

HISTORY OF THE DEPARTMENT OF FORESTRY AND ENVIRONMENTAL
RESOURCES AT NORTH CAROLINA STATE UNIVERSITY, 1979-2008

X. OTHER ORGANIZED RESEARCH PROGRAMS AND PERSONAL RESEARCH

The NCSU-Industry Research Cooperatives and research programs with formal ties to the forest industry sector constitute only a portion of the Department's research effort. Whereas in 1980 the Research Cooperatives constituted the major part of the Department's total research effort, today the Department's other research programs, collectively, are equal in size, scope, and importance to the research programs with direct ties to forest industry. Some of these other research programs maintain close ties to forestry commodity or forest user groups and provide them invaluable research results and access to scientific expertise. Others have extended their purview and clients beyond traditional forestry research. Some of these programs are located in named, organized units. Others are simply groups of faculty members concentrating on areas of common interest while others represent the work of individual faculty members. An important point is that virtually none of these research programs or researchers was in the Department in 1980. They are a clear result of the Department's conscious efforts to broaden its base from a research program built largely on the needs of forest managers to a research program contributing to a wider array of natural resource subjects.

The Center for Earth Observation

The Center for Earth Observation, which was established in 1983, evolved from Siamak Khorram's role as Director of the Computer Graphics Center. This program had been located in Electrical Engineering, and Khorram took over its directorship through his joint appointment with Electrical Engineering. Due to space limitations the Earth Observation program grew slowly through the mid-1980s. However, the design of the first two wings of Jordan Hall allocated the fifth floor of one wing to remote sensing. More important, it allowed the Center for Earth Observation to be combined with research work in Geographic Information Systems being conducted by Dr. Hugh Devine of the Department of Recreation Resources Administration. Khorram serves as Director of the Center for Earth Observation and Devine is Associate Director in charge of the Geographic Information Research and Teaching Program. Faculty and graduate students from many disciplines use the facilities of the Center in their teaching and research programs. The Center for Earth Observation is also an Affiliated Campus of the International Space University in Strasbourg, France. Dr. Khorram served in many capacities at ISU including the Dean and Vice President for Academic Affairs, the Chair of the Affiliate Network, the Chair of the Academic Council, and currently as a member of the Board of Trustees.

The Center has amassed an impressive array of computer hardware and software facilities. The centerpiece of these is the teaching laboratory which has over 30 high-end Windows NT workstations and excellent multimedia instruction capabilities together with interactive, clustered teaching facilities. The Center also contained a research laboratory with one specialized UNIX workstation, several powerful NT workstations, a softcopy photogrammetry workstation, as well as a separate instructional technology development facility. All of these systems are integrated into the University's computer network. In addition, program facilities include digital cameras, film recorders, digitizers, large and small format plotters, color printers, scanners, air photo interpretation equipment, and GPS units.

In addition to Khorram and Devine, faculty members Heather Cheshire and Stacy Nelson carry out active research programs as a part of the Center's work. In addition, over 30 faculty members from NCSU departments use the Center's facilities. Projects conducted in-house described on the Center's web site include:

- Remote Sensing and Image Processing research projects funded by a variety of federal and state governments and private industry. These research projects include water quality modeling in Sicily, Italy, accuracy assessment of satellite based land use/land cover inventories conducted in cooperation with the US Environmental Protection Agency for EPA Regions 4 and 5, and multi-processing research on remote sensing data as applied to natural resources, funded by Cray Research.
- GIS projects, such as technical support for the National Park Service, GIS for regional planning and natural resource management, and instructional technology for GIS and environmental education;
- Development of educational technologies that range across many disciplines and are based on multi-media applied to instruction in spatial analyses;
- Automated and intelligent remote sensing and image processing systems that span the entire remote imaging process from phenomenology through acquisition and data analysis, including automated systems for image classification and change detection, computer understanding of images, neural networks and artificial intelligence, environmental data visualization, and multi-source data fusion; and
- Database projects such as design and development of relational database for National Acid Precipitation Assessment Program investigators."

The breadth of the Center's research program is illustrated by research currently underway or recently completed. This includes numerous projects supported by the National Oceanic and Atmospheric Administration, USDA, USGS, National Cray (supercomputing) Research, Na-

tional Park Service, the US Forest Service, the NC Forest Service, and the National Cooperative Highway Research Program.

An interesting sidelight to the Department's remote sensing research effort occurred in 1980-81 when discussions were initiated with Virginia Tech toward developing a joint VPI-NCSU aerial photography and remote sensing cooperative. After several meetings, which proved inconclusive, the effort was abandoned. In retrospect, neither institution really felt it was to its advantage to cooperate in this important area and, equally fatal, was an almost complete lack of interest among any potential industrial sponsors.

Restoration Ecology

The Department's program in restoration ecology grew out of research in the Hardwood Cooperative by Russ Lea and Doug Frederick in the late 1980s dealing with forested wetland management and on use of hardwood wetlands as sites for treated municipal waste disposal. Initially this work concentrated on creation of forested wetlands and on the question of how soon such artificial wetlands begin to take on the properties of natural systems. Several studies were initiated with TVA and the US Army Corps of Engineers. These projects were managed for a short time by Tim White who had obtained his doctoral degree in the Hardwood Cooperative. White left shortly after taking over the projects and was replaced by Ted Shear in the summer of 1991.

Shear has managed and nurtured the restoration ecology effort into a strong program with a diversified research portfolio and a large number of graduate students. Shear's initial appointments were entirely on external grants, and he was appointed with State salary support in 2000 when he became the first Director of the Environmental Technology Program, which he played a lead role in establishing. He continued work in restoration ecology as well, and now has returned to focus on restoration ecology and mitigation, which remain important subjects for research.

The Department's restoration ecology program conducts research designed to help in the recovery of ecosystems that have been degraded, damaged or destroyed. Emphasis is placed on the actual craft of restoring natural ecosystems as well as the social and philosophical principles that mandate restoration. In many cases the research has been done cooperatively with other NC State departments, and State and Federal agencies. Graduate students have played a major role in execution of the research and Shear is justifiably proud of the success his students have had in obtaining jobs in the field of restoration ecology.

Much of the research has been conducted on forested wetlands and includes projects carried out on the North River in Carteret County, NC, along the Edisto River in South Carolina, at Core Point on PCS Phosphate lands, and on development of wetland forest on farmlands abandoned 50 years on TVA sites in Tennessee. Other wetland projects have led to development of guidelines for the NC Department of Trans-

portation for restoration of forested wetlands, to development of recommendations for minimizing the impacts on wetlands of road location, for analysis of impacts of highway construction on wetlands, and for determination of edge effects in modified wetlands. Shear and his students have also worked in upland sites, on individual species (Chamaecyperis thyoides and Astragalus michauxii), and in urban areas (Cary). The program has also carried its research efforts to locations elsewhere in the world including China, Costa Rica, and Tanzania.

Shear's program in many ways resembles CAMCORE in that it has reached its current status through the hard work of a researcher in a field of growing importance to natural resource management.

Small Woodlot Program

In the late 1970s Lester Holley took a leave of absence from the Department to work in the State Division of Forest Resources. Holley's work was devoted to studying the needs of individual owners of small forest tracts. One of the principal recommendations arising from his work was the proposal of a research program at NC State devoted to the needs of owners of small tracts of forest land. The 1979 General Assembly approved an appropriation of State funds to the College for this purpose. After considerable discussion within the College, and after weighing the advantages of several different "homes" for this program, Dean Ellwood decided that a Small Woodlot Research Program should be created in the Department. Ellwood himself took the lead in recruiting a director for this program and in December 1979 Carlyle Franklin was appointed to the position. Originally, the Program was administered through the Southern Forest Research Center. This affiliation never amounted to much and the Program became a free-standing program within the Department.

The decision to locate the Small Woodlot Program in the Department was not well received by the Forestry Extension Program. The Extension staff felt that objectives of the new program so closely related to their mission that another administrative unit in a different department was not needed. Nonetheless, Ellwood's decision remained final.

Franklin moved quickly to develop policy direction and research priorities for the Program. He concentrated on action areas that would serve to increase the cash value of private land owner's forest holdings. These included incentives such as tax impacts and alternatives and land valuation, technology especially adapted to small non-industrial ownerships, and technology transfer. By 1982 three such studies had been completed: 1) an analysis of North Carolina's present use valuation law as applied to forest land and preparation of a report and recommendations on these findings for a legislative committee dealing with property taxes; 2) studies of management techniques adapted to small woodlot management, and 3) analysis of several industrial assistance programs aimed at small forest land owners. In addition, an Advisory Committee was formed.

During the early 1980s Franklin added several individuals to the Program's staff. Dennis Hazel was hired as a Research Assistant and Gary Kronrad came on board as an Assistant Professor in 1983. Kronrad left in 1986 but Hazel played a major role in the program, staying with it until he moved to the Extension Forestry staff in 2003.

Throughout the 1980s the program continued to carry out studies of issues relevant to small nonindustrial forest land owners. These included the effect of regeneration in enhancing the market value of land, problems of minority forest land owners, comparison of timber sale methods, and present use valuation of land for property tax purposes. In addition, Franklin undertook silvicultural studies directed toward the special problems on nonindustrial forest land owners. Special attention was paid to low cost silvicultural methods appropriate to owners of small tracts of forest land; a study of small scale forestry contractors who might be able to provide these services was also carried out. Considerable attention was devoted to developing a one-year curriculum to train forest technicians. Two fertilization studies were initiated and an evaluation of the usefulness of all terrain vehicles in forest management was conducted in 1986.

During the latter part of the 1980s the Program began to carry out active field studies directed toward management issues. One such study at the Creedmore Agricultural Research Station involved a determination of the usefulness of forests as sites for disposal of run-off from agricultural fields. This study showed that forested zones bordering agricultural fields can play an important role in dispersing runoff, increasing infiltration, and reducing nutrients leaving agricultural watersheds in storm flow. A staff member of the Woodlot Program was trained to use Global Positioning Systems and was authorized to offer training in this technology.

The Small Woodlot Program remained active until Franklin's retirement in 2005. Its scope of work has been dispersed to other programs of the Department, particularly in the Extension group. The Program is no longer recognized as a named administrative unit.

Southern Center for Sustainable Forests

The Southern Center for Sustainable Forests is a cooperative organization comprised of the Department, Duke University's Nicholas School of the Environment and Earth Sciences, and the NC Division of Forest Resources. It arose from a need identified in Governor Hunt's 1996 Task Force on Forest Sustainability and was established in 1997 by a Memorandum of Understanding among North Carolina State University, Duke University, and the North Carolina Division of Forest Resources. Leadership for the Center is shared among the three co-directors, Fred Cabbage in the Department, Dan Richter at Duke, and Barry New for the State Division of Forest Resources.

The Center was established "to provide leadership for research, education, and extension to promote economically and ecologically sustainable management of forests in the South. The Center's objec-

tives were distilled from 11 broad themes identified in group discussion among participants at the founding meeting in High Point, NC, in July 1997. These objectives are: 1) fostering research and applications on the productivity and sustainability of forest management practices on private forests and evaluating the effects of intensive and extensive forestry at the landscape scale; 2) improving state, regional, and interdisciplinary cooperation in technology transfer of existing and new research efforts to forestry professionals and private landowners; 3) promoting balanced discussion about and cooperation among interest groups in achieving sustainable forest management; and 4) assisting in development and use of appropriate guidelines for sustainable forest management that incorporate economic and ecological principles."

The Center's first effort was to sponsor a conference in November 1998 in Charlotte on "Perspectives on Sustainable Forestry for the South." Shortly thereafter it undertook an important and highly controversial job by serving as the unifying organization for a study of "Economic and Ecologic Effects Associated with Wood Chip Production in North Carolina." This study involved investigators from all 3 founding organizations and was a major examination of the expanding wood products harvesting and processing sector in the State and its effects on related economic sectors and the environment. This study was finished in July, 2000, and was instrumental in framing a more informed discussion about the issues associated with wood chip production, environmental protection, and forest management in the South.

In the winter of 2000 the Center sponsored a conference on Forest Certification and in 2001 agreed to coordinate a study of Forest Stewardship Council and Sustainable Forestry Initiative forest certification on its member organization lands. All of the College-managed Forests were certified in this study, as were Duke Forest and Division of Forest Resources lands at Bladen Lakes. Each member institution underwent a side-by-side comparison of SFI and FSC certification to assess their applicability. The project served as a means to examine the extension of certification to nonindustrial private forest lands. The study also involved a reverse certification component which examined the standards that certifying bodies used. In June 2002 a conference was held in Raleigh at which the results of the study were discussed. In 2004 the Center cooperated with governments and universities in 5 countries to develop a course in Temperate and Subtropical Sustainable Forest Management and Forest Certification. The course was offered in Argentina and jointly in 2005 at NC State and in Sweden via teleconferencing and web interactions. In March 2006 the Center co-sponsored a conference on Energy from Wood: Exploring the Issues and Impacts for North Carolina. Currently the Center is focusing its efforts on woody biomass and energy potentials in North Carolina.

Forest Resource Economics, Management, and Policy

No area better illustrates the growth and diversification of the Department's research efforts since 1980 than the areas of economics,

management, and policy. Until the late 1970s the Department had only limited expertise, primarily in economics, in these areas. In fact, it seemed that there was almost an unwritten agreement between NC State and Duke that NC State's strong industry-oriented programs in tree improvement and related areas would not be duplicated at Duke, and that Duke's emphasis on the social dimensions of natural resources would not be duplicated at NC State. Lester Holley was the only active researcher in economics and policy. Holley's major contributions were the study of the research needs of private, non-industrial land owners that led to the creation of the Small Woodlot Research Program, an intensive analysis of the impact of Southern Pine Beetle infestations on the southern forest economy and the economics of marketing beetle-killed timber, and development of a Timber Investment Diagnostic system.

However, circumstances changed when Dave Adams, Art Cooper, and Jan Laarman joined the faculty in the late 1970s. Adams carried out an active personal research program involving coastal resources, wildlife habitat analysis, and studies of issues related to implementation of Federal wetland legislation. Undoubtedly his greatest contribution was authoring a text, "Renewable Resource Policy", that was published in 1993. Because it covered all renewable resources and approached the subject through an institutional context, it was not widely adopted in forestry programs. Nonetheless, Adams' text was described by several policy experts as the "best text of its kind available" at the time. Although Cooper contributed little in the way of publishable research in forest policy, his deep involvement with the implementation of natural resource policy on the State and National level, particularly National Forest planning, inevitably led to a broadening of interest in the social science dimensions of forestry. Laarman's initial interests in labor economics carried over from his doctoral work at UC-Berkeley. However, he quickly found that North Carolina was not a fertile ground for research in labor economics and shifted his interests to the economic dimensions of international forestry, particularly in Latin and Central America. His work in Costa Rica eventually led him to leave the Department for employment there in 1998. Laarman's contributions ranged over a number of topics involving economic impacts of, among others, nature-based tourism, technical change in the Third World, policy planning in Latin America, and development assistance in forestry.

When Bob Abt, Fred Cabbage, Erin Sills, Toddi Steelman, and Sarah Warren joined the Department, economics and policy were represented by a breadth of active researchers whose programs established an expertise in the Department that had not existed before. Consequently, the Department now has a strong effort in economics and policy led by these four researchers that focuses on how the political and economic decisions we make individually and as a society affect our environment. There are now significant research efforts directed toward decision-making and the use, management, regulation, and protection of natural resources. Research is also devoted to the importance of accurate economic analysis in weighing management options, implementing oversight programs, evaluating the effectiveness of strategies, and motivating people to take action.

The research in economics and policy is proactive, in the sense that faculty and students often work together with public and private sector partners to address real-world problems. The scope of research covers a wide array of natural resources and an equally wide scope from local to international problems. Research often collaborates across disciplinary lines, involving other NCSU departments, Duke and UNC faculty, as well as federal, state, and non-profit organizations.

During the past decade, research has involved a number of areas involving policy. Examples include: public and community involvement in environmental and natural resource management, decision-making in communities dependent on natural resources, the economics of agroforestry and econometric applications in forestry, natural resource administration and policy, National Forest management and policy, Resources Planning Act policy and implementation, timber production and harvesting economics, as well as forest certification and the economics of sustainable forest management.

Steelman's work has been a particularly important addition in the policy area. She has brought an interest in governance of environmental and natural resources with an emphasis on science, policy, and decision making interactions. Her current and past projects involve watershed remediation and management, land and open space protection, national forest planning and community forestry, and wildfire. Her current work focuses on reforming current wildfire policy in the United States and how communities interact with natural resource agencies. This sort of research, lying as it does on the interface between natural resource management and social science, represents a new and significant addition to the Department's research capabilities.

Current research involves: development of regional timber supply models, nonmarket valuation, nontimber forest products, and international forestry, impacts of certification as a market policy tool and of government regulation and intervention, forest certification in the Americas, timber investment returns for plantations and native forests in 7 countries in Latin America, and silvopasture systems in Misiones, Argentina, with a parallel study at the Center for Environmental Farming Systems in North Carolina.

Forest Ecosystem Health and Assessment Program

The program is a long-term, national research and monitoring effort that helps resource managers and policy makers manage forest resources, allocate funds for research and development, and evaluate the effectiveness of environmental policies. It began as a program created and managed by Ellis Cowling and dealing primarily with the impact of atmospheric change, primarily acid rain, on forest ecosystems.

NOTE: THIS SECTION REMAINS TO BE COMPLETED

International Forestry and Conservation

It is difficult to argue that "international forestry" is a discrete area of research interest in the Department. Rather, it is a dimension that, except for Bruce Zobel's work in tree improvement, hardly existed prior to 1980 and yet now permeates virtually every area of research that the Department carries out. All of the Cooperatives have some of their research located in other countries and virtually every other faculty member has at one time or another been involved in an internationally-based research project. As the Department's web site declares, "the Department.....maintains partnerships with organizations and universities around the world. These relationships increase our academic and study abroad offerings while enhancing the breadth and quality of our research capabilities." Erin Sills, herself an active researcher with numerous international research projects underway, coordinates the Department's international programs. These include overseas study opportunities for both undergraduates and graduates as well as research.

The Department maintains ties with several universities worldwide. Reciprocal arrangements provide students with opportunities to study abroad while also extending the Department's international research capabilities. Probably the most important of these is with the Swedish University of Agricultural Sciences, a world-renowned institution whose research in forestry and natural resources has provided NC State with a rich source of knowledge over the years. This partnership exists because of the generosity of Gunnar Nicholson who created the Gunnar and Lillian Nicholson Faculty Exchange Fund which supports reciprocal visits between the two faculties as well as funds to support doctoral candidates. Other academic partnerships exist with the University of the Sunshine Coast in Queensland, Australia, the Universidad de Concepcion in Chile, five universities in China, and the University of Rome, Italy, for wildlife studies.

No less than 19 faculty, from virtually every disciplinary area in the Department, are listed as having active involvement in international research programs.

Hydrology

When Jim Gregory arrived in 1978 the Department had no faculty member whose primary interest was hydrology. Nonetheless, hydrologic research had been carried out during the 1950s-1970s by other faculty members and graduate students. Waldy Maki's classic study of the very positive effects of drainage and fertilization on loblolly pine growth on very wet sites in the Hofmann Forest was instrumental in the development of the forest products industry in eastern NC. Waldy Maki and Bill Hafley studied the impact of land use on water quality in the watershed of Lake Michie (which includes Hill Forest), the principal water supply for the City of Durham. Maki and Hafley reported that unpaved county roads were the major culprit of sedimentation in Lake Michie followed by agricultural fields and they recommended maintenance of forested riparian buffers on streams and water bodies as a water quality management tool, the first NC scientists to do so. Maki led a large study of the impacts of stream channelization in eastern North

Carolina. Several students worked with Maki, including Dennis Hazel who is now an extension faculty member. Another study, by graduate student Sharon Haines (nee Gibson, who became an influential industry researcher and who died unexpectedly in mid-2007), involved comparing runoff and water quality from the major Schenck Forest catchment to that from an adjacent agricultural catchment. However, none of these projects led to any coordinated effort to develop an hydrology research program.

Despite a major role in developing and managing the undergraduate forestry teaching program, Gregory also developed a personal program in watershed hydrology. Among his early studies were one on the impacts of upstream urbanization on streamflow and channel characteristics in Petersburg National Battlefield, one on the impacts of peat mining in eastern North Carolina on water quality and quantity, one in which he cooperated with the Small Woodlot Program in determining the sediment and nutrient removal functions of streamside buffer strips, a cooperative study with Weyerhaeuser Company and the Dept. of Biological and Agricultural Engineering of the hydrologic impacts of drainage control with flashboard risers in the pattern drainage systems of wetland loblolly pine plantations, and studies of water quality and water management in the Hofmann Forest. Gregory studied wetland hydrology in many different landscapes, including the ridge and swale topography of Hatteras Woods; mineral and organic flats of the Hofmann Forest, several different Weyerhaeuser Company sites, and the large military bombing ranges in Dare County; flood plains in two different states; and a large Carolina Bay. In recent years, Gregory's research has also focused on headwaters streams including development of methods to define and identify stream types; studies of flow regimes, channel geomorphology and aquatic biology; and the development of new GIS-based methods for more accurate mapping of headwaters streams.

In the early 1980s began what are undoubtedly his most important contributions when he began assisting forest industry and the US Army Corps of Engineers in identifying acceptable forestry practices for use in federally-regulated wetlands. As time progressed, Gregory came to be regarded as a true expert in this ecologically, economically, and socially complex area of forestry. He was widely sought out for his expertise and his level-headed view of wetland management and regulation made him a source of guidance respected both by forest industry and government regulators. He assisted the State Division of Forest Resources in developing its Best Management Practices for Wetlands guidance and participated in every significant workshop held on this subject. At the same time, Gregory's research and technology transfer activities related to headwaters streams have made a significant contribution to protecting the ecological functions of these systems. As Co-Chair of the NC Stream Technical Advisory Committee, Gregory assisted in the development of the NC riparian buffer protection program and the development and testing of a field methodology for identification of the origins of intermittent and perennial streams that is the first of its kind in the country. That methodology has been adopted by several other states for stream protection programs and is being

adopted by the US Environmental Protection Agency and the US Army Corps of Engineers throughout the Southeast.

Despite his retirement, Gregory is still in heavy demand for continuing education programs on wetland management, wetland delineation, stream identification, and stream corridor management. Gregory's heavy involvement in what was essentially extension work in wetland and stream management led the Department to make his appointment the first in its history that involved a split between teaching, research, and extension funds.

Fisheries and Wildlife

NOTE: THIS SECTION SUBJECT TO REVISION

Before discussing research in Fisheries and Wildlife in the Department it is useful to review the history of the Fisheries and Wildlife Program and of its relationships with the Department of Forestry. The Fisheries and Wildlife Program has a long and productive history at NC State. Prior to the late 1970s, all such work was located in the Department of Zoology in the College of Agriculture and Life Sciences. The Head of Zoology, Fred Barkalow, who also held an associate appointment in Forestry, was the principal wildlife researcher, with a particular interest in squirrels. Tom Quay in Ornithology and Bill Hassler in Fisheries also managed highly successful research programs with numerous graduate students in both areas. In 1976 the General Assembly appropriated earmarked funds to NC State to support a fisheries and wildlife program, specifying that some of the support was to go to the School of Forest Resources. After considerable negotiation between Agriculture and Forest Resources, sufficient funds were allocated to establish a position as Coordinator of the Fisheries and Wildlife Program with appointments in both Zoology and Forestry and to support a new position in forest wildlife management in the Department of Forestry. In 1978 Jay Hair assumed the position of Coordinator and Dick Lancia, who had recently completed his doctoral degree at the University of Massachusetts, became the first wildlife scientist appointed in the Department of Forestry. Lancia's position carried a significant teaching commitment, most notably to a new 6-week summer field program in fisheries and wildlife management to be taught at the Hill Forest.

During the 1980s and 1990s Fisheries and Wildlife Management continued as a jointly administered program. In 1981 Hair left to become Executive Vice President of the Wildlife Society. In 1984 Rich Noble became Coordinator, holding the position until his retirement in 2003 when Lancia took over management of the program, holding it until his retirement in 2008. A number of other appointments in fisheries and wildlife management were made in Zoology, including Phil Doerr (1973), Roger Powell (1979), Peter Bromley (), Jaime Collazo (), and B. J. Copeland (); of these all save Copeland had, at one time or another, an appointment (either joint or associate) in Forestry. When

Fisheries and Wildlife moved to Forestry in 2003, Doerr also moved to Forestry; the others remained in Zoology.

In covering research in Fisheries and Wildlife that was conducted in the Department, only that of Lancia and of appointments made into Forestry (diPerno, Moorman, Peterson) will be covered in depth. The work of Barkalow, Quay, and Hassler, although significant, is beyond the scope of this history.

Lancia's initial research can be broadly described as dealing with the habitat requirements of wildlife species, of which he studied a great number including bobcat, otter, and, (with one of his graduate students, on the impact of wild boar in the Great Smokies. Lancia and Dave Adams worked together on habitat description and prediction of the effects of development and management on fish and wildlife habitat, particularly in eastern North Carolina. Also in conjunction with Adams and research associate Steve Seagle, Lancia developed a new change-in-ratio method of estimating deer populations, and carried out studies involving range wide habitat use of Red-cockaded woodpeckers in the Southeast ultimately leading to a paper dealing with opportunity costs of management southern pine for red-cockaded woodpecker habitat. Lancia's work supported that of Phil Doerr, who was a leader in studies of this endangered species, and who held a joint appointment in Zoology and Forestry. The research of both of these men made valuable contributions to the resolution of the dispute between red-cockaded woodpecker and timber managers.

During the 1990s Lancia, together with cooperators on the faculty, carried out studies and published on estimating the number of animals in wildlife populations, particularly the catch-per-unit-effort method. He also cooperated with one of his past graduate students on research on white tailed deer populations in a managed agricultural area on the eastern shore of Virginia. In the late 1990s Lancia was funded by WESTVACO to conduct research on the implications for wildlife populations of its management plans for its lands in South Carolina. This work led to publications dealing with impacts of management activities on breeding bird populations.

Three wildlife scientists have joined the Department in the last 8 years: Chris Moorman (1999) and Chris DePerno (2004) with primary commitments in wildlife extension and Nils Peterson (2007) on the teaching faculty. Moorman's primary interests are in wildlife management, particularly of non-game species and in urban environments, and in environmental education with responsibility for the Department's Project Learning Tree effort. DePerno specializes in population ecology, habitat use and management of big game species and predators, predator-prey relations and sexual segregation and resource partitioning in ungulates. He also works with reptile and amphibian habitat requirements, and as might be expected for an extension faculty member, with wildlife education. Nils Peterson, the newest member of the wildlife faculty, has diverse research interests, including policy analysis, environmental attitudes and behavior assessment, and assessing impacts of human behaviors on endangered wildlife populations.

Mensuration

By 1980 Bill Hafley had established himself as the Department's mensurationist with 15 years of research in growth and yield and application of statistical measures to forestry problems. When Bill Smith joined the faculty in 1978 he quickly teamed up with Hafley to begin more than 10 years of joint research on growth and yield. Their principal project was the development of a bioeconomic model for growth and yield of Loblolly pine supported by the Southern Forest Research Center. Their collaboration initially produced a model simulating the performance of unaltered stands. The model was then adapted for use with thinned stands and to assess the impact of fusiform rust and of hardwood competition. Eventually it was used to permit differentiation of stands into products. They also developed a White pine plantation growth and yield model. In the mid-1980s Hafley carried out a reevaluation of US Forest Service survey data for the Southeast from which it had been inferred there had been a decrease in the rate of growth of pine in the last decade. Hafley identified artifacts in the data that contributed to the observed reduction in radial increment.

Much of Smith's effort during the 1980s was devoted to completing his doctoral dissertation. After that, and before his departure for the US Forest Service in 1994, Smith worked with Joe Roise and Dave Adams to aid the US Forest Service planning effort for the Pisgah and Nantahalah National Forests. His analysis of timber inventory and levels of cut proposed in earlier plans clearly showed that under such cutting regimes the Forests would have been over cut and levels which could not be sustained.

With Hafley's retirement in 1990 and Smith's departure in 1994 the Department was left without expertise in mensuration. This deficiency was remedied in 2002 when Bronson Bullock was hired. Bullock's research focuses on quantitative issues relating to the growth and yield of forest stands with an emphasis on the spatial relationships between individual trees in a stand. He also works with more 'traditional' biometric topics, such as volume, taper, and weight equations derived for various species and regions in the Southern US.

Bullock's research covers a broad range of forest biometrics theory and applications, including juvenile diameter distributions for loblolly pine, deriving the spatial autocorrelation for forested stands, evaluating the impacts of genetic background on individual and stand level growth characteristics, models for Christmas tree production, and using Bayesian multiple imputation techniques to fill in missing observations from large inventory datasets. He has performed applied research dealing with green weight and volume equations to any merchantable upper diameter or height limit with applicability to forestland managers and researchers alike.

Further, Bullock has led and helped to establish two long-term forestry research sites to evaluate the effects of genetics on tree and stand growth. These large study sites will provide a basis for ongoing research during the next thirty years.

A number of faculty members have made contributions to the Department's research portfolio through their individual efforts. These include:

Dave Adams

Despite the fact that Dave Adams' appointment was split 50-50 between the Department and the Division of University Studies, meaning he had heavy teaching and advising loads there, he was able to carry out several significant research projects during his tenure in the Department. His early work centered around habitat description and prediction of the effects of development and management on fish and wildlife habitat using computer models and describing the impacts of proposed dredging in Currituck Sound and the White Oak River. Another project involved three 20-year mining scenarios developed to assess environmental impacts of different intensities of peat mining and reclamation the Albemarle-Pamlico peninsula. Adams also completed an assessment of the implications for the State of North Carolina if it assumed responsibility for issuing Federal section 404 dredge and fill permits. He also re-surveyed a 20-acre plot established on Mt. Mitchell in the last 1950s before deterioration of spruce-fir forest in an effort to provide insights into the impacts of pollutants and other stresses on this high elevation forest. Adams also participated with other Department members in development of responses to public concerns with forest management practices described in land and resource management plans for the Pisgah and Nantahala National Forests; this work was designed to help the US Forest Service identify feasible, alternatives to clear cutting.

Unquestionably Adams' greatest scholarly accomplishment during his tenure in the Department was completion of his renewable resource management text "Renewable Resource Policy: the Legal-Institutional Foundations." Adams wrote this book during his last 5 years in the Department. After several abortive agreements with publishers, it was issued in 1993 by Island Press. The book was modeled after the outline of Adams's course in Renewable Resource Management; ironically, because Adams retired at the end of 1993 he was never able to use it as the text for his course. Although the text was never widely adopted, policy researchers familiar with the book proclaim it to be one of the very best of its kind.

Gary Blank

When Gary Blank joined the Department, on a part-time appointment (the remainder of his time was allocated to Engineering) his efforts were wholly devoted to improvement of the writing skills of forestry undergraduates. His work in this area also involved working with individual faculty members to incorporate and evaluate writing assignments throughout the entire curriculum. He began work for his

PhD in 1981 and completed the degree in 1992. His thesis examined how professional foresters' communication behaviors were differentiated by workplace roles in federal, state, industrial or consulting organizations. During this period, his research concerning communications in natural resources resulted in a variety of proceedings papers and peer-reviewed publications.

During this time Blank's intellectual interests also shifted to include forestry-related problems, especially environmental impact assessment. Editing the Critical Assessment Review Papers on the Acidic Deposition Phenomenon and its Effects (1400+ pages with 66 authors) under direction of Drs. Ellis Cowling and Rick Lindthurst, Blank broadened his expertise in assessment science and policy. Consulting with engineering firms doing environmental assessment projects for the North Carolina Department of Transportation, Blank developed practical knowledge of assessment processes. From 1983 until 1998 he produced technical reports for more than 80 assessment projects across the state of North Carolina. In 1999, under contract with the Division of Forest Resources, he produced *Conserving North Carolina's Forests: Assessment of Need* for North Carolina to participate in the US Forest Service Forest Legacy program.

After completing his doctoral work Blank began to develop professional interests in the history of forestry, environmental history and historical ecology, in both North America and Europe. Largely these research interests evolved from experience in environmental impact assessment. They led to a project on the Harris Tract southwest of Raleigh that involved restoration of a Piedmont transitional longleaf pine site where longleaf had once been abundant. Several students completed Master's degrees under him using work done on the Harris Tract for their theses. Since then, he has continued to present papers and publish on the longleaf restoration project, principally in European venues. Blank's interests in the historical ecology have carried him to Europe several times for research in, among other areas, the Czech Republic and central Europe. Finally, Blank has also been examining environmental change from 1750 to the present in the central Appalachians' Allegany Plateau region, specifically focused on Garrett County, Maryland. A number of conference presentations and one paper have resulted from this project so far.

Richard Braham

Consistent with his devotion to excellence in teaching and advising Richard Braham has maintained an active involvement in research. Most of this work has stemmed directly from Braham's strong interests in the taxonomy and silvics of woody plant species.

In 1999 the Iowa State University Press gave Braham a contract to completely rewrite Dick Preston's dendrology text North American Trees. This three-year project culminated in the publication of the new 5th edition of what is now Preston and Braham's North American Trees in December 2002. During its first year of publication, the text sold about 750 copies, a large number considering there are prob-

ably only about 1000 students who take dendrology in the United States. The text has also been adopted by 11 schools and colleges. Braham also obtained (with Alexander Krings of the Department of Plant Biology) a second contract to prepare a comprehensive manual to the tendrillate vines of Costa Rica and Central America. This work appeared in 2005

Braham has also obtained support for graduate students to carry out studies on endangered plant species. Work on one of these, Michaux's sumac (Rhus michauxii), involved transplantation of individuals from sites scheduled for disturbance. The work has resulted in successful movement of plants to protected sites and has also resulted in several publications. Braham is continuing his work with endangered species and forest types, particularly Longleaf pine on sites in the Piedmont at the western edge of its range.

Braham has regularly contributed articles on individual tree species to Forest Landowner News.

George Hess¹

When Hess joined the Department in 1996 he brought interests and abilities that filled a vacant niche in the Department's research portfolio. He is another faculty member whose research and teaching are tightly integrated, much to his own benefit and to the benefit of the students in his classes.

Hess's research is driven by a strong interest in the conservation of natural resources and biological diversity. Because of his background in biomathematics, he has concentrated on conservation issues amenable to modeling approaches and on examining wildlife conservation in managed landscapes generally, and suburbanizing landscapes in particular. Initially, his work focused on developing an approach to open space planning for wildlife in suburbanizing areas that could be applied by practitioners with readily available data, on understanding and quantifying suburban sprawl, and on the potential effects of increasing timber harvest rates on wildlife. Two important studies that benefited from Hess's work were the 1999 North Carolina Chip Mill Study, in which he and his students quantified the effects of increased numbers of chip mills on wildlife populations, and the "State of Open Space 2000" report on the Triangle Region (he was the lead author) that played a role in igniting greater interest in open space protection in the Triangle.

More recently, Hess has studied urban greenways as habitat for breeding bird species, meso-mammals, bird nest predators, and salamanders, and their value as stopover habitat for migrating birds. The intent of this work is to develop guidelines for developing suburban greenways that maximize habitat for native flora and fauna. Graduate students working with Hess and Chris Moorman of the Extension faculty have examined the biodiversity values of greenways in Raleigh and

¹ Hess supplied materials from which this summary is drawn.

Cary. Hess and the students in his research special topics courses have also studied the potential effectiveness of various approaches to conservation planning, including surrogate species and indicator taxa. This work has been aided by a collaborative relationship with World Wildlife Fund.

Hess recently has added two new dimensions to his research. One is an effort, in conjunction with Toddi Steelman, to determine how to best incorporate scientific findings into local planning activities. The other involves, in collaboration with the Center for Excellence in Curricular Engagement, the scholarship of teaching and learning with respect to service-learning and curricular engagement.

Hess's integration of teaching and research is shown by the evolution of his collaborative research courses taught at the graduate level. Since 2001 teams of graduate students in these courses have undertaken studies including: Measuring Urban Sprawl; Focal Species Planning; Surrogate Species Planning; Regional Biodiversity Patterns; Examining Biodiversity Patterns; Creating Open Space Plans that Work; and Where is Conservation in Local Planning. Scholarly presentations and published papers have resulted from a number of these team efforts.

Hess (Toddi Steelman and Ted Shear are others) is an excellent example of the new direction that the Department is taking in its research efforts. The work not only involves extension of ecological principles into the urban human-forest interface but also includes involvement of personal research in local resource management issues. The Department is clearly recognizing urban dwellers as important focal points for research and outreach related to the management of natural resources.

John King²

King joined the faculty from Michigan Technological University in 2005 to continue the Rooted Cutting research program after Barry Goldfarb became Department Head. However, industry support for that program was terminated at virtually the same time King arrived, leaving him the latitude to pursue other directions in his personal research program.

The conceptual framework of King's research lies in studying the flow of energy through terrestrial ecosystems by quantifying how net primary production is influenced by environmental drivers (CO₂, ozone, temperature, nutrient, and water availability and by biotic factors such as genetics, community composition, and life history traits of the dominant plants. His studies range from the molecular to the ecosystem level and involve a variety of laboratory analytical techniques and field measurements.

² This section based on material kindly supplied by John King.

Currently, King has 6 distinct research projects underway. Four of these continue work that he began in the Lake States with co-investigators while he was at Michigan State and 2 represent new studies undertaken since his arrival at NC State. Three of the Lake States projects are located at the AspenFACE Project in Rhinelander Wisconsin where aggrading communities of Trembling aspen, Paper birch, and Sugar maple have been exposed to atmospheric CO₂ approximating those predicted to occur in 2050. The studies King has been involved in involve various aspects of ecosystem response changed atmospheric conditions. One involves the responses of fine root chemistry to changed atmospheric conditions, a second involves fluxes and rates of carbon and nutrients in leaf litter, and a third seeks to determine how forest ecophysiological responses will influence regional water responses. The other Lake States study King is involved in is a study of biomass production and partitioning in Red pine along a soil chronosequence in the upper Peninsula of Michigan. This study is a bit unique in that a full carbon accounting along the soil chronosequence has been made, including above and below-ground carbon. A tractor and mechanized soil screen was used to excavate and sieve the entire soil volume contained within the plots, thus recovering virtually all of the root biomass.

King has developed two separate projects since coming to NC State. One involves cooperative work with the Tree Improvement Program and involves studies of the effects of genetic improvement on tree physiology, stand-level productivity, and the cycling of carbon and nutrients. This project apparently will take advantage of the large pool of Loblolly pines of known genetic inheritance and known performance rates in the field and should provide physiological and ecological understanding as to why some improved trees perform better in nature. Small scale studies are being conducted in common garden experiments in Raleigh and the stand-level assessments are being conducted at the Hofmann Forest in Onslow County. The other North Carolina-based study deals with partitioning of ecosystem respiration in Lower Coastal Plain forests. This study is just getting underway and will complement two existing eddy covariance flux tower sites in 3- and 15-year old Loblolly pine plantations.

The work King has underway appears to provide the Department an opportunity to provide a physiological understanding for Loblolly pine behavior observed in the Tree Improvement and Nutrition Cooperative programs. No work of this sort has been possible before in the Department, partly due to the lack of a faculty member with appropriate interests and partly due to the lack of equipment and facilities needed for such work. It thus adds an important addition to the Department's research portfolio.

Elizabeth Nichols³

³ Nichols kindly provided a write-up on her research work that serves as the basis for this section.

When Nichols joined the Department in 2002 she brought with her research interests developed while she was on the faculty of the University of Tennessee-Chattanooga. In her six years in the Department she has built on those interests, developing a research program that focuses on chemical and biological mechanisms that control contaminant availability to interact with organisms in soils and sediments. She has worked closely with graduate students in the Department and with students working on related subjects in other departments, as well as with undergraduates. Nichols' program, together with the bio-restoration work of Ted Shear, constitutes the Department's research efforts in environmental technology. Given the growth of that program and the students it has attracted, it is easy to predict that it will be one of the emerging areas of research in the Department.

Currently, Nichols' research centers around three subjects. The first involves studies of how plants impact petroleum hydrocarbon availability in soils and sediments. Working with members of the Departments of Marine, Earth, and Atmospheric Science and Environmental and Molecular Toxicology (where she is an associate faculty member), and with the assistance of Exxon-Mobil Corporation and the Environmental Protection Agency, she analyzed field sediments from a refinery waste pit that had naturally re-vegetated over several decades. Initial results showed that vegetated refinery waste had much less petroleum hydrocarbon contamination than barren refinery waste sediments. These results enabled her to obtain NSF funding to study plant carbon cycling in petroleum waste materials from sites in New Jersey and Indiana. She has also received funding from EPA and North Carolina's Department of Environment and Natural Resources to establish a phytoremediation demonstration at the U.S. Coast Guard Training Facility at Elizabeth City, NC. The project goals are to present the discharge of gasoline-contaminated ground water into the Pasquotank River using trees to retard ground water flow via transpiration.

A second area of study involves using isotopic analyses to monitor water quality in watersheds. This work is a continuation of work she began at UT-Chattanooga in the Conasauga River Basin, GA, where freshwater mollusk populations were rapidly disappearing. After arriving at NC State she was contacted by the Nature Conservancy to carry out a study of contaminants in the Conasauga Basin using funds from the Woodruff Foundation and the USDA Forest Service. She used surrogate snail populations to evaluate if stable nitrogen isotope signatures changed with land use and passive membrane devices to collect integrated samples of water contaminants over time.

Nichols' third area of interest built on work done on the Conasauga River and investigated the use of stable nitrogen isotope analyses of vegetation to monitor ground water contaminated with municipal or livestock waste water. Although snails and mussels are useful organisms for studying stable nitrogen isotopes in water because of their limited mobility, their usefulness is limited by their declining populations. Nichols began to investigate if stable nitrogen analyses of foliar and stem samples from trees would increase if trees were ex-

posed to groundwater contaminated with livestock or municipal waste water. A study was recently established at the Garner, NC, Waste Water Treatment Facility and determination of the usefulness of the approach are ongoing.

Graduate and undergraduate students have participated extensively in these studies and most publications emerging from them have either been authored or co-authored by students. Such collegial work clearly attracts students to the field of environmental technology, a critical factor in the early development of any successful program.

Joe Roise

With the hiring of Joe Roise, who began work in early 1985, into the position vacated by Tom Gemmer's death, the Department acquired a new and important expertise in quantitative decision making. His research work has applied the methodologies of Management Science to integrate information and knowledge from a wide variety of disciplines for the purpose of improved forest resource decision making.⁴

His initial work concentrated on developing a new Nonlinear Programming methodology for estimating optimal combinations of stand-level management decisions, providing forest managers with a significantly improved ability to analyze stand-level management activities. Within 7 years Nonlinear Programming was applied commonly in North America and Scandinavia and are used world-wide today. These methods were extended to analyze multiple objective resource problems. One of the most interesting was development of tradeoff curves between Red Cockaded Woodpecker habitat and net present value of other forest resources. Roise took advantage of advances in computer technology, creating a formulation of the Four Color Theorem to analyze forest level problems. Roise used these techniques when he became involved, with Dave Adams and Bill Smith, in developing early versions of ecosystem management models for the planning efforts of the National Forests in North Carolina. Enhancements of FORPLAN, Spectrum, TerraVision, VDDT, and other mathematical models were used to analyze tradeoffs between policy, objectives, ecosystems, economics, inputs and outputs from the Pisgah, Nantahalah, Croatan, and Daniel Boone National Forests.

Another interest Roise pursued was development of computer software for use in forest product decision making, the most notable being CASP, a Computer Aided Sawing Pattern design program. This program has gone through several iterations and still in use in 2008. Other programs involved COW, a wood products costing program, and BYPS, a bottomland hardwood yield projections system.

As integrating information from a variety of sources ran into an informational roadblock, because key pieces of information were not available and simply making new assumptions was not adequate, Roise

⁴ The narrative on Roise's research program draws extensively on material he kindly provided the author.

studied the use of Neural Networks in an effort to enhance the ability of experts to integrate information. Although theoretically interesting, application of these systems, while possible for limited purposes such as developing prescriptions for certain forest types, still has not been successful for large scale forest management problems. Roise concentrated on applying these systems to specific problems such as development of a pine straw yield model, optimal wetland mitigation and optimal location of roads through wetlands, weight loss equations due to evaporation, forest scheduling pipeline problems, and analysis of competitive timber markets in British Columbia.

In 2004 Roise's research underwent a major change in direction as an old forestry problem that had never been fully resolved became urgent. After 50 or more years of fire suppression in the Southeast hazardous fuel loads had become dangerously high and a method was needed to reduce them. Having been involved in harvesting research earlier, Roise sensed what was needed. When he looked for conventional methods to harvest small diameter woody biomass, he found that no machinery existed that could do the job economically. By mid-2004 when a national energy crisis again loomed, Roise realized that the small diameter woody undergrowth that had once been regarded as a public safety hazard was in reality a huge potential energy resource. He then focused his efforts on developing a machine system to harvest small diameter woody biomass and in 2006 developed a partnership with FECON Manufacturing, Craven Wood Energy, the USDA Forest Service, and the NCSU Forestry Foundation to develop the machinery. By fall 2007 the machine was ready and testing continued into 2008. Roise's students have dubbed the machine "the Kraken" for the mythical Norse beast that eats everything in its path. A second generation machine is being developed in 2008/2009 the result of which will be a system that will harvest small diameter woody biomass thus reducing buildup of hazardous fuels.

Anne Stomp

When Stomp returned to NC State in 1986, and for several years thereafter, she worked with Ron Sederoff on forestry-related problems, making major contributions to the early work of the forest biotechnology program. Chief among these was her work on the use of Agrobacterium tumefaciens to transfer genes into Loblolly pine and a number of other species of pine.

By the early 1990s Stomp's research interests had changed and she was concentrating on genetic engineering in Duckweed (Lemna). Initially, her interest in Duckweed was centered on its potential to grow and remove nutrients from swine waste disposal lagoons. The first studies involved growth of Duckweed in synthetic swine lagoon medium. Duckweed grew and removed significant levels of N and P from the medium. This work led to research on genetic improvement of Duckweed. The work successfully developed Agrobacterium-mediated gene transfer as well as ballistic bombardment gene transfer into Lemna gibba and L. minor. The research also involved Duckweed callus cul-

ture, yielding an alternative means for growing fronds for use in experiments with Agrobacterium.

The work with Duckweed shifted to an emphasis on the ability of genetically transformed plants to produce biologically active polypeptides, ultimately leading to development of methods for the production of therapeutic proteins such as insulin. Because of the large amount of protein Duckweed contains, and its ability to double in size every 24-48 hours, production of insulin this way is potentially less expensive, more productive and less risky than traditional techniques. Stomp has patented the processes she and her co-workers used to genetically engineer Duckweed and develop therapeutic proteins from it. Armed with this important new methodology, Stomp in 1997 launched Biolex, Inc., the first plant biotechnology company to grow out of NC State laboratories and, with a license for her patented technology, Biolex now has the support of significant venture capital funding. Currently, the company is working on an interferon treatment for chronic Hepatitis C. Stomp left Biolex in 2001 and returned full time to the Department.

Currently, she is working with the Department of Biomedical Engineering (a unique Department encompassing both NC State and UNC-Chapel Hill scientists) where she and Donald Bitzer are heading a multidisciplinary group that is applying signal processing principles to study and enhance protein translation. Stomp's career has been marked by an uncommon willingness to strike out in new directions and to think well outside of traditional boxes. To say her work is unique in the Department would be a major understatement.