SELF-STUDY DOCUMENT FOR DEPARTMENT REVIEW

Department of Statistics

10-8-98

Unit authorized to offer degrees:	**Department of Statistics**
College:	**Arts and Sciences**
Exact titles of degrees offered:	**Bachelor of Science**
	Master of Science
	Doctor of Philosophy

1 Our view of the discipline

The Department's personnel decisions, the structure of the graduate program, and the course offerings are all shaped by our view of the discipline. Although not all faculty members might agree completely with the summary below, there is a basic consensus.

The purpose of Statistics as a discipline is to develop tools for designing studies and analyzing data. Use of statistical tools and ideas is pervasive in all disciplines engaged in empirical inquiry. This makes statistical literacy an important requirement for an informed citizenry.

Development of tools cannot take place in a vacuum; it has to be problem driven. Finding and understanding problems requires interaction with other disciplines (such as Genetics, Epidemiology, Economics, Sociology, Atmospheric Sciences, etc.) that acquire and analyze data. **Collaborative research is therefore essential to the continuing viability of the discipline.**

Performance evaluation - does a tool really solve the problem it was designed to solve, and how does it compare to other tools created for the same purpose - is an essential and integral part of tool development. Performance can be evaluated experimentally (by applying the tool to real and simulated examples), or theoretically (by mathematical analysis). **While Mathematics provides the machinery for theoretical analysis of statistical procedures, Statistics is not a sub-field of Mathematics.**

In the last 20 years, data collection and data analysis have been transformed by the computer revolution. Computers have made it feasible to collect large data sets (gigabytes of information). The pervasiveness of computers in daily life brought on by services such as the Web and Internet shopping is giving rise to entirely new data sources and data types. Computers also have tremendously expanded the range of tools that can be implemented The Bootstrap, nonparametric prediction methods like CART and Neural Networks, the Cox model for survival analysis, The Grand Tour and scatterplot painting for data visualization, Bayes nets, and Markov Chain Monte Carlo would have been unthinkable without the advances in computing. **There clearly is an increasing demand for new data analysis tools, and for individuals trained to invent, evaluate, and apply them.**

The increasing importance of computers in both data collection and data analysis has made expertise in computing an important prerequisite for creating and applying new and innovative data analysis tools. Computer Science is approaching a position on par with Mathematics as a foundation for Statistics. **In order to stay at the cutting edge of data analysis, we have to account for this paradigm shift in our research and teaching.**

2 A brief history of the Department

The formation of the Department of Statistics was endorsed on October 26, 1978 by the Ad Hoc Committee on Applied Mathematics, chaired by Associate Dean William Richardson of Public Health and Community Medicine. The Planning Committee on Statistics was formed on January 24, 1979. The committee was chaired by Arts and Sciences Associate Dean Paul Hodge; its members were Hubert Blalock (Sociology), Ben King (Business School), Cliff Lunneborg (Psychology), Donovan Thompson (Biostatistics), Doug Chapman (Fisheries), and Ron Pyke and Galen Shorack (Mathematics). Their mandate was to prepare "a plan whereby the College of Arts and Sciences can best create a Department of Statistics that will benefit the students of the University, the statistics faculty in the various colleges, and the general reputation of the University in the field of Statistics."

Following their recommendation, the Department of Statistics began its life on July 13, 1979 under the chairmanship of Professor Michael Perlman, who was recruited from the University of Chicago. The initial Department members were Perlman, Pyke, and Shorack, with Doug Martin (Electrical Engineering) and Lunneborg (1/3) joining one year later. By September 1987 the Department had reached its current size, and all current Associate and Full Professors except Julian Besag and David Madigan were members of the faculty.

3 Department roles and responsibilities

The responsibilities of the Department of Statistics are:

- **Undergraduate education:** Training of undergraduates in all fields / majors in "statistical thinking" and basic statistical methodology.
- **Graduate education:** Training of future research statisticians.
- **Research:** Development of new statistical theory and methodology. Active participation in research projects in other disciplines – collaborative research.
- **Consulting:** helping scientists in other fields to use statistical methods and thinking.
- **Service** to the University, the region and state, and the scientific community.

Note: Although the boundary is somewhat fluid, we make a distinction between *collaborative research* and *statistical consulting* In a consulting relationship, the client chooses the research project and defines the research goals. The statistician provides the statistical expertise necessary to achieve these goals. In a collaborative research project, the statistician is an equal partner in setting research goals and shares responsibility for all aspects of the project.

4 Organization

As appropriate for a relatively small unit, the organizational structure of the Department is simple. The Chair supervises the Administrator; the Administrator supervises all other staff.

4.1 Committees

The standing committees are

- **Student recruiting and admissions**: Evaluates and ranks applications for the graduate program and decides on offers for admission and support.
- **Teaching effectiveness**: Implements the Department's teaching review plan (see Section 4.2)
- **Computing**: Sets computing policy, advises the Chair on purchases, and oversees the Computing Cost Center (see Section 5.3).
- **Space**: Assigns office space.
- **Faculty recruiting**: Actively searches for suitable faculty candidates, evaluates and ranks applicants, prepares recommendations to the faculty.
- **Probability:** Coordinates teaching of probability courses with the Mathematics Department.

Committees for curriculum review, promotions, and qualifying exams are constituted as needed.

The Department teaches three large service courses that are offered every quarter. Each of these courses is assigned a course coordinator, responsible for ensuring continuity and consistency.

The Department has an extensive Web site, containing information on the unit, papers and reports for downloading, and Web pages for many of the courses (http://www.stat.washington.edu). The site is maintained by a graduate student paid hourly for this task.

4.2 Teaching review

The Department has a Collegial Teaching Evaluation Plan and a standing committee charged with implementing the plan.

At the beginning of each year, every instructor is assigned to one of currently three teaching review groups. Each group member visits one other group member's class and writes a report on the visit, pointing out strengths and weaknesses and suggesting improvements. In addition, instructors are asked to write a self-evaluation.

Groups meet at the beginning of every quarter to review the previous quarter's classes, based on student teaching evaluations, peer review reports, self evaluations, and other material provided by the instructors, such as syllabi, handouts, yellow sheets, etc.

One faculty meeting each year is dedicated to reviewing departmental teaching, assessing the effectiveness of the Collegial Teaching Evaluation Plan, and discussing potential improvements.

4.3 Mentoring of junior faculty

Every Assistant Professor is assigned two faculty mentors whose duty is to provide help and advice. They might introduce a new faculty member into the secrets of writing successful grant proposals, use their connections to get their junior colleague invited to conferences, give helpful hints on how to improve teaching and receive better student ratings, etc.

At the end of Spring quarter the Chair meets individually with each Assistant Professor. The purpose of this meeting is to review performance during the past year, spell out departmental expectations, assess progress towards tenure (for tenure track faculty) or other professional goals, and give advice. A written summary of the meeting is sent to the faculty member and becomes part of the official file. It is also shared with the faculty member's mentors.

4.4 Student participation in governance

The graduate students elect a graduate student representative (GSR). The GSR is invited to all faculty meetings, with the exception of meetings dealing with student evaluation or other personnel matters. While not present during discussion of faculty appointments, the GSR is invited to communicate student opinions and preferences.

The graduate students also have a representative on the Computing Committee and the Space Committee.

5 Resources and support

The total of the Department's state budgets for fiscal year 1998 (7/1/97 – 6/30/98) was about $1.2M. The total grant income during FY 98 was about $1.8M, not all of which was spent within the Department.

5.1 State funds

Faculty
The Department currently has 11.5 state funded faculty FTE, which is essentially unchanged from 11.33 FTE ten years ago. The positions are occupied by

- Full Professors Julian Besag, Peter Guttorp, Douglas Martin (50%), Michael Perlman, Adrian Raftery (50%, joint with Sociology), Galen Shorack, Werner Stuetzle, Elizabeth Thompson, and Jon Wellner;
- Associate Professor David Madigan;
- Assistant Professors Tilmann Gneiting (starting his first year in a tenure track position) and Thomas Richardson (starting his third year)

A 50% tenured position, formerly occupied by Finbarr O'Sullivan in a joint appointment with Biostatistics, is currently open and advertised.

In addition,

- Research Professor Paul Sampson has 50% state support in his role as Director of Consulting;
- Acting Assistant Professor Alejandro Murua (starting his first year) is supported 60% by state funds from the staff position formerly occupied by John McDonald.

Staff
The Department has 5.5 state funded staff positions.

- Judy McPhee, Administrator
- Connie Sugatan, Fiscal Specialist (responsible for all grant budgets)
- Cheryl Bissett, Receptionist
- Kristin Sprague, Graduate and Undergraduate Adviser
- Thomas Wagner, Computer Support
- Carol Quintero, Computing Cost Center Administrator (50%)

Graduate students
The Department has 12 state funded 50% TA / GSA positions.

Operating funds.
The Department has an annual state operating budget of about $35K. This is about 2/3 of operating expenditures.

Capital equipment
There is no capital budget.

Space
The Department occupies 53 offices with a total of 7,411 square feet:

- 29 offices for 37 faculty, staff, and visitors
- 17 offices for 37 students
- Conference room (also used for small classes and some seminars)
- Consulting room
- Two computer labs
- Mail / copy / fax room
- Lounge
- Store room

This represents a significant improvement from the 5,000 square feet ten years ago. However, it falls far short of the 12,000 square feet then promised by former A&S Dean Joe Norman.

5.2 Grants

The grant income during fiscal year 98 (7/1/97 -- 6/30/98) was about $1.8M. Figure 1 shows a history of grant support. See Section 12.2 for a discussion of this development.

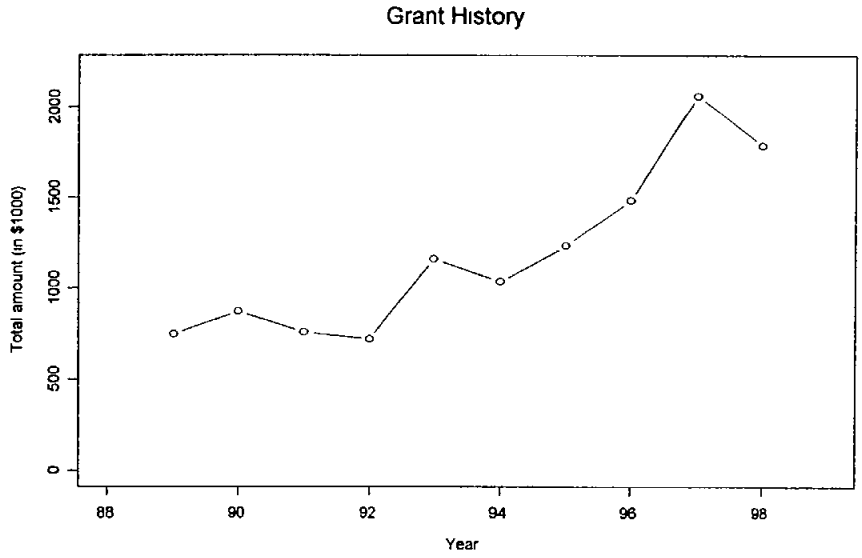

Figure 1. Total income from grants for FY 89 – FY 98

Grants contribute to the Department both directly and indirectly.

Directly,

- Grants partially support Research Associate Professor Judy Zeh and Research Professor Paul Sampson

- Grants support Postdocs Warwick Daw and Jochen Kumm, both working with Elizabeth Thompson, and partially support Research Scientist Chris Fraley, working with Adrian Raftery.
- Grants support 16 of currently 37 graduate students. (Of the remaining 21, 12 are supported on state funded TA / GSA positions, and 8 are supported on fellowships or grants outside the Department.)
- Grants contribute $40K per year to the Computing Cost Center, which is about 2/3 of the total Cost Center income. See Section 5.3 for a discussion of computing support.
- Grants provide summer salary for faculty.

Indirectly,

- The salary recaptured when faculty members buy out of teaching partially supports Acting Assistant Professor Alejandro Murua (40%) and Acting Assistant Professor Joel Reynolds (15%).
- Salary recapture allows us to increase the number of classes we can offer. We charge a faculty member 25% of the nine-month salary to buy out one course (25% of the teaching load), which typically is more than the cost of hiring an outside instructor to teach the course.
- The Research Support Allocation (RSA), a return to the Department from the indirect cost the University charges on grants, provides the 1/3 of operating expenses not covered by the state. It also funds occasional equipment purchases, seminars, and contributions to the startup money for new faculty.

5.3 Computing support and the Computing Cost Center

The Department has about ten Unix workstations (mostly Dec Alphas and SGIs), a half dozen Macs, and a dozen PCs. The trend is towards a mixed Unix / PC environment.

Computing support for the Department is provided by the Math Sciences Computing Center (MSCC). MSCC also supports the Mathematics Department and runs Unix systems, a PC lab, and a Mac lab used for undergraduate and graduate instruction. MSCC has 3.75 state funded staff FTEs, plus the Statistics computing staff position (Thomas Wagner) and a corresponding position from Mathematics.

The Department operates a Computing Cost Center as a means for charging computing expenses to grants. Every user must have an account, and every account must be paid for. Accounts for staff and TAs are paid from state budgets. The account fee is $70 / month. The Cost Center income is around $60K per year It pays some personnel expenses (Webmaster plus a small percentage of our Fiscal Specialist), as well as maintenance and new equipment The depreciation budget of the Computing Cost Center is the Department's only capital equipment budget.

5.4 The Statistical Consulting Cost Center

The Statistical Consulting Cost Center, described in more detail in Section 10.2, is a mechanism that allows us to offer consulting services to paying clients inside as well as outside the University. Since its creation in 1994, the Consulting Cost Center has taken in a total of about $65K. The amount could easily have been higher, had it not been for lack of suitable students and available faculty.

6 Research

Maintaining excellence in research is the number one priority of the Department.

Not only are the results of our research important in and of themselves, but excellence in research is also a prerequisite for a high quality graduate program.

Our faculty members have been among the leaders in a number of recently "hot" research areas, such as Bayesian methods, Markov Chain Monte Carlo, Spatial Statistics, Bayes Nets, semiparametric estimation, and data visualization. The excellence of the Department in research is witnessed by honors received by the faculty, by their ability to attract grants, by their publication record, by invitations to speak at major conferences, and by the demands for their service. Instead of summarizing this information here, we have asked each faculty member to provide a short CV containing

- Education and degrees
- Positions held
- Honors and awards
- Grants for last 10 years.
- Ph.D. students
- Service to profession, university, community (highlights)
- Invited lectures (highlights)
- Most important publications

These CVs are collected in Appendix F.

A distinguishing characteristic and a major strength of our Department is the involvement of our faculty in collaborative research with other disciplines Collaborative research is a symbiotic relationship that ideally benefits the discipline of Statistics as well as the subject matter discipline:

- It benefits Statistics because data analysis problems encountered in collaborative research motivate and drive development of new methodology and, indirectly, new theory.

- It benefits the subject matter discipline because statisticians contribute their expertise in statistical methodology and theory.

Because of our belief in the importance of collaborative research, we present in Section 6 1 some of the collaborative research projects in which members of our Department have been or are currently engaged.

A major example of a collaborative research endeavor originating in our Department is the National Research Center for Statistics and the Environment (NRCSE) described in Section 6.2.

6.1 Collaborative research projects

This is a sample of the collaborative research projects in which members of our Department are or have recently been involved. Some of the projects are extensive and go on for years, while others are smaller. The descriptions do not go into much detail; still, they should be sufficient to give an impression of the scope of the faculty's interests and the diversity of their collaborators.

Access to Reproductive Health Services

Statistics faculty: David Madigan, Thomas Richardson
Collaborators: Sharon Dobie, Department of Family Medicine

Abstract:
We are studying the geographic and temporal distribution of reproductive health services in Washington State since 1980.

Online Assessment

Statistics faculty: David Madigan
Collaborators: Steve Tanimoto, CSE
Earl Hunt, Psychology

Abstract:
We are developing tools to enable instructors to assess on-line student activities and provide tailored instructive feedback to individual students.

CareWave

Statistics faculty: David Madigan
Collaborators: Thomas Hooton, Internal Medicine
Peter Dunbar, Anesthesiology

Abstract:

We have developed wireless telecommunications-based intervention to improve medication compliance for HIV/AIDS patients.

Bowhead Whales Population Study

Statistics faculty: Judy Zeh, Adrian Raftery, David Madigan
Collaborators: G. Givens, Statistics, Colorado State University
J.C. George, Department of Wildlife Management, North Slope Borough, Alaska
C. Clark, Cornell Laboratory of Ornithology
J. Laake and D. Rugh, National Marine Mammal Laboratory,
W. Koski and J. Miller, LGL Ltd, King City, Ontario

Abstract:
We are developing methods to estimate Bowhead whale population size, assess population dynamics, and manage the subsistence harvest of Bowheads.

Epidemiology/Pathogenesis of Asymptomatic Genital Herpes

Statistics faculty: Judy Zeh
Collaborators: L. Corey and A. Wald, Department of Medicine
Z. Brown, Department of Obstetrics and Gynecology
T. Schacker, Medicine/Infectious Diseases, University of Minnesota
J. Benedetti, Department of Biostatistics
R. Ashley and S. Selke, Children's Hospital and Regional Medical Center, Seattle

Abstract:
We are developing statistical approaches to studying patterns in and risk factors for asymptomatic shedding of herpes simplex virus. We are designing and carrying out studies aimed at preventing transmission of genital herpes.

Pareto Optimal Model Assessment

Statistics faculty: Joel Reynolds
Collaborators: David Ford, Forestry
Marianne Turley, Quantitative Ecology and Resource Management

Abstract:
We are developing optimization software to assist users in applying the Pareto Optimal Model Assessment Cycle (POMAC) methodology.

Teakettle Ecosystem Experiment

Statistics faculty: Joel Reynolds
Collaborators: Jim Marra, Forestry
Malcolm North, US Forest Service
Michael Barbour, UC Davis
Martin Jurgensen, Michigan Institute of Technology

Jiquan Chen, Michigan Institute of Technology
Tim Schowalter, Oregon State
Andrew Gray, Oregon State University
Heather Erickson,Universidad Metropolitan, San Juan, Puerto Rico

Abstract:
We are developing statistical methods for a long-term experimental study of a Sierra Nevada mixed conifer ecosystem

Assessment of Environmental Fate and Transport Models

Statistics faculty: Adrian Raftery
Collaborators: Alison Cullen, Graduate School of Public Affairs
Elaine Faustman, Department of Environmental Health

Family Structure and Social Mobility in the US, 1962-1994

Statistics faculty: Adrian Raftery
Collaborators: Timothy J. Biblarz, Sociology, USC
Alexander Bucur, Sociology, USC

Project: Childhood Leukemias and Lymphomas

Statistics faculty: Julian Besag
Collaborators: James Newell, Medical Statistics, University Newcastle
Alan Craft, Child Health, University of Newcastle

Abstract:
We were analyzing cases among children aged 0-14 in Great Britain. Aim was to identify possible causes of childhood leukemias and lymphomas. Apparently successful, but detailed results were deemed too sensitive for open publication.

Remote Sensing in Pacific Northwest Forests

Statistics faculty: Julian Besag
Collaborators: Jeffrey Moffett, Forestry
Simon Byers, Statistics

Abstract:
We are developing methods for classification of Pacific Northwest forests based on satellite data.

Higher-order Markov Random Fields for Reservoir Simulation

Statistics faculty: Julian Besag
Collaborators: Haakon Tjelmeland, University of Trondheim

Abstract:

We are working on Bayesian methods for estimating spatial distribution of minerals from drilling data.

Graphical Markov Models for Multivariate Data

Statistics faculty: Michael Perlman, David Madigan, Thomas Richardson
Collaborators: Steen Andersson, Indiana University
Lang Wu, Harvard School of Public Health
Michael Levitz, Biostatistics

Abstract:
We have introduced a new class of Markov models for chain graphs, which have both directed and nondirected edges to represent both causal and associative relationships.

Graphical Models for Partially Observed Data Generating Processes

Statistics faculty: Thomas Richardson
Collaborators: Chris Meek, Microsoft Research
Peter Spirtes, Center for Automated Learning and Discovery, and Philosophy Department, CMU

Abstract:
We are developing new classes of graphical Markov models that can represent the conditional independence structure induced on an observed set of variables by a data generating process that may be partially observed (e.g. with latent variables) or subject to selection effects.

Analysis of Treatment Effects in Sequentially Randomized Trials

Statistics faculty: Thomas Richardson
Collaborators: James Robins, Harvard School of Public Health

Abstract:
We are applying graphical modeling techniques in the analysis of sequentially randomized clinical trials, where the probability of subsequent treatment may depend on previous observed covariates that are confounded with the final outcome.

Assessment of Statistical Evidence in Legal Contexts

Statistics faculty: Thomas Richardson
Collaborators: Mike Townsend, Law School

Abstract:
We are comparing legal and statistical methods for making inferences, with special reference to Bayesian techniques.

3D Photography

Statistics faculty: Werner Stuetzle

Collaborators: Tom Duchamp, Mathematics
Brian Curless, CSE

Abstract:
We are developing automatic methods for constructing computer models of physical objects and environments.

Statistical Methodology for AIDS Research

Statistics faculty: Jon Wellner
Collaborators: Steve Self, FHCRC
Danyu Lin, Biostatistics

Abstract:
We are developing new statistical methods for AIDS data, focusing on interval censored data, panel count data, and inference for regression models connected with these types of data.

Methods for Nonparametric Maximum Likelihood Estimation

Statistics faculty: Jon Wellner
Collaborators: Piet Groeneboom, Delft University

Abstract:
We are developing new computational methods for nonparametric maximum likelihood estimation.

Robust Statistics in Finance

Statistics faculty: Doug Martin
Collaborators: Tim Simin, Ph.D. candidate, Department of Finance, GSB

Abstract:
We are developing robust methods for estimation of beta, and for portfolio optimization, and are exploring other applications of robust statistical methods to finance.

Seattle Longitudinal Study on Alcohol and Pregnancy

Statistics faculty: Paul Sampson
Collaborators: Ann P. Streissguth (P.I.), Department of Psychiatry and Behavioral Sciences
Fred L. Bookstein, Institute of Gerontology, University of Michigan
Sterling K. Clarren, Professor, Department of Medicine

Abstract:
The Seattle Longitudinal Study on Alcohol and Pregnancy has been following approximately 500 children since their birth in 1975-76 to assess the consequences of maternal alcohol consumption on the health of offspring We have been developing new multivariate methods for analysis of the enormous database of neuropsychologic assessments made at birth, 8 and 18 months, and 4, 7, 14, and 21 years of age. We have also contributed to the development

and application of morphometric methods for analysis of facial photographs acquired in the study of "Fetal Alcohol Syndrome."

Neuroanatomic-Neuropsychologic Analyses of FAS/FAE Deficits

Statistics faculty: Paul Sampson
Collaborators: Ann P. Streissguth (P.I.), Department of Psychiatry and Behavioral Sciences
Fred L. Bookstein, Institute of Gerontology, University of Michigan
David Haynor, Department of Radiology

Abstract:
We are attempting to quantify and link the neuroanatomic and neuropsychologic abnormalities in people with brain damage caused by prenatal alcohol exposure. A large database of 3D MRI images and neuropsychological tests is being assembled.

Automatic reconstruction of left ventricle from 3D Echocardiography

Statistics faculty: Paul Sampson
Collaborators: Florence Sheehan, Department of Cardiology
Robert Haralick, EE

Abstract:
We are developing statistical and morphometric methods for the creation or "reconstruction" of 3D heart models from echocardiographic data.

Feline and mural hematology

Statistics faculty: Peter Guttorp
Collaborators: Janis Abkowitz, Hematology
Sandra Catlin, University of Nevada, Las Vegas

Abstract:
This projects deals with modeling the basic blood cell production in cats and mice, and eventually in humans. The probabilistic basis for the modeling work is a hidden two-compartment Markovian structure, only limited aspects of which can be directly observed. Simulation, Pareto optimal model selection, and likelihood estimation are important tools, and predictions based on the current model are tested using new hematological laboratory techniques.

Atmospheric Science/Hydrology/Climatology

Statistics faculty: Peter Guttorp, Don Percival
Collaborators: Chris Bretherton, Applied Mathematics
Martin Wiemann, Mike Wallace, Atmospheric Science
Dennis Lettenmaier, Civil Engineering
Efi Foufoula-Georgiou, University of Minnesota
Byron Brown and Stephen Charles, CSIRO, Australia

Abstract:
Stochastic modeling of precipitation is useful in a variety of situations, including general circulation model downscaling, forecasting, and simulated inputs to hydrologic models. The current model is again a hidden Markov model, but here the transition probabilities are non-stationary and driven by atmospheric observations. The main statistical tool is likelihood estimation. There are interesting questions relating to model selection.

6.2 The National Research Center for Statistics and the Environment

The National Research Center for Statistics and the Environment (NRCSE) was created in 1996 through a cooperative agreement with the Environmental Protection Agency after a nationwide competition. It is funded at the level of $1M per year for five years. The purpose of the Center is to develop statistical methodology relevant to environmental problems in a broad sense, with particular focus on those of main interest to the EPA.

Professor Peter Guttorp is Director of the Center. There are 24 other members from 14 Departments (Applied Mathematics, Applied Physics Laboratory, Atmospheric Sciences, Biostatistics, Civil Engineering, Environmental Health, Fisheries, Forestry, Geography, Management Science, Public Affairs, Sociology, Statistics, and Zoology) in seven schools and colleges.

The work at the Center is carried out in a variety of modes. Center members at the University of Washington can apply for research funds annually. There is also a substantial budget for visitors to the Center. During Autumn 1998 the visitors are Merlise Clyde from Duke University, Dianne Cook from Iowa State University, Allan Marcus from the EPA, Eric Smith from Virginia Polytechnic Institute, and Per Settergren Soerensen from the Danish Technical Institute and the Danish Institute for Water Environment. In addition, the Center sponsors and organizes workshops and conferences. For example, the 1998-99 year of concentration on particulate matter air pollution is starting off with a workshop in October, to which leading researchers in a variety of areas have been invited.

The research at the Center focuses in five different areas.

- **Space-time modeling** is a methodological focus in a variety of areas. Current projects include, for example: analysis of space-time series of proportions, with applications to benthic populations as indicators of water quality; spatial covariance modeling on the globe, with applications to climate change studies; and aspects of the modeling and analysis of air quality monitoring data.
- In many areas of environmental science, deterministic models are developed, which need to be compared to observed data. The area of **model assessment** is aimed at this type of problem. Three research groups deal with such studies: one with generalizations of block kriging for the assessment of air quality model predictions, one with Bayesian model

uncertainty assessment focussing on environmental transport and toxicodynamic models, and one with Pareto optimality methodology and its applications to model assessment and model development.

- **Sampling** and monitoring protocols for environmental assessment is an important area of research. Current work focuses on methods of composite and ranked set sampling.
- **Environmental and ecological modeling** deals with measurement and indexes of environmental quality, development of environmental standards, and economic analysis of environmental impacts.
- **Risk assessment** is aimed at developing quantitative measures of the risks associated with environmental decisions, remediations, etc. Some of the current projects are aimed at assessing the risk of cleanup projects, and at determining quantitative effects of certain environmental toxins.

The Center has a large outreach program, much of which is focused on the Web page at http://www.stat.washington.edu/NRCSE. NRCSE seminars are video taped and made available as "Seminars On-Demand" using streaming video Internet technology. In addition the Center supports activities aimed at scientific education in public schools, assists the local EPA office with statistical help, develops basic tutorials for use in governmental agencies, and has carried out research projects for the Washington State Department of Ecology.

7 The graduate program

The main objective of our graduate program is to educate Ph.D.s for positions in teaching and research.

7.1 Characteristics of our graduate program

- We focus on preparing our students to do research, and de-emphasize "vocational training" – the Ph.D. is a research degree.
- We start this preparation early on, with class projects incorporating all phases of a research project: formulation of project goals, implementation, report writing, and oral presentation.
- In keeping with the diversity of research interests among the faculty, we give our students flexibility and a wide range of choices in courses and exams.
- We provide opportunity (and role models) for collaborative research.
- We require training in consulting.
- We require all students serve as Teaching Assistants for some time, to gather teaching experience. Graduate students also occasionally teach regular classes or, more frequently, courses offered by UW Extension.

7.2 The graduate program in numbers

Between AY 88/89 and AY 91/92 the graduate program had around 30 students. Since then we have been close to our approved size of 40.

AY	88/9	89/0	90/1	91/2	92/3	93/4	94/5	95/6	96/7	97/8
Enrollment	34	30	31	32	36	39	39	40	37	38

Between 1/3 and 2/3 of our students are international students, coming from all over the world (Australia, New Zealand, India, China, Germany, France, England, Ireland, Denmark, Romania, Brazil). No particular nationality dominates. Almost half of our graduate students are female; we currently have one minority graduate student.

Statistics on applicants

The number of (Fall quarter) applications has been down in recent years, since peaking at 111 in AY 94/95. We typically offer admission to around 25% of applicants, and have an acceptance rate of around 55%.

AY	88/9	89/0	90/1	91/2	92/3	93/4	94/5	95/6	96/7	97/8
Applicants			71	71	100	87	111	84	70	69
Offers			19	20	19	22	32	19	12	15
Accepted	9	6	9	12	12	12	14	11	5	9

Especially in recent years there was little difference in GPA and GRE scores between students who were offered admission but declined, and those who were offered admission and accepted.

Statistics on graduation

The Department has produced a total of 55 Ph.D.s since its inception in 1978, 42 of them since AY 88/89. All the statistics given below refer to the students who graduated since AY 88/89.

Ph.D. graduates

AY	88/9	89/0	90/1	91/2	92/3	93/4	94/5	95/6	96/7	97/8
Ph.D.s	3	4	3	2	6	6	2	4	4	8

Median time to Ph.D. is 17 quarters (4.25 years); the quartiles are (15, 20) For comparison, the UW average is 6.9 years.

Advisers:

Besag 2	Guttorp 6	Madigan 4	Martin 3
O'Sullivan 3	Pepe 1	Perlman 1	Possolo 1
Raftery 6	Stuetzle 2	Thompson 6	Wellner 6

Note that some faculty members have also served as committee chairs for students in other departments, in particular Biostatistics.

Since AY 88/89, 42 Students have left our program with a M.S. degree. Median time to M.S. is 9 quarters (2.25 years); the quartiles are (8, 12). The UW average is 2.6 years.

Since AY 88/89, 4 students transferred from the Statistics graduate program to other UW grad programs without obtaining a Statistics degree. 23 students withdrew without obtaining a degree.

7.3 Graduate course offerings

The principal courses for M.S. students in Statistics are:

- Stat 512/513 Statistical Theory
- Stat 421/423 Statistical Methodology / Applied Statistics

We also offer a number of additional advanced undergraduate or lower level graduate courses targeted primarily at graduate students in other departments.

The core of our Ph.D. curriculum consists of five three-quarter course sequences:

- Statistical Theory (Stat 581/582/583)
- Statistical Methodology / Applied Statistics (Stat/Biostat 570/571/572)
- Stochastic Modeling (Stat 516/517/518)
- Statistical Computing (Stat/Biostat 534/535/538)
- Probability Theory (Stat/Math 520/521/522)

We also have a number of courses that are taught regularly, though not necessarily yearly):

- Time series analysis (Stat 519)
- Spectral Analysis (Stat/EE 520)
- Sample Survey Techniques (Stat/Biostat 529)
- Wavelets (Stat 530)
- Classical Theory of Linear Models (Stat/Biostat 533)
- Log-linear Modeling and Logistic Regression for the Social Sciences (Stat/Soc 536)

- Multivariate Analysis (Stat 542)
- Bayesian Statistical Methods (Stat 544)
- Inference for Stochastic Processes (Stat 565)
- Statistical Methods for Categorical Data (Stat/Biostat 573)
- Multivariate Statistical Methods (Stat/Biostat 574)
- Advanced Design and Analysis of Experiments (Stat/Biostat 577)
- Special Topics in Advanced Biostatistics (Stat/Biostat 578)
- Advanced Data Analysis (Stat/Biostat 579)
- Martingales: Survival Analysis (Stat/Biostat 586)

Every year we offer several (typically between two and five) special topics courses, on topics such as Empirical Processes, Graphical Models, Supervised Learning, Spatial Statistics, Semiparametric Models, etc.

Graduate students are strongly encouraged to attend our regular Monday seminars. We have recently supplemented our pool of speakers from the UW with high profile visitors.

Besides the officially scheduled classes there are usually several informal working groups meeting weekly, in areas like model based clustering, graphical models, empirical processes, and statistical genetics. The Department has an increasing number of visitors, and the working groups provide a framework in which those visitors can present their work and interact with faculty and graduate students.

7.4 The M.S. degree

Our graduate program with its emphasis on preparing students for research is primarily geared towards educating Ph.D.s. We do not have a "terminal" M.S. program, or courses specifically designed for M.S. students. Only a small minority of our graduate students enroll with the intention of getting a M.S., and we do not categorize the students we admit into candidates for M.S. or candidates for Ph.D.

For students entering with a Bachelor's degree the decision as to whether they will finish with a M.S. degree or go on to a Ph.D. is often made at the end of their first year. By this time they have taken calculus, the M.S. level Statistical Theory sequence (Stat 512/513), the M.S. level Statistical Methodology / Applied Statistics sequence (Stat 421/423), and the M S. level theory exam. From their performance in these courses and the exam it is usually apparent whether or not a student is able and willing to tackle the Ph.D. level course sequences and pass the Ph.D. qualifying exams.

As stated in the M.S. graduation requirements (Appendix H), M.S students have to pass an "appropriate final Master's exam " To satisfy this requirement, a student can either write a Master's thesis and give a seminar based on the thesis, or pass the Ph D. level "Applied

Exam". The latter is a one week take home exam, where students have to carry out a data analysis, write a report on their findings, and defend the report in an oral exam.

7.5 Ph.D. requirements

The course and exam requirements of our Ph.D. program (Appendix I) have evolved over the past six years, in response to several factors:

- The changing nature of our discipline, in particular the increased importance of computing.
- The increasing diversity of the faculty's research interests.
- The feeling among the faculty that students were spending too much time listening to classes and taking exams, and were getting into research too late in their graduate careers.

We used to have three "core" graduate course sequences, in statistical theory, probability theory, and applied statistics, each with a corresponding qualifying exam. Students were required to take (and pass) all three sequences, and to pass two of the three qualifying exams.

Three years ago we added two more "core" sequences, Stochastic Modeling (Stat 516/517/518) and Statistical Computing (Stat 534/535/538). Students can now choose any three of the five core sequences, and pass any two qualifying exams. We advise students to take at least one of the more mathematically oriented sequences (theory or probability), but we have refrained from making this a formal requirement.

The Stochastic Modeling and Statistical Computing sequences both emphasize longer-term student projects over weekly homeworks. In particular, the third quarter in both sequences is dedicated to student projects. The corresponding qualifying exams are project based as well. Students typically expand on their project from the last quarter of the sequence, write a report, and give a seminar presentation. Projects do not have to be supervised by the instructor teaching the corresponding course sequence. Instead, a student's project may be supervised by the student's future thesis adviser, and may lead into, or be related to, the student's thesis research.

The Stochastic Modeling sequence and exam have been quite popular. The Statistical Computing sequence was successful the first time it was taught, but drew only few statistics students the second time, and was not offered last year. We have decided to teach the first course of the sequence yearly and require it from all our graduate students, but offer the last two quarters only bi-yearly.

It is too early to assess the impact of the change in requirements on the quality of the Ph.D. theses and the employment prospects and careers of our graduates We will continue to monitor the situation.

7.6 Advising

Every new graduate student is assigned a faculty advisor who helps the student with planning his or her program, and in general lends an open ear and a helping hand. There is no assumption that this faculty advisor will become the student's thesis advisor. The Department's graduate (and undergraduate) advisor, Kristin Sprague, keeps track of each student's progress, makes sure that all the administrative requirements are met, and has also been known to counsel the students on personal or professional problems She contributes a lot to creating a sense of community among the graduate students.

Students typically choose a Ph.D. advisor and form their thesis committee when they have completed qualifying exams.

Every Spring quarter the Department holds a faculty meeting dedicated to reviewing student progress. After the meeting each student receives a letter evaluating progress, spelling out expectations for the following year, and specifying the extent and kind of financial support.

During the review meeting we also choose the winner of the Department's Z.W. Birnbaum award, named after the "Father of Statistics in the Pacific Northwest" and Emeritus Professor of Statistics and Mathematics. The award recognizes the best performance in a Ph.D. General Exam during the past year. We also give an award for the best TA during the past year.

During the week before the start of Fall quarter the Department organizes an orientation for the new graduate students. Activities during orientation week include TA training, introduction to the use of computing facilities and library, a survey of the graduate program and degree requirements, and social events like a wine-and-cheese party, a hike, joint attendance of a baseball game, etc. One day is devoted to lectures where faculty and graduate students talk about their research. This gives the new students an impression of the quality and the diversity of the program.

7.7 Evaluation

An important indicator of the quality of a Ph.D. program is the quality of the Ph.D. theses. One, admittedly crude, quality measure is the extent to which thesis research makes its way into peer reviewed conference proceedings or journals. In Appendix G we list, for every Ph.D. thesis completed since AY 88/89, the publications which resulted from it. **The overwhelming majority of Ph.D. theses result in refereed publications.**

Another important quality indicator is the employment history of graduates. Information on initial and current employment of our Ph.D. graduates (if known to us) is also presented in Appendix G. In summary,

- Roughly 25% of our 42 graduates since AY 88/89 went on to Postdocs (tendency increasing).

- About 45% accepted Assistant Professor positions (or equivalent) as their first employment. Our best students secured positions in Departments of quality comparable to ours (Berkeley, Stanford, Wisconsin, UW Biostatistics). The majority accepted faculty positions at less prestigious schools (Montana State, Colorado State, Nevada, George Washington, etc).
- About 20% took other research positions.

Looking at current employment (which for many recent graduates is the same as initial employment), it appears that

- About 50% of our Ph.D. graduates currently hold faculty positions.
- About 35% hold other research positions (including Postdocs).
- The rest are in positions where research is not the primary task.

8 Relationship with other graduate programs

8.1 Relationship with Biostatistics

Since the establishment of the Statistics Department in 1979 there have been close connections and extensive collaboration between the Departments of Statistics and Biostatistics.

Joint appointments form the institutional basis of this collaboration. Two Biostatistics faculty members, Tom Fleming and Richard Kronmal, have 0% appointments in Statistics, and two Statistics faculty members, Elizabeth Thompson and Jon Wellner, have 0% appointments in Biostatistics. While not carrying any salary, 0% appointments give full voting rights in faculty meetings. In addition there is a faculty position that is 50% in Statistics and 50% in Biostatistics. This position was originally occupied by Finbarr O'Sullivan (who unfortunately moved to a Chair at University College, Cork), and is currently advertised.

The most important benefit of this collaboration is sharing of graduate courses and qualifying exams. We share the M.S. level Theory sequence (Stat 512/513), the Ph.D. level Theory sequence (Stat 581/582/583), the Ph.D. level Statistical Methodology / Applied Statistics sequence (Stat/Biostat 570/571/572), the Computing sequence (Stat/Biostat 534/535/538), and the Statistical Consulting Program (see Section 10.1).

We also share the M.S. level Theory exam, and the Ph.D. qualifying exams in Statistical Theory and in Statistical Methodology / Applied Statistics.

Sharing courses and exams has significant benefits. Not only does it conserve resources and thus allow us to expand our course offerings in other areas; it also exposes students to a more diverse set of viewpoints and broadens their education.

Preserving the close and friendly relationship with Biostatistics and the spirit of cooperation is a top priority for our Department.

8.2 Relationship with Social Science programs

Over the past ten years, we have been actively involved in collaboration with and participation in social science graduate programs, in particular Sociology, Demography, and Social Work. This has taken various forms: teaching graduate courses, collaborative research, consulting, participation by our students in social science graduate programs, and participation by social science students in our graduate programs. This has been facilitated by Professor Adrian Raftery's 50% joint appointment with the Sociology department, which has been our longest lasting joint appointment.

Adrian Raftery has taught a range of graduate quantitative methods courses in the Sociology department, and several of these have been jdint-listed with Statistics. These include Applied Linear Regression for the Social Sciences, Logistic Regression and Loglinear Modeling for the Social Sciences, Event History Analysis, and Causality in the Social Sciences Several of the sociology Ph.D.s who went through these courses went on to faculty jobs at top Sociology departments (University of Chicago, Stanford, University of Southern California, among others), and there have taught quantitative methods courses that reportedly owed something to their UW training in the courses mentioned. Raftery has also served on many Sociology Ph.D. committees.

In Spring 1997, a series of Lectures on Causality in the Social Sciences was organized jointly by the Sociology, Statistics and Economics departments. Nine of the world's leading researchers on causality, from five different disciplines, participated as
Lecturers, and the series was run in conjunction with a graduate seminar, attended by graduate students from several departments. This interdisciplinary initiative was very successful, and attendance at the Lectures totaled about 1,600.

The Department has collaborated closely with the Center for Studies in Demography and Ecology (CSDE) over the past ten years. Raftery is a member of CSDE and has collaborated actively on grants and research projects with CSDE's social researchers, and other faculty members have interacted with CSDE members on occasion. CSDE members have also collaborated with NRCSE. CSDE has funded four statistics graduate students over that period, who received extensive demography training as a result. This was very successful, as all four went on to put their demographic and statistical expertise to work in social science settings: Cynthia White at the University of Wisconsin Department of Sociology; Renato Assuncao at the Demography Center in Belo Horizonte, Brazil; Steven Lewis at the School of Social Work here at UW; and Carl Barden at the Bureau of Labor Statistics.

8.3 Relationship with QERM

The interdisciplinary graduate program in Quantitative Ecology and Resource Management (QERM) provides a special opportunity for students to study the application of statistical, mathematical, and decision sciences to a broad array of terrestrial and marine ecology, natural resource management, and biometrical and mathematical biology problems. The program leads to the Master of Science and the Doctor of Philosophy degrees, and it is designed to attract students interested in working on contemporary ecological or resource management problems from a quantitative perspective.

Statistics faculty members Peter Guttorp, Paul Sampson, and Elizabeth Thompson also serve on the QERM faculty, and QERM faculty member David Ford has an adjunct appointment in Statistics. Elizabeth Thompson currently is the Alternate Graduate Program Coordinator for QERM.

8.4 Relationship with Mathematics

The departments of Mathematics and Statistics share the undergraduate probability sequence (Stat/Math 394/395/396), the undergraduate stochastic processes sequence (Stat/Math 491/492), and the graduate probability sequence (Stat/Math 521/522/523). Teaching of these sequences alternates between the Departments.

Mathematics Professor Chris Burdzy holds an adjunct appointment in Statistics, and Statistics Professor Galen Shorack is an adjunct in Mathematics.

8.5 Contributions to other graduate programs

Many of our graduate courses, such as Time Series (Stat 519), Spectral Analysis (Stat 520), Wavelets (Stat 530), Stochastic Modeling (Stat 516/517/518), and Statistical Computing (Stat/Biostat 534/535/538, attract significant numbers of graduate students from other departments. Statistics faculty members frequently serve on Ph.D. committees for students in other programs.

Professor Elizabeth Thompson is participating in the NSF funded Mathematical Biology Fellowship Program; two of her students have been trainees under the program. She is on the faculty roster for the NIH-funded training grant in Molecular Biotechnology, and has participated in the COMBI computational molecular biology seminar series, and other courses and seminars associated with this training grant. Together with Professor Ellen Wijsman of the School of Medicine, she has coordinated a weekly seminar in Statistical Genetics for the last nine years. This seminar is currently offered every quarter under a BIOSTAT 580B course label, and attracts about 10 students each quarter.

9 Undergraduate education

The ability to understand and to interpret basic quantitative data, in the form of numbers and graphs, is a functional necessity for an informed citizenry in the modern world. Correspondingly, the ability to use quantitative data in a productive fashion to explain social, political, and economic phenomena has become one of the most rewarded skills in today's job market. Unfortunately, statistical illiteracy, as witnessed by the confusing presentation of statistical information in the mass media, appears to be endemic in American society. The overarching goal of our undergraduate program is to address this problem. In our classes we seek to link the teaching of methods and substantive content in a way that provides a compelling learning experience for our students and imparts invaluable real-world skills.

The Statistics Department contributes to undergraduate education mainly by teaching service courses, i.e. courses that are not directed primarily at Statistics majors.

We have an undergraduate degree program leading to a BS in Statistics (see Appendix K), which graduates about 10-15 students per year, a number of them double majors. While we believe that Statistics is a crucial component of undergraduate education across a broad range of disciplines, we feel that it is too narrow a field of specialization at the undergraduate level. We have therefore not pushed to increase the number of Statistics majors.

Instead we have joined forces with the Departments of Applied Mathematics, Computer Science and Engineering, and Mathematics, to create a new undergraduate degree program in Applied and Computational Mathematical Sciences (ACMS).

9.1 Service teaching

Our undergraduate program consists of three large introductory courses offered every quarter, together with a variety of more specialized courses.

The introductory courses are

- **Basic Statistics** (Stat 220). This is a five credit, pre-calculus course using "Statistics" by Freedman/Pisani/Purves as a textbook. It has about 500 students per year.
- **Elements of Statistical Methods** (Stat 311). This is also a five-credit course, on a slightly higher level than Stat 220. It has about 450 students per year.
- **Probability and Statistics in Engineering and Science** (Stat/Math 390). This is a four credit, calculus level course directed mainly at Mathematics and Engineering majors. We are currently using "Probability and Statistics for Engineering and the Sciences" by J Devore as the textbook. If has about 350 students per year.

The audiences in both Stat 220 and Stat 311 are extremely diverse. There does not appear to be any dominant major, and up to 1/3 of the students can be pre-majors.

While smaller in terms of enrollment, our more specialized classes - Probability (Stat/Math 394/395/396), Mathematical Statistics (Stat 341/342), Statistics for Social Scientists (Stat 361/362), Applied Statistics and Experimental Design (Stat 421), Regression and Analysis of Variance (Stat423), and Categorical and Multivariate Data Analysis (Stat 427/428) – also serve a wide audience from a variety of disciplines. For example, in Fall 97, Stat 361 had 25 students from 10 Departments, running the gamut from Linguistics through Chemical Engineering to Business Administration. Eleven of the students were graduate students. Stat 341 had 25 students from about a half dozen departments. Stat 421 had 15 students, nine of them graduate students from six different departments.

9.2 Improving the large service courses

The large service classes (Stat 220, Stat 311, Stat 390) face some major challenges:

1. How do we harness computing technology to improve the student learning experience in the context of large classes?
2. How do we adapt these courses to reflect the rapidly changing nature of the subject itself?
3. How do we deal with the diversity and the variable, but mostly low, level of mathematical sophistication in Stat 220 and Stat 311?
4. How will we address the growing demand for distance education?

As a Department we have invested considerable manpower resources to address these challenges. Associate Professor David Madigan in particular has taken a leadership role. His efforts in this area, as well as his excellent record in classroom teaching, have won him a University Distinguished Teaching Award.

Specific innovations include:

Online Learning Communities: For several years now, we have experimented with creating small group-virtual learning communities via the Web. In particular, students asynchronously collaborate in groups of 6-8 to solve challenging real-world statistical problems in a highly structured and guided fashion. We call this "Virtual Benchmark Instruction" (see http://www.stat.washington.edu/andrew/fbl.html). A paper describing this work has been tentatively accepted by the *Journal of Statistics Education* and was also a component of Andrew Schaffner's Ph.D. dissertation in the Department.

Case-Based Statistics Education: With financial support from the Dean for Undergraduate Education, Peter Guttorp, David Madigan, and June Morita have been developing a novel case-based introductory statistics course. These cases provide in-depth descriptions of challenging, discipline-specific problems, emphasizing scientific questions and statistical

principles rather than methodological details. To date we have developed six cases and have used them in several of our existing courses.

Facet-Based Learning: Together with Jim Minstrell (Mercer Island High School) and Earl Hunt (Psychology), David Madigan has been engaged in a multi-year effort to catalog student conceptions and misconceptions (called "facets") in probability and statistics. These facets provide a basis for powerful computer-based and classroom-based educational tools. This work is also the basis for a paper tentatively accepted by the *Journal of Statistics Education.* Madigan and Steve Tanimoto (Computer Science and Engineering) are co-PI's of an NSF-funded project to build INFACT, a software tool that enables instructors to quickly diagnose facets in students' online work and suggest instructional activities.

Curriculum Reform: The very nature of Statistics has changed dramatically in the last decade. Driven by advances in computing, the field has moved from a focus on elaborate mathematical characterizations of relatively unrealistic statistical models to statistical modeling driven by complex real-world problems. Our Department has been at the vanguard of efforts to adapt the introductory statistics curriculum accordingly. Werner Stuetzle, Doug Martin, and David Madigan have introduced a variety of curricular innovations such as Classification and Regression Trees, Permutation-based methods, and Clustering to Stat/Math-390 in particular, but also to Stat-311. We have also developed a Web-based statistical tool ("DORUS: Distributed Open Resource for Understanding Statistics") to support these innovations – see http://www.stat.washington edu/greg/DORUS.

Our long-term objective is to deepen the abilities of undergraduates to apply critical reasoning skills and quantitative methods in the context of learning the substance and principles of different disciplines - we will continue to innovate and experiment in this direction.

9.3 The ACMS program

The Applied and Computational Math Sciences (ACMS) program is a multidisciplinary Bachelor of Science degree program in the College of Arts and Sciences. The program is jointly administered by the departments of Applied Mathematics, Computer Science, Mathematics, and Statistics. The program started admitting students in Fall of 97 and is still ramping up. It currently has 52 students.

The aim of the program is to provide a solid foundation in both applied and computational mathematical science with areas of application. A core set of courses in the basic tools common to many disciplines is followed by a broad set of pathways to suit different interests. Flexibility in the requirements allows students with specific interests in another area to pursue a double major. Successful graduates of the program will be prepared to occupy a variety of positions in industry, or to go on to graduate or professional school. A list of the core courses and a sketch of the Statistics pathway is presented in Appendix L.

9.4 The VIGRE grant

Creation of the interdisciplinary ACMS major provided the impetus for the Departments of Applied Mathematics, Mathematics, and Statistics to jointly apply for a NSF VIGRE grant supporting integration of research and education. Besides ours, only five more proposals were funded (out of 32 applications), coming from Colorado, Columbia, Harvard, Penn State, and Princeton. The grant is for an initial period of 3 years, with the possibility of two additional years following a review. Funding level is $500K per year, for TA/RA positions, Postdocs, course development, outreach, etc.

Our vision is one of horizontal as well as vertical integration in the applied and computational mathematical sciences. We intend to collaborate on the task of providing a better and more integrated learning environment for students at all levels, undergraduate through postdoctoral. Specific activities planned under the VIGRE umbrella include

- Formation of cross-disciplinary research groups to increase the involvement of students from all three departments, at all levels, in group-oriented research.
- Development of a new course on Scientific Communication, teaching students to communicate mathematical ideas both orally and in writing.
- Creation of a diverse internship program, allowing more students to gain experience outside of the University, or with research groups in other disciplines at the University. This will be combined with faculty or postdoctoral mentoring in order to ensure that it is a positive experience for both the students and hosts.
- K-12 outreach efforts, which we consider as critical for the health of the mathematical sciences, both within our departments and in the broader community. In particular, by increasing interaction with secondary schools we can help to improve the preparation of students entering the University.

Although funds from the VIGRE grant will not arrive till Fall 99, we are already starting on some of the activities, such as developing the communications course. We expect the grant to have a significant positive impact on instruction on all levels, as well as on research.

10 Consulting

The Department has two organizational structures for providing statistical consulting services, the Consulting Program and the Consulting Cost Center.

The Consulting Program has two functions. It allows our graduate students to gain practical experience in consulting, and it provides free advice to a wide range of clients from within the University of Washington. It is headed by Research Professor Paul Sampson, who receives 50% state support in his function as Director of Consulting.

In contrast to the Consulting Program, the Consulting Cost Center offers services for remuneration. It takes on major projects requiring not only advice, but also data analysis and report writing. The Consulting Cost Center has supported graduate students and partially supported temporary faculty, specifically Acting Assistant Professor Joel Reynolds. Like the Consulting Program, it is directed by Paul Sampson.

10.1 The Consulting Program

The Consulting Program of the Department of Statistics is managed and run in cooperation with the Department of Biostatistics. It offers free consultation and advice to University faculty, staff, and students engaged in:

- the design of studies and experiments, including the preparation of grant proposals,
- the statistical and graphical analysis of data,
- the choice, application, and reporting of probabilistic and statistical methods, and
- the statistical review of research papers.

The advice is provided through scheduled one hour consulting appointments. Inquiries are welcome at any time during a study, but involving a consultant during the planning stage(s) is recommended.

During AY 97/98 the consulting program served over 100 clients from 60 different units / departments.

Two faculty advisors, one from each department, supervise a total of eight students each academic quarter. Twelve appointment hours are scheduled each week, six in each department. Two students and a faculty advisor participate in each appointment. The student consultants are responsible for taking notes, writing consulting
appointment summaries, carrying out research/investigations necessary to address client problems, and writing two formal reports each quarter.

Each week the faculty and student consultants meet for a 1.5 hour group session during which the previous week's appointments are reviewed and solutions to difficult problems are discussed at length.

In addition, during the Fall and Winter quarters there is a consulting lecture series, typically organized and supervised by Paul Sampson, during which a number of academic and non-academic statistical consultants address a range of statistical and non-statistical topics important to the education of a practicing statistical consultant.

The faculty advisor – for Statistics this is usually Paul Sampson - is involved each week in 6 appointments, the 1.5 hour group session, and the 1 hour consulting lecture. He also supervises the students and evaluates their performance.

10.2 The Consulting Cost Center

In 1994, the Department of Statistics established *the Center for Statistical Consulting* as a University of Washington approved "cost center". The College of Arts and Sciences provided seed money to support an RA for a year.

The Consulting Cost Center (CCC) accepts clients from within the University of Washington and, to the extent possible, from the outside. It charges by the hour. The graduate student rate is $49/hour for UW clients and $65/hour for outside clients. The corresponding faculty rates are $74/hour, and $145/hour, respectively. The outside rates were set to be roughly comparable to those charged by professional statistical consultants. Total income of the CCC has been about $65K.

Since 1994 the CCC has provided support for one consulting RA position, with the exception of 3 academic quarters for which there was either no appropriate graduate student or no funding. Five different graduate students have held this position.

The CCC has carried out projects for a wide range of clients from within the UW (Anesthesiology, Mechanical Engineering, Radiation Oncology, Anthropology, Music, Nursing) and from the outside (Kapsales/ATT Wireless, Boateng Associates, ISG/NCD, U.S. Department of Justice, Washington State Departments of Agriculture and Ecology.)

Particularly noteworthy is a Department of Ecology project to coordinate meteorological adjustment and analysis of 20 years of surface ozone monitoring data. This project, jointly funded by Washington State Department of Ecology's Air Quality Program ($23K) and the National Research Center for Statistics and the Environment ($17K), supported Acting Assistant Professor Joel Reynolds (40% for 11 months and 20% for 9 months) and RA Barnali Das (50% for 9 months). The project was also an important factor in the NRCSE's involvement in a current EPA-funded review of statistical methods for meteorologically adjusting surface ozone observations.

10.3 Consulting for the Center for Human Development and Disability

Since AY 95/96 the inter-disciplinary, NIH-funded *Center for Human Development and Disability* has paid 40% of a Statistics faculty member (first Acting Assistant Professor Christian Posse, currently Acting Assistant Professor Joel Reynolds) to serve as an on-site statistical consultant. The demand for services from CHDD researchers in psychology, neuropsychology, and behavioral development has continued to grow as awareness of the service has spread. In the last academic year (1997-1998) the consultancy served 14 CHDD

Research Affiliates on a larger number of projects, resulting in 5 papers and 4 presentations utilizing the statistical consultant's services Besides providing statistical advice, methodological research, and analysis facilities (computer hardware and software), the consultant also maintains a growing lending library of statistical reference material. Most importantly, the consultant acts as a liaison between the CHDD and the departments of Statistics and Biostatistics, lessening the demand on those departments' joint consulting services while reducing the 'wait-time' for CHDD affiliates.

The arrangement is mutually beneficial. It helps us fund an Acting Assistant Professor and thereby infuse some new blood into the Department. It helps CHDD because it assures quality and continuity in the consulting service.

11 Service

In this section we outline activities that benefit the UW or the wider community, but do not fall under the primary missions of teaching and research.

11.1 Consulting

Probably the most important service we provide to the UW as well as to state and federal agencies is statistical consulting, described in detail in Section 10. Some of the collaborative research projects listed in Section 6.1 also have a substantial consulting component.

11.2 Connections with local industry

We have ties to a number of local companies including Boeing, Microsoft, and Mathsoft. These ties take several forms.

- **Graduate student internships**. We have had interns at all three companies mentioned above.
- **Research collaboration**. We have research contacts to a number of local companies, in particular Mathsoft. Several of our faculty have helped members of the Mathsoft research staff write SBIR proposals, and have served as consultants on such proposals. Boeing employee Fritz Scholz has long standing association with our Department and is an Affiliate Professor.
- **Seminars**. Employees of local companies frequently attend our Monday seminars, and have also participated in working groups.

These contacts benefit us as well as our industrial counterparts.

11.3 K-12 outreach

Senior Lecturer June Morita has devoted a large effort to K-12 outreach. Besides getting actively involved in classroom teaching, she has obtained grants from the Washington Higher Education Competitive Grant Program ("Eisenhower grants") to support quantitative literacy training for elementary school teachers. The teacher training workshops now continue to be offered through University Extension, and are supported through contributions from the Departments of Statistics and Biostatistics. In addition to her involvement in the workshops, June has spoken at a number of conferences on mathematics teaching in schools, such as the 1997 Fall Conference of the Hawaii Council of Teachers of Mathematics, the 1996 Seattle Public School Faculty In-Service Day, the 34th Northwest Mathematics, and at the 1997 Creating a Community of Learners Summer Institute.

11.4 Spinoff companies

Department members have started two successful local companies, Talaria Inc. and StatSci, Inc. (now the Data Analysis Products Division of Mathsoft, Inc.). These companies benefit the local economy, provide employment for graduates and consulting opportunities for faculty, and also an avenue for obtaining research funding (SBIR grants) not otherwise accessible to faculty.

Talaria, Inc.

Talaria develops technologies and products focused on healthcare, education, and doctor-patient communication. Talaria's multidisciplinary team includes seven full-time Ph.D.-level employees with backgrounds in Medicine, Mathematics, Statistics, Psychology, and Education. The four company founders are on the faculty at the University of Washington: Charles Chabal, C. Richard Chapman, Peter Dunbar are in the Department of Anesthesiology and David Madigan is in the Department of Statistics. Talaria's Scientific Advisory Board also includes several faculty members from the University.

Talaria is located in Seattle near the U.W. The University holds an equity stake in the company.

The Data Analysis Products Division of MathSoft, Inc.

The Data Analysis Products Division (DAPD) of MathSoft, Inc. develops and markets the S-PLUS product line for data analysis and statistical modeling, and provides related Educational/Training Services and Consulting Services. DAPD also has a Research

Department which focuses on government funded grant and contract work in diverse areas such as missing data methods, robust methods, wavelets, pharmacokinetics, survival analysis, image analysis, spatial statistics, document image retrieval, group sequential methods in clinical trials, long-memory processes. DAPD has approximately 90 employees, of whom 30 are in the Research Department. About 30 of the DAPD employees hold Ph.D. degrees.

Over the years DAPD has provided full-time employment to approximately 15 graduate students upon completion of their work at the University of Washington, from both the Department of Statistics and from other Departments such as Biostatistics, Economics, Electrical Engineering, and Computer Science. Some of the DAPD Research Department grants and contracts have helped fund graduate students in the Department of Statistics, either through direct work at DAPD or through subcontracts to the University of Washington. Furthermore, DAPD has employed a substantial number of University of Washington faculty members as consultants on SBIR grants and contracts, e.g., David Madigan, Werner Stuetzle, Norm Breslow, Scott Emerson, David Haynor, etc.

DAPD was founded by Professor R. Douglas Martin, under the original name Statistical Sciences, Inc. (StatSci). Martin sold StatSci to MathSoft, Inc. in 1993. In 1996 he reduced his Statistics Department position to a 50% position in order to serve as Chief Scientist of DAPD, with a focus on special research projects and future directions for the S-PLUS product line.

When StatSci was originally formed, some code that was developed in the Dept. of Statistics was included in the original release of S-PLUS. A special arrangement was made between StatSci and the University of Washington Technology Transfer Office, whereby the Dept. of Statistics receives S-PLUS free of charge and the University of Washington at large receives a discount in S-PLUS purchases relative to the standard academic pricing, in return for continued access to code developed in the Department and voluntarily released to DAPD by the author of the code.

12 Strengths, challenges, initiatives

12.1 Strengths

- **Faculty.** We have a faculty with international reputation and visibility, as witnessed by honors, invitations, demands for service, grants, and publications.
- **Research.** Our theory and methodology research is at the leading edge Our extensive involvement in collaborations - a distinguishing characteristic and a major strength of our Department – benefits not only us, but also our partners.
- **Ph.D. training.** We are leaders in innovative graduate education with opportunities for cross-disciplinary research.

12.2 Challenges

Retaining faculty and attracting new talent

Many of our core faculty members were hired during the buildup of the Department, when they were fairly junior. Their careers have prospered, but their salaries have not kept pace. This has left us vulnerable. Within the last six months, two faculty members (Adrian Raftery and David Madigan) have received outside offers, and two more are about to receive offers. We are a small group, and losing anyone would have a big impact. **It is crucial for the well being of the Department that the University continues to support us in retaining our faculty.** We will continue to use our raise pools (minute as they may be) to correct salary inequities caused by matching offers.

Almost as important as holding on to the current faculty is attracting new talent. We have not seen any net growth in regular faculty for over ten years. We have been using salary recapture funds to hire Acting Assistant Professors, but this is not an ideal solution. First, it means that fewer courses are taught by regular faculty. Second, temporary faculty can not be expected to make the same contributions to grant acquisition and Ph.D. advising as regular faculty.

Maintaining grant funding

Over the last five years grant funding has become more unbalanced, with a few large grants contributing the bulk of the income. This is partly due to cutbacks at ONR, ARO, and DOE, which traditionally have given significant support to Statistics. It is also due to policy changes at NSF Math Sciences, where the typical grant now seems to be $40K per investigator. This covers roughly one month of summer salary and about 2/3 of an RA. Clearly we could not run the Department on NSF grants alone. A significant reduction in grants would be highly detrimental to the graduate program.

While risky and potentially destabilizing, increasing dependence on large, multi-investigator grants might be a sign of the times. We have had success in attracting such grants, like the NRCSE grant and the VIGRE grant. NIH is another source of substantial support. Still, a number of our faculty have been "stuck" with NSF Math Sciences. We need to cast a wider net. **The University can help by identifying opportunities, coordinating efforts, and providing matching funds.** The latter is crucial. Our Department has submitted two Group Infrastructure Grant (GIG) proposals to NSF, neither of which was funded. We were informed by NSF that the University's matching contribution was considered too small.

Improving undergraduate education.

We want to improve our large undergraduate service classes (Stat 220, 311, 390.) We have already invested significant effort into those courses (see Section 9.1), but more has to be done. We need to segment the market, review the course contents, decide on a delivery modality – frontal lectures to 100-200 students might not be the best option – and develop outcome measures that are more meaningful than teaching evaluations. To accomplish all this, **we need to dedicate more resources to the large service courses** – mere encouragement of instructors is not enough. The VIGRE grant will provide some funds to help start this effort. To achieve a significant and lasting improvement we might do well to emulate the example of CSE's programming service courses (CSE 142/143). CSE has hired a Lecturer who is responsible for these courses. A single faculty member obviously could not teach all our large service courses. However, he/she could work on market segmentation and course development, experiment with delivery modalities, develop and collect outcome measures, and maintain the infrastructure (Web pages, collections of examples, homework problems, solutions, projects, etc.)

We also want to involve undergraduates in our research. Again, the VIGRE grant will provide some resources. Finally we need to continue improving the ACMS program to make it more attractive and achieve greater balance between pathways.

12.3 Addressing the challenges

In this section we present several initiatives addressing the challenges outlined above. There is a common thread – they all build on our strength in collaborative research. The Department is currently investing substantial effort into securing resources for these initiatives.

Proposal for a Center for Statistics and the Social Sciences

In close collaboration with the College, the Department has identified a significant opportunity for the University to propel itself to a leadership position in the empirically-oriented social sciences. Motivating our initiative is the observation that in the post-cold war era the United States is channeling substantial resources towards challenging social science research questions. "Social Science" research now embraces problems in business, child development, economics, education, government, health, international affairs, journalism, law, and politics. The scope and complexity of the research questions being posed demands that successful social science research groups include world-class expertise in multiple disciplines, both qualitative and quantitative. Here are some typical (currently funded) research projects:

- What effect does outside-the-home child care have on children's development during the preschool years and the transition to school?
- What are the barriers to treatment among crime-involved cocaine-dependent women?
- What are the effects of community violence on women and children?
- What are the outcomes of sexual harassment in the workplace?
- What is the role of psychosocial factors in the development of hypertension and cardiovascular disease?

Addressing research questions such as these requires a highly sophisticated approach to data gathering and analysis. Such expertise does exist on campus, but it is fragmented, scarce, and much in demand. Access to world-class quantitative and computing skills is a key barrier to improving the University's competitive position in the social sciences.

The proposed Center will bring together a group of 4-6 outstanding faculty members combining expertise in statistical methods and in social science methodology, with track records of successful collaborative research. This will provide a resource for researchers across campus and enable the University to compete for large-scale funded research projects.

The Center will offer a series of courses targeted at both upper division undergraduates and graduate students that are designed to raise the level of competence in statistics and quantitative social science on campus and provide a talent pool for researchers to draw upon. The Center will also offer a lower-division undergraduate social science quantitative literacy sequence that can streamline statistics education in the social sciences at the UW. From the outset, two faculty members from the Center will take responsibility for this educational mission. One member will take primary responsibility for the graduate courses and one for the undergraduate courses. At both levels, the new courses will completely rethink the standard curricula and harness computing technologies to improve the student learning experience.

We believe that the Statistics Department is extraordinarily well-positioned to bring this Center into being and ensure its success. We have faculty members - Adrian Raftery and David Madigan - who can provide leadership, and we have a track record for collaborative research.

The Center speaks directly to the three challenges outlined above. In particular, the new faculty positions would address the urgent concerns about our faculty structure, the Center's focus on grant funding directly addresses our concerns in that area, and the Center's teaching mission affords us an opportunity to reshape Statistics education for the social sciences.

Proposal for a Program in Quantitative and Computational Finance

The proposed program is highly interdisciplinary and consists of two components:

- A Master's Degree program in "Quantitative and Computational Finance".

- An associated graduate research program to be funded by fractional faculty positions, post-doctoral positions and graduate research assistant positions.

The program is designed with the following objectives in mind:

1. Create a research environment that can substantially leverage the research and teaching capabilities of current faculty members across several departments and colleges.
2. Provide a viable M.S. degree whose graduates will be highly employable in a modern and dynamic finance industry. This requires an appropriate blend of finance, economics, mathematics, statistics and computing education. The latter has become particularly important in the modern world of finance.
3. Provide important, new subject matter instruction that is not currently offered at the University of Washington, and is unlikely to be offered without such a program. Examples include: Risk Management, Derivative Pricing Theory and Practice, Optimization in Finance, Object-Oriented Programming and Data Structures for Financial Objects, Analytical Finance for Engineers and Scientists.
4. Provide a small, but potentially important trickle-up flow of students from the M S. program who will be strong Ph D. candidates for degrees in Finance, Economics, Statistics, Mathematics, Computer Science and Electrical Engineering.
5. Create a modern Computational Finance Laboratory that combines analytical software tools with a facile access and delivery platform to bring the broadest range of security types to the fingertips of the researcher and student.

The proposed program is consistent with a recent trend in the creation of new programs in Mathematical Finance and Computational Finance. The Carnegie-Mellon Master of Science in Computational Finance provides a leading example of a new strongly interdisciplinary program of this type.

We would expect participation in the program from a wide range of units:

- The Department of Finance (Wayne Pherson, Andrew F. Siegel, Avi Kamara) in the College of Business Administration.
- The Departments of Mathematics (Jim Burke, Chris Burdzy), Economics (Charles Nelson, Eric Zivot), and Statistics (Doug Martin) in the College of Arts and Sciences.
- The Department of Computer Science and Engineering (and possibly the Department of Electrical Engineering) in the College of Engineering.

Proposal for joint appointments

Joint appointments can form an institutional basis for collaboration in both teaching and research. Their potential benefit is exemplified by Adrian Raftery's joint appointment with Sociology.

For many years we have attempted to arrange a joint appointment with Engineering One of our large service courses, Stat/Math 390, is targeted to a large extent at engineering

undergraduates, and several of our graduate courses (Spectral Analysis, Wavelets) draw most of their audience from Engineering. The undergraduate course in particular could benefit from Engineering input.

Industrial Engineering has a graduate program with a substantial statistics component, and in some ways appears to be a natural candidate for a joint appointment. Actually, there were concrete attempts in this direction, culminating in a faculty search.
Sadly, for a variety of reasons, this appointment failed to materialize.

Electrical Engineering has a substantial statistics component as well, in areas like signal and image processing, neural nets, speech recognition, computer vision, etc., and a joint appointment would make a lot of sense and could be beneficial to both Departments.

Another area of opportunity for a joint appointment is the burgeoning field of computational biology (in the wide sense), where we have a strong core already (Elizabeth Thompson.)

Finally, significant benefits can also come from regular visits by faculty whose primary appointment is not at the UW. A case in point is Professor Piet Groeneboom (Delft University), an internationally respected mathematical scientist with an eclectic taste for deep and challenging problems and a wide range of interests in statistics, probability theory, and applications. He has visited us before, taught an excellent special topics course, and had a lot of interaction with our graduate students. We would like to give him a permanent appointment that would allow him to spend a quarter each year at the UW.

13 Appendix A Graduate student summary

	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98
Autumn Quarter Enrollment										
Enrollment History										
Total	34	30	31	32	36	39	39	40	37	38
Full-Time	32	28	28	30	33	36	36	39	36	38
Part-Time	2	2	3	2	3	3	3	1	1	0
Male	27	22	22	22	29	30	28	27	23	23
Female	7	8	9	10	7	9	11	13	14	15
Ethnic	1	1	1	1	2	1	2	3	1	2
International	13	13	16	13	15	17	25	27	23	24
Wash	9	6	5	5	8	10	6	4	5	6
Non-Residen	25	24	26	27	28	29	33	36	32	32
New Student Enrollment	9	6	9	12	12	12	14	11	5	9
Continuing	25	24	22	20	24	26	25	29	31	29
Annual (Sum-Spr qtrs)			73	77	104	88	114	86	71	
Autumn Quarter			71	71	100	87	111	84	70	69
Autumn Quarter Denials			47	50	76	64	71	60	55	50
Autumn Quarter Offers			19	20	19	22	32	19	12	15
Autumn Quarter Percentages										
% Denied (of Apps)			66 2%	70 4%	76 0%	73 6%	64 0%	71 4%	78 6%	72 5%
% Offers (of Apps)			26 8%	28 2%	19 0%	25 3%	28 8%	22 6%	17 1%	21 7%
% New Enrollees (of Apps)			12 7%	16 9%	12 0%	13 8%	12 6%	13 1%	7 1%	13 0%
% New Enrollees (of Apps)			47 4%	60 0%	63 2%	54 5%	43 8%	57 9%	41 7%	60 0%
Autumn Minority Admissions										
Application			6	4	5	3	7	4	4	6
Denials			3	2	3	2	4	3	3	5
Offer			2	2	2	1	3	1	1	1
Autumn International Admissions										
Application			47	45	59	58	63	58	49	48
Denials			36	39	50	50	46	45	42	39
Offer			7	6	7	8	15	10	5	6
Applicant Average GPA										
Denied			3 28	3 35	3 38	3 47	3 30	3 50	3 51	3 36
Accepted But Not Enrolled			3 68	3 82	3 55	3 76	3 79	3 75	3 83	3 66
Accepted and Enrolled			3 49	3 61	3 61	3 39	3 59	3 85	3 71	3 66
Applicant Average GRE										
Denied										
Verbal Score			397	439	469	491	462	483	517	475
Quantitative Score			721	752	764	751	735	743	759	745
Analytical Score			592	596	632	625	646	642	678	643
Accepted But Not Enrolled										
Verbal Score			574	638	590	594	592	583	591	575
Quantitative Score			749	744	766	769	777	774	751	757
Analytical			711	657	695	681	702	734	709	713
Accepted and Enrolled										
Verbal Score			531	588	550	530	510	570	610	583
Quantitative Score			751	751	770	738	726	763	760	749
Analytical Score			736	679	657	647	618	679	712	706
Annual Degrees (Sum-Spr qtrs)										
Masters	5	6	4	6	7	7	12	5	4	4
Doctoral	5	2	5	1	5	4	4	6	1	6
Ph D Candidates			0	0	0	2	4	3	8	3
Autumn Quarter Financial Support										
Teaching		13	10	13	12	13	18	16	12	18
Research		15	10	12	19	17	16	16	15	15
Fellowship		0	1	1	0	0	0	3	3	3
Traineeships		0	0	0	0	0	0	0	1	1