1992; and Oates, 1992). More such collections are being prepared. Other recent initiatives worth mentioning are a yearly series of advanced surveys of selected topics in E&RE (Folmer and Tietenberg, 1997, 1999; Tietenberg and Folmer, 1998), and a special issue of *Environmental and Resource Economics* on 'Frontiers in
Environmental and Resource Economics' (Sterner and van den Bergh, 1998). Last, but not least, there are two other handbooks on E&RE, namely Kneese and Sweeney (1985/1993) and Bromley (1995). Both contain excellent surveys at an advanced level. However, most contributions to the first collection are already more than 13 years old, while the second collection is rather a mix of surveys and in-depth articles. Most importantly, these handbooks omit a number of exciting and modern research areas in E&RE. The present collection aims to offer a more comprehensive as well as up-to-date advanced survey of E&RE – complementary to rather than a substitute for these earlier handbooks.

The purpose of this chapter is threefold. First, it offers a short overview of research topics in E&RE, based on a discussion of the main contents of each chapter in the handbook. Along the way, where relevant, classic contributions and more extensive surveys will be mentioned. It should be noted that, given the large number of chapters, it is inevitable that the presentation omits backgrounds and explanations, and instead focuses on broad aspects and key issues. A second objective of this chapter is to indicate which particular topics are discussed in multiple chapters. This is done because chapter titles cannot possibly reflect all the issues discussed. Furthermore, several issues are approached from alternative perspectives, leading to complementary and sometimes opposite approaches. For a number of selected topics I have tried to indicate where in the book such alternative perspectives can be found. One may argue that a 'subject index' is intended to serve this purpose, but I doubt whether readers would prefer to sift through an index. The overview given in this chapter will allow readers to glance through the list of topics and see if there are any corresponding with their interest. Finally, the book is certainly not complete in terms of its coverage of topics in the realm of E&RE. I have therefore tried to indicate, for a few significant omissions, which literature sources can be consulted in case readers are interested in learning more about the respective topics.

The organization of this chapter is as follows. Section 2 provides an overview of the contents of the book. Section 3 indicates the topics that receive discussion in multiple chapters. Lastly, Section 4 presents a list of omitted topics and suggests some entrances to the literature on these.

2. An overview of the handbook
The present Part I of the book contains one other chapter (2), which offers a short and elegant history of environmental economics. I recommend this without hesitation as essential reading. The remainder of this section is devoted to a short account of the main issues addressed in Parts II to X of the book. In places this is complemented by information on classic publications, more elaborated surveys or introductions to the respective topics. As
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A result, this summary of the handbook can also be regarded as a broad survey of E&RE.

Part II Economics of natural resources (Chapters 3–12)
The second part of the book considers selected topics in natural resource economics. These relate to particular problems, resources or sectors. First, the conventional non-renewable resource economics theory is presented at an advanced level, in four chapters (3–6). Chapter 3 addresses optimal extraction under competitive conditions without capital (the Hotelling cake-eating problem) and with capital (the Ramsey growth problem and the Hartwick rule). Attention is also given to extraction under uncertainty and to research and development. Chapter 4 reviews resource markets under imperfect competition. Two general cases are considered, namely monopoly and oligopolistic markets. The latter involve cartel-versus-fringe models in which Stackelberg-type of strategic behaviour equilibria are examined. Chapter 5 contains a concise discussion of optimal revenue and Pigouvian taxation analysed in resource models. Chapter 6 is devoted to the international trade aspects of resource markets under various market configurations. Attention is also given here to the well-known Hartwick rule on sustainable consumption, which has received much attention due to its relation to sustainable development and growth. Topics in resource economics have been best covered in the classic text by Dasgupta and Heal (1979), and in the third volume of Kneese and Sweeney (1993), which is entirely devoted to advanced resource economics. Accessible introductions to the theory are Hartwick and Olewiler (1998) and Neher (1990), while Howe (1979) pays more attention to broader and practical economic issues of resource use.

Following the first set of chapters, which address mainly theoretical issues, Chapter 7 is devoted to indicators of resource scarcity. It offers a combination of theory, empirical results and weaknesses for three classes of approaches. These are based on classical, neoclassical and biophysical models of scarcity.

Subsequently, recent developments are surveyed in two areas of renewable resources: fisheries and forestry. Chapter 8 on fisheries addresses a range of issues, from basic textbook issues to topics such as alternative management techniques, uncertainty, investment, and marine reserves. Chapter 9 on forestry deals with theoretical, empirical and multiple-use issues. The classic introduction to renewable resource economics (sometimes referred to as 'bio-economics') is Clark (1990). For a more detailed account of fisheries economics, see Clark (1985) and Hannesson (1993), and for a perspective focusing on uncertainty, see Walters (1986). Forestry is discussed thoroughly in Johansson and Lofgren (1985).
Finally, environmental economics aspects of three specific resources or sectors receive detailed attention, namely water resources, agriculture and energy resources. These include general issues that link to some of the previous chapters, as well as specific issues related to the features of the resources or the institutional setting of the problems examined. Chapter 10 on water resources deals with farm-level decisions on irrigation, surface and groundwater allocation mechanisms, the spatial management of water, and the economic analysis of water projects. The latter includes discussions on irreversibility, externalities, institutions, restoration and equity. Chapter 11 on agriculture and the environment adopts a broad economic approach, and surveys different categories of pollution originating from agricultural practices, technical progress and policy trends, land conversion and degradation issues, rural amenities, and the impact of environmental pollution on agricultural production. Chapter 12 on energy and the environment also adopts a broad approach, and considers environmental impacts of energy use, energy demand, energy conservation and efficiency, the liberalization of energy markets, renewable energy and energy policy. For various collections of articles on agriculture and environment see Hoggart (1992), OECD (1994) and Ruttan (1994). Bredahl et al. (1996), Merrett (1997), and Spulber and Sabbaghi (1997) discuss economic aspects of using water resources. A variety of perspectives on energy, environment and policy is offered by Kneese and Sweeney (1993), Martínez-Alier (1991) and Peet (1992).

Part III Economics of environmental policy (Chapters 13–25)

This part of the book on pure environmental economics and policy covers the standard theory and insights, as discussed most thoroughly in the classic text by Baumol and Oates (1988). In addition, surveys of topics were sought that are usually only marginally addressed or even ignored in (advanced) textbooks. The part opens with two chapters on fundamental concepts, namely externalities and environmental risk. Chapter 13 includes a general discussion of market failures, a careful consideration of a definition of externalities, and various insights into the relationship between allocative efficiency and equity. Chapter 14 focuses on risk situations where individuals can alter risk by choice. Attention is devoted to the theory, assessment, valuation and management of endogenous risk.

Many of the remaining chapters in this part of the book are concerned with the choice of policy instruments in relation to efficiency, equity and other criteria. First, the archetypal opposition of standards and taxes is considered in Chapter 15, which discusses the efficiency advantages of taxes over standards, as well as qualifications to these. The literature on uncertainty, and on other criteria such as equity, political and ethical perspectives, is also surveyed.
The next few chapters cover modern topics such as imperfect markets, technological innovation, transaction costs, tradable permits and environmental tax reform. The cases of environmental policy under monopoly and oligopoly are surveyed in Chapter 16, which reviews the literature on market entry, the use of policy instruments, and impacts of environmental degradation on market demand or supply. The last section of this chapter deals with the impact of environmental policy on R&D related to environmental characteristics of production. Next, Chapter 17 considers the implications of transactions costs on the design of environmental regulation. Transactions costs arise from exchange and maintenance of ownership and use rights, are related to informational imperfections and asymmetries, and may apply to both market parties and regulating institutions. The chapter presents a broad overview, giving attention to policy choice, policy implementation, the operational phase of policy, and interactions between these three policy stages. Subsequently, two chapters discuss advanced theory and practical lessons of experience with tradable permits. Chapter 18 treats tradable permits under imperfect competition and barriers to entry, the lack of trade in permit markets, and the auctioning of permits. Chapter 19 draws lessons from the experience with permit-trading programmes in the US, considering different local and global environmental problems related to lead in petrol, ozone depletion, acid rain, and so on. The evolution of the regulation programmes is carefully traced, by examining programme design goals such as cost-effectiveness, reduction of transactions costs and improved air quality. Spatial issues and the context of developing countries are also considered. Chapter 20 reviews the debate on the double dividend of environmental tax reforms. It opens with the theory of second-best environmental taxation, distinguishing between three versions of double dividend, namely 'weak double', 'strong double' and 'employment double'. Subsequently, a survey of empirical studies is presented. The chapter ends with a consideration of political implications, and concludes that a double dividend cannot occur without shifts in income distribution. For more discussion of this topic, see Bovenberg and Cnossen (1995), Carraro and Siniscalco (1996) and O’Riordan (1997).

The policy perspective is widened by the last five chapters in this part of the book, which address a broader range of criteria for instrument choice and in particular deal with distribution issues in environmental policy. In Chapter 21 on comparison of instruments, 10 categories of instruments are evaluated on the basis of 12 criteria. These criteria cover, among others, static and dynamic efficiency, informational demands, ease of monitoring and enforcement, flexibility, the institutional demands of agencies and regulated parties, political dimensions and perceived a priori risks. For
other surveys of instruments in practice, with a particular focus on market-based instruments, see, for instance, Sterner (1994) and Opschoor et al. (1994).

Chapter 22 is devoted to public economics and environmental policy. Cooperative and non-cooperative mechanisms in the provision of environmental goods and services as public goods are discussed, while attention is also given to the use of public funds and environmental policy design. Chapter 23 considers political aspects of the evolution of environmental regulation. Attention is devoted to political pressure from various interest groups, such as polluters and environmentalists, and to the role of actors in the public sector, such as politicians and bureaucrats. The final two chapters on distribution or equity may be of special interest to many readers, as together they provide a balanced account of the economic analysis of distribution issues in environmental economics. Chapter 24 presents a historical background and discusses efficiency–equity trade-offs in the context of standard welfare theory. It then goes on to consider extensions and alternatives, such as utilitarianism, Rawlsian theories of justice, and libertarian thought. Subsequently, principles of equity and efficiency are discussed, and the use of cost–benefit analysis is examined from the equity perspective. All these elements are examined further in an application to global warming. Chapter 25 takes a more critical approach to welfare-based evaluations of the distribution impacts on environmental regulation, and offers a broad literature review of critiques and alternative suggestions for conceptualizing equity issues. It is argued that efficiency and distribution in general equilibrium models are non-separable, and that a unique determination of 'correct' prices is impossible. As an alternative approach, neo-Ricardian and Sraffian reproductive modelling instead of allocative modelling of economic and ecological distribution is discussed. The chapter ends with a consideration of the intergenerational distribution issues related to sustainability and time discounting.

Part IV International aspects of environmental economics and policy (Chapters 26–34)

Since the mid-1980s E&RE has included much research on the international dimension of environmental economics and policy. Until then, most policy theory was dominated by insights based on models of closed economies. One can consider three main topics in E&RE that have an international dimension: cross-boundary and global environmental problems; the interface between foreign trade and environmental externalities; and international policy coordination and trade agreements. Some of this material has reached a few recent advanced textbooks, but these are unsuitable to convey the diversity of approaches, models and insights as presented
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Trade issues are covered here by five chapters that address theoretical and empirical issues, a range of equilibrium approaches, and the context of developing countries. Chapter 26 provides a broad introduction to the environmental policy dimension of foreign trade, focusing on environmental policy as trade policy, the restriction of trade for environmental reasons, 'environmental protectionism', and the GATT/WTO. The other chapters consider in detail particular formal approaches to analyse the trade–environment interface. Chapter 27 evaluates partial equilibrium analysis of the trade–environment interface. This is a sensible approach when economy-wide effects of environmental policy can be assumed negligible, and the 'rest of the world' does not act strategically. The environmental impacts of trade liberalization and environmental policy are examined for a number of cases: production and consumption externalities; small and large countries (that is, fixed or variable terms of trade); and local and transboundary pollution. The use of 'general models' is surveyed in Chapter 28. These models can address questions related to specialization patterns, interlinkages of economic production sectors and markets, the feedback effects of policies, distribution issues, and leakage effects. A detailed consideration of Heckscher–Ohlin models extended with environmental variables is followed by discussions of statistical–econometric and applied general equilibrium models. These three 'general model' categories are regarded as being largely complementary to each other. Some important conclusions are that research on trade–environment interactions needs to address spatial distances, technological innovation and particular features of developing countries. Next, Chapter 29 addresses strategic environmental policy in the context of transboundary pollution or international trade characterized by imperfect competition. Among other things, ecological dumping and the Porter hypothesis related to the impacts of environmental regulation on R&D efforts are discussed in this context. The last survey on trade issues, in Chapter 30, focuses on the environment–trade interface in relation to developing countries. It opens with a discussion of alternative conceptual models of this relationship, based on concepts such as environmental capital, equity, harmonization and diversity. Subsequently, a number of issues are considered, including political dimensions and the Rio Declaration on Environment and Development, foreseeable and potential changes in North–South comparative advantages, and policy issues focusing on multilateral agreements and eco-labelling. The rest of this part of the book is devoted to other topics in 'international environmental economics'. In Chapter 31 a survey is offered of formal modelling of environmental conflict, bargaining and cooperation.
Attention focuses here on self-enforcement and the stability of international environmental agreements, using models derived from game theory. Two specific issues are addressed: transfers to compensate countries that lose by signing an agreement, and issue linkage aimed at improving the profitability and stability of agreements.

The final three chapters address specific categories of environmental problems. Transboundary environmental problems are considered in Chapter 32. A general formalization of these problems is presented, followed by focused discussions on ‘acid rain’ and ‘global warming’. Various models are surveyed, of non-cooperative and cooperative solutions, the design of international agreements, and the relations between trade and transboundary pollution. Global environmental issues are treated further in the last two chapters. Chapter 33 discusses ‘global warming’, stratospheric ozone and biodiversity, and tries to consider these problems within a single economic framework. Attention is devoted to economic value, uncertainty aspects and policy instruments. Chapter 34 presents a mixed theoretical-empirical discussion of a specific category of policy instruments that has received much attention in the context of curbing CO$_2$ emissions, namely ‘carbon taxes’. This includes, among other things, considerations of efficient specification, dynamic issues, interactions with other taxes, international bargaining and coordination, and barriers and problems.


Part V Space in environmental economics (Chapters 35–40)
Economists seem to have paid little attention to the spatial dimensions of environmental problems, environmental policy, and environment–economy interactions, including issues of growth and environmental sustainability. There is still much to do in this area, especially in a multidisciplinary setting where information from natural sciences is used. For
instance, in hydrology, geography and ecology, spatial disaggregate frameworks and models are very common (see Part VIII). Spatial mismatches between environmental, economic and policy systems and processes may offer important and interesting research themes.

This part of the book addresses the conventional issues that have received some attention, such as non-point source pollution, land use, urban environmental problems, location choice and transport. Chapter 35 offers a broad introduction, relating historical developments in environmental and spatial economics. To motivate the interconnection it is argued that ‘space’ is the geographical medium for environmental externalities, which is both heterogeneous and scarce. Next, a survey is offered of how the interconnection of spatial and environmental economics has occurred in theory, in modelling and in applied policy studies. Chapter 36 considers the problem of non-point source pollution, which has so far received little attention in advanced textbooks. This is a relevant problem in the context of diffuse sources such as farmers, households and mobile sources (transport vehicles). It can be regarded as both a spatial and an information asymmetry problem, where the latter results from the imperfect observability of the polluters by the regulator. Different incentive schemes, such as input and ambient taxes, are examined on a theoretical level, while applied issues are also briefly discussed. Next, Chapter 37 is devoted to land use and environmental quality, adopting a broad perspective. This includes a short introduction to non-residential land use and environmental issues at the global level, followed by a discussion of the mutual dependence between environmental quality and residential land use. The conceptual model used to structure the survey is based on the impact of the environment on land use via amenities and disamenities. Attention is devoted to issues surrounding the interpretation of hedonic price studies and urban development and land price theories. Chapter 38 provides a short but broad account of studies on urban sustainability issues. This is done by considering three dimensions, namely land, energy and transport, and by referring to a range of applied studies. Subsequently, in Chapter 39, the issue of endogenous location of plants induced by relative strictness of environmental regulation is surveyed, a phenomenon that is sometimes referred to as ‘relocation’ or ‘capital flight’. First, a general model with graphical illustrations of the location problem is presented, which gives rise to considerations of economies of scale, market structure, multinationals, and transport costs. Next, policy competition between regions or countries in the presence of footloose industries is surveyed in more detail. A final section examines the empirical support for some of the hypotheses generated by the theoretical literature. Chapter 40 offers a concise survey of research on transport and the environment. It opens with some illustrations
of social costs and the energy efficiency of transport, followed by an account of demand-side developments in the areas of passenger and freight transport. It closes with a discussion of the economic and social feasibility characteristics of transport–environment policies.

Some of the topics in this part of the book can also be regarded as relevant at an international level, in which case the distinction from Part IV becomes rather vague. The purpose of both Parts IV and V is to broaden the horizon of the non-spatial and closed-economy environmental policy discussions that have long been common in many E&RE textbooks and policy discussions. A very accessible introduction to both spatial and international dimensions in environmental economics is provided by Siebert (1985, 1995).

Part VI Environmental macroeconomics (Chapters 41–50)

‘Environmental macroeconomics’ is a term coined by Daly (1991b), who argues that environmental issues have barely been discussed or even noted in standard macroeconomic textbooks. Environmental macroeconomics may be regarded as covering theoretical and empirical issues related to growth, sustainable development, and the physical scale of the economy. These have given rise to much debate among economists, and between economics and other sciences. This part of the book aims to survey the various approaches and stances. It includes a somewhat diverse collection of contributions, many of which relate to research on growth and sustainable development.

The opening Chapter 41 offers a general account of macroeconomics and modelling in environmental economics, while also devoting attention to economics in global modelling and integrated assessment. Macroeconomics is discussed in relation to regionalized world models, environmental input–output models and qualitative scenario studies. The topic of endogenous growth and the environment receives separate treatment in Chapter 42, as it has been the subject of numerous articles in recent years. This chapter discusses the general structure of such models, presents an archetype model, and examines the role of behaviour and policy. It ends by considering the question of whether sustainable growth is possible from the perspective of modern growth theory. In this context, some empirical findings are also referred to.

Next, several chapters offer elements of the growth debate. This debate is most clearly presented by two opposing views, a ‘growth-optimistic view’ by W. Beckerman in Chapter 43, and a ‘growth-pessimistic view’ by H.E. Daly in Chapter 44. Following these, Chapter 45 suggests a typology of perspectives in the broader growth debate. This includes main perspectives, that of the moralist, the pessimist, the technocrat, the opportunist and the
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optimist. This categorization essentially follows three questions: Is growth desirable? Is growth feasible? Can growth be controlled or directed? The various stances in this debate are considered in more detail in the following publications: Lecomber (1975), Mishan (1977), Daly and Townsend (1993), and Myers and Simon (1994).

Next, Chapter 46 presents a survey of empirical research with a macroeconomic orientation towards growth and environment, dominated by a search for ‘environmental or green Kuznets curves’. Here attention is devoted to the choice of indicators, data, statistical methods, the interpretation of empirical results, and policy implications. The final survey related to growth, in Chapter 47, reviews studies on national or economy-wide policies in the context of growth and environment. This contribution looks, among other things, at the environmental impacts of such policies and their timing and sequencing. An action impact matrix is discussed as a general tool for policy analysis, formulation and coordination. A large number of studies is reviewed, covering macroeconomic and sectoral reforms, stabilization policies, and so on.

Four chapters deal explicitly with ‘sustainable development’, namely Chapters 38, 48, 49 and 72. Chapter 48 provides a definition and a short history of sustainability as a general concept. It distinguishes environmental from economic and social sustainability, and relates intergenerational to intragenerational equity. Subsequently, it tries to answer the question of what should be sustained, such as environmental source or sink capacities, life support functions, or biodiversity. It concludes by considering the relationship between sustainability and substitutability, arguing that the latter is the exception, rather than the rule. Chapter 49 surveys the literature on indicators of sustainable development. This covers a conceptual framework for indicator development, and discussions of aggregation and spatial and analytical demarcation. Three types of approaches are recognized: (i) a single aggregate indicator such as ‘green GDP’, genuine savings measures, and so on; (ii) multiple economic and environmental indicators, each closely linked to the economic system, for example, based on the system of national accounts; and (iii) ‘free form’ indicators which can address all elements of economic–environmental cause–effect chains.

A final survey in this part of the book, Chapter 50, addresses the relation between poverty and environment in developing countries, taking the sustainability perspective to a different level. It starts by framing the UNCED/Rio 1992 benchmark, in which development and environment were firmly linked at a political level. Subsequently, resource dependence in developing countries is examined, and it is concluded that the natural asset base of the poorest economies is being quickly eroded, while economic growth is largely absent. Next, the concentration of poor people in
marginal areas is considered, and it is argued that environmental degradation creates the greatest threat for the poorest people in developing countries. Lastly, the poverty–environment trap is examined, that is, the question whether poverty causes environmental degradation; it is emphasized that the determinants of behaviour need more study, and that the poor should not be treated as a homogenous group.

Readers interested in good surveys of theoretical economic views on growth, environment and sustainability may want to consult the excellent article by Toman et al. (1995), the older but very readable Pezzey (1989) (which includes a long list of definitions of sustainable development), or recent contributions by Hartwick (1997) and by Aronsson et al. (1997). A wide range of indicators of sustainable development is presented in Atkinson et al. (1997). An interesting systems perspective on sustainability has been put forward by Clayton and Radcliffe (1996). A broad view on development, poverty and environment is provided by Pearce and Warford (1993). For less orthodox discussions of environmental problems in developing countries see Martínez-Alier (1995) and Guha and Martínez-Alier (1997).

### Part VII Economic valuation and evaluation (Chapters 51–58)

Valuation has received ample attention in E&RE textbooks, and has also been well covered at the theoretical and methodological level in monographs (Freeman, 1993; Johansson, 1987) and edited volumes (Braden and Kolstad, 1991; Bromley, 1995). An accessible introduction to this theme is Hanley and Spash (1993). Although some repetition of these excellent surveys seems inevitable, both the theory and the main methods have been included in a number of separate chapters here, covering recreation demand models, hedonic pricing models, and contingent valuation (CV) approaches.

Chapter 51 reviews recent progress on environmental valuation theory. It provides a short introduction to compensated money measure concepts, and a survey of, among other things, important conditions for market valuation, the logical properties of money measures, altruism and other non-use values. Chapter 52 on recreation models reviews progress on valuation methods that includes indirect methods, recreation demand models and traditional travel costs models, all using travel costs as core information. The differences between these relate to continuity versus discreteness of demand, that is, they focus on the number of visits to a particular site versus the choice between alternative sites, respectively. Chapter 53 surveys the development and application of hedonic pricing methods, with detailed attention being devoted to various sophisticated theoretical and statistical refinements, such as the timing of adverse impacts of environmental pollution on property values, functional forms and two-stage models. Some of
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Chapter 54 on contingent valuation (CV) offers a very thorough overview of the huge amount of research that has developed and applied this method in the last decade. This pays attention to the construction of CV experiments, and a number of strongly debated issues, such as altruism, the comparison of elicitation formats, embedding and sequencing, the willingness to accept/willingness to pay (WTA/WTP) disparity and the focus on mean versus median. Two early books on CV are Mitchell and Carson (1989) and Cummings et al. (1990). After the Exxon Valdez oil spill in Alaska in 1989, the method was heavily debated (see Carson et al., 1992; Hausman, 1993; Arrow et al., 1993). Since then, many publications on the subject have appeared (for example, Bjornstad and Kahn, 1996; Kopp et al., 1997). Some aspects of CV research relate to experimental economics, which is covered separately in Part IX of the book.

Next, two less common topics are addressed. The first of these, meta-analysis, treated in Chapter 55, has recently received some attention, also in relation to benefit or value transfer. This is approached from a broad perspective, covering conceptual issues, statistical issues, alternative methods, the relation with benefits transfer, and the fundamental and practical limits to meta-analysis (see van den Bergh et al., 1997). The second less common topic, surveyed in Chapter 56, is concerned with the ethical dimensions of economic valuation, an issue which is conspicuously absent in many environmental economics textbooks (note that a broader perspective on ethics in relation to environmental policy is discussed in Chapter 66 in Part VIII). This chapter discusses subtle criticisms of the standard assumptions of economic valuation methods. This concerns issues of altruism, ethical attitudes and CV responses, ‘citizen responses’ (Sagoff, 1988) and the non-existence of ordinary utility functions, due to lexicographic preferences, responsibility considerations, moral satisfaction, and the like. In addition, the use of estimated economic values in cost–benefit analysis is considered from an ethical perspective.

This part of the book ends with two chapters on methods for project or policy evaluation. Chapter 57 discusses the conventional cost–benefit analysis (CBA) approach. It gives a short introduction and includes discussions, among other topics, of irreversibility, complexity, discounting and discount rates, and sustainable development and CBA. Chapter 58 presents multi-criteria evaluation methods. A conceptual and methodological discussion is offered, which includes a typology of methods, a treatment of uncertainty and ‘fuzzy evaluation’ problems, and an example illustrating many of the elements and methods discussed. An accessible introduction to multi-criteria evaluation in the context of environmental economics is Janssen (1992).
Part VIII Interdisciplinary issues (Chapters 59–67)

The purpose of this part is to offer a more detailed background on insights from the natural sciences relevant to studies of environmental problems than is usual in (advanced) environmental economics textbooks. The contributions have been specifically oriented towards the demands and knowledge of environmental and resource economists. The first set of chapters addresses issues related to physics and biology, offering information about material flows, energy transformation and ecological processes that may be regarded as required basic knowledge for economists involved in environmental research.

Chapter 59 on ‘physical principles’ provides a short introduction to the material balance principle and the ‘entropy law’, and then considers how these have been incorporated into environmental economics studies. This survey is categorized according to production processes, economy–environment interactions, and long-run growth. Chapter 60 presents a detailed discussion on materials in relation to environmental problems. It offers short informative introductions to four main groups of materials, namely fuels, metals, non-fuel minerals, and packaging materials and synthetics. Subsequently, it discusses product cycles, ‘dematerialization’ and recycling, and related policy issues. The topics of these two chapters – materials, energy and thermodynamics in relation to economics and the environment – are more extensively discussed in a variety of ways in Ayres (1978 and 1988), Ayres and Ayres (1996), Daly and Umaña (1981), Faber et al. (1987), Georgescu-Roegen (1971, 1976), Kandelaars (1999), Kneese et al. (1970), Martinez-Alier (1991), Noorman and Uiterkamp (1998), Peet (1992), Perrings (1987) and Ruth (1993).

Chapter 61 considers another set of basic insights to E&RE, namely ‘ecological principles’. This chapter devotes attention to the structure, classification, succession, development and management of ecosystems. Subsequently, the importance of biological diversity for ecosystem functioning is examined. Next, economic issues are introduced, focusing on ecosystems as factors of production, and improvement of the interaction between humans and ecosystems. More descriptive details of global nutrient cycles and human interference in these is covered in Chapter 62. Here, information from ecology, physics, chemistry and economics is combined, which is referred to as ‘industrial metabolism’. A four-box scheme is put forward to describe biogeochemical reservoirs and cycles of the nutrients carbon, nitrogen, sulphur and phosphorus, which are important as they can be considered ‘scarce’ in the biosphere. In addition to a detailed discussion of each of these cycles, two fundamental issues are raised, namely the thermodynamic disequilibrium of these cycles, and the slow acidification of the environment at the global level, that is, beyond the usually empha-
sized local effects. For a set of more pragmatically oriented perspectives on several of these issues see Klijn (1994).

Two additional chapters provide creative views on macro or system indicators and energy systems analysis that have received some attention in ecology and ecological economics. Chapter 63 is devoted to indicators of economic and ecological health (see also Costanza et al., 1992). Here it is argued that ecologists can come up with measures of ecological health at a national level by combining elements of ecology and economics. The discussion pays attention to characteristics of GNP and accounting, ecosystem goals and outputs, aggregation, discounting, and so on. The chapter ends by discussing the integration of economic and ecosystem output measures in a single system ‘health’ indicator. Chapter 64 deals with ‘EMERGY analysis’ (note the ‘m’ instead of the ‘n’), developed by H.T. Odum, which is aimed at quantifying the role of the environment in supporting economic activity. This involves a comprehensive method that traces all environmental services back to the ‘captured energy’ of sunlight. The basis of this method is the principle of maximum power, which is regarded as relevant for both ecosystems and economic processes. Differences from conventional energy analysis are briefly indicated (see also Brown and Herendeen, 1996). The chapter ends by outlining applications to various problems.

Following these natural science backgrounds to research in environmental economics, Chapter 65 is devoted to evolutionary perspectives in economics as applied to the context and problems of environmental economics. Attention is devoted to traditional and modern insights of evolutionary biology and how these have influenced evolutionary economics. Other influences are also discussed, notably Schumpeterian theories and thermodynamics. This is followed by an account of modelling of evolutionary systems. Special attention is given to a number of topics, including mechanisms for the selection of economic agents, hierarchical organization, structural economics, and the management of evolutionary natural systems. It seems that there are almost as many evolutionary perspectives in environmental economics as there are authors addressing this issue, which is partly due to the fact that such perspectives are still exceptional. Some relevant publications are Boulding (1978), Clark et al. (1995), Faber and Proops (1990), Gowdy (1994), Munro (1997) and Norgaard (1994).

Next, Chapter 66 discusses alternative ethical stances and their relationship with environmental policy. It is argued that clarifying the role of ethics in the preparation of, and the choices made in, environmental policy can sharpen the debate on issues which increasingly involve complexity, uncertainty, conflict and irreversibility. For this purpose, a number of steps are taken. The discussion opens with the link between normative collective
decisions and ethics. Next, a number of deficiencies of standard environmental economics practice, according to various authors, are briefly mentioned. The main body of the chapter is devoted to a review of the ethical bases for environmental concern. These are classified into humanism, ethical extensionism, and strong non-anthropocentrism. Attention is also given to environmental values of the public (or lay people). A final section examines the relationship between consequentialism, deontology and the use of evaluation frameworks and methods in environmental economics. Introductions to ethical issues are provided by Maclean and Brown (1983), Devall and Sessions (1984) and Pierce and Vanderveer (1995). The latter offers a very rich collection of views from economists, natural scientists and philosophers.

Many of the foregoing issues in this part of the handbook receive more explicit attention in ecological economics than they do in conventional environmental economics. Chapter 67 goes into more detail about what the essential differences are between these two areas. It examines whether ecological economics offers an alternative and competing paradigm to that represented by conventional environmental economics. It is argued that the mild acceptance of ecological-economics-oriented research in various mainstream journals implies that ecological economics is a fruitful field of interdisciplinary cooperation rather than an alternative paradigm. Some focal points and core concepts of ecological economics are briefly examined, covering sustainability, technical change, optimal scale, thresholds, resilience, valuation, ethics and sociology. An earlier attempt to indicate differences between ecological economics and standard environmental economics is Turner et al. (1997).

Introductions to ecological economics are provided by Costanza et al. (1997a,b). Collections of articles from ecological economics conferences offer a good impression of the variety of views and approaches in this field: Costanza (1991), Costanza et al. (1996), Jansson et al. (1994), and van den Bergh and van der Straaten (1994, 1997). Ecological economics critiques, based on considerations of an institutional, ecological or physical nature, have been largely neglected by mainstream environmental economists. Several publications have offered criticism and alternative views on how environmental economics should proceed, for instance: Boulding (1978), Costanza (1991), Daly (1991a), Daly and Cobb (1989), Ekins and Max-Neef (1992), Faber and Proops (1990), Georgescu-Roegen (1971), Norgaard (1994), and Sagoff (1988). A pluralistic introduction to economics oriented towards non-economists interested in environmental issues is offered by Gowdy and O'Hara (1996). Many of these authors argue that standard environmental economics focuses too strongly on static equilibrium processes and isolated rational individuals, and should take more
account of physical, historical and cultural processes in economics, extreme uncertainty and surprises, social contexts and other models of behaviour, and institutions in a broader sense than merely markets and policy instruments.

I have explicitly chosen to mention a relatively large number of references here, so as to provide an easy entry into ecological economics, particularly for economists and other social scientists. Some readers may wonder why I spend so much time on this in a survey of environmental economics. In my view, the divide that presently exists between ecological and 'standard' (or 'mainstream', 'orthodox', 'neoclassical') E&RE is undesirable, and the two areas should communicate and reinforce each other in the long run. This may require more open-mindedness from neoclassical economists, especially those who think that a single method of scientific research is sufficient to understand our complex reality and to suggest solutions to pressing problems. To me it is evident that science and pluralism go hand in hand, which is perfectly consistent with individuals specializing in one specific method of research. Some regard scientific pluralism as essential for the survival of science and the planet in the long run, regarding both of these as subject to evolutionary processes that require a minimal amount of internal diversity, as has been most clearly expressed by Richard Norgaard (1985, 1989, 1994). Any scientific approach misses out on some aspects of reality and is partial in some sense, and from a multidisciplinary perspective the same is true for any monodisciplinary research approach. Environmental economics certainly seems one of those areas inside economics where a mind open to multidisciplinary aspects and problems is essential in order to come up with relevant and socially acceptable suggestions for solutions. 'Multidisciplinary' refers not only to natural science, but certainly also to social science in a broad sense, including history, sociology, political science, institutional economics and evolutionary thought.

On the other hand, many 'ecological economists' (ecologists, economists and others) may realize that 'neoclassical' economics is the only approach that has been able to come up with an impressive and coherent structure of rigorous, clearly founded and subtle insights, in particular related to environmental policy analysis and economic valuation of environmental change. Given the long tradition and large body of work in 'mainstream' E&RE, the approach associated with this dominates in the present book. Summarising this intermezzo, the collection of authors and contributions in this book is aimed to offer a greater diversity of perspectives on E&RE than is usual in most other surveys.
This part of the book presents a range of methods that are frequently applied in E&RE research, and in fact have been mentioned, or underlie most insights discussed, elsewhere in the book. The chapters here cover general features of the methods, specific issues relevant to their application to E&RE, and a survey of such applications. The main method used in environmental economics is (partial or general) equilibrium analysis. A specific treatment of this is not included here, as it is well covered in standard economic and environmental economics textbooks (notably in Baumol and Oates, 1988). Elements of it appear in various places in the book, notably in the opening chapter of Part III and in Chapter 69.

Chapter 68 presents a survey of the use of input–output (I–O) analysis in environmental economics. It includes an introduction to standard I–O analysis, various extensions in environmental economics applications, materials balance and physical models, dynamic models, and social accounting matrices extended with economy–environmental flows. This chapter concludes by proposing a ‘structural economics’ on the basis of I–O analysis and the previous extensions, focused on issues, scenarios and a minimum of assumptions. Chapter 69 surveys the use of applied or computable general equilibrium (CGE) models to answer questions in environmental economics. This chapter covers methodological principles and the standard elements related to producer and consumer behaviour, foreign trade, multiregional models, dynamics, and closure rules. In addition, specific environment-related elements are discussed, such as abatement technologies, environmental policy instruments, and measures of welfare change. Lastly, a survey is presented of important applications of CGE models to environmental policy questions.

The following two chapters shift attention to more theoretical methods. Chapter 70 is devoted to game theory in environmental policy analysis. It opens with a short introduction to core concepts and approaches in modern game theory. Next, it examines three areas of application in environmental economics, namely international environmental problems, interaction between a regulator and regulated agents, and strategic competition between governments or between economic agents. Chapter 71 considers optimal control techniques, which are used to solve environmental economic problems formulated as continuous dynamic optimization models. After a discussion of a basic resource–environment model and aspects of the technique as applied in economics, specific models are surveyed.

In the next two chapters, broader categories of models are discussed. Chapter 72 addresses alternative concepts and models of sustainable development. It distinguishes between discounted utilitarianism, inter-
generational equity, weak and strong sustainability, stationary state and optimal scale, and ecological stability and resilience. Subsequently, four ways of modelling sustainable development are given more detailed attention, as follows: economic growth theory; sectorally disaggregate models; disequilibrium, evolutionary and integrated models; and empirical studies. Books by Faucheux et al. (1996), van den Bergh (1996), and van den Bergh and Hofkes (1998) provide a range of economic modelling perspectives on sustainable development. Chapter 73 surveys models that consider the relationship between economic structure, energy and the environment. This contains discussions of energy resource modelling based on economic and physical inputs, and output-oriented models including integrated assessment models (see Rotmans and de Vries, 1997). Furthermore, a number of issues are examined, such as aggregation, top–down versus bottom–up structure, neo-Keynesian versus CGE models, and time dimensions.

The subsequent two chapters introduce decomposition methods for analysing changes in economic structure as related to energy, material and environmental indicators. These have been mostly applied to energy demand analysis, but may be applied to a range of issues in environmental economics, using environmental indicators, so that it seems useful that environmental economists take note of these methods. Chapter 74 addresses methods related to the solutions to index number problems in economics. It starts with a basic form model founded on aggregate energy intensity, discusses different index methods, and reviews past applications. Next, methods for energy consumption level and energy elasticity approaches are considered. Subsequently, alternative formulations of these models are presented. This is followed by a discussion and survey of the decomposition of environment-related indicators. The chapter concludes by discussing a number of application issues, such as method selection, residual treatment, data, period-wise versus time-series analysis, and sector disaggregation. The presentation is supported by showing what information each method generates based on a single numerical example for 2 sectors and 2 years. Chapter 75 explains decomposition analysis of economic change by way of comparative static changes in input–output tables. After a discussion of basic elements and extended decomposition analysis comes a survey of theoretical underpinnings and applications.

Next, Chapter 76 is devoted to the use of experimental methods in environmental economics. Some historical notes, interpretations of 'experiment' and discussion of methods are followed by two main categories of applications in environmental economics: institutional experiments aimed at examining the impact of environmental control on the allocation of scarce resources, via market and other mechanisms; and valuation experiments aimed at discovering private preferences for market or non-market
goods by controlling behaviour. Finally, Chapter 77 considers a method specifically developed for environmental policy and management, namely natural resource accounting. It discusses resource and pollution accounting, different systems of national accounts, stock accounting, and a range of accounting approaches to valuation. In the latter context, the net-price method, the user-cost approach, renewable resources and shadow pricing receive detailed attention. Finally, some attention is given to mixed systems of measurement such as NAMEA – ‘national accounting matrix including environmental and economic accounts’ (see also the chapter on I-O analysis – Chapter 75).

Part X  Prospects (Chapters 78 and 79)
The final part of the book contains two short chapters that look towards the future of E&RE along monodisciplinary and multidisciplinary dimensions, respectively. Chapter 78 considers recent developments in economic theory that may be relevant to environmental economics research. This chapter opens with a broad policy context, concluding that the general framework of environmental economics has changed from one characterized by partial externalities studies to one which regards environmental issues as a particular dimension of human development. A number of major research areas are indicated, namely sustainable development (or environment and development), transboundary and transnational environmental issues and policy, uncertainty and the role of information, environmental management, and urban issues. This chapter also presents a very interesting and informative evaluation of trends in the environmental economics literature, based on a survey of over 1400 papers from two main journals (Environmental and Resource Economics and the Journal of Environmental Economics and Management (JEEM)) and annual European conferences, between 1990 and 1997 (a similar survey was done for JEEM by Deacon et al., 1998).

Chapter 79 presents a broad perspective on the integration of views from economics, ecology and the social sciences. It describes the prospects of communication between environmental economics and other disciplines. This will involve a preparedness to shift from a multidisciplinary to a transdisciplinary approach. Subsequently, it is discussed how to address the biophysical foundations of, and natural constraints to, economic activities, based on physics and ecology. More detailed discussions are provided of thermodynamics, resilience and evolutionary modelling. Finally, environmental philosophy is considered, where a distinction is made between ethical and epistemological issues. In both multidisciplinary and economic directions much further work remains to be done, and readers may find some useful ideas in these final chapters.
3. An overview of multiple treatments of particular topics

The handbook contains various sets of chapters that offer multiple views on specific topics. These are either complementary or opposing. This section is intended to offer a systematic account of them.

Several views on criteria for choosing environmental policy instruments are put forward in Part III, notably in Chapters 15 and 21. Contributions offering complementary views to the standard externality-based theory of optimal environmental policy relate to risk (Chapter 14), to transaction costs (Chapter 17), to distribution issues (Chapters 24 and 25), to steady state and optimal scale (Chapter 44), to sustainability (Chapter 48), to ethics (Chapter 66), to incommensurability (Chapter 58), to evolution (Chapters 65 and 79), and to various issues considered in ecological economics (Chapter 67).

On the topic of distribution and equity there are two main chapters (24 and 25). In addition, Chapters 13, 15, 20, 21, 22, 23, 66 and 67 devote brief attention to issues related to equity and fairness. Together, these various chapters provide a complete and diverse survey of distribution issues in environmental policy.

A number of chapters in Part IV (26–30) address the relation between trade and environment, adopting various theoretical and empirical perspectives, as well as considering the context of developing countries. In addition to these, Chapter 6 considers natural resources from an international trade perspective, and Chapter 39 surveys models of international relocation or 'capital flight'.

Global environmental issues are explicitly discussed in Chapters 24, 32, 33, 34, 41, 62 and 73. Biodiversity is discussed from an economic perspective in Chapter 33, and from an ecological perspective in Chapter 61. Chapter 79 also contains a short discussion on biodiversity.

Spatial issues are mainly discussed in Part V. However, land use and non-point source pollution issues not only receive attention in Chapters 36 and 37, but also in Chapters 10 and 11 on water resources and agriculture.

Environmental sustainability and sustainable development are the subject of a number of chapters, namely Chapter 8 on fisheries, Chapter 33 on global environmental issues, Chapter 38 on urban sustainability, Chapter 48 on the biophysical foundation of sustainability, Chapter 49 on indicators, Chapter 60 on global nutrient cycles, and Chapter 72 on perspectives and models. The link between sustainability, discount rates and future generations is discussed in Chapter 25. Discounting is also discussed in Chapters 57, 63 and 72.

Multiple chapters in Part VI discuss economic growth and environment (Chapters 41–47). A survey of neoclassical exogenous growth models has not been separately included, but is treated briefly in Chapters 3, 41 and 72.
Endogenous growth is dealt with in Chapter 42. Evolutionary perspectives and long-run modelling in environmental economics are discussed in Chapters 65, 72 and 79.

Several chapters, spread throughout the book, address energy-related issues: see Chapters 12, 59, 62, 63, 64, 73, 74 and 75. Chapters 74 and 75 survey decomposition methods, applications of which have been mostly related to industrial energy demand. Similarly, various chapters address the physical–material dimension of the economy, notably Chapters 59 and 60 and, on a more abstract level, Chapters 3–7.

Indicators of various types are discussed in Chapters 7, 46, 48, 49, 58, 63, 64 and 77. Valuation approaches are discussed in a number of chapters in Part VII (51–55), and from an accounting perspective in Chapter 77. Meta-analysis in relation to valuation is discussed from a broad perspective in Chapter 55, and in relation to hedonic pricing models in Chapter 53. Evaluation methods are discussed from the perspective of methods in Chapter 57 (cost–benefit analysis) and 58 (multi-criteria analysis), and from an ethical perspective in Chapters 24, 56 and 57. Ethical issues are extensively discussed in Chapters 56 and 66, and briefly in Chapters 15, 21, 24, 67 and 79.

4. Missing topics and recommended reading

It is fair to say that even if the book gives an impression of completeness at first sight, there are a few topics that have not been included, as no suitable authors could be found, or the respective authors dropped out at a late stage of the project, or the subject was simply forgotten. The most important area omitted is perhaps environmental management or ‘business and the environment’ (see Chapter 78). This covers topics such as environmental care systems, environmental strategies, internal organization, environmental accountancy, environmental reporting, environmental cost accounting and green marketing. Most textbooks do not integrate environmental economics and environmental management. The reason is perhaps that the group of readers interested in ‘general’ environmental economics seems quite disconnected from those interested in environmental business management. Evidently, this handbook has been limited to cover only the first area. Adequate treatment of the second area would very likely need a separate volume in itself. Fischer and Schot (1993), Welford and Starkey (1996) and Folmer et al. (1995, part 3) have presented various interpretations of the contents of environmental management.

Other topics have been omitted. I will mention some of them, and make a few reading suggestions. First, institutions and property rights are not discussed in a separate chapter here (see Bromley, 1991 and 1997). Green GDP has not received much attention either (see Chapter 49), although a
related topic on natural resource accounting is discussed in Chapter 77 (see Aronsson et al., 1997; Daly and Cobb, 1989; and Hueting et al. 1992). The question whether discounting is (ethically) indefensible, or whether discount rates should be adapted for projects or investments with (irreversible) environmental consequences, is not discussed in a separate chapter, although short discussions on discounting have been included in various chapters (see the previous section). A classic text is Lind (1982), a concise account of the main issues Markandya and Pearce (1988), and a recent discussion Azar and Sterner (1996). Regrettably, population and environment were not given separate attention. Informative short introductions are provided by Perman et al. (1999, ch. 11), Tietenberg (1994, ch. 5), and Dasgupta (1995). The relation between development, poverty and population issues is surveyed in Demeny and McNicoll (1998), and a very thorough account of population issues is Cohen (1995). Although climate issues are dealt with in several places in this book (see the previous section), more could have been said about the subject. A collection of 'classic articles' is contained in Tietenberg (1997). Joint implementation is a related topic that is also missing; it has recently received much attention, notably in the context of the Kyoto negotiations to reduce greenhouse gas emissions (see Kuik et al., 1994; Jepma, 1995; see also the newsletter Joint Implementation Quarterly). More information on the neoclassical exogenous growth theory with natural resources and environment, mainly developed in the 1970s, can be found in Dasgupta and Heal (1979), Beltratti (1996), Chichilnisky et al. (1997) and Toman et al. (1995). In the context of valuation some topics are missing here, notably related to uncertainty, ecosystems and biodiversity. Excellent discussions and surveys of valuation under uncertainty, option value and quasi-option value can be found in Freeman (1993) and Bromley (1995). The valuation of ecosystem changes is discussed in Barbier et al. (1994) and Gren et al. (1994). Biodiversity can be approached from the perspectives of economic valuation, systems stability or sustainability (see Perrings et al., 1995a and b). For broader and critical views by natural and social scientists, see Gowdy (1997) and various papers in Wilson (1988). I hope the most important omitted topics are covered in this short list.

Notes
1. Many introductory and advanced textbooks have recently appeared or been revised, for instance: Bowers (1997); Callan and Thomas (1996); Common (1996); Costanza et al. (1997b); Dodds et al. (1997); Field (1996); Folmer et al. (1995); Goodstein (1995); Hanley et al. (1997); Hartwick and Olewiler (1998); Kahn (1998); Lesser et al. (1997); Perman et al. (1996); Siebert (1995); Tietenberg (1996); and Turner et al. (1994).
2. A survey chapter on this young field was originally planned.
References
An overview


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