THE EVOLUTION OF ACIDIFICATION IMPACT FRAMES IN EUROPE: ASSESSMENT OF FOREST CONDITIONS

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CITATION, CONTEXT, AND REPRODUCTION

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The Global Environmental Assessment (GEA) project is a collaborative team study of global environmental assessment as a link between science and policy. The Team is based at Harvard University. The project has two principal objectives. The first is to develop a more realistic and synoptic model of the actual relationships among science, assessment, and management in social responses to global change, and to use that model to understand, critique, and improve current practice of assessment as a bridge between science and policy making. The second is to elucidate a strategy of adaptive assessment and policy for global environmental problems, along with the methods and institutions to implement such a strategy in the real world.

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Publication abstracts of the GEA Project can be found on the GEA Web Page at http://environment.harvard.edu/gea. Further information on the Global Environmental Assessment project can be obtained from the Project Associate Director, Nancy Dickson, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, 79 JFK Street, Cambridge, MA 02138, telephone (617) 496-9469, telefax (617) 495-8963, Email nancy_dickson@harvard.edu.

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FOREWORD

This paper was written as part of the Global Environmental Assessment Project, a collaborative, interdisciplinary effort to explore how assessment activities can better link scientific understanding with effective action on issues arising in the context of global environmental change. The Project seeks to understand the special problems, challenges and opportunities that arise in efforts to develop common scientific assessments that are relevant and credible across multiple national circumstances and political cultures. It takes a long-term perspective focused on the interactions of science, assessment and management over periods of a decade or more, rather than concentrating on specific studies or negotiating sessions. Global environmental change is viewed broadly to include not only climate and other atmospheric issues, but also transboundary movements of organisms and chemical toxins.

The Project seeks to achieve progress towards three goals: deepening the critical understanding of the relationships among research, assessment and management in the global environmental arena; enhancing the communication among scholars and practitioners of global environmental assessments; and illuminating the contemporary choices facing the designers of global environmental assessments. It pursues these goals through a three-pronged strategy of competitively awarded fellowships that bring advanced doctoral and post-doctoral students to Harvard; an interdisciplinary training and research program involving faculty and fellows; and annual meetings bringing together scholars and practitioners of assessment.

The core of the Project is its Research Fellows. Fellows spend the year working with one another and project faculty as a Research Group exploring histories, processes and effects of global environmental assessment. Academic year 1997-8 focused specifically on the past three decades of climate change, long-range transport and tropospheric air pollution assessment experience with special attention to Europe and North America. These papers look across a range of particular assessments to examine variation and changes in what has been assessed, explore assessment as a part of a broader pattern of communication, and focus on the dynamics of assessment. The contributions these papers provide has been fundamental to the development of the GEA venture. I look forward to seeing revised versions published in appropriate journals.

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ABSTRACT

This paper investigates the processes of producing information about impacts for both national and regional decision-makers. Relatively little research from a historical perspective explores the complex interactions between politics, scientific methods and infrastructure, and assessment activities that shape this information. The forest impacts of acidification in Europe are among the most researched and assessed impacts under the Long Range Transport of Air Pollution Convention. Between the late 1970s and 1998, the regional and national assessment processes under the Convention have played a key role in assembling forest impacts from a growing mass of scientific and technical data.

This paper further develops the concept of "frames" as a research indicator to understand the evolution of forest impact assessment over time. Frames are social cognitive lens through which scientists, assessors, policy-makers, and lay people interpret environmental phenomena. They can become embodied in scientific research programs and assessment practices, and be communicated via assessment processes to scientists, assessors, policy-makers, and lay people. In the assessment and research of forest impacts, three broad impact frames can be glimpsed: forest decline, forest die-back, and forest health. This paper focuses on the regional assessment of forest impact frames by the Economic Council for Europe under the LRTAP Convention and in Finland, Germany, and the United Kingdom as specific comparative country studies.

Key conclusions include: interpretations of the causes and effects of forest damage in Western Europe have been influenced greatly by regional assessment processes that promote greater standardization and transnational analysis. The specific measures of forest damage, together with the research programs required to elucidate causal relationships, have been increasingly standardized across the member countries of the LRTAP regime. This is an attempt to establish and verify the forest damage problem as an "European" issue, not simply a national issue. The processes of building and reconstructing frames is closely intertwined with setting up a wide-ranging and complicated survey and research program that is carried out in many individual countries. Significantly, initial conditions (such as the adventitious use of surveys in Germany) can affect the broader structure and process of research and policy-making. Impact frames, however, do not remain static: they can undergo reconstruction over time through being influenced by new entrant actors, the emergence of new scientific data, or domestic politics, for example. Moreover, despite the shift towards standardization, scientists and policy-makers in each member country often interpret the specific character of forest impacts differently from other countries. This "local" knowledge can mean that specific countries may apply regional standards variably in their practices. It also can support their efforts to promote their interpretations of forest impacts within the regional assessment processes of the ECE.

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ACRONYM LIST

APS	Air Pollution Series
BFH	German Federal Research Center or Forestry and Forest Products
BML	German Federal Ministry for Nutrition, Agriculture and Forestry
EC	European Commission
ECE	Economic Commission for Europe
EU	European Union
HAPRO	Finnish Acidification Programme
ICP	International Cooperative Programme
IIASA	International Institute for Applied Systems Analysis
ITE	British Institute of Terrestrial Ecology
LRTAP	Long Range Transport of Air Pollution
Metla	Finnish Forestry Institute
NGO	Non-governmental organization
OECD	Organization for Economic Cooperation and Development
SWAP	Surface Waters Acidification Programme
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environmental Programme
WG	Working Group
VYH	Finnish Environmental Institute

INTRODUCTION

Acidification was one of the first transboundary environmental problems to emerge in Europe and North America. It is thought to cause, or contribute to, diverse impacts across Europe. These impacts include increased soil acidification, loss of forest foliage, changes in aquatic ecosystems, and corrosion of historic monuments (Dobris Report, 1995). In the late 1970s and early 1980s, when acidification was beginning to be recognized by scientists, policy-makers and the broader public as a major problem, it was difficult to detect the patterns of damage across Europe. There was a complicated mosaic of variable and widely spread effects (cf. Irwin, 1992). Little integrated knowledge about acidification impacts existed and theories regarding the cause-effect relationships were in flux.

When *Waldsterben* was first publicized in Germany in 1981, there were widespread public and scientific concerns that forest and aquatic ecosystems across Europe could be irreversibly degraded by acidification. In 1984, Postel stated: "In just a few years, forest damage has spread with frightening rapidity through portions of central Europe. Trees covering between 3.5 and 4 million hectares now show signs of injury linked to air pollutants" (Postel, 1984, at 7). More is now known in 1998 about the impacts of acidification. A causal framework has been built by European scientists and policy-makers, featuring multiple causal agents and pathways. For example, there is strong consensus that air pollution (much broader than acidification per se) plays a key, if uncertain, role in forest condition. The precise nature and manifestation of that role has, however, been contested vigorously at both regional and national levels. Despite significant reductions in sulphur emissions since the 1980s, only 35 percent of forests in Europe are reported to be "healthy" as of 1998 (ENDS).

Between the late 1970s and 1998, extensive scientific work has gone into assembling cause-effect relationships from a growing mass of scientific and technical data. The work has been carried out at both regional and national levels in a multi-lateral assessment[1] and policy-making system established under the Long Range Transport of Air Pollution (LRTAP) Convention. In this work, there have been many debates among European scientists and assessors over the broad causes and effects of forest damage, the specific effects which need to be addressed in policy-making, the role of climatic and soil conditions, and the standards to be applied in judging scientific research. These debates have occurred within particular countries, and in regional fora, often reflecting political differences in the views and interests prevailing (or contested) in these countries and fora. The frames (or social cognitive prisms) of acidification impacts held by scientists, assessors,[2] policy-makers, and lay people are an important indicator of the knowledge about acidification impacts produced over this period.

This paper focuses on some of the interactions between scientists and assessors at regional and national levels in building up an understanding of forest impacts in Europe. Relatively little scholarship investigates the processes by which environmental information is produced for use by scientists, policy-makers, and lay people. This information is shaped by the frames that influence research, assessment, and policy-making activities. It does not simply exist in report form, but may emerge from a complex, changing, multi-layered assessment process often involving many actors spread out over a large region (as with Europe). The frames held by

different actors at various layers of the assessment process can change how and what information is produced. Thus, this paper asks: what frames of forest damage can be seen in the LRTAP assessment process, and how do their elements change over time? What are some of the dynamics that can be glimpsed in shaping information about forest impacts through the emergence and development of the ECE assessment processes, as seen in terms of frames? How do individual countries (Finland, Germany, and the United Kingdom in this study) differ in the frames prevailing in their scientific research and assessment?

Two key aspects are explored: the ways in which assessments of forest condition by the ECE have increasingly promoted greater standardization and transnational analysis; and the ways in which scientists and assessors in Finland, Germany, and the United Kingdom may interpret ECE standards differently from each other, as well as applying their own versions of forest damage frames. The emphasis is on the character of frames in scientific processes of producing information about forest impacts, not on the policy-making processes of using and interpreting this information. By doing so, it is possible to track to some extent the co-evolution of cause-effect analyses, methods, participation, institutional practices, and politics that can shape how and what information is produced within and between countries.

In section 2, I briefly outline the conceptual frame and the methodology for this paper. Section 3 outlines the broad trends in the frames of acidification impacts over time, while section 4 outlines how and what forest impacts are studied, and explores in detail (1) how ECE forest assessments have increasingly promoted standardization and scientific rigor between 1983 and 1997; and (2) how scientists in Finland, Germany, and the United Kingdom have framed forest impacts in their national research and assessment during this period. Finally, I draw several implications for the assessment of acidification impacts in Europe.

CONCEPTUAL STRUCTURE

Frames are the **social cognitive** lens through which scientists, assessors, and users interpret their world, and decide on the significance, reliability, and weight of different knowledge claims (Miller et al, 1997). Via frames, agents organize information about complex environmental, political, social, and economic phenomena into fields of bundled experiences, perceptions, assumptions, and norms. Frames are cognitive in being based on the knowledge of the assessors, as well as on underlying structures of belief and perception regarding the world (cf. Schon and Rein, 1994). They also are social because they are not simply held by individual agents, but are shared (to greater or lesser degrees) by many actors, often in the context of expert and lay communities. They are embedded in the social practices and discourses of carrying out research, assessment, and policy-making – which is the principal focus of this paper.

For example, framing "forest die-back" as the research problem at hand reflects, and reinforces, the assumption that acid deposition is the culprit in forest damage. [3] This frame suggests that the key research issue is to determine how fast, and where, forest die-back is occurring within a country; and that defoliation, discoloring, and tree death are the important

indicators of forest die-back. Forest surveys, therefore, can quickly and efficiently help reveal trends in forest condition. Government and private foresters, as well as environmental NGOs, can participate in these surveys. Carrying out forest surveys can communicate trends and the existence of the die-back to the public and government decision-makers, both in a particular country and in other countries, who are skeptical about forest impacts. Because sulfur emissions are viewed as the primary cause, and the die-back happens across Europe at unprecedented rates, reductions in emissions are seen to be desirable, rather than adaptive measures, such as liming or changes in forest management. Finally, policies can be judged by the extent and rate to which forest die-back is viewed as being reduced.

Frames differ from scientific theories of change, such as the paradigm shifts proposed by Kuhn (1962), or the evolutionary movement of Mayr (1997), in that they have political, experiential, and normative dimensions. They are not simply accounts of scientific ideas about complex environmental phenomena, but also organize information in terms of how agents experience these phenomena, behave politically, and think normatively. To some extent, they can be compared to the "cultural models" shared between people with regard to interpreting environmental problems (Kempton, Boster, and Hartley, 1995).

- In the **experiential** dimension, frames can emerge from the practical experiences of scientists, assessors, decision-makers, and lay people in dealing with environmental and scientific issues. Thus, for example, early interpretations of environmental degradation can greatly influence how it is categorized in later research and assessment. Later experience can contribute to reconstructing a frame, or to the diminishing influence of a frame vis-a-vis other frames. Experiences and interpretations can vary markedly between countries, localities, and agents. This is a key aspect of the "local knowledge" theme explored later in this paper.

- In the **political** dimension, frames are often associated with important stakes and audiences in political coalition-building, promoting the entry of new agents into the scientific and political arena, disciplinary approaches, domestic research traditions, and policies. Frequently, there are co-existing, multiple frames held by different actors in a specific country, or in a regional forum. The agents may actively work to persuade decision-makers, lay people, and scientists that their frame is an authoritative or credible account of the science, promote particular courses of action (e.g., do nothing except carry out more research), or entrench their frame in scientific research and assessment activities. Which frame dominates in a country or a regional process may matter significantly for the agents' influence over science, politics, and policy.

- In the **normative dimension,** frames can embody assumptions about how (for example) environmental degradation should be viewed and treated by a society. They may claim that the degradation must be evaluated in terms of single causes rather than multiple causes, or that it is only scientists and assessors who are able to produce information about the degradation, or that a country must act authoritatively and urgently to fix the degradation. Normative claims can exist in many overlapping varieties.

Frames may, or may not be, stable over time. The elements of a frame, or a dominant frame, can be reconstructed by actors as a result of changes in experience, assessment processes, participation, scientific data, politics, or norms. The reconstructive aspect is particularly evident in the evolving dynamics of producing scientific information about forest impacts explored in this paper.

In the development of forest impact assessments carried out in the ECE and in Finland, Germany, and the UK, three major impact frames can be discerned: forest die-back, forest decline, and forest health. **Figure 1** summarizes these frames, which were assembled by the author on the basis of a detailed review of the scientific and assessment literature from 1983 to 1997.[4] They highlight broad cause-effect assumptions, together with the research priorities, data and methods, actors and institutions, audiences, and policies that appear to be associated with each specific frame. The elements of each frame do not always all develop or coexist at the same time, but may emerge at different times. That is, there is significant overlapping of frames over time, and frames may be dominant at one time, or in a particular country, before becoming less influential at a later time (as the evidence amply suggests).

Frames in the context of a multi-layer regional system

The literature on frames is steadily growing (e.g., Jasanoff and Wynne, 1998; Jachtenfuchs, 1995; Schon and Rein, 1994). The ways in which the framing of problems for scientific research and assessment can affect the production of knowledge are being explored. Nevertheless, the nature and development of frames within a multi-level, regional scientific research and assessment system, such as that for acidification impacts in Europe under the LRTAP Convention, has not yet been investigated in depth. In such a complex system with many sub-national, national, and regional layers,

- *Frames can originate in specific layers and be diffused to other layers via national and regional assessment processes* (operating as communication processes: GEA, 1997). In this diffusion process, **standardization practices** (e.g., the European Union's efforts to create a transnational forest survey system), **normative views** regarding the regional nature of environmental problems and solutions (e.g., that because forests everywhere in Europe are being affected, there must be Europe-wide policy-making), and **political stakes** in domestic and regional arenas (e.g., promoting a country's interpretation of forest damage to downplay the need for sulfur emission reductions) can act as important forces pushing, or altering, frames. It is therefore crucial to look at the building of assessment practices over time.

- *Agents and institutions in individual countries can nevertheless interpret and apply regional standards and practices differently from other countries*, influenced by their particular frame versions. Each country produces its own scientific and technical information to varying degrees (depending on its resources, political stakes, and research traditions). As well, the politics and entrenchment of existing assessment practices (e.g., forest surveys compared to intensive research sites) in a particular country can be in

tension with "regionally" promoted frames. It is, again, crucial to examine how this "local knowledge" or experience affects the country's participation in regional assessment, and how regional assessment is shaped by the domestic experiences, norms, and politics of specific countries.

The production and nature of information for use by regional and national decision-makers reflects the changing interplay of these factors. Forest impact information can not be separated from the practices, norms, experiences, and politics that help create, and are sustained, by frames. This paper does not explore the interactions between regional and national layers from a causal directional perspective, but is suggestive with regard to the importance of researching these interactions further.

Diffusion of Frames and Standardization Practices.

Frames can emerge in specific sub-national, national, and regional layers within the ECE system, and diffuse via assessment processes to other layers. Regional assessment processes, such as the forest surveys of the ECE, can absorb, combine, and modify frames coming from particular countries as part of their work to standardize methods, data collection, and analysis across the region. Regional assessors may also generate new frame versions from data produced by the regional assessment, and communicate these frames to participating countries via changes in standards and regional aggregation of the data. Powerful normative and political factors can underlie this activity, especially with regard to building up "regional" and "national" layers.

How a "layer" becomes defined is key to framing forest impacts in Europe. As glimpsed in this paper, there is a continuing tension between viewing forest impacts "Europe-wide" and seeing these impacts in terms of the specific conditions of each country. There also is considerable unease over which "Europe" should be used to delimit the "Europe-wide" perspective: the European Union (15 countries), the UN ECE membership (33 countries), or the entire Eurasian continent (including the "Asian" constituents of the Former Soviet Union).[5] As discussed below, forest impact assessment in Europe has been greatly affected by a growing collaboration between the European Union and the ECE in designing and implementing forest surveys from the late 1980s onwards. Originally, there were separate EU and ECE assessment processes, but the processes have become increasingly integrated over time, and the EU may be gradually creating a new arena for forest impact framing to occur in. Thus, the politics of defining forest impacts *relevant* to "European," "European Union," "ECE," and "national" stakes and decision-making are deeply embedded in the development of forest impact frames in Europe.

An important feature of frames is that they do not simply exist as ideas held by scientists and policy-makers, but become *embodied in the practices* of scientists and policy-makers as part of building up assessment processes and institutions. These practices include research programs, publications, procedures for participating in institutions, methods, making policies, and decision-making processes. This paper concentrates on the ways in which frames have been diffused, and changed, across Europe over time via **standardization and comparison practices** with regard to methods and data collection. While there is much contingency in how forest impacts are framed, the story is also that of a massive standardization effort.

The emergence of a regional assessment process involving many countries, each with their research priorities, capabilities, and methods, requires an infrastructure that allows the transport of knowledge between these countries (Jasanoff and Wynne, 1998). Especially in a system that relies on aggregating national data, the activities occurring in every country must be coordinated according to common methodologies and measurements, or the results will not be comparable between the countries.[6] At the same time, framing forest impacts as "regional" requires that the impacts in each country should be translated into patterns across the region, which needs a standardized process to link together impacts (Waterton and Wynne, 1996).

Promoting standardization across a regional assessment process often depends on the capacity of regional assessors to persuade each other, and their counterparts in national assessment activities, that standards will make the output more scientifically rigorous and comparable (Latour, 1988). It also depends on evaluating and "policing" national activities for their compliance with standards (Law, 1986). Building increasingly elaborate and authoritative regional institutions, downplaying the importance of local differences, bringing together heterogeneous data sets, quantifying information (Porter, 1995), and expanding the participation of scientists and assessors from many countries can diffuse standards.[7] In short, standardization can affect what, where, and how assessments are done – and shape information for policy-making.

But standardization can conceal significant power issues. In propagating standards regionally, some countries, institutions, and assessors may have much greater influence than others. They may have been among the earliest national assessors, and their methods may become regional standards. Different countries can differ greatly in their influence over how, what, where, and when frames are generated. For example, Germany dominated the early production of forest impact frames because it supplied most of the data and methods used by the regional assessment process. Standardization also can affect who is recognized as a legitimate participant in assessment processes, or as a source of reliable and useful knowledge. If standards require high levels of technical knowledge and adherence to professional scientific norms, then agents (e.g. foresters) who have detailed local knowledge of impacts may not be accepted as sources of information.

Consequently, within a multi-layered regional system, it is important to appreciate how frames can be generated and communicated between layers, as part of a continuing effort to build a "regional" forest problem, not simply a problem of individual countries. It also is key to see how exercises in comparing data and methods across the region can become intertwined with normative and political stakes.

Local Knowledge and Interpretation of Regional Standards

Scientists, policy-makers, and lay people in individual countries may view forest impacts differently from other countries. They may do so despite the efforts of regional assessors to standardize scientific research and assessment across the region. The impact frames generated and communicated via the ECE regional process do not necessarily shape the impact frames found in specific countries. Individual countries may have dominant frames (or mixes of

frames) that differ from those in other countries, and in the ECE process. This may emerge from the contingently evolving interplay between experiential, normative, and political factors in a country. Moreover, several frames may coexist within a particular country, especially where there is a large and diverse scientific community with several research traditions. The role of contingent "local" knowledge in researching and assessing forest impacts is highlighted by the work of Hajer (1995) comparing acidification science and policy in the UK and the Netherlands; and by the study of acid deposition research in the United States by Zehr (1994).

In each country, and often across its territory, agents and institutions may interpret forest impacts differently because of their prior and initial experiences with regard to forest damage. For example, if a country has little evidence of dramatic forest damage, and has a very high level of forest cover, scientists, policy-makers, and lay people may be less inclined to perceive the damage as significant. Likewise, within a country, foresters who have extensive experience with forest management (and therefore have built up a history of forest dynamics) may have very different views from lay people who live in urban areas and who rely on mass media for information about forest damage. The value and nature of normative assumptions can vary greatly between countries. For example, Finland, Germany, and the United Kingdom value the precautionary principle differently; they also give varying priority to immediate and long-term forest impacts. Scientists and policy-makers may have political stakes in promoting their own frame versions vis-a-vis those of the regional process, or of other countries. Specific political coalitions, or new actors, may be brought into domestic debates over forest impacts in a particular country, but not elsewhere.

Within a particular country, there may be ongoing, or momentarily flaring, debates among scientists, policy-makers, and lay people over how forest impacts should be interpreted. Frames can have different levels of specificity, and can be held by many agents who do not share key beliefs or assumptions, even though they may accept a broad definition of the problem.[8] For example, while most scientists and assessors in Germany agree on the endangerment of forests, they also hold widely differing specific views relating to effects, pathways, and policy needs. Information regarding the effects of acid rain in Europe is largely produced by scientists and assessors funded by, or working for, governments, the European Union, and the ECE. Thus, policy-makers and scientists can have strong political stakes in promoting within domestic debates, or diffusing to other countries and the regional layer, specific frames.

Sometimes, though, non-state agents with power and resources, such as media, environmental NGOs, and forestry industry associations, can shape frames underlying research and assessment activities. They can challenge parts of a frame within a particular country, as seen in Germany's sporadically revived debate over forest condition. Alternatively, they may develop and advance their own impact frames, especially in the early development of knowledge when cause-effect relationships and potential policy responses are still uncertain.

Scientists and assessors in a specific country often may interpret regional standards in terms of their own conditions, priorities, and research. The information collected in a country may differ from other countries in definitions, purposes, institutional needs, scale of investigation, and degree of completeness (Waterton and Wynne, 1996). Different criteria of reliability, validation, and relevance may be used. As a result, applying standards to particular contexts requires the use of local skills and interpretation. Scientists and assessors also may question the

credibility and reliability of regional frames for their national context by adding their own data and methodological requirements to the standardized format.

These developments have significant implications for the nature and extent of a shared or consensual knowledge regarding acidification impacts. Instead of universally applicable knowledge, different countries have varying knowledge arising from both their local experiences, norms, and politics; and from how their institutions, practices, and cultures encounter the regional level.

Note on Methodology

It is possible to track the emergence and development of frames in the ECE regional assessment process via the Air Pollution Series reports, published annually by the United Nations, and the documents produced for the semi-annual meetings of the Working Group on Effects. Similarly, these frames can be discerned in the major forest assessments carried out by each country investigated. Finland, Germany, and the United Kingdom were chosen as specific case studies because they all have engaged in extensive forest assessment over time, are among the most active and well-resourced countries in the LRTAP regime, and have significant differences in their research histories, forest coverage and industry, and assessment practices. Finland and the United Kingdom have a comparatively small set of forest assessments because they either had an one-off comprehensive assessment (Finland), or an assessment irregularly occurring every five or six years (Britain). Germany publishes an annual forest assessment, the *Waldschadenberichte* [forest damage report].

Forest surveys carried out by specific countries are usually reported as part of the ECE reports, so these reports constitute a rich body of information about national trends, research priorities, and methods. Phrases such as "forest die-back," "forest decline," and "forest health" are used in the ECE and national assessments, much more frequently at specific times than at others. By studying the range of research priorities, data and methods, cause-effect relationships, institutions, and audiences associated with these phrases in the reports, it is possible to infer the nature of the frames. To date, the frames have been viewed as plausible accounts by several key scientists in the ECE assessment process.[9] In this research, I have used a combination of review articles, scientific publications, ECE/EU documents, and a number of interviews.

This paper does not directly investigate the ethnography of frames as held by particular scientists and assessors, but infers their nature from collective assessment discourses and practices. Frames can be *indicators* of the debates over how fragmented, disparate, and complicated pieces of evidence should be interpreted to create an explanatory framework. Thus, they can illuminate some of the dynamics in the evolving scientific processes for producing forest impact information in the LRTAP regime. Nonetheless, frames should not be reified as discrete entities, and are seen through the understandings, practices, memories, and discourses of the various agents and institutional networks involved.

OVERVIEW OF THE DEVELOPMENT OF ACIDIFICATION IMPACT FRAMES AND THE ECE

ASSESSMENT PROCESS

In this section, I briefly describe the early history of acidification impact frames, and then outline several trends in the impacts that the ECE assessment process has focused on since the early 1980s.[10] These trends provide a broader context for the discussion of forest impact assessments in section 4. As well, I summarize several key developments in the ECE assessment process. An important caveat is that this history is largely West European and Scandinavian in character because Southern, Central, and Eastern European countries were (and are) mostly not leaders in scientific research and assessment regarding acidification (VandeVeer, 1998).

Early acidification impact frames

Initially, the effects of acidification were viewed as largely undifferentiated. The process of differentiating between impacts, and defining their cause-effect relationships, is a history of many debates among European scientists and assessors over how to interpret the complex, fragmented, variable mosaic of scientific evidence. It is a history (not told here) of how many actors collectively pieced together the disparate impacts and interpreted them as stemming from acidification and sulfur emissions. In particular, while forest impacts were among the earliest significant impacts to be perceived, their character was not investigated and debated extensively outside Scandinavia until the early 1980s. Apparently isolated instances of forest damage, such as those in the Black Forest in Germany in the early 1970s, were not linked together as "acidification" effects – but were interpreted in the light of Bavarian experiences with forest management dating from the 1920s. Yet, as discussed below, forest impacts became central to the ECE assessment and policy-making during the 1980s.

During the late 1960s, researchers in Sweden discovered that some freshwater lakes were depleted of fishes and crustaceans. Because the lakes were highly acidic, they hypothesized that acid precipitation was responsible for the ecological damage (Bolin et al, 1972; Brosset, 1973; Brousset, 1976). They also feared that tree growth may be compromised by soil acidity, as well as by ambient exposure, though there was little evidence to date. The Swedish forest industry was thought to have 10 to 15 percent less raw material available by 2000 (Bolin et al, 1972).

Expanded from a Scandinavian research venture, the OECD Long Range Transport of Air Pollution Programme took place between 1973 and 1976. Finland, Germany, and the UK were all participants. This program established that there was transboundary movement of sulfur emissions occurring across Europe, but did not investigate the effects of acidification extensively, which were left to individual countries to explore in their domestic research activities (Ottar, 1976). Importantly, the OECD program helped create the beginnings of an Europe-wide emission and deposition monitoring system. The existence and coverage of monitoring systems and research programs are crucial factors in whether a specific country detects acidification impacts in their full range. The OECD program also began the reframing of acidification as a regional, rather than merely local, problem. Effects could be experienced in remote places, rather than near emission sources.

Research and assessment of acidification impacts in the late 1970s focused on the effects of ambient concentrations of sulfur emissions on aquatic and terrestrial ecosystems. These two impact areas were the focus of the first major international conference on acidification impacts, held in Norway in June 1976 (Report, 1976). This early focus has dominated acidification impacts, which are fundamentally divided into aquatic and terrestrial domains, with their own sub-domains. Decreases in freshwater pH were associated with changes in biological and nutrient cycles, elimination of fish species or populations, and shifts in water plant composition (Schofield, 1976). By contrast, researchers understood little about forest ecosystems, although field and laboratory experiments had suggested that acid precipitation could lead to mineral leaching in soil, decreased soil microbial activity, and leaching of nutrients from leaves (Knabe, 1976). Scientists concluded that no unambiguous effect on tree growth had yet been proven.[11] Nevertheless, extensive research into soil chemistry and ecology, if not tree morphology, was already occurring at this time.

Some researchers looked at the human health effects of sulfur exposure, a legacy of the local air pollution problems in Europe, especially Britain, during the 1960s. There were extensive epidemiological studies of the link between health and high atmospheric SO_2 concentrations, but it was, and has been, difficult to establish the specific details of human health effects (Magee, 1977). Also, human health does not fit readily into either of the dominant aquatic and terrestrial domains. British, Norwegian, and Swedish scientists undertook a range of exposure experiments investigating the effects of O_3, SO_2, and NO_x on agricultural crops, which were considered as part of a broad category of "vegetation" until the early 1980s. The corrosion of materials and historic monuments attracted far more attention, with several long-running international research programs being established and later enrolled in the ECE institutional network.

Significantly, British scientists played an important role in the early research and assessment of acidification impacts, looking at multiple air pollutants while most research concentrated on sulfur emissions. This was prior to the identifying of British coal and electricity generation as a major culprit. Finnish scientists appear to have played a limited role, with major Finnish acidification research not beginning until 1985. At this time, Germany officially did not take the view that it suffered from acidification impacts, though some researchers (such as Ulrich) were investigating soil chemistry in the Solling forest, and had reported by 1979 that forest conditions were being impaired by soil acidification (Ulrich, 1990).

Around 1980, the basic reactants and chemical reactions underlying acid deposition were understood relatively well (Jacob, 1997). It was at this time that researchers began to shift to the effects of deposition, rather than the effects of ambient exposures. A distinction has been drawn between the direct and indirect impacts of acidification since the early 1970s. Increasingly, from the early 1980s onwards, the indirect effects have been given much more attention than the direct effects. These trends are related, because direct effects tend to be associated with exposure to ambient concentrations, or to physical contact with acid precipitation (e.g., leaf necroses caused by absorption via stomatal openings: Knabe, 1976). By contrast, indirect effects include a wide range of subtle, often difficult to identify changes in

soil chemistry, microbiology, root morphology, nutrient uptakes, and others that can in turn make trees more vulnerable to climatic, pest, or disease action. These effects result from the entry of acid ions into the soil and their subsequent movement through the soil. Some specific details pertaining to forest impacts will be discussed in the next section.

The emergence of the ECE assessment process

The negotiations of the LRTAP Convention between 1977 and 1979 were largely not motivated by acidification impacts (except for Sweden and Norway), but were driven by the diplomatic interests of Western countries and the Soviet Union (Jackson, 1990). Germany and the UK were reluctant to sign the Convention, but gave into the pressure of other countries and the EU. Concurrent to the negotiation of the LRTAP Convention between 1977 and 1979, the first components of the Cooperative Programme for the Monitoring and Evaluation of the Long Range Transport of Air Pollutants in Europe (EMEP) were established (for further details, see Dovland, 1987; Farrell and Keating, 1998).

In 1980, the Interim Executive Body established a body of scientific experts, the Working Group on Effects, to compile a report on what was known about acidification effects for the Executive Body's first meeting (which occurred in June 1983). These effects were defined as physical, with economic and policy effects being excluded, though these effects are now more closely enmeshed via the various ECE Task Forces. This was the first impact assessment carried out under ECE auspices.

The Working Group (WG) on Effects now oversees scientific research and monitoring activities at the national level. Since 1983, the WG on Effects has submitted an annual report on acidification impacts to the Executive Body at its annual meeting in Geneva.[12] This report is the major source of assessment information and summarizes a range of scientific and technical reports prepared by the various sub-groups for the WG on Effects. Nevertheless, it appears that the Executive Body rarely discusses the report in detail, and simply accepts it as a statement of science (even though it is in reality a document that emerges from extensive negotiations in the WG on Effects and its innumerable sub-groups).. Usually, the WG on Effects meets twice a year to discuss and evaluate the results of its various sub-groups. The currently existing institutions established under the LRTAP Convention are shown in **Figure 2**.

Since its inception, the WG on Effects has undergone significant changes, particularly in institutional terms, and in the extent to which it coordinates research activities across Europe. In particular, the WG on Effects has taken an increasingly active role in identifying gaps in knowledge about acidification impacts, and has encouraged (but not commissioned) research to resolve these uncertainties. While the WG on Effects has been reflective about its lack of knowledge about many aspects of impacts, it works on the assumption that this uncertainty can be overcome with additional, and more rigorous impacts research, especially in the forests area.

During its lifetime, the WG on Effects has been largely dominated by several West European countries, namely Germany, Norway, Sweden, Britain, Switzerland, the Netherlands, and more recently Finland (Jhaveri et al, 1997). It is these countries who provide leadership, funding, and headquarters for specific impact research programs, as a result of their national interests and

research traditions.[13] While there is a LRTAP Secretariat based at the ECE in Geneva, it is small and overworked. Thus, nearly all of the substantive work is carried out by thousands of scientists, assessors, and technical experts from member countries as part of an ever-growing ECE institutional network. Whereas the WG on Effects is largely comprised of technically qualified government decision-makers, the task forces and international cooperative programmes are made up of technical experts. Throughout the story of how forest impact frames have evolved in Europe, most of the key debates and negotiations happening with regard to designing standards, evaluating national research and assessment activities, and working out cause-effect relationships occur in the technical sub-groups of the ICP on Forests and the WG on Effects. It is not clear to what extent the regional assessors represent their own national interests and frames, or have become entrained within a process, politics, and norm of "Europe-wide" assessment.

In framing the acidification impacts assessed by the ECE Working Group on Effects early on, existing research and monitoring mattered greatly. As a result, acidification effects were interpreted in terms of several broad categories: freshwater lakes and rivers; forests and plants; and building materials. What was known by 1983 to 1985 was a product of the European research done during the 1970s, which originated principally from Britain, Sweden, Norway, and Germany to a lesser extent. For example, the ECE assessors relied considerably on German and Scandinavian research in preparing the first appraisal of forest damage in 1983.

The WG on Effects differs from most other assessment processes in that it coordinates research activities across Europe, and is highly decentralized with many institutionalized networks of scientists working in specific impact areas. Between 1983 and 1985, the WG on Effects assessed existing research on acidification impacts, similar to the approach taken by the IPCC for the most part (see, e.g., Agrawala, 1997). From 1985 onwards, however, the WG on Effects has taken a role in coordinating scientific research to help inform its assessments. In 1985, two International Cooperative Programmes (ICPs) on Forests and Freshwater respectively were established with the aims of increasing the usefulness of research through standardization, and of building an Europe-wide research program to leverage existing resources better. Since then, several more ICPs have been established to investigate crops, materials, and integrated ecosystem monitoring, all by 1991.

The ICPs reflect the initiatives of specific countries who volunteer to lead Europe-wide research programs (Jhaveri, 1997). Norway heads the ICP on Freshwaters, Germany directs the ICP on Forests, Finland is key to the ICP on integrated ecosystem monitoring, the UK manages the ICP on crops, and Germany and the Netherlands (via the Coordination Center on Effects) oversee critical load mapping. Generally, international cooperative programme centers are financed by the country which heads the specific work, but each country is responsible for its own national research costs. This means that, in practice, it is the West European and Scandinavian countries which can most afford to participate in ECE assessment. Little assistance is made available by the ECE to Southern, Central, and Eastern European countries (VandeVeer, 1998). Member countries are obliged by the LRTAP Convention, as well as by the protocols, to monitor acidification impacts on forests, lakes, crops, human health, and

buildings. This data, where it is generated, is relayed to the specific ICP and processed before being reported to the WG on Effects.

The ECE assessment process has considered some specific acidification impact areas much more frequently than others.[14] Forest surveys have been reported annually since 1986, whereas ground water and aquatic ecosystems have been reviewed every three or four years, though still more frequently than other areas. This reflects, again, the division between aquatic and terrestrial domains. It also mirrors the greater political salience of forest and aquatic ecosystems, together with the greater magnitude of research activity occurring in these domains. Corrosion and materials were assessed in 1983, but not again until 1989. Several major materials research programs have been underway since the early 1980s, in the ECE and the EU. Other impact areas have largely vanished from the ECE assessment agenda. Visibility was assessed in great detail in 1983, but almost all the data originated from the United States and Canada, and this area has not been much studied by European scientists since then.

During the 1990s, three important trends can be seen in the ECE assessment process. First, the European Union has become a key participant in the ICPs, especially the ICP on Forests. There is considerable overlap between many of the environmental, forestry, and agricultural research and policy-making in the EU and the ECE's LRTAP work. Air pollution and acidification have been part of the EU's environmental policies since the early 1980s. Recently, in March 1997, the EU has released an Acidification Strategy which includes, among other things, ratification of the new LRTAP protocols by EU members and continued exchanges of research and information. The EU has acquired a growing role because of its greater legal capacity and its expanding membership. As a result, EU priorities and activities (especially those relating to standardization) have affected the ECE assessment process in varying ways (Farrell and Keating,1998; VandeVeer, 1998; Botcheva, 1998).

Second, critical loads have become key to research, assessment, and policy-making in the ECE. Under the critical load concept, attention is focused on the levels of deposition of sulfur, nitrogen, or total acidity below which no damage to sensitive ecosystems is currently known to occur (Hettelingh et al, 1991). While early ECE assessments had endeavored to identify dose-response relationships, the evolving scientific view of multiple causal pathways and local variability meant that it was difficult to generalize these relationships across Europe. Moreover, flat reduction targets applied everywhere ignored the different distribution of costs. In the view of the Dobris Report, "Previous attempts to reduce [acid] depositions were based only on the vague understanding that damage was occurring and that emissions needed to be reduced" (Dobris Report, 1995). Hence, critical loads represent a major shift to ecosystem-based abatement strategies. Emission reductions were viewed by some countries, notably the Scandinavian ones, as needing to be tied to ecosystem effects if they were to work effectively.

As a result of the emergence of critical loads, impact research and assessment in the ECE and in national programs are increasingly structured around generating the data required to map critical loads.[15] The key values used for mapping critical loads on specific geographic areas are specified in terms of soil acidity and water acidity, reflecting the dominant division of impacts into aquatic and terrestrial domains. A complex and diverse range of data needs to be combined from emission inventories, reduction cost estimates, transport models, blame matrices, and

ecological studies to give rise to emission reduction scenarios based on critical loads. Countries that have ratified the second sulfur and first NOx protocols are obliged to monitor acidification impacts to enable the mapping of critical loads. Mapping critical loads assumes that cause-effect relationships are understood relatively well.

Finally, there has been a strong shift towards multi-pollutant, multi-impact approaches based on critical loads. It is increasingly recognized that existing protocols under the LRTAP Convention are inadequate, especially because the air pollution problem in Europe involves a matrix of intertwined compounds and impacts (Grennfelt et al, 1994). As discussed in section 4, the insights gained by the ECE via its forest assessments likely have played a central role in this shift. It has become clear that air pollution is a significant agent in forest ecosystems but has multiple pathways, multiple pollutants, and multiple effects so that it is difficult, both technically and politically, to separate these in making policies. Although some countries experience more impacts caused, for example, by ammonia emissions than others, these effects are interrelated with other impacts. Controlling specific problems, impacts, and compounds affects others.

ASSESSMENT OF FOREST IMPACTS

Forest impacts have been one of the two most assessed impact areas in the ECE assessment process (the other being freshwater impacts),[16] and are at the core of most national research and monitoring programs in Europe. They also have been the most contested impacts, particularly in Germany and the United Kingdom. Not only are forests significant in the economies of many European countries, they also provide recreational and amenity experiences, and often have great cultural and historical value locally. At the same time, there are great uncertainties about the causes, pathways, symptoms, and long-term prospects of forests. Impact frames, therefore, play a key role in shaping how researchers, policy-makers, and lay people diagnose and evaluate forest impacts. This paper focuses only on the impact frames held by scientists and assessors, and does not examine those of policy-makers or lay publics.

First, the key kinds of forest impacts are summarized, together with the methods used to identify, monitor, and analyze these impacts. This relates to the basic issue of how forest impacts are interpreted by scientists, assessors, policy-makers, and lay people. Frames are especially visible through highlighting specific types of an impact domain because this influences the methods, data, and actors involved. Next, the evolution of impact frames in forest assessments carried out by the ECE between 1983 and 1997 is investigated, with particular attention to cause-effect relationships, the role ascribed to air pollutants, the status of national forest surveys, the data and methods required for scientific credibility, and the institutions involved. These frames include "forest decline," "forest die-back," and "forest health." Finally, the extent to which these frames can be seen in Finland, Germany, and the United Kingdom is briefly explored. The emphasis here is on how these may, or may not, differ from those of the ECE assessment process.

Overview of forest impacts and methods for assessment

The impacts of acidification (or air pollution more generally) on forests are diverse and difficult to classify. There are many possible kinds of effects and pathways that could be considered at a specific locality. As a Finnish acidification research report states, a vast mass of details about the various aspects of acidification effects on forests exists (Kauppi et al, 1990). Tree morphology, root structure, cellular processes, nutrient uptake, leaf composition, stomatal absorption, soil chemistry, and tree vulnerability to insects and diseases are only some of the variables that may affect forest condition. Moreover, these conditions vary greatly across many localities in Europe, because of geography, climate, acid deposition rates, and forest ecosystem composition. This gives rise to another level of investigation, that of determining the distribution and role of causes and pathways across a large geographical region.

Identifying forest impacts is a process of defining an environmental problem where the impacts can be interpreted in a multitude of ways because of their uncertain, fluctuating, and heterogeneous nature (cf. Irwin, 1992). However, the assessment of forest impacts has tended to focus on a few key features over time. Impact frames influence how scientists and assessors concentrate on these features. Boundaries are usually drawn by scientists and assessors between leaf and crown appearance, soil condition and chemistry, cellular processes, vulnerability to naturally occurring damage agents, and ecosystem stability. These key features are summarized in **Figure 3**. The boundaries originate in disciplinary organization of scientific knowledge. Studying forest impacts is a complex undertaking because it requires the combination of many scientific disciplines, as well as forest management techniques, to address all the varied biological, soil chemical, physical, and ecological effects (Kowalak, 1993).

This activity imposes cause-effect relationships on the complex mass of details, even though it can be difficult to distinguish between the impacts. By focusing on specific types of forest impacts, scientists and assessors need different kinds of data and methods, and work within specific temporal and spatial scales. As Wentzel pointed out in Germany during 1982, these impacts also tend to reflect human interests (e.g., economic and aesthetic benefits) rather than ecosystem functions (Wentzel, 1982).

For example, much of the earliest research into forest condition related to soil conditions. Acid deposition can lead to changes in the ionic composition of the soil, and to leaching of nutrients, heavy metals, and cations from the soil. By itself, this soil acidification may undermine the long-term buffering capacity of the soil. It also may change the nutrient make-up of the soil, reduce microbial activity, and damage root tissues and structure. These impacts may lead to changes in water and nutrient availability and in leaf composition. The tree may become more susceptible to pests, climate, and disease. These are all examples of indirect impacts, which are difficult to identify because they are literally underground and indiscernible; and which require highly specialized, technical investigation by scientists over a long period of time because they are gradual and cumulative.

By contrast, most of the assessment in the early 1980s focused on visible tree injuries. These injuries include leaf yellowing and reddening in broad-leaved species, loss of needles in

conifers species, deformed leaf shoots, crown thinning, and tree and stand death. It had been known for several decades that short-term ambient exposure to sulfur at high concentrations could lead to acute and chronic damage to trees and other vegetation (e.g., Bolin et al, 1972). During the late 1970s and early 1980s, this frame was converted into one where acid deposition at low atmospheric concentrations over a long period could give rise to these effects.

Because it was assumed that air pollution (or acid deposition) was the primary cause of defoliation, discoloring, and crown thinning, it was thought by many decision-makers, scientists, and lay people that inspection could determine whether a tree was damaged by air pollution. Thus, forest surveys or inventories checking sample trees at sites spread out over a country could track the extent and rate of forest die-back (and, later, forest decline).[17] Ulrich's research results first reported in 1979 were based on soil chemistry implicating anthropogenic gases, not on observations of tree appearance. However, in 1982, when the German federal government responded to public concerns about forest die-back, forest surveys were used because they could quickly respond to public concerns, generate data about trends in forest damage, and be undertaken by existing forestry management institutions (Jager et al, 1998). Images of tree defoliation and discoloring pervaded German media accounts of forest die-back.

As a result, assessment became "pictorial," relying on visual representations and interpretations of trees in the field (cf. Lynch, 1990; Lynch and Law, 1990). To some extent, this development reflects the normative, experiential, and political values of "seeing" a phenomenon (Ezrahi, 1990). The apparent accessibility of knowledge to lay people and decision-makers may become more important than technical problems perceived by experts, at least during periods where the debates over how to interpret forest damage are in the broader public. As will become clear later, the recent history of forest damage assessment appears to have "retreated" into a technical realm, and the debates have shifted to the language and concerns of technical experts.

The process of translating field observations into the tables of survey figures reported in the ECE and national forest inventories is a complex one, beyond the scope of this paper. Nevertheless, forest surveys are hybrid, combining both scientific and forest management knowledge, and are subjective. They also have rather limited knowledge production value, at least from the normative perspective of scientists concerned with establishing cause-effect relationships via rigorous and credible methods.

Initially, the German forest surveys of 1982 and 1983 were carried out by foresters working for the Land governments, and assembled by the federal ministry of agriculture and forestry. As well, it was possible for environmental NGOs, forest industry associations, and other lay people to carry out forest surveys and come to their own conclusions (as also occurred in the UK in the early 1980s). The experiential process of judging the extent of defoliation and crown thinning can be subjective, and can vary across many observers because of differences in perception, training, forest knowledge, classification criteria, and even physical location for observing a tree. Indeed, the early forest surveys produced by ECE discuss the disparities between and within countries resulting from the different training and perceptions of surveyors.

German and British surveyors both were studied by government forestry departments at some length in this light.

In turn, the choice of tree and site samples affects the extent to which a forest inventory can be considered to be "representative." It was difficult, in the early 1980s, to identify the degree and nature of tree damage from the air, let alone by satellite. Thus, inspection on the ground was necessary. Where the surveys are carried out matters strongly for their results. For example, in 1983, the Forestry Commission studied sample trees across most of Britain, whereas the Friends of the Earth focused on southern England. This may have partly led to their divergent conclusions, where the Forestry Commission identified little tree damage, and the Friends of the Earth contended that tree damage rates were high (Hajer, 1995; Waterton, 1998).

Finally, there has been continuing controversy over how useful forest damage inventories are (Nilsson and Duinker, 1987).[18] As Ulrich (1990) points out, such inventories typically focus on the vitality of tree canopies by evaluating only leaf discoloring and loss. They do not consider root development, nor the cellular chemistry of trees, for example. These can only be identified and monitored by site-specific research. Finnish scientists also have pointed out that acidification may upset the biological and geophysical processes of forest ecosystems (e.g., by changing composition of tree species and stand ages) over time. These impacts can only be tracked by integrated monitoring of ecosystems. Such impacts may be more important in the long term, even though they are subtle and gradual. Looking at leaf loss and discoloring also does not reveal much about their causes, since they are examples of non-specific injuries with many possible causes (APS, 1991).

In response to these types of criticism, the WG on Effects has endeavored to reinforce the scientific character of forest inventories by adding new features to the ECE assessment process, especially in the form of transnational surveys. It also has promoted site-specific research projects and integrated monitoring of ecosystems in combination with surveys. This is a key focus of the next sub-section.

Assessments of forest impacts at the regional level

The assessment of forest impacts by the ECE since 1983 has been marked by a series of significant shifts in dominant impact frames. These shifts have moved between conceiving of forest damage in terms of three major frames:

- **forest die-back** [emphasizing (a) the sudden system-wide collapse of forests because of a single operating agent, sulfur emissions, (b) the visual symptoms of tree damage such as defoliation, (c) national forest survey programs, and (d) policies to reduce sulfur emissions];

- **forest decline** [accentuating (a) the geographically and temporally variable decline of forest condition because of a mix of air pollutants, (b) the "invisible" damage done to trees by soil chemical processes as well as the visual symptoms, (c) transnational forest survey programs and more focused intensive research into soil biochemistry, and (d) policies to reduce various air pollutants]; and

- **forest health** [highlighting (a) the broad state of forest ecosystem (not simply tree) health which can be affected by a combination of climatic, soil, and management conditions as well as a range of air pollutants, (b) the subtle ecosystem effects as well as the visible and invisible damage done to trees, (c) elaborate cross-linking of transnational surveys, experimental programs, intensive research, and integrated ecological monitoring, and (d) policies to improve forest management as well as control of air pollution].

Significantly, these frames have co-existed in the ECE regional forum (as well as in Finland, Germany, and the UK to greatly varying degrees). The dynamics suggest that there have been non-linear, non-progressive "swings" between different frames at specific points in time with regard to their dominant influence on the ECE assessments. As discussed below, such swings may be linked with changes in variables such as **key agents** (e.g., the emergence of Finland and the UK as significant producers of information about forest impacts), **interpretations of scientific data** (e.g., the observation of multiple effects that can not be explained by a single causal agent theory), **domestic politics** (e.g., the stake held by Britain in ensuring that its economic and sovereignty interests were not jeopardized by ECE action), or **competing institutional networks** (e.g., the rise of the European Union, with its own standards, interest in creating an "European" science and politics, and its greater resources).

Nevertheless, the early standards, forest survey practices, and forest die-back frame promoted within Germany, and then in the ECE regional forum, continue to be important even now. They have become entrenched within the ECE institutional network and its research and assessment activities. Forest surveys are still at the heart of the ECE and the EU activities. This is an example of how initial conditions can affect the structure and process of the assessment process. But because of the varied interests of individual countries, and the ECE's emerging cooperation with the EU, the assessment process has become a vast, poorly-defined conglomerate of programs accreting around the original forest surveys. For example, Finland's political stake in forest health and precautionary norm has helped lead to growing interlocking between the international programmes on forests and ecosystem monitoring. Britain's reluctance to accept sulfur emissions as the causal agent, and preference for a broad multi-pollutant explanation, has played some role in the ECE's deliberations over how to interpret the changing forest impact patterns across Europe.

An important trend has been the ways in which the ECE assessment process has promoted growing standardization and comparability between countries in the region. This reveals how impact frames are produced and communicated by regional assessors to participating countries and scientists, but also how frames can move from specific countries to the ECE assessment process.

Early ECE and national assessments

Following the signing of the LRTAP Convention, the Interim Executive Body established in 1980 a Working Group on Effects of Sulfur Compounds to report on the state of knowledge regarding acidification impacts. This was the first scientific and technical advisory committee set up under the ECE regime, before forest impacts came to public and political prominence in

1982, and before the elaborate research system was built up during the 1980s. As such, the first two reports in 1983 and 1984 were based on the scientific research carried out during the 1970s. The WG on Effects was influenced by the research foci of the International Conference on the Ecological Impact of Acid Precipitation, held in Norway during 1980 (Falkenmark, 1980).[19]

Forest ecosystems were considered, together with agricultural crops, as "soil, vegetation, and groundwater." Forest ecosystems were not evaluated in their own right, nor was any mention made of the concept of forest inventories as a research priority or a source of data. Rather, air pollution was recognized as only one potential cause of forest damage. Other stress factors such as weather, pests, and diseases needed to be accounted for. The prevalent focus on visible injury in the form of leaf chloroses and necroses was criticized, because "whole vegetation communities" can have limited growth and reduced resistance.

Extensive attention was given to soil acidification. The WG on Effects highlighted the argument first made in 1981 by Ulrich that decreased root growth of beech is associated with increased aluminum and decreased soil moisture. It was recognized that, because soils vary widely in their physical, biological, chemical, mineral, and hydrological conditions, soil effects would be difficult to identify. The ECE assessors recommended that scientific work be done on establishing dose-response relationships for exposures to air pollution, studying experimentally the effects of different amounts of acidic inputs on soil, and preparing internationally acceptable guidelines for methods of analyzing soil properties relevant to acidic deposition (APS 2).[20]

Some evidence of the forest decline frame can therefore be seen in the first two ECE assessments, in that they emphasize the possible multiple causes of forest impacts, the importance of "invisible" damage such as soil chemistry compared to visual damage, and intensive research rather than surveys. This contrasts vividly with the stress on visual symptoms, surveys, and sulfur emissions in the forest die-back frame which began to emerge rapidly during the early 1980s (see below). It is important, for now, to see that the forest die-back frame became so persuasive for most scientists, assessors, policy-makers, and lay people in much of Western Europe that it pushed aside an already existing body of significant (largely German) research suggesting a more complex phenomenon.

During 1981 and 1982, non-scientific actors and institutions in Germany (which is discussed in greater detail in the country study below), Austria, and Switzerland played a crucial role in defining the problem of forest die-back and endorsing forest inventories as a valid way of producing knowledge about forest condition. By 1983 to 1984, the scientific research on soil acidification had temporarily become secondary to the need to establish the extent and rate of forest die-back.

Germany was the first one to conduct a national survey in 1982, and neighboring Western European countries such as Austria, Switzerland, the Netherlands, and the United Kingdom followed in 1983. The results of these early surveys suggested that significant forest die-back was occurring across Europe. Simply because defoliation, discoloring, and crown thinning were apparently worsening rapidly over a short time, were spread across a wide geographical

region, and could not be adequately explained by natural causes, these impacts were viewed by many scientists and assessors in Central Europe as *neuartige waldschaden* (novel forest damage) caused by the 'new' cause of air pollution (Jager et al, 1998). These surveys reflected, and reinforced, the forest die-back frame. This frame also had a particularly strong normative tenor, in that it assumed that forests were originally always robust, stable, and – and that their deterioration meant that

The initial observations of "catastrophic" forest damage in the mountains of Germany, Austria, and Switzerland helped form the experiential dimension of the forest die-back frame. These observations had great political and normative significance. With little of a historical baseline to go on, the damage was interpreted as a *departure from the past*: as new damage that was so marked as to require immediate and drastic policy action as a norm. Thus, policies had to be taken to "restore" or "save" forests as part of Europe's natural and cultural heritage (cf. Bohmer-Christiansen and Skea, 1991). Moreover, forest die-back can help build a sense of a shared, Europe-wide problem that almost every country, certainly the powerful countries and the largest emitters, is (or could be) affected by forest damage. In this way, frames can be seen as including, and arising from, an intertwining of experiential, normative, and political dimensions.

In 1985, the first detailed ECE forest assessment appeared, reflecting concerns about the "rapidly spreading damage to forest ecosystems occurring today in many ECE countries" (APS 2). While there was no scientific proof for air pollution causing forest damage, the WG on Effects listed a set of "indicative proofs" excluding natural biotic and abiotic factors as primary causes of the damage.[21] Forest management could be discounted, so the most plausible explanation was that of sulfur and nitrogen emissions. "Without air pollution and its wide dispersion, the recent forest damage could not have occurred in its present form and extent" (APS 3, 1985). The WG on Effects focused on the symptoms of defoliation and yellowing, which occurred in many species in many locations. It did note that it was difficult to estimate the extent of forest damage caused by air pollution because its effects could not be distinguished from natural causes, the effects could be latent or hidden, and international standards of comparison were absent.

Significantly, the WG on Effects reviewed the forest damage known to exist as of 1985 in each participating country, and the country's view on cause-effect relationships. It was aware that the UK considered air pollution to be only a slight threat, with other causes being more important, and that Finland was concerned only about possible long-term effects on its forests (in line with their forest health frames). It recognized that different countries weighed the various possible causes of damage differently, for reasons of ambient air quality, geographic and climatic conditions, and research traditions. While the WG on Effects emphasized both soil conditions and leaf processes, the German assessors focused only on the latter. Yet the forest die-back frame dominated the ECE conclusions here, and for the next three to four years. Trees were accepted as biological indicators of forest damage caused by air pollution, and as part of a monitoring and surveying process. In this way, the early experiences, norms, and politics arising in Germany had a great influence on the emergence of the ECE institutional network

and assessment process. Moreover, these early developments were largely based on non-scientific and non-state actor interpretations of forest damage, rather than those of technical and state experts, who came to take up the former interpretations for political and experiential reasons.

Nonetheless, despite the emergence of the forest die-back frame, the survey results were perceived by many scientists and environmental NGOs across Europe as highly variable in their reliability, representative coverage, and credibility. The federal Ministry for Nutrition, Agriculture and Forestry (BML) in Germany, for example, surveyed only 60 percent of its forested area in 1982 and asked managers of large private and Lander owned forests for rough estimates of damage. The tree damage was classified as weakly, medium, or strongly damaged without any further criteria used. No allowance was made for trees that had already been removed.

The ICP on Forests

In response to these concerns about survey deficiencies, during July 1985, the Executive Body of the LRTAP Convention decided to establish the ICP on Assessment and Monitoring of Air Pollution Effects on Forests (ICP on Forests). This new institution was to oversee the collection by participating countries of "comprehensive and comparable data" on changes in forest condition to enhance understanding of trends in damage caused by air pollution and to clarify cause-effect relationships. The data was to be collected on a national basis. The ICP on Forests has always been headed by Germany, with the programme coordination center currently based in Hamburg. Between 1985 and 1990, the operating costs of the ICP on Forests were met by the United Nations Environment Programme (UNEP). Since then, each participating country has borne its own research and survey costs, and Germany has supported the programme coordination center.

In 1986, the ECE Manual on Methodologies and Criteria for Harmonized Sampling, Assessment, and Analysis of Air Pollution Effects on Forests was prepared to guide the various participating countries. These standards, and subsequent revisions, were made by the scientists and assessors who participated in designing and building up the ICP on Forests. It appears that, like other LRTAP bodies, most of the members of the ICP on Forests during the 1980s and 1990s have been drawn from West Europe, rather than the other sub-regions of Europe VandeVeer (1998). At least in terms of those who actually attend key decision-making meetings, they often are senior scientists from forest research or government forest departments. How they make decisions is unclear. In theory, ECE decision-making is formally consensus-based, but there may be extensive negotiations occurring in the ICP on Forests with regard to how to design standards and evaluate data sets.

It is important to note that, around this time, the European Union also first introduced its own forest monitoring standards, via Regulation 1696/87. This regulation, automatically binding in EU member legal systems, requires the annual submission by member governments to the European Commission (in reality, the German Federal Center for Forests and Forest Products, which aggregates and reports the data to the Commission) of information regarding: country, plot number, plot coordinates, altitude, aspect, water availability, humus type, soil type, age of stand, tree numbers, tree species, observations of easily observable damage, and date of

observation. These data requirements, together with the definitions of tree species, tree sample sizes, criteria for judging sample representativeness, and survey grids, differ somewhat from those of the ECE standards – notably in requiring considerably more site-specific data. While the ECE assessors worked to promote and implement their new standards, they were conscious of their EU-supervised counterparts. Indeed, the EU member countries were carrying out multiple surveys: transnational surveys complying with EU standards, national surveys complying with ECE standards, and national surveys designed in the light of pre-existing domestic politics, institutions, and monitoring traditions. During the 1990s, this trend seems to have included more non-EU member countries, often those seeking admission to the European Union (cf. Botcheva, 1998).

Significantly, much of the ECE Manual's content was borrowed from the forest inventories carried out by Germany since 1983, reflecting political and experiential factors. Most of the early data and methods were produced by Germany, which therefore had much experience in surveying forests, compared to other countries. Moreover, the German approach to surveys was taken up at the regional level, partly because of the politics involved. German decision-makers had formerly believed in the 1970s that acidification was not problematic, but were suddenly eager in the early 1980s to take regional policy responses to assuage domestic concerns. There was, therefore, a German political stake in encouraging other European countries to document their forest damage. Germany played an early critical role in promoting the forest die-back frame in the ECE assessment process, as a way to create new political coalitions, bring new agents into the debate, and exporting its technology-based policy solutions. In particular, the classification criteria was adopted from the German surveys. Trees were classified in terms of damage categories depending on the estimated percentage extent of leaf or needle loss:

Step 0	no signs of damage	0-10%
Step 1	slight damage	11-25%
Step 2	medium damage	25-60%
Step 3	strong damage	>60%
Step 4	dead	100%

Over time, these categories have been combined in different ways to determine specific ratings, usually with Germany leading the way in its domestic surveys. Moreover, Germany has always had the largest samples and numbers of trees in the ECE surveys by far (typically 70,000 to 220,000 trees on around 5000 to 7500 plots). By comparison, the UK did not have more than 1400 trees in its surveys until 1991, while Finland's resource investment has hovered around 4000-4500 trees on about 400 plots.

At this time, the classification scheme did not distinguish between biotic and abiotic causes. Importantly, the manual required countries to report only the damage that was thought to be caused by air pollution, and did not oblige countries to differentiate between different

observable and suspected causes (like fungi, pests, climate, or disease) even though Austria and Switzerland did so for their national surveys (Nilsson and Druinker, 1987).

In short, the forest die-back frame was dominant in the ECE regional assessment process in the mid-1980s. Assessment was mainly aimed at determining the extent and rate of forest die-back across Europe, and at aggregating the numerous local effects into an "Europe-wide" view. The broader political context is key. During the mid-1980s, several ECE countries (Germany, Austria, Norway, and Sweden) believed that air pollution caused forest damage, and sought an uniform reduction in sulfur emissions across the ECE member countries as a policy response. Such a response meant that technological measures had to be taken to modify coal-fired power plants, which were viewed as the key culprit of sufur-related forest damage. Other countries (especially Britain) were more skeptical about this cause-effect relationship and policy response, partly because of their domestically dominant forest decline or forest health frames, but also because of their dependence on coal-fired power generation and industry. Air pollution was viewed by British policy-makers and scientists as just one factor in the phenomenon of forest decline, so that targeting coal-fired power plants was argued not to be an answer (Bohmer-Christiansen and Skea, 1991; Hajer, 1995).

As the ECE assessment process evolved, it built up assessment practices that implicitly **compared** forest damage between countries, even though there were constant warnings in the ECE assessments that the data could not be readily compared. Despite these supposed warnings, the ECE assessments rated each participating country, with regard to conifer and broad-leaved trees, in terms of three broad categories of damage: low (below 30 percent), moderate (between 30 to 50 percent), and severe (over 50 percent). Between 1985 and 1990, the countries were also sorted into classes based on their government's view of the extent of air pollution's role in their forest damage. This is key evidence for the differences in frames dominant in individual countries. Such comparison practices not only promoted the forest die-back frame, but also brought the more skeptical countries within the frame, at least at a regional level. Britain and other countries which denied that they were significantly affected by acidification were faced with the evidence of the comparative surveys. For example, the first few ECE forest condition reports after 1984 specifically refer to British examples of effects and research, perhaps trying to underscore Britain's vulnerability to forest damage.

The influence of the growing ECE assessment process and institutional network, but also Britain's endeavors to promote its own forest decline frame, can be seen in the activities of British scientists and assessors over time. British scientists and assessors could have ignored the practices and standards of those in other countries, but they have been preoccupied with how the UK compares with other ECE countries. By 1990, the UK Terrestrial Effects Review Group was explicitly referring in their national forest assessment reports to the comparative figures of other countries as evidence that forest damage needs to be taken seriously, as well as pointedly praising Swiss standards (which emphasized a multi-effect, multi-pollutant model even during the 1980s, in strong contrast to German standards). In 1987, British forest assessments were adjusted to Swiss standards, resulting in a perceived deterioration in forest condition between 1985 and 1987. Britain had a small national survey until 1991, hovering around levels of 1800 sample trees and 75 sample plots, but covering the country's entire forested area.. Between 1990 and 1992, under the influence of the ECE surveys, the British

forest inventory rapidly expanded to some 8800 trees on 370 plots. In other words, while Britain was affected by the standardization push of the ECE from the late 1980s onwards, it also continued to apply and interpret its own standards and surveys (based on forest health frames).

The new figures generated by the ECE assessments meant little, though, without promoting the comparability of surveys. In 1985, the WG on Effects stated that: "Because of the dissimilarities of the methods for observation an evaluation, the national results concerning damage extent are only partly observable." Hence, the ICP on Forests began to engage in extensive standardization work. It has worked to "harmonize" individual national inventories, by carrying out "intercalation" exercises to compare their reliability and compliance with the manual. Independent "control teams" perform reviews of survey data in the field. As well, studies were carried out on the extent to which observers agreed on their assessment in specific countries, notably Germany and the United Kingdom.[22]

This was not necessarily a German-led process, because Germany had numerous variations in survey criteria among the Lander governments (see below). Even within Germany, there was extensive criticism of government research priorities and assessment methods during the early and mid-1980s. At the same time, as explored in section 4.3, individual countries did not necessarily accept, or implement uniformly, the new regional standardization pressures. Britain, for example, did not implement the ECE standards set out by the ICP on Forests in full until 1991, when its forest condition figures suddenly worsened, but not necessarily because of intensifying damage rates per se. Around 1990, Belgium, Italy, and East Germany combined both defoliation and discoloring, while Italy and Austria surveyed only trees over 60 years in age. Thus, there were marked divergences in forest surveys across Europe. In the ECE, there seems to have been a growing criticism of the German standards from the late 1980s onwards, on the ground that they were heavily biased toward the forest die-back frame when newly emerging experiences suggested that forest damage was a much more complex phenomenon, in line with the views that had prevailed in the ECE prior to 1983 and 1984.

The emphasis in the ECE between 1986 and 1989 was on what could be gleaned from the forest inventories, and on making these surveys more rigorous from the viewpoint of scientists from Britain, Switzerland, and the Scandinavian countries. ECE assessors perceived a need for information that was capable of affecting policy-making. Much less discussion of cause-effect relationships occurred in the ECE assessment process, since the forest die-back frame was dominant. At the same time, some of the ECE assessors were reflective and skeptical of many elements of the forest die-back frame. This is shown, for example, by the extensive discussion in 1986 of the effects of air pollutants on soil, which highlights the indirect impacts of multiple pollutants, and the chemical and physical changes occurring in the soil (e.g., metal mobilization, nutrient cycling, and cation leaching). The assessors point out that repeated soil inventories are the only way to establish soil acidification processes, and refer to the Solling forest results of 1979, which remained the only such source of information available. Thus, elements of the forest decline frame were always present in the ECE assessment process, if downplayed in assessment practices during this period.

Even as the regional assessment process sought to build an "Europe-wide" view, it highlighted the great diversity of forest impacts and possible causal pathways across Europe. Within Germany, for example, forest impacts seemed to take different forms according to geographical location. Previously, the focus had been on defoliation and discoloring as indicators of forest damage. Several developments in the ECE assessment process seem to have been important in promoting a major shift back towards the forest decline frame from 1988 onwards:

- the ECE surveys were expanded to include the Mediterranean countries, where climate, natural fire, and land management tend to affect forest condition more clearly than in northern Europe;

- the ECE surveys began to incorporate a spatial break-down of forest condition, not simply by countries, but by regions defined in terms of climate and ecology, so that defoliation rates were particularly high in some regions (mainly Central and Eastern Europe);

- the ECE surveys started to include detailed break-downs of specific tree species across Europe, rather than by types of trees alone, so that some species were seen as much more adversely affected than others;

- with greater attention to the above trends over time, it became obvious that forest damage fluctuated from year to year, with regard to specific countries, types of trees, age, and species. (For example, in 1990, decreases in defoliation occurred in 7 countries, while increases happened in 18 countries.);

- experimental and field observations suggested that multiple air pollutants and interactions between pollutants, climate conditions, and edaphic conditions were involved; and

- it became clear that dose-response relationships could not be readily established for air pollution's effect on forests (except possibly ozone).

These collective experiential developments meant that it was difficult to explain forest damage by reference to air pollution acting as the primary cause. Therefore, the forest die-back frame began to diminish in influence at the ECE level, with the forest decline frame assuming greater prominence. Given the apparent variability and unpredictability of effects, what did policy-makers need to make "better" policies and to ensure that emission reductions would work?

Normatively, the forest decline frame suggests that, if forest damage happens as part of a complex, multi-causal phenomenon, then it can not be resolved by simplistic solutions. Responsibility can not be so easily affixed to coal-fired power plants alone. A more varied and technically sound policy response is preferable to tackle the causes wherever, and whenever, they are operating most powerfully. It is better to do more research, be more certain about the cause-effect relationships, and tailor solutions to the different conditions prevailing throughout Europe (cf. Bohmer-Christiansen and Skea, 1991). These themes are more in line with the kinds of views taken by British scientists and policy-makers, but are also in line at once with the ecological emphasis of the Scandinavian countries, who were becoming more concerned with focusing on the parts of ecosystems most vulnerable to acidification (via the critical load

theory: Dietrich, 1994). Thus, the forest decline frame can satisfy the different political stakes of many more countries in Europe than the forest die-back frame, as well as helping organize emerging experiences with forest damage more coherently than the die-back frame, and sustaining calls for new kinds of policies (protocols based on critical loads and modeling).

At this time, in Germany, many hypotheses were proposed to explain forest damage in a very intense domestic scientific debate that did not necessarily influence policy-maker views. Some, such as the Ulrich hypothesis, treated air pollution as key, but only in interaction with other biotic, abiotic, and anthropogenic causal agents. Another hypothesis emphasized the multiple stresses on trees from climate, land use, air pollution, and geophysical change over time. These multi-causal hypotheses could not be proven through forest inventories, but needed detailed, site-specific studies combined with time series. They also could be supported only by the technical work of scientists, not by comparatively untrained and subjective surveyors working by themselves. Beginning in 1987, the ICP on Forests started to refer to three categories of cause-effect relationships: air pollution could play a predisposing, inciting, or contributing role in forest health. This emphasizes the continuing importance of German scientific research and assessment in the ECE regional process.

One crucial problem for the ECE assessors in the later 1980s was how to classify the threshold of visible damage for a tree to be viewed as "damaged," since site-specific observations were demonstrating that trees naturally lose leaves or needles, or thin in their crowns, with age, as well as fluctuate in their condition from year to year. Therefore, trees in class 1 were not necessarily "damaged." This has important consequences for the extent and rate of forest damage. If classes 1 to 4 are added together, rather than classes 2 to 4, the total percentage of damaged trees increases markedly for most ECE countries. For example, in Germany in 1991, if classes 1 to 4 were combined, this would mean that 66.3 percent of broad-leaved trees were damaged. If class 1 (with 40.3 percent of trees) was excluded, the proportion of damaged trees would be 26.0 percent. Thus, the apparent extent and rate of die-back would be much less dramatic than it might be – which is conducive to political coalition-building by Germany, but which can be used to support norms and politics not compatible with other countries and frames. From 1989 onwards, the ECE assessors decided to combine only classes 2 to 4, thus reworking their assessment practices in terms of the forest decline frame. This general shift to forest decline facilitates the entry of new agents, such as Finland and the European Union (which play a pivotal role in the next phase of the story), new kinds of political coalitions (both domestically and regionally), and new kinds of assessment practices and policies.

The original shaping of the ECE assessment process and institutional network by German experiences, norms, and politics has been very powerful. As is underscored in the next section, not only do forest surveys remain at the heart of the ECE assessment, the science follows developments in Germany to some extent. Nevertheless, the forest decline frame reflects, and supports, a greater role for scientific practices and ideas from sub-regions in Europe other than Central Europe. Significantly, in the late 1980s, the ICP on Forests also began referring to "forest health" instead of forest damage, though it still emphasized damage in practice. As seen in the next section, the eventual response was to expand and strengthen regional assessment

practices according to the forest health frame, revealing the growing political, experiential, and normative influence of countries other than Germany and the United Kingdom.

Forest assessments by the ECE and EU according to forest health frames

As mentioned above, while the ECE was setting up a national forest inventory system during the late 1980s, the European Union was carrying out its own forest condition survey of member countries. In 1986, the EU had enacted Regulation 3528/86 on the protection of forests against air pollution, with detailed rules for inventories, monitoring, and reports. From 1987 onwards, parallel forest condition reports were produced by the ECE and the EU (albeit for widely diverging memberships with an EU member core of 10 to 15, compared to 33 countries in the ECE). At first, these parallel surveys were reported separately, but in a key development in 1991, the EU and ECE assessors decided to combine the surveys in a single report. The EU also participates in the ICP on Forests. The EU represents a competing institutional network with greater prestige, power, and resources than the ECE forum (VandeVeer, 1998). Many ECE member countries from Central and Eastern Europe have applied for, or would like to seek, EU membership (Botcheva, 1998). The EU now funds much of the work by the ICP on Forests in a context where the United Nations has become less interested in supporting forest inventories.

Consequently, the emergence of the EU as a key agent in forest assessment in Europe has had important effects on the ECE assessment process. ECE assessment standards have moved closer to the more data-intensive EU standards, the standardization process has intensified during the 1990s, and ECE/EU assessment strategies have shifted away from the national forest inventories characteristic of the forest die-back frame towards a complicated ecosystem monitoring system to establish cause-effect relationships. In particular, over time, the EU-designed forest surveys and research projects have contributed significantly to changing assessment methods and data sets in terms of a new forest health frame. This frame suggests that forest damage is caused by not only multiple pollutants, but also by multiple non-pollutant causes, such as climate, forest management, disease, or insects, that vary greatly across Europe. In short, the "health" of the forest ecosystem needs to be assessed, not simply the visible and invisible damage done by air pollutants to trees.

The European Commission is politically interested in the assessment and management of forest damage. Because the Commission wants to expand its influence over the agriculture and forestry policies of EU member countries, promoting sustainable forestry may be viewed as one desirable avenue of increasing this influence. Linking sustainable forestry and air pollution monitoring also may be seen as a process of strengthening "European" identity via science and technology (cf. Waterton and Wynne, 1996; Waterton and Wynne, 1998). This is underscored by the dominance of "transnational" forest surveys, which require many countries to build up "common tree samples" that are periodically re-assessed, and apply externally defined data collection methods, so that the results can be compared across the European region and over time. This contrasts with the earlier ECE strategy of "national" forest surveys that draw on the results produced by nationally-designed methods (often developed for forestry purposes rather than air pollution monitoring goals) that look at different tree samples each year. This "Europe-wide" view is first fully realized in the 1996 forest assessments when the

Pan-European Programme for the Intensive Monitoring of Forest Ecosystems produced its first major results.

From a normative perspective, the new forest health frame suggests that one version or another of the precautionary principle is desirable. Because the interactions and synergistic effects of various types of global environmental change are unpredictable and contingent, forest ecosystems are not necessarily "saved" or "restored" if pollution emissions are reduced. Even relatively small exposures to air pollution might affect adversely an ecosystem's functioning in the long term, if they interact with climate change and land use trends. This concern underlies the forest health frame being promoted by Finland, but not the version of Britain (which is more concerned with domestic policy politics), nor the version of the EU (which is interested in "European" identity-building and expanding its policy influence). In brief, if there are many non-air pollution causal agents operating, then the solution is to focus not only on acidification control, but also on a broad sustainable forestry strategy to address these causes. Also, a much more complex and analytical research program is needed to disaggregate the causal agents more effectively, to see their respective contributions, and to decide which causal agents to target.

During the late 1980s, while the ECE and EU forest assessments were being reported deparately, there were key differences in ECE and EU forest surveys despite the EU standards having relied on the 1986 ECE Manual (see above) as a starting point. These differences persist in many ways even now. The EU transnational surveys always have had a strictly enforced standard 16 x 16 km^2 grid, have collected much more information about site-specific parameters (such as soil and climate), and have used "stringently defined statistical procedures" (APS 10, 1993) to choose sample trees. As a result, especially because of the new common tree samples promoted by the EU standards, the EU/ECE assessors could detect, already in 1992, a "real" deterioration of tree condition over time, rather than worrying about distorted survey results by the addition of new tree samples. By contrast, national forest surveys still vary greatly in their grid densities, reflecting national priorities, institutional set-ups, and extent of forest coverage. Their data is perceived by EU/ECE assessors as lacking in comparability and reliability.

The EU transnational survey strategy has markedly influenced many national surveys in the 1990s. As well, the transnational surveys have expanded to include non-EU member countries, highlighting the EU's growing influence in the ECE (which now has 33 members compared to 12 in 1986). The ECE's history is that of more and more forest surveys and participating countries, but the EU's version is of intensifying research practices and standardization. This is reflected in the transnational survey report's explicit distinction between the data reported by EU members, and that reported by the ECE as a whole.

Since 1991, the ECE/EU assessments have highlighted continuing uncertainty over whether discoloring, defoliation, and crown thinning actually correlate with forest damage. There is now evidence that crown thinning may partly be a function of tree aging. Also, the variations in biological, soil, climate, and ecosystem conditions make it difficult to link these visible

symptoms to specific dose-response relationships. Different tree species may respond differently to air pollution and other causes. Attention is focused more on the subtle changes in tree morphology, soil chemistry, and ecosystem dynamics (e.g., generation profile and ecosystem fluxes) that may be occurring. While individual trees may not be affected much by air pollution, the forest ecosystem as a whole may be affected by air pollution acting synergistically with other natural causes and anthropogenic changes (e.g., climate change, ozone, biodiversity loss, and land use).

In 1991, there was an interim report on cause-effect relationships in "forest decline." This report reviewed the activities of both regional and national assessment processes, though many countries did not provide much information to the ECE about their own assessment and monitoring. Its major conclusions included the idea that "there is no single forest decline problem" (APS 8, 1992). Rather, "a variety of different types of declines exist, some of which can be spatially delimited and which are characterized by specific symptoms." Air pollution probably has not played a significant role in directly affecting forests at a "regional scale" outside Central Europe, though it has been associated with many indirect impacts via acidic deposition.

As part of this change in cause-effect assumptions, the ECE/EU assessors have moved from a forest decline frame to a forest health frame based on an ecosystem perspective. In December 1990, the European Union Ministerial Conference on the Protection of Forests in Europe, held at Strasbourg, stipulated that a second network of permanent sample plots should be set up by EU member countries, and that various ecological databases should be merged to integrate environmental data. This was the first significant call for integrated monitoring of forest ecosystems. Currently, the purpose of the ECE/EU assessment (as described by the EU) is to act as the major source of information about the health of European forests. As stated in the 1992 forest assessment, "The condition of European forests depends on species composition, age structure, site and climatic factors, management practices, silviculture, and traditional forms of damage" (APS 8, 1992). For example, the forests of Britain (defoliation by insects in spruce) and Portugal (drought and fire) were seriously affected in health by causes other than air pollution.

The ECE/EU assessments changed significantly during 1991 to 1994 in their views of causation, the range of effects that need to be monitored, the methods required to establish cause-effect relationships, and the data needed to support regional policy-making. In turn, these changes were embodied in the assessment practices, new institutions and research programs set up under the ICP on Forests, as well as in the joint work increasingly undertaken with the EU. For example, in 1992, for the first time, the following data is provided in the forest surveys:

- discoloring of leaves (simply because most countries were now collecting this data, compared to the 1980s when few countries had this information);
- forest condition by easily identifiable damage in eight categories including fungi, insects, fire, poor forestry techniques, abiotic agents like wind, and climate;
- time series based on forest survey results across a number of years.

A new classification system also was instituted, in which damage was assessed in discrete steps (5 percent for transnational surveys and 10 percent for national surveys). This new classification allowed annual variation to be tracked more accurately. It replaces the old system of steps 0 to 4, which were thought by the ECE assessors to be too indiscriminate and unscientific for an increasingly detailed and multi-layered assessment process.

The focus has shifted to building up data sets that can be used to establish cause-effect relationships, not simply to illustrate the extent and rate of forest damage (as in the forest die-back frame). The Pan-European Programme for the Intensive Monitoring of Forest Ecosystems is an outcome of this work, and has begun to generate results in the past two years, which are described by EU/ECE assessors as indicating that forest health is seriously impaired across Europe because of a complex set of pollutant and non-pollutant causes. In this new programme, a distinction is increasingly drawn between large-scale monitoring for defoliation and discoloring (called by the ICP of Forests, Level 1), which can provide a highly aggregated picture of trends, and site-specific research projects that can help determine causation (Level 2). This distinction had been made in the ICP on Forests' original work plan in 1985, but the forest die-back frame had promoted forest inventories over site-specific work. Thus, the ICP on Forests is now attending more to identifying site-specific parameters, such as soil characteristics, site climate, and forest properties.

At the same time, integrated ecosystem monitoring is viewed by the ICP on Forests as Level 3 in the assessment process. This is to be carried out via a number of permanent sample plots that "scrutinize the complex interactions between all compartments of the ecosystem in detail" (ICP on Forests, 1997). As well, extensive work is to be done on integrating the various databases accumulated since the early 1980s by the different ICPs, task forces, the Center for Coordination of Effects, and EMEP so that deposition, aquatic, soil, tree, and others can be mapped onto each other in a multi-layered system. Not foreseen in 1985, Level 3 is only beginning to emerge in practice, and requires much more collaboration between the various bodies of the WG on Effects before it can emerge fully.

With these changes in research priorities, data needs, and methods, the ICP on Forests has become larger, more specialized, and institutionally decentralized. It has five "Expert Panels" on soil, foliage, increment, deposition, and crown condition. The Expert Panels also are supported by a Forest Soil Coordinating Center and a Forest Foliar Coordinating Center. In turn, each of these bodies produce technical reports for the ICP on Forests and the WG on Effects, so that there is extensive networking and information flow now occurring. Researchers and assessors in each participating country are brought within the ECE assessment process. As well, a number of "sub-manuals" on very specific technical topics (e.g., foliar analysis, deposition measurements, and soil chemistry analysis) have been prepared by the ICP on Forests.

This highlights the ways in which frames become embodied in assessment practices, as well as the ways in which debates over the meaning of forest damage have shifted from public arenas into technical fora, and assessment demands increasingly can be carried out only by those

countries with a strong and well-resourced research infrastructure. The new integrated ecosystem monitoring probably can be most effectively implemented by West European and Scandiniavian nations, therefore continuing the comparative exclusion of other European sub-regions from full participation in building up the "material culture" of assessment (cf. Miller, 1998). As seen in the country studies below, however, national forest inventories continue to be important for domestic constituencies and national policy-making agencies even in West Europe. They coexist with the ECE/EU assessment process.

In this shift towards the forest health frame, Finland, Norway, and Sweden have been key agents in the EU/ECE assessment process, in calling for greater use of critical loads in policy-making and analysis from the late 1980s onwards; and then for integrated ecological monitoring during the 1990s to support ecosystem-sensitive policy-making. Their normative, experiential, and political stakes differ from those of Germany and other Central European countries who still officially favor the forest die-back frame in national assessment and policy. The German federal government tends to favor a technology-based approach to rectifying forest damage (as in other environmental policy arenas: Liefferink and Anderson, 1995). As seen in the Germany case below, despite the sporadically flaring domestic debate over forest damage and the shift of many German scientists and assessors towards a sort of forest decline frame (or even a forest health frame, which might characterize Ulrich's work), Germany tends to retain forest inventories designed in terms of forest die-back.

Unlike Norway and Sweden, both of which experience significant forest and aquatic ecosystem damage, Finland has experienced comparatively little forest damage to date that can be traced to air pollution (see the Finland case below). Thus, both the forest decline and die-back frames do not resonate with Finnish experience. Nonetheless, Finnish scientists and policy-makers are somewhat concerned with the potential longer-term impacts of climate change, ozone, and acidification in interaction. Therefore, they have played important roles in building up the ECE integrated ecosystem monitoring system, to embed their interpretation of the precautionary norm into ECE assessment. Significantly, Finland manages the programme coordination center for the ICP on Integrated Ecosystem Monitoring, responsible for overseeing many of the activities under Level 3. Thus, while Finland does not participate much in the ICP on Forests, compared to Germany and the UK, it has rapidly growing influence on the ICP on Forests via its leadership in integrated monitoring.

As explored in the British case below, British scientists and policy-makers have long asserted that non-air pollutant causes are more important than air pollution in affecting forest health (or "tree health") within Britain. To some extent, this reflects experience with British forests, but also the domestic politics of resisting the changes in coal-fired power generation sought through early ECE policy-making (as manifested in the first sulfur protocol of 1985). British assessors have long relied on many more measures of tree crown condition and environmental variables than Germany and other ECE countries, and their work is closer to the forest health frame. Normatively, the frame does not oblige technology-based change, but supports a multi-causal agent policy-making process – which suits British policy-making. Therefore, to some degree, an evolving, loose political coalition between Finland, Britain, and the EU can be seen helping drive a shift towards the forest health frame, contrary to Germany's continuing preference for forest die-back in its national assessment practices.

Still, the whole ECE forest assessment system is still based around forest inventories. The more recent changes have simply accreted around the forest inventories, therefore preserving the normative, political, and experiential stakes held by earlier dominant agents, and adding the stakes of new entrants into the ECE institutional network. The initial, and adventitious, nature of forest surveys in the early 1980s shaped the institutional network greatly, as well as the information that became available for policy-makers. It is an example of how initial frames can affect the evolution of an assessment system. The growing complexity of the system conceals the variety of stakes held by the participants: under the apparent surface of "Europe-wide" agreement on assessment methods and frames, there can be widely differing interpretations and versions of frames between countries. This is further suggested by the summaries of the case studies below.

Forest Impacts in National Assessments and Local Knowledge.

As suggested by the increasing numbers of countries participating in ECE/EU assessments since the early 1980s, and their growing use of forest inventory and site-specific research standards, the ECE/EU assessment process has been important in shaping and communicating forest impact frames at a regional level. An extensive institutional framework and range of assessment practices have been built to help make sense of diverse and variable forest impacts via an "Europe-wide" perspective. Standardization has helped entrench and diffuse specific forest impact frames from the regional level into many national research and assessment programs. Many scientists and assessors, in the hundreds, now participate in one way or another in forest impact assessments.

Despite these developments, the ECE/EU assessments do not represent a homogenous knowledge shared by all countries and participants. Not only do the countries carry out their own national research programs and forest inventories, they also use their own skills and technical resources to interpret ECE/EU standards, according to their own impact frames, political priorities, and research histories. Within each country, there also may, or may not, be domestic debate over how to frame forest impacts. Depending on the specific circumstances, such as the presence of powerful non-state actors, the size of the scientific and technical expert community, or the institutional opportunities for challenging environmental policies, different countries vary in the extent to which domestic actors hold and negotiate differing frames.

Here, the national assessments of forest impacts performed in Finland, Germany, and the United Kingdom are briefly *summarized* in terms of their underlying frames. (**Figure 5** compares the forested areas, assessment details, and extent of defoliation as of 1996 for each country.) The aim in this paper is not to analyze the detailed history of frame development in each country, but to illustrate that there are often marked differences between countries in how they interpret frames, apply regional standards, and engage in domestic debates over forest damage. Instead of universally applicable knowledge, different countries have varying knowledge arising from both their local experiences, norms, and politics; and from how their institutions, practices, and cultures encounter the regional level.

Germany

Germany has long been one of the leaders in the ECE assessment process, and was the first country to institute a national forest inventory in 1982. It is one of the more forested countries in Europe, with forests covering around 29 percent of its land, and the forestry industry is a core part of the German economy. While the early forest surveys suggested a massive forest decline, measures of defoliation have remained relatively stable over time, ranging between 14 percent to a peak of 26 percent in 1992 (after the inclusion of East Germany) before decreasing to 20 percent in 1996.

The dynamics of frame development in Germany are unlike Britain and Finland. They differ in that there has been continuing domestic debate over frames among scientists, policy-makers, and non-state actors; there has been a shift from the forest decline frame to the forest die-back frame and then a shift back to a mix of forest decline and forest health frames among scientists; and the forest die-back frame remains entrenched in government and NGO practices even though the urgency of the forest damage problem has dissipated more broadly at the public level. Especially in Germany, non-state actors have been influential at times in framing forest impacts.

As Jager et al (1998) point out, German scientists and policy-makers were aware of the possible links between air pollution and forest damage from the early 1970s onwards. For example, studies in Bavaria in 1976 documented serious damage to pine forests. While Germany participated in the OECD LRTAP study between 1974 and 1976, it did not have a strong domestic acidification research and monitoring program in place until the mid-1980s. German scientists and government agencies first became interested in freshwater acidification in the early 1980s, with the federal Environmental Agency (UBA) beginning a large-scale study in 1983, long after Finland and the United Kingdom.

Similarly, large-scale forest research and assessment began later. Researchers at the University of Gottingen, led by Ulrich, were carrying out long-term ecological field observations in the Solling forest under the International Biosphere Programme. In 1979, the first results of the observations became available, and suggested that soil acidification caused aluminum toxicity and, therefore, forest decline. Most of this early research centered on soil chemistry and metal leaching, not on visible symptoms or ecosystem analysis. Therefore, the forest decline frame was dominant, although it tended towards viewing forest damage as largely caused by acidification.

It was not until 1981 that the media first picked up on the idea that catastrophic forest damage might be occurring. The story of how forest damage became a prominent public issue is well-known (see, e.g., Boehmer-Christiansen and Skea, 1991). What is significant is that non-state actors, the media, environmental NGOs, and forestry associations, played a major role in changing the dominant frame into a forest die-back frame. *Waldsterben* was the dominant image of acidification impacts in Germany, and initially drove forest assessment and research during the early 1980s. Forest damage was defined in terms of discoloring and defoliation. As suggested by Jager et al (1998), the dominant media images of forest damage in Germany were of leaf loss and yellowing. This highlights the experiential dimension of framing: the problem

was viewed in terms of the apparent sudden emergence of *new* damage that could be attributed only to sulfur emissions.

Following a hasty survey in 1982, the Federal Ministry of Nutrition, Agriculture, and Forestry (BML) estimated that forest damage affected 562,000 hectares, or 8 percent of forests. The second annual survey in 1983 found that forest damage had apparently increased to 2.5 million hectares, or 34% of forests, partly because of a more comprehensive study. Initially, the forest damage was officially described as *neuartige*, or novel, highlighting the theory that new causes (acidification) were at play. As explained in section 4.1, an elaborate forest inventory system was rapidly built up, embodying the assumption that acidification was the primary cause of forest die-back. In 1982, Peter Schutt, a prominent forest scientist, argued that biotic conditions were not responsible for the observed phenomena because of its rapid spread and novel symptoms within Germany as well as in Austria and Switzerland.

According to Agren (1998), there has been a strong domestic consensus among scientists, policy-makers, and lay people in Germany that forests were in serious jeopardy. By contrast, there has been continuing debate over the cause-effect relationships, and the data and methods required to determine these relationships. Officially, Germany has always been one of the few participating countries to assert in the ECE assessments that acidification (later, air pollution) is a primary, or predisposing, factor in forest damage. During the late 1980s, the ECE assessments consistently stated that "several thousands of hectares of forests on mountain tops are expected to die in the next 5 to 10 years." Trees in older stands on high elevations in Central Europe were, and are, the most adversely affected in Europe. This die-back frame has become deeply entrenched in the domestic norms and politics of German policy-making, even though the scientists and assessors have questioned die-back in the light of experience and ECE regional assessment results.

Nonetheless, there were significant domestic conflicts during the early 1980s over the causes of the forest die-back, centering on what air pollution emissions were involved, and on who the emitters were. Prior to the German government's policy-making and the European Union's Large Combustion Plant Directive of 1988, there were many domestic actors either carrying out their own forest surveys, or critiquing existing survey results. They included NGOs, federal government agencies, and state government agencies.

The German coal industry in the early 1980s took the view that acidification was not a major cause of forest die-back. For example, at a roundtable conference in 1982, the Hard Coal Association asserted that air pollution contributed five to ten percent of soil acidification, contrary to Ulrich's findings that at least fifty percent of soil acidification arose from air pollution (Jager et al, 1998). Other industry associations suggested that the forest damage was simply an outcome of insect attack since the 1960s. Conversely, the German Forestry Association published a report in 1984 claiming that the causes of *Waldsterben* were sulfur, nitrogen, and ozone emissions, which had synergistic effects. These varied interpretations suggest the existence of differing experiences of forest damage among domestic agents, even if

there was a shared political stake in the health of German forests, and thus differing norms (with regard to what needed to be done).

In turn, many scientists increasingly accepted the views that the causes of forest damage involved multiple pollutants and multiple pathways. This view grew out of the experience that forest damage differed greatly between regions in Germany in their causal pathways. Initially, researchers discovered that forest damage was greater on west-facing mountain slopes exposed to more rain and fog and perhaps acid deposition. Thus, many scientists assumed that acidification was the primary cause. Such correlation studies, however, were asserted by other scientists not to constitute proof of forest damage. Ulrich and others have long criticized German forest inventories as inadequate to deduce cause-effect relationships (e.g., Ulrich, 1991; 1995). During the early 1980s, Peter Schutt also was very critical of the deficiencies in national research and assessment activities. To some extent, the domestic re-emergence of the forest decline frame resulted from the participation of German scientists in the ECE assessment process, where the die-back frame was severely challenged by scientists favoring a multi-causal explanation. German scientists were able to examine the patterns of forest damage across Europe, on the basis of growing survey experience, and to identify variability that contradicted the single-cause explanation. In the light of *regional* experience, the forest damage in Germany could be reappraised more subtly. Evidence from other countries could be used to support domestic scientific arguments regarding the resurgent theories.

In 1985, an advisory research council was established by the German federal government to report on *waldschaden* (forest damage). It concluded in late 1985 that "There is no single type of forest damage and no single cause of damage. We are dealing with a very complicated phenomenon which is difficult to untangle and in which air pollutants have a very significant influence." The contributions of photochemical oxidants and the steadily increasing emissions of NOx from motor vehicles were increasingly recognized. From this point onwards, the "newness" of the forest damage diminished in normative and political significance. The forest decline frame was, again, becoming more influential in German research, if not necessarily in assessment and policy-making.

Reflecting the shift of many scientific experts to forest decline, in 1987, the German Council of Environmental Advisors pointed out that soil acidification was not assessed on a long term basis across Germany. The Solling forest remained the only locality where careful measurements of ion fluxes in a forest ecosystem had been made, even though Lander governments had carried out some studies in Bavaria and North-Rhine Westfalia. The dominant method of forest damage assessment was the forest inventory, reflecting the dominance of forest die-back among many policy-makers who funded the assessment, as well as the rapid institutionalization of die-back in assessment practices.

Germany was, and is, the dominant European producer of research into the forest effects of acidification. As well, Germany sponsors a number of collaborative projects with neighboring Central European countries, notably the Czech Republic and Poland.[23] This means that Germany's data and results are fundamental to the work of the ICP on Forests. While Germany carries out its national forest assessments, it also participates in the transnational and Pan-European monitoring activities of the ECE/EU process. This is an example of how national and

transnational surveys can coexist within individual countries. Significantly, German national assessments of forest condition have not fully conformed to the ECE/EU standards (see above).

In some countries, particularly Germany, the national surveys seem to have greater normative and political credibility than the transnational surveys – as is suggested by the recent domestic debates about the differing conclusions to be drawn from national and ECE/EU survey results. The German federal government, together with the loose coalition of industry, Lander government, and NGOs supportive of technology-based approaches to rectifying environmental problems, tends to favor the national survey results over those of the transnational surveys. Likewise, the British prefer their own national results, but will refer to the transnational results if they rely on criteria compatible with their forest health frame version. Even in Finland, where much attention is given to the ECE/EU assessment, the Finnish national forest assessment varies greatly from the ECE/EU standards.

Germany differs from most other EU and ECE countries in a key way. The federal Ministry of Nutrition, Agriculture and Forests did (and does) not conduct forest surveys, but has collected and assembled data from the surveys carried out by the forestry departments of the Lander governments since 1983. Thus, there is not much federal control over the process of carrying out national forest surveys, with the Lander governments having their own political and experiential stakes in the process. Individual Lander had begun forest surveys before 1982, with foresters in the Black Forest and in Bavaria filling out questionnaires on whether they had observed tree damage. After the first forest survey, some scientists criticized the Lander surveys as too subjective, and called for standardization through methods such as photographs (Schutt, 1982). From 1983, the federal government did not call on forest owners to provide estimates, but set up a sampling program carried out by the Lander, with specific criteria, standard photographs, and surveyor damage. The forest surveys are reported in *Waldschadenberichtes* (forest damage reports) annually.

Examples of the lack of conformity of German standards with ECE/EU standards include the wide variance in the sampling grids used by the various Lander until 1991, ranging from 4 x 4 km^2 to 16 x 16 km^2, despite the standardization pressures of the ECE assessment process. The new standard 4 x 4 km^2 grid used for national surveys still does not match that of the EU transnational survey (which has its own tree sample population, grids, and survey infrastructure, being overseen by the German Federal Center for Forests and Forest Products). As well, the German national forest surveys have focused on defoliation and discoloring, as was the case in the ECE surveys; but the transnational surveys require much more detailed investigation of soil, climate, and ecological conditions.

As seen in section 4.2, there has been a shift in the ECE assessment process towards a forest decline, and then a forest health, frame. This shift is not clearly mirrored in Germany, though it undoubtedly arose in part from the observations made by German scientists as to the multiple causes and pathways of forest damage. Scientists in other West European countries, particularly Finland and the United Kingdom, highlighted the role of climate, fungi, insects, and disease as causal agents in addition to air pollution. They also viewed forest impacts as

taking place in a broader ecosystem context. These views tend to be downplayed among policy-makers in Germany, together with the critical loads concept, which is based on ecological parameters, in favor of technology-based standards addressing air pollution. It appears that, while there are many studies on forest condition in Germany, they are not well coordinated, or linked to an ongoing national forest assessment process.

The forest die-back frame seems to be still highly influential among German policy-makers and many government assessors, even through the academic research community has moved towards the forest decline frame. This can be seen in the German federal government's rejection in 1996 of reforms to its damage classification scheme for its domestic surveys, proposed by the Council of Environmental Advisors. Thus, the forest die-back frame continues to be deeply embedded in domestic German assessment practices.

At the same time, the urgency of the forest die-back frame appears to have weakened greatly. In September 1997, the federal government officially released a forest inventory report that found improvements in forest condition, especially in eastern Germany. The Council of Environmental Advisors also does not mention acidification in its latest biannual report to the federal government in 1998. This is particularly noticeable, given the former dominance of acidification on the political agenda in the 1980s. In the 1990s, the domestic debate over forest damage is largely limited to scientific and policy circles, with some environmental NGOs such as Robin Wood participating as well. Disagreements over forest condition persist, as is shown by the reception in Germany given to a 1996 report by the European Forestry Institute.

In conclusion, Germany shifted from the forest decline frame to the forest die-back frame during the early 1980s, but has shifted back to the forest decline frame during the 1990s, at least among scientists and assessors. To a great extent, this mirrors frame developments in the ECE process. German domestic assessment practices and policy, however, still largely embody assumptions based on the forest die-back frame. While Germany has influenced greatly the standards and practices of the ECE assessment process, its influence has weakened in the 1990s. Other countries, notably Britain and Finland, have played increasingly influential roles in forest assessments, and have communicated their versions of frames via the ECE process.

The United Kingdom

The UK has long had an ambivalent attitude to the ECE assessment process. While the UK first established an acidification research program in the early 1970s, and began a national forest inventory in 1983, it rejected until 1986 the idea that policy measures needed to be taken on a regional (as opposed to national) basis. Even then, Britain has tended to be skeptical of the scientific and policy work of the ECE, being late to accept ECE forest assessment practices fully. With 9 percent of forest cover, the UK is among the least forested countries in Europe, and does not have a large indigenous forest industry (which differentiates its experience markedly from Germany and Finland, both of which are heavily forested and have a strong domestic forest industry). It imports over 80 percent of its timber needs from abroad. British surveys have had highly volatile results, ranging from 25 percent in 1988 to a peak of 58 percent in 1992, before a dramatic drop to 17 percent the following year, and to 14 percent in 1996.

In Britain, there has been only a low level of domestic debate over forest frames, virtually ending by the mid-1980s when a version of the forest health frame became dominant among scientists and policy-makers (Hajer, 1995). Unlike Germany, non-state actors were influential in shaping forest assessment practices only during the early 1980s. Since then, it has been the ECE/EU assessors who have helped to shape these practices, beyond the activities of the British scientists and assessors themselves. Therefore, there were few political and normative stakes held in the environmental effects of forest damage, as contrasted to the economic effects of policies targeting coal-fired power plants.

Britain has had a significant acidification research program since the early 1970s. Following the claims of long range transport of air pollution made by Sweden and Norway, British scientists (largely based in government departments and institutes) participated in the OECD project, and carried out extensive experimental work on the effects of sulfur and photochemical oxidants during the 1970s. This work included the use of open-top chambers with rye grasses and agricultural crops, unlike other European countries, but was left in abeyance from the late 1970s onwards. As well, British scientists began a long-standing collaboration with their Scandinavian counterparts, which culminated in the Surface Waters Acidification Programme (SWAP) begun by the Royal Society in 1984 and ending in 1990. Little monitoring of acidic depositions occurred until 1986; before then, there were many biases in the air pollution monitoring network, such as insufficient coverage of rural areas.

No monitoring of forest condition took place until 1984, when the Forestry Commission conducted a trial survey in response to the developments in Germany, the acidification impacts conference held in Norway in 1982, and domestic NGO pressures. This survey has evolved into a national inventory focusing on a broad cross-section of tree species, covering common, commercially vital, historically significant, and aesthetically important species. This survey became fully operational only in about 1988. Unlike Germany and Finland, the British national surveys have tended to include a broader coverage than commercially significant species, and to add trees found in urban areas. This reflects differing experience with forest management. Like Germany, the British have tended to rely on forest inventories as a major means of collecting data about forest damage, but have recognized the limitations of this method for understanding cause-effect relationships.

Compared to Germany, the scientific and technical community is significantly smaller, with relatively few key players. These actors are largely state-supported and include the Forestry Commission (which conducts both national and ECE surveys), the UK Acid Rain Review Group and the UK Terrestrial Effects Review Group (who act as national assessors), the Institute for Terrestrial Ecology (which conducts experimental work), and the Department of Environment (which commissions assessments). The major non-state actors have been Greenpeace and Friends of the Earth (who used to act as critics of the Forestry Commission), as well as the Imperial College, London (who are occasionally called on by the Department of Environment as consultants). This has important implications for the intensity and scale of domestic debate over forest impact frames, methods, standards, and forest inventories. Because the scientific assessment of forest damage is largely technical and dominated by state

agencies, or research bodies supported by the state, there is little deconstruction of claims about forest damage by either NGOs, or by scientific bodies reviewing assessment practices (as with the German Council of Environmental Advisors). Rather, the state-sponsored assessors have strongly shaped the domestic debate, with their norms, politics, and experiences tending to mirror government policies.

Like Finland, British scientists and assessors have had a comparatively strong domestic consensus over forest impacts. Since the mid-1980s, the United Kingdom has emphasized the concept of "pollution climate" in terms of evaluating the interactive effects of pollution loads, rather than focusing on any particular causal pathway or impact. "Tree health" has been the dominant frame, with assessment aimed at understanding the state of tree health, which is not explicitly defined in ecosystem terms (unlike Finland, whose version of the forest health frame has stressed an ecosystem view). This frame is a version of the forest health frame. Unlike Finland and Germany, there is not much interest in soil chemistry; ambient exposures and ecological parameters attract most of the researchers. The forest die-back frame has never been dominant, even during the early 1980s when it dominated in the ECE, and has been held only by the few environmental NGOs interested in acid rain issues (mainly in the mid-1980s). Even in the late 1980s, Britain's dominant forest health frame differed from that of the ECE's forest decline frame, in that Britain focused on non-pollutant causes as well as pollutant causes. The ECE assessment process has moved closer to British views during the 1990s in this regard, but has also shifted closer to the ecosystem views of Finland, Sweden, and Norway.

Two reports by the UK Terrestrial Effects Review Group in 1987 and 1993 have been influential in shaping the domestic forest health frame. This group concluded, in both reports, that there was no evidence of a widespread decline in crown condition in Britain, though tree health might be inferior compared to other ECE countries. The effects of air pollution could not be separated readily from other causal agents via surveys, so forest inventories could not be used to prove cause-effect relationships. The Terrestrial Effects Review Group emphasized that many agents other than air pollution cause forest damage, especially climate and soil conditions, as well as biotic agents like fungi and insects. They also highlighted the deficiencies in experimental evidence, soil acidification assays, and case histories. It was normal for trees to show signs of past or recent damage. Nevertheless, air pollution could be *a* factor adding to the environmental stresses on forests.

The main instance of an intense domestic debate over impact frames is the challenge posed by Greenpeace and Friends of the Earth to the Forestry Commission's survey methods in 1985. Following the Forestry Commission's first survey, these NGOs brought German forest experts to the United Kingdom to carry out independent surveys on their behalf. Significant gaps and flaws were identified in the Forestry Commission's approach (e.g., inadequate sample coverage, unclear thresholds for forest damage), and were widely publicized in the British media (Rose and Neville, 1985). As a result, the Forestry Commission introduced more rigorous standards and greater transparency into its survey methods. This, however, did not lead to the acceptance of a forest die-back frame by government officials and academic researchers – unlike Germany, where non-state agents seem to have been highly influential in shaping domestic politics during the mid-1980s.

Like Germany and Finland, British scientists and assessors have taken up the ECE/EU standards in carrying out transnational surveys, but also continue to diverge markedly from these standards in performing national surveys (which are tacitly considered as more informative and credible by British policy-makers). They have shaped the ECE/EU standards in their own right, following German dominance of the ECE assessment process in the 1980s, yet also continue to regard these standards warily in favor of their "local" interpretations of what science is needed to address policy-maker needs. The forest health frame held by many British scientists and assessors was one of the key influences on the ECE assessment process from the late 1980s onwards. While German assessors largely focused on multiple air pollutants, their counterparts in Britain and other leading ECE countries seem to have concentrated on multiple *non*-air pollutant causal agents. This has important normative and political implications, and reflects domestic political motivations. This focus on non-pollutant causal agents was taken up by the ECE assessors in the early 1990s, when they changed their assessment criteria to include observations of visible and invisible damage agents other than pollution (see section 4.2).

Conversely, the ECE process has influenced forest assessments in Britain to some extent. As in the broader LRTAP context, Britain has had a history of questioning and resisting ECE standards and practices. This can be seen in the ways in which British assessors have changed their standards at several points during the late 1980s and the early 1990s, leading to high volatility in inventory results (and demonstrating that survey results depend fundamentally on the standards employed). For example, Britain had a small national survey until 1991, hovering around levels of 1800 sample trees and 75 sample plots, but covering the country's entire forested area. Until this point, British forests were regularly rated by national assessors as among the most seriously affected in Europe, ahead of Germany and Finland, even though their relative coverage is one of the smallest in Europe. Between 1990 and 1992, under the influence of the ECE/EU standards and transnational surveys, the British forest inventory rapidly expanded to some 8800 trees on 370 plots. These levels have remained stable since then. Britain had 16 x 16 km^2 national survey grids between the early 1980s and 1991, when grid sizes became *randomized* – contrary to the transnational survey sizes of 16 x 16 km^2. As a result of the technical changes in 1991, overall defoliation dropped from 59 percent in 1991 to 17 percent in 1992.

Significantly, as shown in the UK Terrestrial Effects Review Group report of 1993 for example, British assessors have been preoccupied with how the UK compares with other ECE countries. While noting that the ECE/EU sample plots and sizes do not enable inferences about cause-effect relationships, and that UK surveyors tend to record significantly higher rates of foliar loss (12% more compared to French teams, 6% more compared to German teams), they suggest that "the most recent UN/ECE survey of tree health in 1991 cannot be discounted."

It is clear that British assessors emphasize the need for greater scientific rigor. They represent their research and assessment activities as more advanced than in most other ECE countries. "For example, Forestry Commission surveyors assess crown density more pessimistically than surveyors in France, Germany, and the Netherlands" (UKTERG, 1993). Interestingly, the UK

Terrestrial Effects Review Group held Switzerland's standards up as an appropriate model for British forest assessments, which were adjusted to Swiss standards in 1987, resulting in a deterioration in forest condition between 1985 and 1987. As well, the British assessors claim to have developed at least thirty different measures of crown condition by 1989, "enabling a much more detailed assessment of crown condition than is possible in the standard European survey" (UKTERG, 1993). Various other "extra" measurements have also been taken by British scientists. In this way, the British assessors have emphasized their own skills and knowledge in contrast to that of the ECE assessors as a whole – which affects how the ECE/EU frames are interpreted and applied in Britain. A distinctly "British" version of the forest health frame can be detected in British assessments.

In conclusion, the UK has been relatively impervious to frame developments at the ECE/EU regional level, since it has consistently questioned ECE standards, and has had a version of the forest health frame (without an ecosystem perspective) from the 1980s onwards, in contrast to the ECE/EU frame swings. British assessment practices and research activities are less patterned on forest inventories than in Germany, but still have been somewhat influenced by ECE/EU standards, as well as shaping these standards. With the expansion of the ECE regional assessment practices, British assessors appear to have influenced their design in terms of multiple causes, not just air pollutants, and in demanding greater site monitoring to identify cause-effect relationships. While adopting the ECE/EU standards, British assessors diverged markedly from these standards in carrying out their national surveys, adding features that are normatively and politically important in a context of continuing tension with European institutions such as the ECE and the European Union.

Finland

Until the 1990s, Finland had played a relatively low profile, but important, role in ECE assessments of acidification impacts and policy-making, especially within the Nordic Council arena. It is the most forested country in Europe, with a forest coverage of 66 percent. of its land, and the forest industry is the largest economy sector by far. Finland's forests have remained relatively stable in their condition, decreasing from a peak of 18 percent in 1988 to 13 percent in 1996 (in common with Britain, another nation where the experience of forest damage differs greatly from Germany). Finland has had a forest health frame (with a strong ecosystem flavor) since the mid-1980s, and to have participated extensively in the ECE/EU integrated monitoring scheme as well as the ICP on Forests. Non-state actors, such as the media and environmental NGOs, have played virtually no role in these developments (Agren, 1998).

Although Finland has participated in the Nordic Council since the 1970s, and has keenly followed developments in acidification science and policy, it did not establish a large-scale research and assessment program until 1985, when the Finnish Acidification Programme (HAPRO) was set up. As well, environmental policy was not given much attention by the Finnish government until the mid-1980s; the HAPRO program was the first major environmental research and policy initiative (Andersen and Liefferink, 1997). HAPRO was a single comprehensive research program between 1985 and 1990, resulting in a large assessment report in both Finnish and English (Kauppi et al, 1990). Since then, there has been

little large-scale assessment activity on a domestic level, and domestic attention has shifted to participating in the ECE assessment process, especially following Finland's entry into the EU in 1995.[24] Most of the Finnish research and assessment activity is designed as a contribution to the ECE process, whereas German and British counterparts carry out their own work, not necessarily connected to the ECE process.

HAPRO focused on a relatively small range of acidification impacts, mainly deposition, forest ecosystems, and aquatic ecosystems. This reflects the research history of Finland, which concentrates more on ecosystem and tree morphology effects than on soil chemistry and cation diffusion. Forest damage is officially stated as negligible to date, though there are localized patches, and there is concern that damage may be synergistic and cumulative. Most of the forest damage identified by the national and ECE/EU surveys is found in two regions: in the South-West where most of the population resides; and near the Kola Peninsula. These highlight the experiential and normative dimensions of Finnish interpretations of forest damage, which seem to have shaped Finnish domestic debates more than political factors. Finnish agents tend to use experiential baselines based on a very long sequence of forest surveys dating from the 1920s, and therefore do not see forest damage as "new" in the way that German agents did in the early 1980s (without any such historical baseline).

Key findings of HAPRO included the importance of biotic and abiotic factors other than air pollution in forest damage (Nevalanein and Ylu-Kojola, 1990). The Finnish assessors focused on "forest vitality" and criticized the ECE assessments for focusing excessively on air pollution as a primary causal agent. To some extent, fungi, elk, wind, and frost were implicated as significant causal agents in forest damage (though not insects). Extensive research also was carried out on the dynamics of forest growth via observations and modeling (Hari et al, 1990). Attention was given to explaining the historical growth of Finnish forests since the 1950s, using forest records since 1922 when the first National Forest Inventory was begun (Nojd, 1990). It seems that HAPRO led to a domestic rethinking of forest impacts in terms of the synergistic and cumulative effects of acidification, climate change, ozone depletion, and land use patterns – departing from the ECE frames of forest die-back and decline.

As stated in the HAPRO report, the Finnish government was, and is, primarily concerned about preserving the viability of Finland's commercial forestry operations. The idea is that a precautionary approach needs to be taken to guard against the possibility of long-term cumulative damage to Finnish forests, given that emission and deposition rates are low and readily masked by natural variations. This is in line with a forest health frame. Finland initially treated forest damage in terms of a multi-stress view, but shifted to a concept of ecosystem health from the early 1990s onwards. Unlike the UK, there is little mention of tree health (that is, individual trees compared to forest stands).

Compared to Germany and Britain, a small number of state-supported scientists and assessors are involved in forest assessments. Two government research centers are the leading assessors: the Finnish Environmental Institute (VYH) and the Finnish Forest Research Institute (Metla). Metla, especially, has focused on large-scale forest damage surveys since the early 1980s with

the aim of understanding cause-effect relationships through intensive, multi-layered monitoring and statistical analysis (like the new ECE system described in section 4.2). This includes regional studies in Lapland, West coastal Finland, and Karelia as well as studies at some permanent sample plots (Lindgren, 1998). Environmental NGOs do not play any influential role in Finland with regard to acidification issues. Thus, unlike Germany or Britain (during the mid-1980s), non-state actors do not shape domestic debates over how to interpret forest damage, which affects the ways in which domestic frames might be negotiated or reconstructed within Finland. As an example, the development of the new integrated monitoring and assessment approach has taken place in a highly technical context, without much connection to lay public or politician debates.

Unlike Germany and the UK, Finland (which is an unitary state like the UK) does not carry out annual national-wide surveys, though it conducts the ECE/EU surveys annually. The National Forest Inventory has been carried out every six or eight years since the 1920s, highlighting commercial forests. This survey did not cover all the regions until the 1990s. There are different sampling methods depending on the nature of forests: the forests in the northern regions are sampled by aerial photographs because they are less commercially valuable. In 1985, a network of 3000 permanent sample plots was established to cover Finland systematically, using a grid of 16 x 16 km in southern Finland and 32 x 24 km in northern Finland. Complete surveys are now made every five years. This highlights the ways in which Finnish assessors and forest managers preserve their local knowledge in the face of regional standardization.

While Finland carries out transnational surveys for the EU, it gives greater priority to national surveys for domestic policy-making purposes (like Germany and Britain). Possibly, these differences reflect the ways in which assessment practices have become entrenched in Finnish government institutions and culture, revealing the role of domestic experiential, normative, and political stakes. Government agents and forestry industry operators prefer to retain the established system; they are used to the experience of little forest damage; and they believe that the survey process is how forests should be monitored. This is similar to the situations in Germany and Britain.

Finland, however, has become a leading player in the ECE/EU regional assessment process during the 1990s, and consequently has promoted its forest health frame regionally, in contrast to Germany's formerly dominant forest die-back frame (Lindgren, 1998; Johannson, 1998). It has supported the expansion of the ECE/EU assessment practices to include integrated monitoring, covering tree growth, cell chemistry, soil and climatic condition, among other targets. It also has encouraged integrated modeling, ecosystem modeling, and database linkages. These practices reflect the Finnish interest in trying to identify and track the synergistic and cumulative effects of acidification, climate change, ozone depletion, and land use patterns. From the perspective of Finnish scientists, forest inventories do not address these effects. Unlike Germany and Britain (which are only beginning to establish their own programs), Finland has had its own national integrated ecosystem monitoring program since the beginning of the 1990s, well before the ECE/EU assessors took up the concept of integrated ecosystem monitoring from 1995 onwards. Importantly, Finland manages the focal coordination center for the ICP on Integrated Ecosystem Monitoring.

Here, Metla is said by Finnish scientists to be influential, since it has active members in all expert panels of the ICP on Forests, as well as in the task forces for the ICPs on Forests and Integrated Monitoring. According to Finnish scientists, "Because of the strong involvement of [Metla] in both ICPs, Finland has had a significant effect on the harmonisation and standardization of the ICPs internationally." Finland seems to have a key political stake in spreading its normative approach to forest assessment throughout the ECE/EU process, linking up with the multi-causal agent and forest management themes of Britain and the EU respectively. Instead of performing its own national acid rain-centered assessments, Finland has built up a new "material" network, and sought to leverage it into the ECE/EU network as a whole, accreting around the older forest inventories favored by Germany.

In conclusion, Finland is not particularly concerned about forest damage except in terms of possible long-term synergistic and cumulative effects that might have economic consequences for the Finnish forest industry. It has had a strong ecosystem-based forest health frame, similar to the frame now promoted by the European Commission in its forest programs, since the mid-1980s. With a high level of domestic consensus on the forest health frame, and a small but deeply engaged scientific and technical community, Finland has become influential in the ECE/EU regional process in the late 1990s, leading the ECE/EU's shift towards forest health and integrated forest monitoring.

CONCLUSIONS

The history of forest assessments in Europe reveals that forest impact frames have undergone significant change in some regards, but also have remained stable in other regards, between 1983 and 1998. Frames of forest decline, forest die-back, and forest health have appeared as ways of interpreting the diverse, variable, and messy phenomena of forest damage. They have markedly influenced how and what knowledge about forest impacts has been produced by national and regional scientists and assessors over this period. Some key conclusions drawn from this paper are:

- **Frames have significant experiential, normative, and political dimensions.** The nature and implications of frames can not be separated from the experiences, norms, and politics of the agents creating the frames. They help agents organize the complex, fragmented, and variable effects of acidification. Especially in a multi-layered regional system, frames are associated with important stakes and audiences, and may co-exist with each other. Frames can embody assumptions about how forest damage should be viewed and responded to in policy-making terms. For example, the forest die-back frame stresses the newness and catastrophic nature of forest damage in visual terms, and suggests normatively that urgent policy action is needed to reduce sulfur emissions. Due to domestic politics, Germany communicated the die-back frame via promoting forest inventories at the ECE regional layer. Consequently, the information produced about forest impacts tended to focus only on a small number of visible tree symptoms, and on an ad hoc analysis of each country. This may have encouraged particular interpretations of the problem of forest damage, as

well as specific approaches to policy-making over other possible kinds (cf. a sulfur emission reduction protocol with the multi-pollutant, multi-effect protocols now being developed by the LRTAP regime, or the forest management approach of the EU).

- **Frames can undergo significant reconstruction, or fluctuate in their dominance, within regional and domestic arenas over time.** Which frame prevails in a country or a regional forum at a particular point in time can have important implications for the agents' influence over science and politics. The dynamics suggest that there have been non-linear, non-progressive "swings" between different frames at specific points in time with regard to their dominant influence on ECE assessments. Such swings may be linked with changes in variables such as key agents, interpretations of scientific data, domestic politics, or competing institutional networks. This paper has touched on some of these variables. In particular, at the regional level, the dominant frames have shifted from forest decline at the end of the 1970s, to forest die-back during the early 1980s, then back to a version of forest decline in the late 1980s, giving way to forest health during the 1990s. By contrast, frames have been more stable in some ECE countries during this time, notably Finland and Britain, both of which have favored versions of forest decline and forest health. This has had important implications for the nature of information produced regionally and nationally over time, since the extent to which frames undergo critique based on norms, experiences, and politics can matter greatly.

- **Forest damage frames are embodied in assessment practices and discourses.** They are not simply cognitive in nature, but can become entrenched in assessment practices, institutions, and research programs over time. For example, forest die-back was associated with visual tree symptoms and forest inventories, whereas forest health involves an elaborate integrated ecosystem monitoring system. Therefore, assessment practices and discourses can be significant indicators of frames. It is crucial to look at the building up of assessment practices over time, in both regional and national arenas. Information can not be separated from the practices that gave rise to it.

- **Standardization is an important process in communicating frames across a region.** What is striking about European forest assessment is the extent to which regional assessors have engaged in an ongoing process of building up an increasingly complex, technical, and decentralized institutional system based on standardization. Regional assessors may generate new frames from the data and analysis produced by the regional assessment, and communicate these frames to participating countries via changes in standards and regional aggregation of the data. For example, the ECE/EU assessors have sought to standardize forest inventories across Europe, especially via the new transnational survey system, to improve comparability of damage between countries. Latterly, they also have tried to standardize intensive research and integrated ecosystem monitoring protocols to enhance the ability of scientists to draw conclusions about cause-effect relationships in a world where a multi-causal agent theory has become dominant. Information about local interpretations of problems, effects, or policies can be tacit or downplayed in standardization efforts – therefore pushed under the surface of an "universal" system.

- **Identity-building also may be an important process in communicating frames across a region.** A key factor that seems to underlie the forest assessments of Europe is the ways in which European institutions, such as the European Union or the United Nations ECE, promote understandings of "European" identity via their decisions about who to include in reporting survey results, or what can be considered "valid" science and policy in the acidification debate. While this factor is diffuse, it may be seen in the trend towards building transnational surveys and the Pan-European Programme on Integrated Ecosystem Monitoring, vis-a-vis the national surveys that dominated in the early efforts of the ECE regional process. To some extent, this is associated with the shift in framing acidification issues from "local air pollution" to "transboundary pollution" (Keating and Farrell, 1998).

- **Initial developments in frames can affect the organization of assessment processes over time.** Forest inventories are still at the center of assessment practices, especially in Germany, reflecting the forest die-back frame. However, the subsequent emergence of new agents and political coalitions, norms, or experiences can mean that new institutions, practices, and interpretations accrete around the original system, making it ever more complex – and capable of satisfying the political, experiential, and normative stakes of the many actors in a multi-layered regional system.

- **A regional frame does not mean that there is universal scientific knowledge in the region.** While standardization can promote greater comparability of data, methods, and frames between the multiple agents active in a regional assessment process, it can also coexist with extensive "local knowledge" in particular countries. Each country produces its own scientific and technical information to varying degrees (depending on its resources, political stakes, and research traditions). As well, the politics and entrenchment of existing assessment practices in a particular country can be in tension with "regionally" promoted frames. Different countries have varying knowledge arising from both their local experiences, norms, and politics; and from how their institutions, practices, and cultures encounter the regional level. The extent to which knowledge about forest impacts is shared among scientists, assessors, policy-makers, non-state agents, and lay people is, therefore, highly contingent.

These developments all have important implications for the nature of information about forest impacts that is produced by assessment processes in Europe. They shape what kinds of information is generated by, interpreted, or sought by scientists and policy-makers. In short, this paper shows how environmental information can not be separated from the assessment practices and frames that helped shape its character. To adequately evaluate information from policy-making, assessing, or researching perspectives, it is important to look at the history, practices, and frames that form the context of the information.

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FIGURES

Figure 1: Forest Impact Frames in ECE Assessments

Frames	Cause-Effect Assumption	Research Priorities	Data and methods
forest die-back (~1982 to 1987)	air pollution (sulfur) is primary cause of forest decline in Europe	extent and nature of tree damage; rate of change; tree and stand death; correlation between deposition and effects;	Forest surveys; defoliation;
forest decline (~1970s to 1981) (~1987 to 1992)	air pollution (sulfur and nitrogen) is one of primary causes of forest damage; damage in some or many countries	extent and variation of tree damage; soil chemistry; interaction with age, species, climate; root and leaf morphology; soil chemistry studies; comparative damage rates between countries; ratings of countries	national forest surveys; standardized methods; exposure experiments; defoliation; root studies;
forest health (~1992 to date)	air pollution (sulfur, nitrogen, ozone, and others) is predisposing factor in some countries or localities, contributing factor in most countries and localities	Specific role of air pollutants; vulnerability to pests, diseases; ecosystem conditions; Europe-wide data site-specific parameters;	transnational forest inventories; integrated monitoring; common tree samples; time series; defoliation and discoloring; root studies; ecosystem modeling;

This table simplifies a complex, overlapping, and heterogeneous range of frames. Often, different features from different frames will coexist within the same country, institution, or actor. The table does not imply causal linkages, but highlights broad patterns that seem related. Different features may emerge at different times. The periods given for each frame refers to the time when the particular frame appears to have dominated at the regional level. Individual countries may have dominant frames differing from the regional frame at various times.

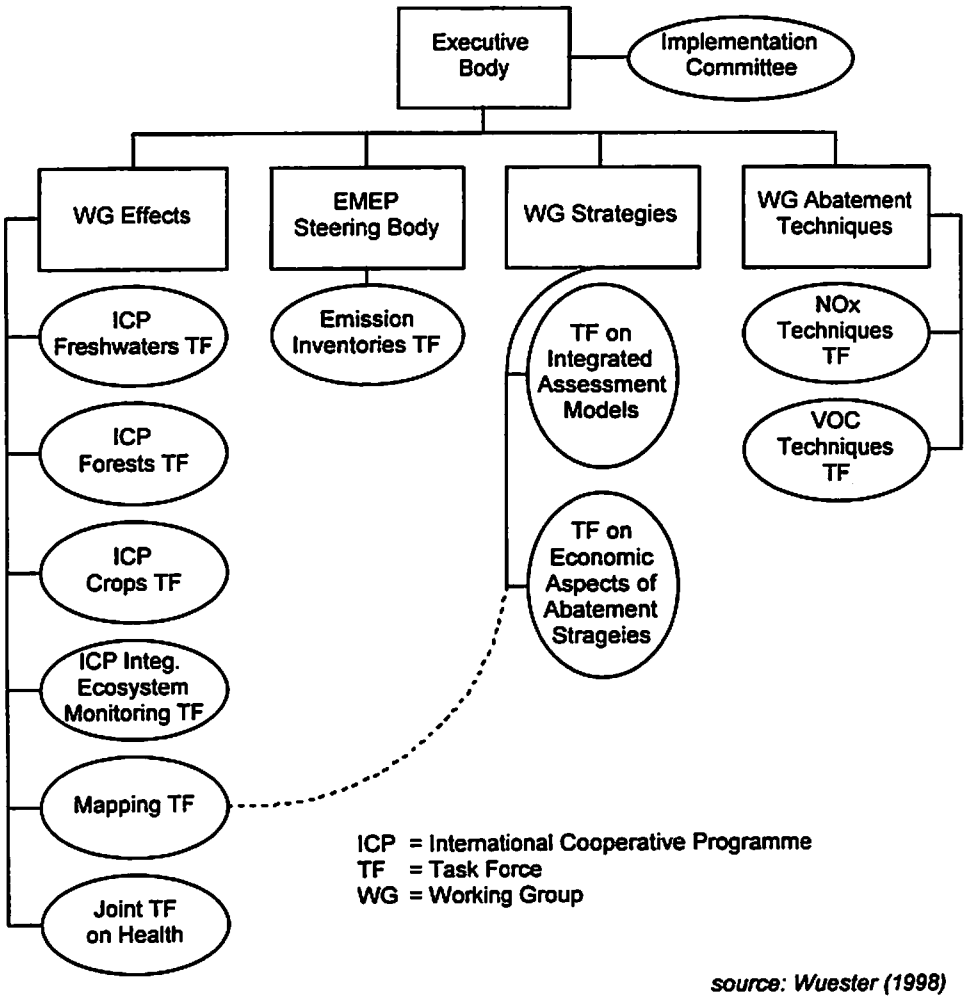
Frames Actors and Institutions Policies

forest die-back national researchers; participation in ECE
NGOs; forestry commissions; and LRTAP Convention;
public sub-national and national
forest surveys and
research programs; negotiation
of protocols based on flat
reduction targets;

forest decline ECE WG on Effects; participation in ICP on Forests;
ICP on Forests; national national forest surveys;
researchers and assessors; negotiation of protocols based
national focal centers on critical loads;

forest health European Union; transnational forest surveys;
ECE WG on Effects; national forest surveys;
ICP on Forests; Expert Panels; participation in ICP bodies;
Focal national centers; negotiation of multi-pollutant,
multi-effect protocols based on
critical loads; sustainable forestry

Figure 2—LRTAP Organizational Chart



source: Wuester (1998)

Figure 3: Types of Forest Impacts

Direct impacts/pathways/imtermediate causes

leaf/needle surface damage from acidic deposition

absorption through cuticules and stomata

tissue composition

leaf/needle morphology

cellular processes

Indirect impacts/pathways/intermediate causes

root morphology

nutrient uptake: roots, amount and composition

water uptake: roots, amount

leaching of soil nutrients, metals

soil acidity and movement of acid ions

soil microbial activity

vulnerability to climate, pests, weather, diseases (natural causal agents)

trunk wood and bark

Figure 4: Country Comparison in 1996

	Finland	Germany	United Kingdom
Total area	30.46 m ha	35.56 m ha	24.10 m ha
Forested area	20.03 m ha	10.19 m ha	2.16 m ha
Proportion of forested area:	66%	28.86%	8.96%
Forested area surveyed:	15.30 m ha	9.46 m ha	2.16 m ha
Number of sample trees:	8732	62421373	
Number of sample plots:	4552627	8952	
Grid size:	16 x 16 (south/Europe) 24 x 32 (north)	16 x 16 (Europe) 4 x 4 (national)	random
Extent of defoliation of all trees (classes 2 to 3):	13.2%	20.4%	14.3%

[compared to Netherlands, 34.1%; Italy, 29.9%; Poland, 39.7%; France, 17.8%; Czech Republic, 71.9%]

Note: the figures above are extracted from the 1997 Executive Report on Forest Condition in Europe (BFH, 1997).

ENDNOTES

[1]Assessment processes are social processes that synthesize, review, and communicate scientific, policy, and technical information between scientists, assessors, and policy-makers regarding environmental problems. They can take numerous forms, including scientific panels, interdisciplinary collaborations resulting in reports aimed at informing policy-making institutions, literature reviews, journal publications of research, workshops and conferences, or briefings of decision-makers by scientists. They are not confined to documentary form. In this research project, I study the forest impact assessments carried out by the United Nations Economic Commission for Europe (ECE) that feed into the decision-making processes of the Long Range Transport of Air Pollution Convention. As well, I study the forest impact assessments performed by assessors in Finland, Germany, and the United Kingdom.

[2]Assessors are technically qualified people, mostly scientists, who direct, participate in, and communicate the results of assessment processes. In my research, I focus on the scientists who participate in the ECE and European Union assessments of forest conditions, as well as in Finnish, German, and British programs. These scientists tend to constitute a mix of disciplines: forest ecology, biology, toxicology, soil chemistry, and others. Thus, disciplinary perspectives play a key role in forest condition assessments, but I do not investigate the nature and role of these perspectives, due to my focus on impact frames.

[3]This is an extremely simplified version of some of the views that prevailed during the early 1980s, and is meant only to illustrate the possible effects of framing.

[4]These frames will be tested via further interviews with key participants in forest impact assessments during the 1980s and the early 1990s.

[5]This paper needs to be read in parallel with VanDeveer (1998), who discusses the role and influence of the "periphery" countries in Central and Eastern Europe within the LRTAP process. This paper focuses on the West European "leaders" in the LRTAP process; nonetheless, it reveals that even among these leaders, there are significant differences in the influence of each country on the evolution of forest impact frames in the ECE.

[6]The lack of standardized methods and data does not necessarily stop the regional assessment process from aggregating impact assessments from particular countries, nor from creating a ranking system that implicitly compares the severity of impacts between countries, as happened in forest condition assessments in Europe.

[7]Standardization does not imply that there must be a "central" body that supervises standard-setting and that communicates standards to participants. There could be relatively decentralized regional assessment institutions in place, as in the LRTAP system. Rather, there is a web of activities promoting a "regional" perspective, and enrolling many scientists and assessors from individual countries in the regional process.

[8]As Schon and Rein (1994) point out in the different context of policy frames, "institutional frames" are not single and coherent, but can include a range of frames that are used by actors at different levels, or with regard to different features of the problem at hand.

[9]For example, Leen Hordijk (the Netherlands) and Christer Agren (Sweden) suggest that the frames are plausible. It is my intention to further test the frames in additional discussions with forest experts in Germany, Finland, and the United Kingdom.

[10]Excellent overviews of the development of acidification research and assessment can be found in Cowling (1982) and Nilsson and Cowling (1991). Thus, I extract only the aspects that bear on my research questions.

[11]Note that there was already a strong link between exposure to sulfur at emission points and vegetation damage, known for many decades. However, there were weaker links with regard to long-range transport of sulfate particles.

[12]It seems that the Executive Body tends to accept the scientific and technical reports of the WG on Effects, as with other WGs, as the state of the art: Jhaveri et al, 1997. Unfortunately, there are relatively few documents from the WG on Effects that reveal much about the debates that occur in the WG and its sub-groups. Thus, extensive interviews to draw out the understandings and institutional memory of the participants are needed, if the role of domestic frames in the WG's deliberations is to be adequately explored. This will be part of future research activities by the author.

[13]The participation of Eastern and Southern European countries in the WG on Effects as well as its various ICPs and Task forces is very limited, partly because of funding issues (van DeVeer, 1998). Inadequate funding, national research programs, and monitoring networks are significant impediments to this participation. For example, in the ICP on Freshwaters, 4 out of 18 countries were Eastern European in 1995. In December 1996, the Executive Body noted that broad areas of Southern and Eastern Europe were not covered by monitoring stations.

[14]Specific details can be found in Nilsson and Cowling (1991).

[15]While critical loads are widely accepted, they have been criticized by some commentators, particularly in Germany and Britain, both of which do not adopt the forest health frame: see Patt (1998) for an overview. It seems important that critical loads are apparently related to ecosystem conditions, and therefore harmonize with the forest health frame. A question is whether, and to what extent, the forest health frame helped construct the ecosystem perspective in which critical loads are embedded.

[16]Freshwater impacts would constitute an interesting comparative case study in combination with forest impacts. While there is still extensive uncertainty and debate among scientists, assessors, and policy-makers over the character and cause-effect relationships of forest impacts, the science of freshwater impacts appears to be relatively settled.

[17]As the ECE assessors stated in 1985, "trees themselves are available as biological indicators. The visible symptoms allow a quick overview of the extent of damage, but need not necessarily be related to any specific pollutant or to air pollution in general. On the other hand, leaf and needle analyses are sufficiently specific indicators of pollutants" (APS 2, at paragraph 90).

[18]Even in 1985, the ECE emphasized that recording the extent of tree damage does not indicate possible causes of damage. "Reliable assertions about damage causes may be expected only when [surveys] have been combined with air analyses and deposition measurements" (APS 2, at paragraph 98).

[19]About 300 scientists from 17 countries participated; Scandinavia, North America, and Britain dominated the participation. Germany and Finland were not well represented.

[20]Significantly, the WG on Effects declared that "there is a need for closer contacts at the bench-level between the teams in the different countries concerned with the effects of atmospheric pollutants on terrestrial ecosystems. It is recommended that small informal study groups ... should be formed" (APS 1, 1983).

[21]Even then, the WG on Effects stated: "the recent widespread forest damage is presumed to be caused by a complex set of factors whose relative importance varies according to site conditions." Natural stress factors at small and large scales could explain the heterogeneous occurrence, appearance and intensity of forest damage across Europe. It was difficult to identify damage process because several pollutants, many individual and synergistic mechanisms, and direct and indirect effects were involved. There was a lack of internationally harmonized methods for damage assessment. Thus, the WG on Effects had two frames coexisting at once, with the forest die-back frame beginning to become dominant at this time.

[22]Importantly, the 1997 ten-year review of ECE forest assessments reveals that, even with training and "rigorous improvement," a maximum agreement of 30% between two observers is likely. If a difference of 5% defoliation is allowed, the agreement increases to 60%, and if the difference is 10%, the agreement further increases to 80%. The review notes that detection of discoloring is vastly worse. See BFH, 1997.

[23]It was German-supported research in 1996 that revealed that forests in the Czech Republic were seriously affected.

[24]Note that a large project on global climate change followed HAPRO, occurring between 1990 and 1996, and that the assessment priority currently has shifted to biodiversity.

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