CHAPTER 4

Multiple Use Forest Management in a Catchment Context

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4.1 Introduction

Over the past several decades there has been an acceleration of needs, uses, and expectations of forest lands in many countries. Indeed, foresters in the US are faced with exciting opportunities to provide answers on complex issues of planning, policy, and science related to multiple use management. Integrated catchment management provides a powerful analytical framework for evaluating alternative mixes of forest uses across multiple scales of spaces and time.

In addressing this topic, the objectives in this contribution are: 1) to briefly review the history of multiple use forest management on public lands in the US.; 2) to illustrate, with examples, past and present approaches to multiple use management in a catchment context; and 3) to suggest promising approaches, methods, and technology to meet future needs. Present concerns and issues related to multiple use forest management have previously been reviewed for Great Britain (Innes, 1993) and for the United States (Kessler *et al.*, 1992, Swank, 1995). In fact, the literature is replete with essays on our "state-of-affairs" and what we should be striving to accomplish. Less evident are recorded efforts to meet the more important need for application and testing of current theory on real-world forested landscapes. However, there is a reason to be optimistic about the future as reflected by conferences such as the one whose proceedings constitute this book (and related field trips to project areas), and recently published findings on perspectives of ecosystem management (Ecological Applications, 1996; Swank and Van Lear 1992).

4.2 Multiple Use Management on Public Forest Lands

The roots of multiple-use management are deeply embedded in USDA Forest Service philosophy, policy, and programs in the management of public forests and grasslands. This was true informally in the early history of the agency, created in 1905, and formally since enactment of the Multiple Use Sustained-Yield Act in 1960. The Forest Service mission is to care for the land and serve people with a mandate to provide sustainable multiple benefits to the public through proper management and use of natural resources. These benefits include clean water, abundant fish and wildlife, a sustainable supply of wood and paper products, quality environments for outdoor recreation, wilderness and scenic rivers, supplies of energy and minerals, forage for livestock, and development of human resources.

The mix of uses and benefits has evolved in response to changing public needs, new legislative mandates, advances in technology, and improved scientific information. Controversial issues are attendant in this evolution; in fact, controversy has long been a trademark of public land management. For example, controversy about the role of forests in regulating the flow of navigable streams produced the statutory authority for the Weeks Act of 1911, which allowed the Federal government to purchase private lands for National Forests in the eastern US. The primary forestry issues on public lands from the early 1900's to about 1930 were related to fire protection, reduction of timber theft, and overgrazing of rangelands. The period of World War II and post-war years through the early 1950's entailed an increased demand on the National Forests as a source of timber. Concurrently, there was also an accelerated increase in demands for recreation, hunting, fishing, and wilderness on the National Forests. Subsequently, elevated public interest in National Forest management has intensified conflict over the proper balance of multiple uses and benefits which, in simplified form, encompasses two views (Kessler *et al.*, 1992). One view emphasizes the production of valuable commodities such as water, fiber, wildlife, and minerals for human use. The other view considers public lands as special settings for recreation, aesthetic, spiritual, and educational experiences.

This rapidly growing range of public interest and opinions about the best uses of the Nation's natural resources sets the stage for perhaps the greatest challenges and opportunities the Forest Service has encountered in its history. This situation is more clearly evident in the southern US than perhaps in any other region of the country. Demographic shifts, job opportunities, increased standards of living, attractive environments, and other socio-economic factors have contributed to an exploding South. Mixed forest ownerships in the region contributes to the complexity with over 70% of the forested lands in non-industrial private ownership.

In response to changing views of land and natural resources, the Forest Service has taken a new direction in its research and management programs. Ecosystem management (EM) is currently the operating philosophy of the Forest Service with the objective of using an ecological approach to achieve broader multiple use objectives (Thomas, 1996). The agency view of EM is to integrate ecological, economic, and social factors to maintain and enhance the quality of the environment to meet current and future needs.

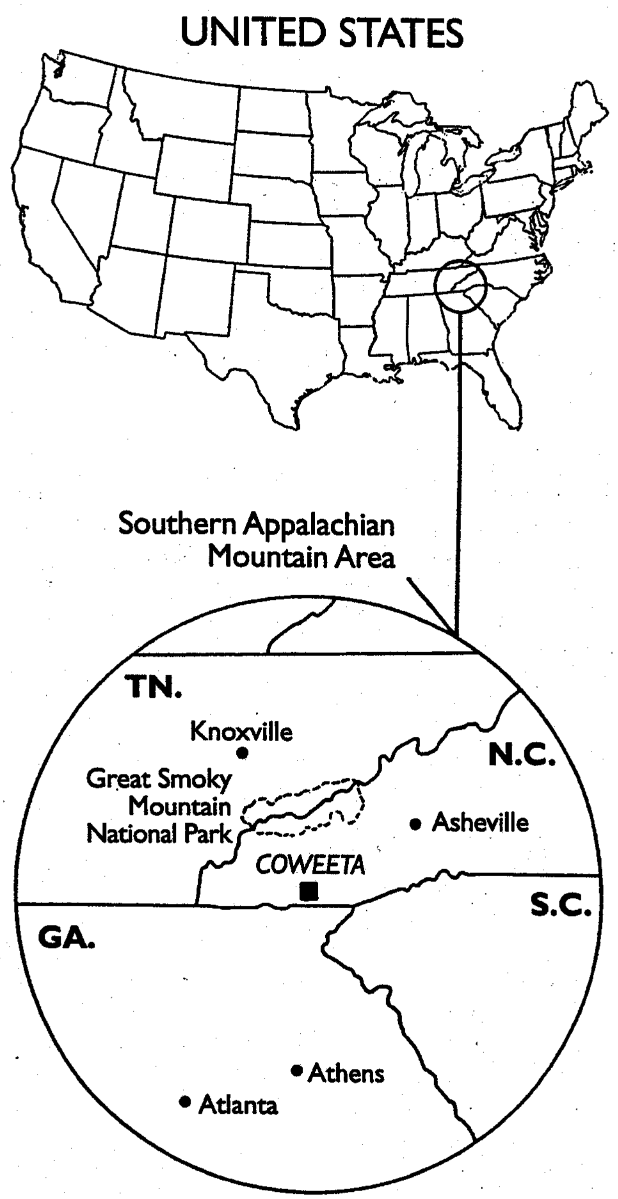

Figure 4.1 The Coweeta Hydrologic Laboratory is located in south western North Carolina, about 190 km north of Atlanta, GA. The Laboratory is a 2-hr drive north from the University of Georgia in Athens and is also in close proximity to other universities and centers of ecosystem research.

4.3 Experimental Setting

The Coweeta Hydrologic Laboratory, established in 1934, is a 2185 ha USDA Forest Service research facility within the Blue Ridge Physiographic Province of western North Carolina (Fig. 4.1). Elevations range from 675 m in the administrative area to 1592 m at Albert Mountain. The area is blessed with abundant precipitation, ranging from 1800 mm annually at low elevations to 2500 mm at high elevations with all months typically receiving at least 110 mm of precipitation. The climate is classed as Marine, Humid Temperate and the vegetation is mixed mesophytic hardwoods with four major forest types occurring over the basin (Day *et al.*, 1988). There are about 74 km of streams within the Laboratory, composed of first through fifth order streams, and perennial flow is typical for areas of 9 ha or larger. Of the 32 stream gauging weirs originally established, 16 remain active for continuous discharge measurements.

The Laboratory was originally established to develop and test theories of forest hydrology and to assess the effects of alternative management practices on the amount, timing, and quality of streamflow. Subsequently, in 1968, an ecosystem approach to research was initiated with a focus on processes related to forest biogeochemical cycles and this research was a logical extension of the hydrologic research. This research represents a continuum of theory, experimentation, modelling and management application, using catchments as the basic integrating landscape unit (Fig. 4.2). Two underlying philosophies have guided the research approach, *i.e.*, 1) that the

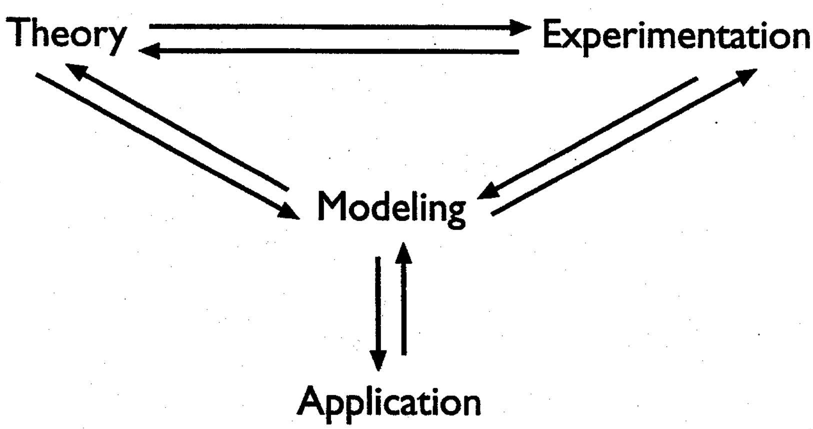

Figure 4.2 The approach to long-term forest ecosystem and multiple use management research at Coweeta includes a melding of theory, experimentation, and modelling with subsequent management applications. This approach entails dynamic feedback between all components of the research process.

quality, timing, and quantity of streamflow provide an integrated indictor of the success or failure of land management practices, and 2) good resource management is synonymous with good ecosystem management.

We have continuously attempted to integrate individual research efforts into a holistic concept of catchment response, and the ecosystem program has grown to more than 100 scientists (including 50 graduate students) annually conducting research through various co-operative efforts with universities, managers, state and federal agencies, and conservation groups. A principal effort is with the Institute of Ecology, University of Georgia, and our collaboration within the Long-Term Ecological Research Program, a network of 18 sites, funded by the National Science Foundation. More detailed site, programmatic, and research descriptions can be found in Swank and Crossley (1988).

4.4 Pilot Program of Multiple Use Forest Management

One of the earliest, and certainly most practical, demonstrations of the multiple use concept in a catchment context in the eastern United States was developed at Coweeta (Hewlett and Douglass, 1968). In 1962, a forested watershed at Coweeta was placed under management for multiple use. At that time, controversy reigned over the Multiple Use Act passed earlier in 1960, but foresters had little opportunity to see this form of management on the ground. The decision was made to pilot-test the concept of managing a hardwood-forested catchment for the uses to which it seemed best suited, namely water and timber production, hunting, fishing, and hiking. Objectives and prescription delineations were selected by scientists (in the absence of agreement among policy makers and users) to evaluate conflict among uses and to show how forest resource management might be practised in future years (Hewlett and Douglass, 1968).

4.5 Pretreatment Conditions

The 144 ha catchment selected for study, Watershed 28, was previously logged of old growth in 1923-1924. Harvesting intensity varied over the catchment from selective high grading of the large, better trees on the slopes to essentially clearcutting the cove (moist valley) forest because of species composition (mainly yellow poplar - *Lirodendron tulipfera*) and their size (>150 cm dbh). Thus, by the 1960's, the forest on the slopes was comprised of degraded stands, while in the cover a dense stand of yellow-poplar was regenerated after cutting but with stagnated growth because of the heavy stocking. The main stream channel contained native brook trout, while deer, grouse, turkey, bear, squirrels, fox, bobcat, raccoon, and many different bird species inhabited the catchment. The Appalachian Trail, a primary route for hikers in the east, traversed the upper portion of the catchment. Otherwise, a lack of roads and trails prevented access to all except the ardent recreationalist.

4.6 Prescriptions

The first task in implementing management was to provide access on the catchment without impairing other resource objectives. Properly planned access is the key to managing lands, regardless of topography or designated resource use. The approach was to provide an access system that would meet all present and future needs and yet still protect water quality. Five classes of roads and trails were specified. These ranged from forest roads engineered at specified standards to those built by logging contractors for regulated use, including climbing roads, contour roads, tractor skid trails, and foot trails. Roads were built using criteria developed from forest road research previously conducted the last 25 years at Coweeta and some new ideas for design criteria. These standards, along with subsequent road research at the Laboratory, have been highly effective (Swift, 1988) and adopted in Best Management Practices guidelines used by managers in federal and state agencies and private industry.

The catchment was then divided into natural compartments corresponding to prescriptions for achieving management objectives. Silvicultural needs of existing stands dictated clearcutting on the slopes and ridges to regenerate the degraded forest from previous selective logging and to produce the maximum yield of water and deer browse. Thinning

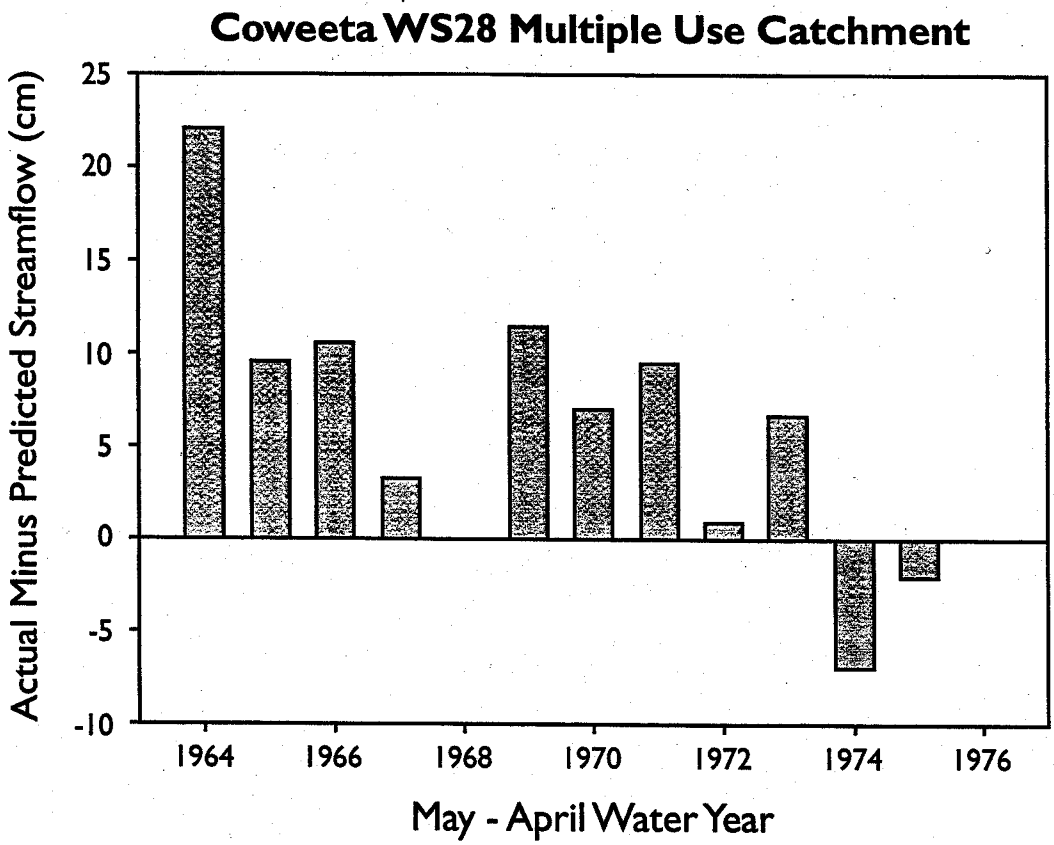

Figure 4.3 Annual streamflow increases following implementation of multiple use prescriptions on Coweeta WS 28. Water yield responses are derived from the paired (control) watershed method using regression analysis, where actual minus predicted streamflow are deviations from the pre-treatment calibration regression.

was prescribed in the cove forest to increase growth of the yellow-poplar stand along with removal of the residual poor quality overstory trees remaining from the old-growth forest. In addition, eastern hemlock *Tsuga canadensis*) and dogwood (*Cornus florida L.*) were not cut because of their visual appeal.

Trout habitat improvement consisted of removing the tangle of brush and old logging debris from the lower portion of the main stream and construction of small log dams to create more riffles and pools. To enhance recreation, the Appalachian Trail was improved and interpretative signs were installed at strategic locations. At the highest elevations, protection forest was left intact to enhance recreation and wildlife values.

4.7 Forest Resource Responses to Management

4.7.1 Water Yield and Storm Runoff

In the Appalachians, forest cutting increases water yield in proportion to the basal area cut and the solar radiation index of the catchment (Douglass and Swank, 1975). In the first year following harvest on WS28, streamflow increased 22 cm above pre-treatment levels and then declined exponentially as a function of time over the next 9 years before returning to baseline level (Fig. 4.3). The total cumulative increase in flow from the catchment was 80 cm, or over one million m^3 of water. Much of this extra water was delivered to the stream when flows are lowest (autumn season) and aquatic and human water demands are most important.

Some of the extra water was delivered during storm periods when quick-flow volume, or direct runoff was increased by an average of 17% (Douglass and Swank, 1976). Peak discharge also increased, with the largest changes coincident with active logging activity when average peak discharge was elevated by about 33%. Thereafter, following road stabilization with grass and recovery of evapotranspiration with rapid forest regrowth, elevation of peak flows declined rapidly.

4.7.2 Water Quality

The effects of harvesting on turbidity were inconclusive, but the increased frequency of cleaning the weir ponding basin

Table 4.1 Mean annual increase in solute export from Coweeta WS28, 10-12 years following initiation of multiple-use prescriptions.

Solute	Net loss: Net budget of WS 28 compared to net budget of adjacent control WS (kg ha^{-1} yr^{-1})
NO_3^- -N	2
Ca^{++}	10
Mg^{++}	4
K^+	3

Table 4.2 Density, basal area, and dominant tree genra on the clearcut area of Coweeta WS 28 for pre and post-treatment periods.

Period	Density Stems ha^{-1}	Basal area $m^2\ ha^{-1}$	Dominant Tree Genra
Pre-treatment	NA	28	
Year 2 following CC	15,000	NA	*Quercus, Lirodendron,*
			Prunus, Betula
Year 5	9,000	>7	*Fraxinus, Tilia*
Year 11	7,000	11	*Acer*
Year 30	NA	>30	

clearly indicated that bedload movement was accelerated. Much of the bedload scouring occurred in the lower stream section, where fish dams were constructed and reflects readjustment of the stream energy gradient. Effects of management on stream chemistry were not measured in the early years, but in 1972-1974, about 10 years after disturbance, net nutrient budgets (compared to adjacent control watersheds) showed small but measurable losses of nutrients (Table 4.1). For example, NO_3^- -N losses were increased by about 2 kg $ha^{-1}\ yr^{-1}$ while Ca^{++} Mg^{++}, and K^+ increased by about 10, 4, and 3 kg $ha^{-1}\ yr^{-1}$ respectively. The magnitudes of elevated exports are relatively small compared to ecosystem pools and the annual internal fluxes of nutrients and potential effects of productivity must be considered in relation to sources of nutrient replacement (Swank, 1994; Swank and Waide, 1980).

4.7.3 Vegetation Responses

Hardwood regeneration is rapid following cutting in southern Appalachian forests due to both sprouting and seedling establishment. In the 73 hectares of clearcut, two years after logging, stem density was more than 15,000 ha^{-1} with an abundance of *Quercus* species and yellow-poplar (Table 4.2). On the moist lower clearcut slopes, species composition was similar to the cove forest; because this 16 ha area contained enough yellow-poplar sprouts for future crop trees, it was considered a cove extension (Douglass and Swank, 1976). Five years after cutting, basal area was >7 $m^2\ ha^{-1}$, with more than 9,000 stems ha^{-1} and an abundance of species available for timber and wildlife habitat. By age 11, basal area had increased to 13 m^2 ha^{-1} and stem density was still >7,000 ha^{-1}. Today, 30 years after harvesting, basal area exceeds that of the forest prior to cutting (30 $m^2\ ha^{-1}$) and the species composition is greatly improved with an abundance of *Quercus, Prunus, Betula, Fraxinus, Tilia, Acer* and *Lirodendron* species. Present stand conditions offer a wide array of alternative management options for the future.

In the cove forest, the silvicultural prescription of thinning was equally successful (Table 4.3). Thinning in 1963 reduced overstory basal area from 28 $m^2\ ha^{-1}$ to 16 $m^2\ ha^{-1}$ and by 1975, 11 years after treatment, basal area was 32 $m^2\ ha^{-1}$. By age 30, basal area had increased to 46 $m^2\ ha^{-1}$ and, at all stages of succession, yellow-poplar has been the dominant over-story species with a mixture of *Tsuga, Quercus, Prunus* and *Betula*. The goal of increasing the growth rate of dominant and co-dominant yellow-poplar was clearly achieved (Fig. 4.4). Mean annual tree basal area increment began increasing several years after thinning and has continued to the present time to exceed growth rates of adjacent, unthinned poplar stands on similar sites of the same age (Parr, 1990). Annual growth rates are frequently more than 40% greater than in unthinned stands. A study of long-term secondary succession in the cove has shown that over time overstory canopy diversity has decreased slightly, advance regeneration

Table 4.3 Basal area and dominant tree genra in the thinned cover area of Coweeta WS28 for pre and post-treatment periods.

Thinned Cove

Period	Basal Area $m^2\ ha^{-1}$	Dominant Tree Genra
Pre-treatment	28	*Quercus, Lirodendron*
Year 1 following thinning	16	*Tsuga, Prunus*
Year 11	32	*Betula*
Year 30	46	

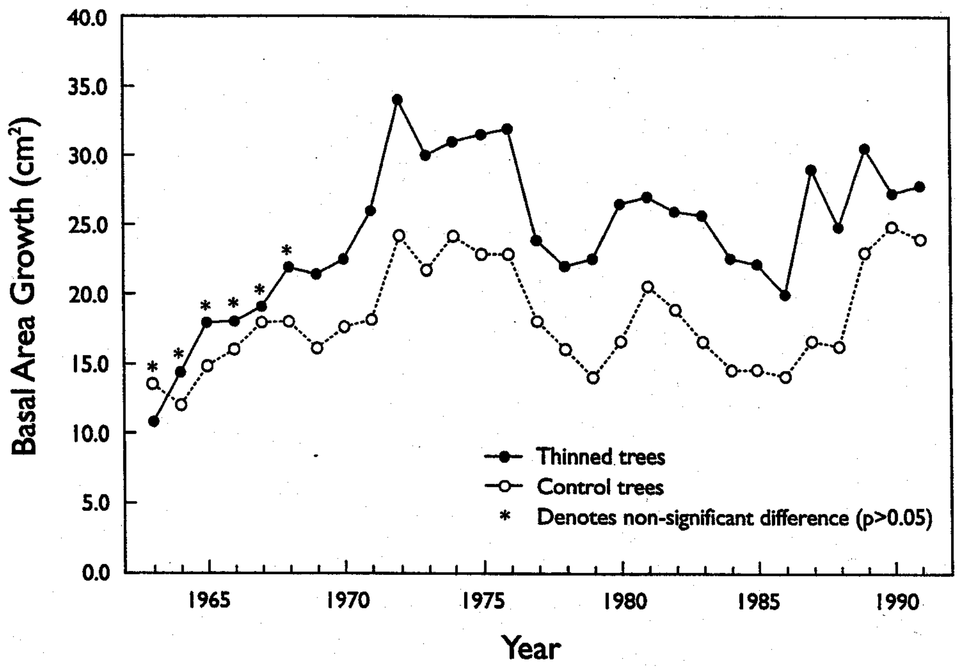

Figure 4.4 Mean tree annual basal area increment of dominant and co-dominant yellow poplar in the thinned cove on Coweeta WS 28 and adjacent, unthinned control trees (after Parr 1992).

and understory diversity has increased, and there is a highly diverse herbaceous layer with 43 species present (Parr, 1990).

4.7.4 Responses in Other Uses

The effects of the prescriptions on other resources and uses were only partially evaluated. It is well known that thinning and clearcutting improve deer habitat in hardwood forests by producing abundant browse. After about age 10 in the clearcut, most of the browse has grown out of the reach of deer; however, the cove understory remains a source of browse. Young successional hardwood forests are also prime habitat for ruffed grouse. Use of the area by both deer and grouse increased after treatment and, with improved access, the catchment became a favourite hunting area; this situation is still true today. The most striking change in wildlife was the dramatic increase in wild turkey populations. Although stocking efforts have produced a regional trend of increased turkey populations, the varied habitat on the catchment has been a strong attractant for turkey foraging and it is not uncommon to see a flock of 12 or more birds when traversing the area. The decision to leave hemlock in the cove forest to lend pleasing aesthetic value during stark winter months, when hardwoods are leafless, also greatly benefitted turkey because this is the preferred tree species for roosting. A reproducing population of native brook trout are still resident in the main stream, but regrowth of streamside vegetation hampers accessibility and fishing remains a minor use. The road network over the catchment has become a favourite area for the casual day hiker, particularly during the spring season. An abundance of flowering dogwood, over much of the catchment, provides splendid beauty along with wild flame azaleas that became established on the edge of roadway clearing.

Other research has shown that the catchment has been improved for some non-game species. For example, because of habitat variety produced by silvicultural prescriptions, road construction, and retention of old-growth forests, species diversity of breeding birds is greater on the catchment than in undisturbed forests (Tramer, 1969; Tramer, 1994). Forest alterations also increased the variety of some small mammals such as shrews and mice (Gentry *et al.,* 1968).

4.8 Synopsis

This pilot study of multiple use management, initiated more than 30 years ago, has demonstrated that indeed, forested catchments in the southern Appalachian can be managed for a variety of objectives even though there may be conflicts among uses. Clearly, not all the ecological consequences of resource prescriptions have been evaluated. However, it is important to recognize that ecosystem changes are not irreversible and opportunities are available to meet alternative future goals. Perhaps the most significant contribution of this pilot project and similar ones is the demonstration and education value; *i.e.,* a catchment landscape where management decisions are made, applied, and evaluated. A place where managers, policy makers, a variety of user groups, students, conservation and environmental groups, and scientists can view and discuss issues on the ground. Based on many years of interaction with numerous groups who tour Coweeta and this catchment, I firmly believe in such approaches to advance integrated catchment management.

4.9 Integrated Catchment Ecosystem Management

In this section I will leap forward by three decades in time to current trends and programs of multiple-use management. Beginning in 1990, the Forest Service began taking a new direction in its research and management programs for 191 million acres of national forests and grasslands, in response to changing views of land and natural resources. Ecosystem management is currently the operating philosophy of the Forest Service with the objective of using an ecological approach to achieve broader multiple use objectives (Kessler *et al.*, 1992; Thomas, 1996). Ecologically based concepts, principles, and technology provide the underpinning of this new direction. In 1991 we organized a technical symposium that was convened as part of the American Association for the Advancement of Science (AAAS) Annual Meeting in Washington, DC. Our goals were: (1) to share the concept, philosophy, needs, and opportunities related to Ecosystem Management and (2) illustrate with examples specific applications of ecosystem research to multiple-use management as viewed from a broader perspective. Subsequently the papers were published in a special selection of Ecological Applications (Swank and Van Lear, 1992) and encompass a variety of topics for diverse forest ecosystems across the country. An example most relevant to our present conference is watershed ecosystem analysis as a basis for multiple-use management of eastern forests (Hornbeck and Swank, 1992). More recently, a compendium of essays on ecosystem management was published in Ecological Applications (1996) which represents a wide range of viewpoints on this topic.

There are several major differences between the "pilot" test of multiple use management demonstrated earlier at Coweeta and present efforts. Specifically, the public has a major role in the decision making process, the approach to planning is more comprehensive, the science is even more interdisciplinary, modelling provides a synthesis tool, and technology such as geographic information systems and decision support systems facilitate data management and interpretation. There is also one important, fundamental commonality of the past and present; *i.e.*, the catchment still provides the integrating framework for examining and viewing multiple use issues and concerns.

There is no blueprint for implementing ecosystem management; in fact, a variety of approaches will be required to meet the needs across the varied regions of the US. In this section I will outline and summarize one approach we have taken. Beginning in 1992, we developed and initiated an ecosystem management project in Wine Spring Creek Basin and in western North Carolina (Swank, 1994) about 50 km from Coweeta. The 1820-ha catchment has a mix of hardwood forest types, first- through third-order streams, and diverse flora and fauna. Project boundaries were defined by catchment boundaries and not by ownership; although most of the basin is National Forest land, portions are in private ownership at the base of the catchment where the stream enters Nantahala Lake which is an important reservoir in the region.

Participants in this project include an interdisciplinary team of over 55 scientists and managers in 5 research units in the Southern Research Station, National Forest Systems, and seven universities; state agencies; conservation and environmental groups; and the public. Our approach to research and management planning utilized the basic framework of existing land and resource management plans and was innovative in defining desired future resource conditions and specifying prescriptions to achieve conditions (Fig. 4.5). The centrepiece of defining project goals was a series of workshops, comprised of interested and responsible stakeholders, conducted over an 18 month period. The experience in reaching consensus was educational for all parties involved; the public, scientists, managers, and user groups developed a broader appreciation for the concerns, issues, constraints, needs, and options of others and for the complexity of ecosystem management (Meyer and Swank, 1996). From this consensus building process, 35 desired resource conditions were initially identified for the project area. The major themes for research and management that emerged from this effort (Table 4.4) encompass both traditional values such as wildlife, water quality, timber and

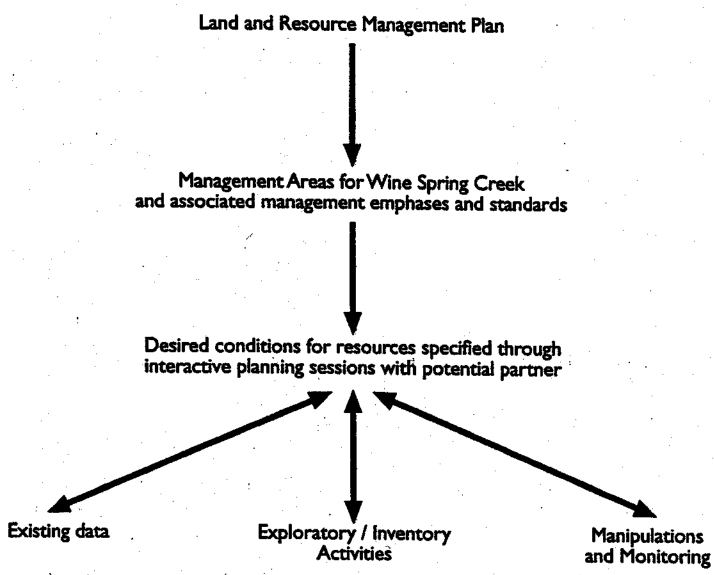

Figure 4.5 Outline of approach to implementation of ecosystem management on the Wine Spring Creek catchment. Existing management plans were combined with stakeholder workshops to define desired future conditions for natural resources of the area, which subsequently, were used to identify research and prescription activities.

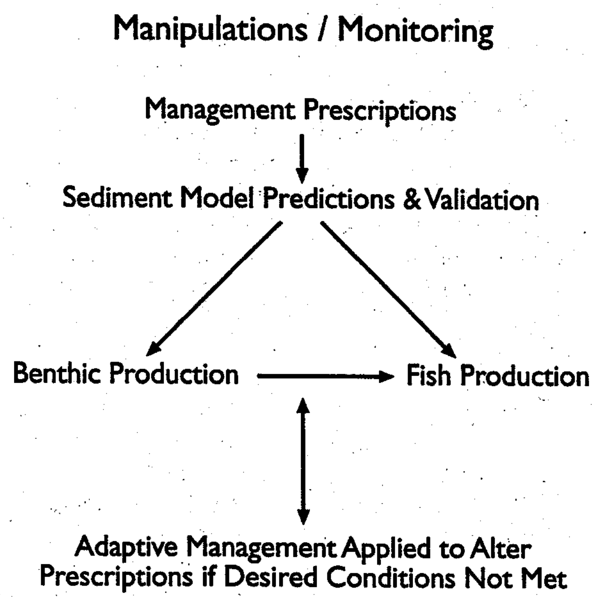

Figure 4.6 An example of how management prescriptions are linked with modelling, monitoring, and stream research to evaluate results and identify the need for adaptive management.

recreation an non-commodity values; for example, increased native fish populations and improved scenic values of trails. Social and economic science research have been particularly valuable in the early stages of this project to identify need and expectations of user groups and the general public.

Monitoring and adaptive management are critical aspects of our approach as Phase I prescriptions involving stand restoration burning, oak regeneration harvests, and stream habitat improvements are implemented to move toward some of the desired resource conditions. For example, management prescriptions are linked with research on sediment modelling and monitoring which is coupled with stream benthic and fish production (Fig. 4.6). Simultaneous examination of processes improves the likelihood of detecting cause and effect relationships and making appropriate recommendations for remediation.

Table 4.4 Major research and management themes derived from enumeration of desired future conditions for resources on the Wine Spring Creek basin.

Ecological Classification
Riparian Zone Management
Aquatic Productivity/Water Quality/Habitat Alteration
Sustainable Productivity (Regeneration, Biodiversity, and Biogeochemical Cycles)
Social Value Assessment
Economic Analyses
Mammal and Bird Population Dynamics
Special Ecosystems ("Balds")

A final important component and challenge in our approach to ecosystem management is the development of interactive, spatially explicit models that synthesize our knowledge and afford all participants an opportunity to view outcomes or proposed management. For example, we are incorporating principles and research findings from this project into a Decision Support System, designed in modular form (Nute *et al.*, 1995, Rauscher *et al.*, 1995), with models of soil erosion and stream transport, nutrient cycling, and forest productivity among others (Swank, 1994).

4.10 Regional Scale Analyses

The complexities of multiple land use management increase by several orders of magnitude as one moves to larger (>1,000 m^2) regional scales of analyses and assessment. However, resource planning and management must be considered at broader spatial and longer temporal scales to meet increasingly complex environmental issues and to provide societal needs.

We recently initiated regional scale research in the southern Appalachians as part of our Long-Term Ecological Research program to assess the effects of human-caused disturbances on ecological processes. This interdisciplinary effort involves 30 co-principal investigators, including social and economic scientists in addition to terrestrial and aquatic ecologists who have traditionally cooperated in previous ecosystem research at Coweeta (Swank and Crossley, 1988). The region of interest is a 15,000 km^2 section of western North Carolina that encompasses two main river basins - Little Tennessee and French Broad (Fig. 4.7), which is about one-half the areal extent of northern Scotland. The area is a popular tourist and recreation attraction with more than 25 million visitors annually. Agriculture, forestry and small industry are also important to the regional economy and the area is experiencing rapid population growth with associated urban/suburban development.

The goal of our research is to develop a predictive understanding of the social, economic and environmental factors that

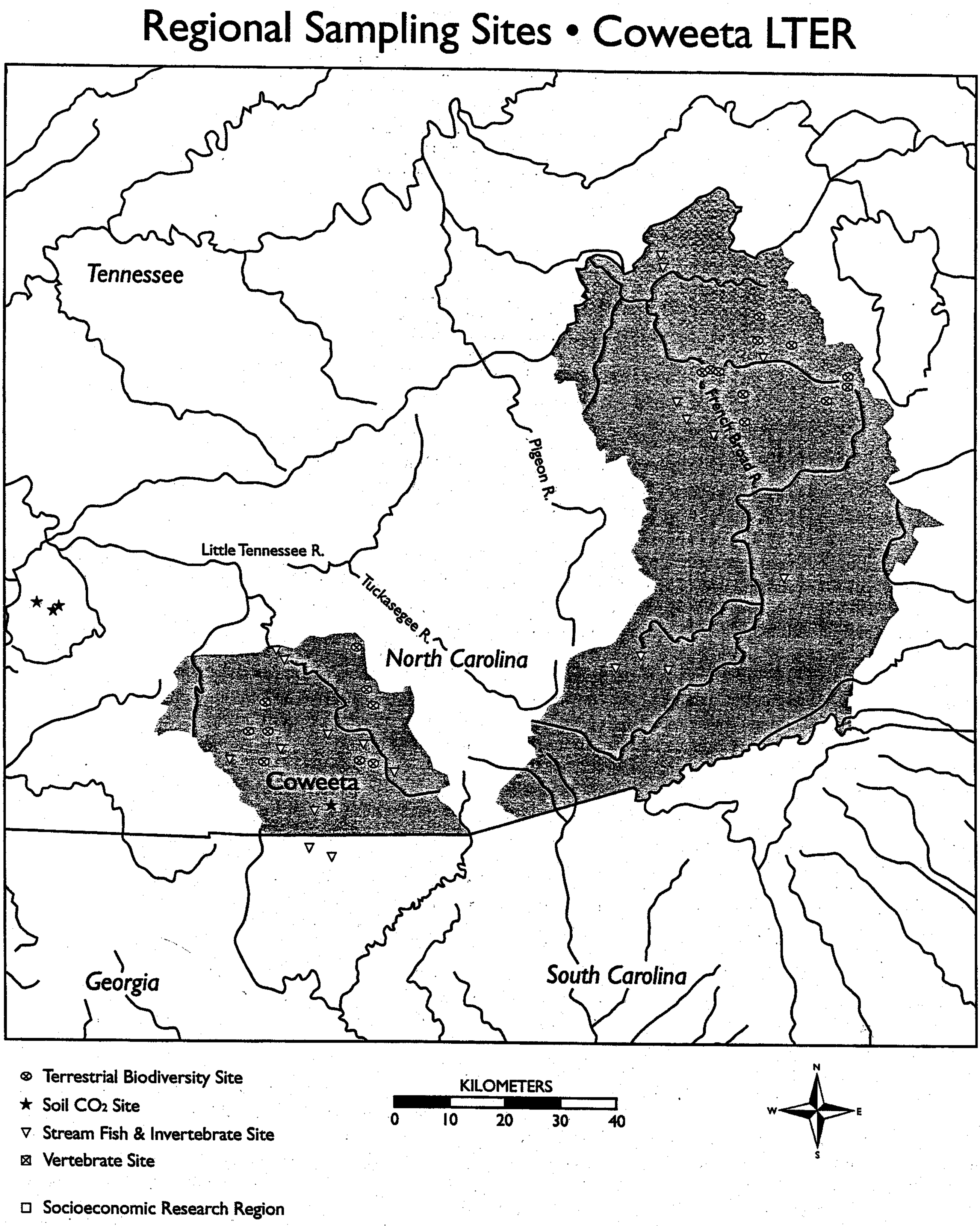

Figure 4.7 Location and spatial distribution of sampling sites for a regional scale, integrated assessment of multiple land use management in Western North Carolina.

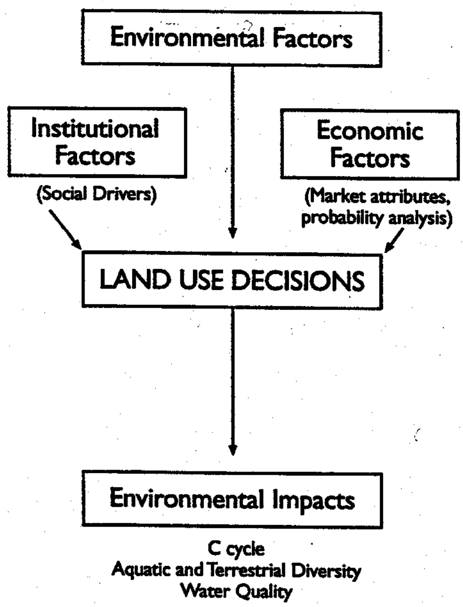

Figure 4.8 Social and economic sciences are linked with ecological research to evaluate factors driving multiple land use decisions and the consequent environmental impacts of those decisions at a regional scale. The feedback between impacts and drivers of land use changes are also evaluated.

drive land use/cover changes and the ecological consequences of those changes for regional C cycles, terrestrial and aquatic biodiversity, and water quality (Fig. 4.8). Human caused land use change is being quantified in detail at decadal time steps for the past 60 years and will be linked with process level research on the carbon cycle of early successional forest, mature forest, old-growth forest, and pasture at a number of sites in the region to include a range of abiotic and biotic driving variables. Process driven models are then being used to scale to larger areas through spatially-referenced driving variables. In other research, the legacy of land-use affects on community composition, heterogeneity of the biota within forest patches and species abundance and diversity are being examined for both terrestrial and aquatic ecosystems. Linkage of environmental and socio-economic models and their feedbacks (Fig. 4.8) will provide a method for forecasting the consequences of future land use practices and policy.

4.11 Future Needs, Issues, and Approaches

The management of forests for multiple uses has developed at a slow to moderate pace over the previous four decades in most developed countries. However, as we approach the 21st century, it is apparent that human needs and management issues are increasing at an exponential rate in both content and complexity. Specific factors driving these changes vary widely, but are generally related to social, environmental, and economic issues and situations. It is clear that public interest in, and expectations of, forests and related management has greatly accelerated in recent years; the trend will continue.

The future role of forest science in addressing management issues offers exciting and important challenges. I believe that traditional forest research conducted during this century provides a solid foundation for moving to the future. For example, much is known from silvicultural research about stand management and fiber production for many forest communities; important principles related to the effects of management on hydrologic cycles are established, and habitat requirements and management for select wildlife species are known, to recount a few topics. However, emerging natural resource demands require a more holistic or ecosystem approach to science and acknowledgement of humans as components of ecosystems. I suggest that significant and meaningful progress will entail the inclusion of some of the following elements in multiple use programs.

- Consensus building with various stakeholders to define objectives and actions must be a central element in research and management planning strategies.
- An interdisciplinary approach involving not only natural scientists but also social and economic scientists who participate fully on the "front-end" of the research and management planning process.
- Development of strategies that incorporate long-term planning and commitment but recognize the need to make short-term decisions.
- Recognition that adaptive management and monitoring are integral components of multiple-use management.
- A commitment to long-term research that utilizes catchment or basin scale demonstrations of multiple use forest management.
- Modelling at various levels of ecosystem organization to synthesize system interactions and feedbacks, to identify critical thresholds for processes and research gaps, and to provide predictive assessment tools for evaluating management alternatives.

- Development and application of technology such as decision support systems, geographic information systems, and remote sensing which provide powerful tools to analyse environmental impacts and constraints of resource management options.

- Development and evaluation of a central theory and methodology for valuing non-commodity components and functions of forest ecosystems; for example, EMERGY analysis advocated by Odum (1966).

- Linkage of forest multiple use assessments with broader, regional scale land uses such as agriculture, urbanization and transportation networks to place environmental, social, and economic issues in perspective.

In conclusion, the melding of multiple use, or more broadly, ecosystem management with natural resource management is in its infancy. New terminology, technology, methods, and approaches are evolving rapidly. Early in the process, as we move from concepts to on-the-ground practices, there will undoubtedly be more failed than successful efforts. But lessons learned can lead to progress and the real gains occur through action rather than rhetoric.

Acknowledgements
I wish to thank the Macaulay Land Use Research Institute and sponsors for the invitation and support that made my participation in this conference possible. The organizers are to be congratulated for convening this successful meeting on multiple land use and catchment management, a challenging topic of great significance to the natural resource community and humankind.

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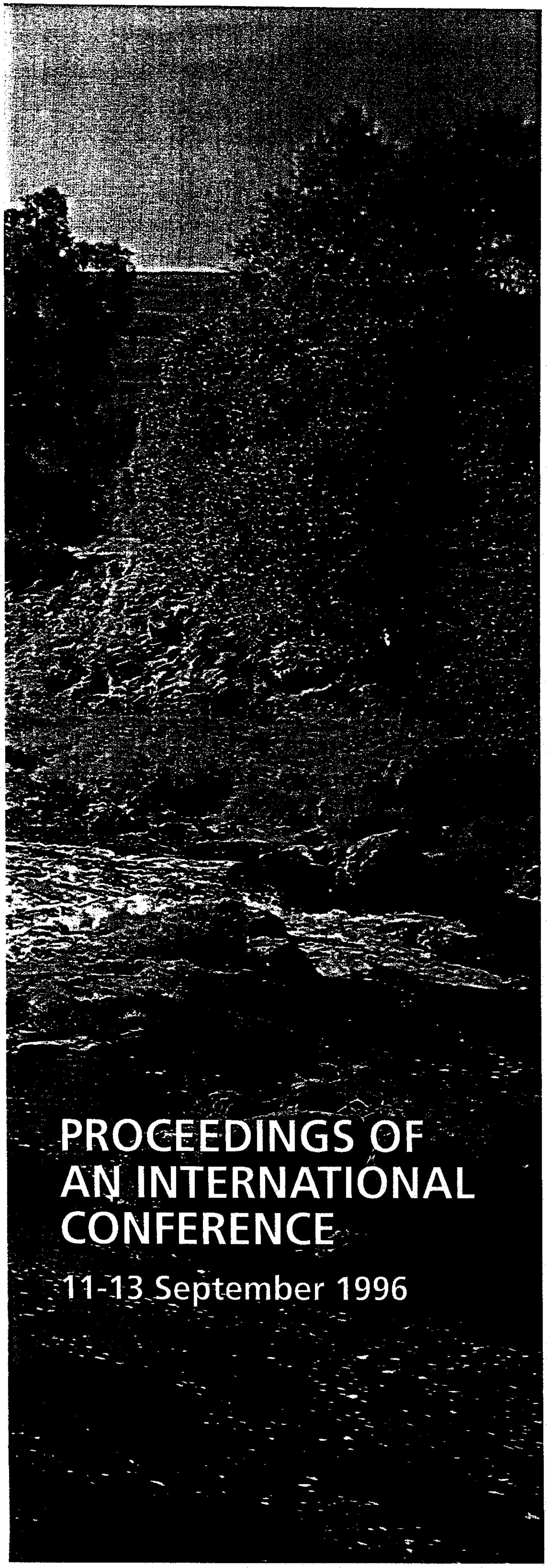

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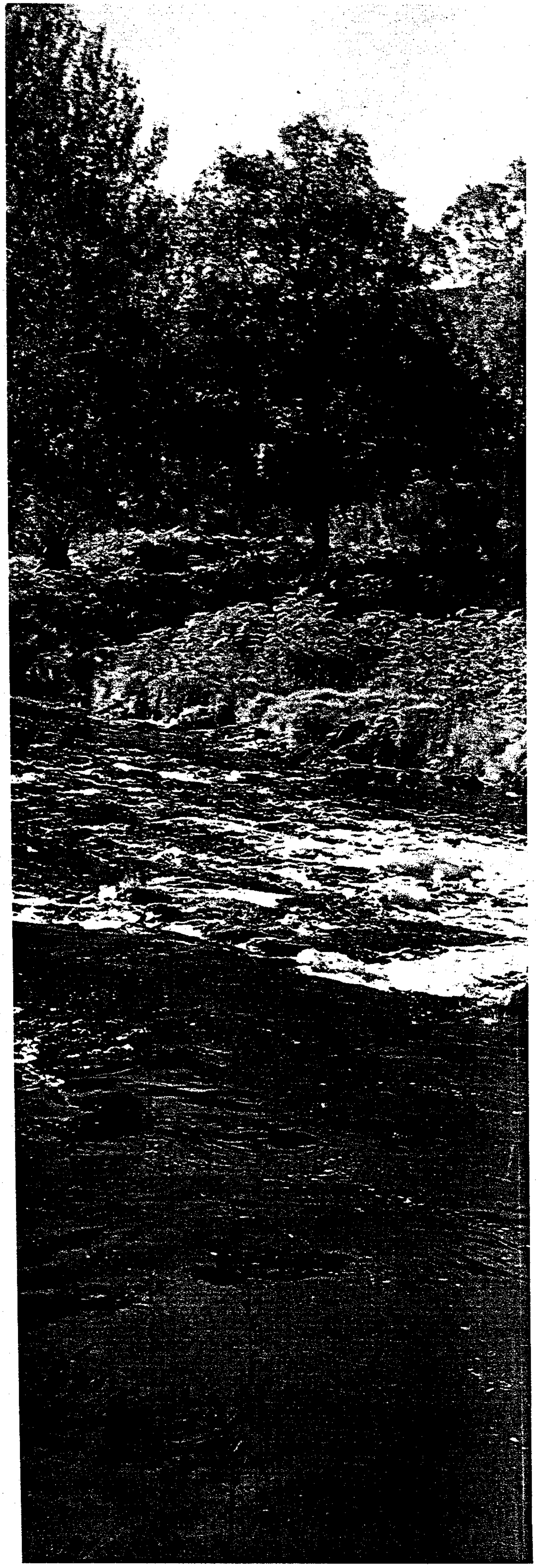

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