Statistical Society of Canada
Société statistique du Canada

Report to the Long Range Steering Committee

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1. Introduction

Research and innovation in the statistical sciences are driven by problems in practical applications. Very few disciplines lie at the intersection of so much of the physical and social sciences, simply because the explosive increase in the availability of data has magnified the importance of the science that draws information from data. While a part of statistical research is heavily mathematical or very computational, the genesis of the subject, its historical motivation[1], its primary source of new challenges and directions, is traditionally rooted in practical problems ranging from health, agriculture and biology to finance, economics and sociology. This is a discipline that cannot grow, disconnected from these roots. To flourish, it must exist in an environment free of the artificial barriers which often evolve between academic disciplines and university departments. It is the primary responsibility of government, funding agencies and research agencies to allow and foster this continued growth, free of barriers, in directions that will ultimately benefit all of science. Much of this report will revolve around how this is to be affected within the structural and budgetary constraints that Canadian researchers must observe.

2. Scientific Context

Statistical tools and methods provide the logic and language of the modern scientific method[2]. Statistics deals with iterative learning from data and as such is essential to scientific progress. We quote here from Paul F. Velleman[3] who distinguishes between mathematical statistics, often driven by strong design and optimality criteria, and "scientific statistics", which is necessarily more exploratory, graphical and reactive.

> *However, much real-world data is serendipitous. By that I mean that it arises not from designed experiments with planned factors and randomization, nor from sample surveys, but rather as a by-product of other activities. Serendipitous data reside in databases, spreadsheets, and accounting records throughout business and industry. ..... Traditional statistics are often inappropriate for serendipitous data because we cannot reasonably make the assumptions they require. Much of the technology of classical statistics and of traditional statistics software is designed to analyze data from designed studies. This is a vital function, but it is not sufficient for the future. In his landmark paper, "The Future of Data Analysis," John Tukey identified the difference between mathematical and scientific statistics, and called for a rebirth of scientific statistics.*

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[1]See for example *Cross-Disciplinary Research in the Statistical Sciences*, (1988) Report of a panel of the Institute of Mathematical Statistics, http://nisla05.niss.org/reports/crossd2.html

[2] The scientific method entails: *conjecture or hypothesis, plan or design, data collection, analysis, modify the conjecture*, etc.

[3]Proceedings of a 1991 forum on the Future of Statistical Software http://www.nap.edu/openbook.php?record_id=1910&page=15

This passage illustrates the rapidly changing nature of the discipline, accelerated by demands for information and parallel explosive growth in the availability of observational or "serendipitous" data in the language of Velleman, and extraordinary computational resources. These changes do not remove the need for traditional statistical methodology but impart more rapid growth to the requirements for "scientific statistics".

The statistical sciences are concerned with foundational issues in scientific inference, the development of innovative methods to address important problems in science and technology, through interdisciplinary research, stochastic modeling and methods of decision making. Our interests therefore span a wide range of areas including theory, methods and applied statistics which advance science and technology. While mathematical techniques are used in this research, our language, aims and values are different from those of mathematicians. It is in the context of the advancement of science as a whole that statistical research is to be assessed, of which innovation in statistical methodology, because of the potential portability across area of application, is a very important component.

2.1 Impact of Scientific Developments on Research in Statistics

How has Statistics changed over the past few decades? While the foundations are as relevant now as they were, two revolutions have radically changed the nature of the problems addressed and the solutions proposed. There has been a massive increase in the availability of data across the whole spectrum of human activity, driven by a need for reliable information and technological advances which permit nearly continuous monitoring of processes. One example of this is the measurement and assessment of the risks of financial services firms. This real-time problem with an extraordinary requirement for data and analysis is more difficult and more important[4] by orders of magnitude than it was even 20 years ago. In parallel to this has been the extraordinary growth of computing power, which not only allows the analysis of much larger data sets, but radically alters what analyses are feasible. Models are larger and more complex, methods are more iterative and more highly computational, and often more exploratory. These have resulted in the redirection of much statistical research and practice. Computational tools, software, empirical analysis have supplemented more traditional mathematical statistics and asymptotic results. New applications in high frequency trading, actuarial science, genomics, biostatistics, genetics, machine learning, climatology, etc. were as unforeseen 25 years ago as the next break-throughs are today. Rather than try to anticipate the direction of these changes[5], an enlightened research support system will provide sufficient resource and flexibility so that researchers can investigate and exploit such developments quickly and train Highly Qualified Personnel (HQP) who will turn these break-throughs into competitive advantages in the Canadian economy. For the statistical sciences, this will rely on our ability to engage in and encourage collaborative research with those in other disciplines such as medicine, biology, finance, engineering, and computer science.

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[4] Statistical "Gaussian copula" models for pricing credit derivatives, whose underlying (faulty) assumptions were poorly understood by most purchasers, had a major role to play in causing the 2007 global financial crisis.

[5] *"It is an abiding mystery why having failed so definitively to pick winners in the marketplace for goods, governments have been empowered to pick winners in the far more subtle marketplace for ideas."* Nobel prize winner John Polanyi, http://www.theglobeandmail.com/servlet/story/RTGAM.20090429.wcoscience30/BNStory/specialComment/home

2.2 Impact of Statistical Research on Science, Technology and Industry

Canadian universities have taken several initiatives geared at the industrial sectors. Financial statistics, Actuarial Science and Biostatistics have all experienced a significant growth over the 2000-10 period[6]. Canadian universities now have more researchers and more graduate training programs in these areas as compared to 10 years ago. Two of the most vaunted Canadian industrial sectors, the financial services and pharmaceutical companies in Canada, owe much of their success and perhaps their solvency, in part to statistical methods. Risk management requires a strong ability to measure and assess risk, and to critically assess the statistical models that others use to quantify risk. Measuring risk, whether financial, environmental or medical is inherently a cross-disciplinary activity which requires significant input from statisticians, both in terms of the adequacy of the models and their underlying assumptions and the robustness of their conclusions. The recent Japanese earthquake, tsunami, nuclear reactor damage and its consequences for health, safety and the economy is a possible example of the potential costs of not carefully assessing the robustness of a model and the consequences of its failure. All such activity, indeed all risk assessments, are inherently highly collaborative. For example the 1986 Challenger shuttle disaster was not a simply a failure of engineering, it was a failure in properly assessing and clearly communicating the risk of a leakage in the "O-ring" seal partly due to faulty design combined with the unusually cold weather. A successful presentation of the available statistical evidence of a high level of risk to the relevant administrators would have required the kind of cross-disciplinary skills that are inadequately encouraged in our academic and research infrastructure.

3 NSERC Research Programs

3.1 Discovery grants

The NSERC Discovery/Operating Grant system was, at its inception, visionary. It put the primary responsibility on the research focus where it belonged, on the individual scientist, who had to justify the merit of the research in a court of his/her peers. It was neither elitist nor easily politically manipulated. While it was possible for scientific superstars to emerge, the primary benefits were to the nation through the broad support of statistical research in diverse topics and regions, and the training of HQP. While a PhD was once a rarity in our banking industry, there is now a wide and hot market for statistics PhD's. Graduate enrolment in Statistical Science has grown at a phenomenal pace (see Appendix 2), in contrast to the decline in the level of statistics individual discovery grants in real terms[7]. For example in the Department of Statistics and Actuarial Science at the University of Waterloo there are approximately 150 full-time graduate students, roughly one third of these Ph.D. students. This number (and the cost of support) has more than doubled over the past 10 years.

There were, of course, always perceived inequities in research funding, especially between disciplines, and on the disadvantaged end of this scale lay the Statistical Sciences. In some cases there were simple

[6] See the report of the SSC Research Committee, Appendix 2.

[7] In real terms, the average discovery grants in Mathematics and Statistics have declined by around 24% since 2004, although the number of funded applicants declined by around 5%. See Appendix 1. Average grants in Statistics have been lower than those in the Mathematics and Statistics Evaluation group.

explanations for the differences such as requirements for lab equipment, but in others such as industrial engineering or computer science, where research requirements were similar, it was and remains much more difficult to justify the large disparities. These disparities continued in the 2010 competition. For example in Mathematics and Statistics, there was an allotment of around 10K of new money for new applicant compared with around 19K in Computer Science. We commend the increased NSERC attention to the training of HQP in discovery grants, but especially in the Statistical Sciences, where graduate enrolment is high, the additional costs of supporting the training of these HQP need to be adequately addressed. Since these costs vary within the mathematical and statistical sciences enormously, and are quite different than the other costs of research, they should be addressed with a "HQP supplement" which is provided to a grant-holder specifically for the training of HQP.

3.2 Strengthening Statistical Research and Technology Transfer

The last thirty years have seen an unprecedented blossoming of the Statistical Sciences in Canada. The Statistical Society of Canada has experienced a vigorous growth in this period with around 1000 members and annual meetings with upwards of 500 participants. The demand for HQP[8] in Statistical Science is higher than ever. Canadian universities responded to new challenges facing the Statistical Sciences by hiring more statisticians[9]. The survey report a 25% increase in Statistical Science faculty for the 2000-2010 period. The NSERC discovery grant program has traditionally contributed to this success by allowing statisticians to identify growth areas for their own science. In 2008, the Statistical Sciences NSERC Liaison Committee in "Restructuring GSC 14: Submission from the Statistical Sciences NSERC Liaison Committee" proposed the creation of an evaluation group (EG) in "Statistical and Quantitative Interdisciplinary Sciences" in order to put the methodologies associated with data collection, analysis, and computation under one roof (see Appendix 3). This proposal failed, but the issues that led to it remain. Either through the discovery grant adjudication system, or through a Statistical Science Institute, or through some other mechanism, the future growth and success of statistics rests on its ability to interact with all areas of methodology as well as current and potential application. The training of HQP is critical to the future of the discipline since this is the source of much of the interaction. An "HQP supplement", which would be peer reviewed by the same panel as the discovery grant, but adjudicated based on both the added value of the HQP trained and the quality of research and would help redress some of the disparities in the Discovery Grant program. Since the support of graduate students is often the single largest load on a discovery grant, and since individual researchers are in the best position to evaluate potential graduate student researchers, such a change could substantially improve technology transfer in our discipline. By having such an award separated from the regular DG, some of the perceived inequities of funding within the mathematical sciences would be ameliorated. It would also be desirable if the amounts awarded and criteria for the awards for the HQP supplement were consistent across evaluation groups.

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[8] For example "...the clinical research workforce has not grown …. with obvious shortages of biostatisticians , health economists, clinical epidemiologists, social scientists, ...most academic health science centres conducting clinical research report a critical shortage of biostatisticians and methodologists " in *Trials*: http://preview.trialsjournal.com/content/pdf/1745-6215-12-48.pdf

[9] See the report of the SSC Research Committee, Appendix 2.

3.3 Filling the Gaps in NSERC Research Funding

The current structure of a Mathematics and Statistics Evaluation group with individual grants "binned" by a small panel and then funding within that bin determined at the evaluation group level may significantly distort NSERC funded research in Statistical Science away from some of its areas of highest growth and potential. Because grants in all related disciplines are higher, and often a great deal higher, there is a resulting flow of interdisciplinary work away from this Evaluation Group and towards other NSERC Evaluation Groups or non NSERC funding sources. What are the consequences of this migration? There will inevitably be inferior peer evaluation of mathematical or statistical components of these research projects, in part because of the nature of the evaluation group, in part because journals with lower statistical standards will be encouraged. For example, highly computational research projects in machine learning or involving Markov Chain Monte Carlo methods adjudicated by researchers in Computer Science or Engineering may suffer from a lack of rigorous mathematical or statistical assessment. Similarly, biostatistical research may suffer from inadequate attention to the methodological aspects of the study.

Disparate levels of discovery grants in different areas result in gaming the research grant system. The simplest remedy for this is to remove the incentive to do this by reducing the disparities. This requires insuring that projects of similar quality and with similar research costs in similar areas receive similar levels of funding regardless of the EG. The simplest approach to a remedy within the current structure is to address the inequity in the grant levels in the Mathematics and Statistics EG.

3.4 Suitability of the Resource Mix for Statistical Science

Statistics, because it is essential to many different scientific activities, must retain its strong national presence and the discovery grant system remains the keystone to statistical research for most statisticians. There is concern that a model may evolve which encourages statistical research primarily at a few Canadian Universities and this would not only impair the national development of statistics but also of many other affiliated disciplines. Unfortunately, the current mix of resources, Mathematics Institutes and discovery grants provide inadequate levels of funding, particularly to collaborative research projects involving the statistical sciences.

4. The Mathematical Institutes and BIRS

The Banff International Research Station (BIRS) and the three mathematical institutes (PIMS, Fields, and CRM) have achieved remarkable growth since their inception and now constitute a considerable force for mathematical research. While many of their programs are geared towards researchers in pure or applied mathematics, there has been some support for workshops in topics in probability, statistics, biostatistics, mathematical finance and others. Nevertheless it is often felt that the priorities of the institutes, even in topics that overlap with probability and statistics, are not well aligned with those of the majority of SSC members and that the statistical sciences, as well as other disciplines that primarily *use* mathematics such as computer science or physics have benefited little from the institutes. Given the extraordinary pressure on discovery grants, funding the mathematical institutes is not a high priority for most of the statistical community, which largely feels disassociated from programs and priorities at the Institutes. Indeed a separate brief submitted by biostatisticians in the SSC clearly expresses the view that mathematics institute support should be secondary to adequate levels of support for the Discovery Grant program. Low levels of the discovery grants in Statistical Science makes it difficult to provide research support to large numbers of PhD students or post doctoral fellows. There are almost no universities in Canada where NSERC discovery grants, even if pooled among statistics researchers in common areas and combined with departmental money, will support significant numbers of visitors or post docs in Statistical Science. As a result new PhD's take employment in institutions with high teaching loads, or in non-academic institutions, when their research potential is at its prime, with a resultant negative impact on productivity of the individual and the overall impact of statistics. Support of new researchers is a potentially valuable role for an institute with principles and priorities aligned with the statistical sciences

4.1 Institute Recommendations for Statistics

Despite strong support from the statistical community and very positive reviews, the MRS application for a Statistical Institute was not funded. The main goal of a *National Statistical Science Institute* (similar to the institutes established in the U.S.[10]) is to support and structure collaborative interdisciplinary research involving the statistical sciences, for the benefit of researchers in all areas of science where massive amount of data are routinely collected. Without an institute or body which speaks for the *interdisciplinary aspects of our discipline*, unskewed towards mathematics, our community is constrained with respect to the natural cross-disciplinary directions of future growth. In general, the statistics community continues to favour a national institute dedicated to the Statistical Sciences. However, there are available remedies that do not incur the full costs of providing funding for infrastructure, staff and programs of a stand-alone *National Statistical Science Institute*. The primary objective of the SSC is that research directions involving the statistical sciences are supported based on of their (scientific) research potential, not primarily on their expected contribution to the mathematical sciences. Potential developments and opportunities across the wide range of statistical theory and application is best judged by a mix of statisticians and those with expertise in one or more potential areas of application. The formation of a *National Statistical Science Institute* that shares the physical space and infrastructure of one or more of the mathematics institutes is a cost-efficient alternative, one that permits both continued interaction with the mathematics community and a more independent voice regarding priorities that are unique to statistics and its collaborative nature[11]. A recommendation for an institute in statistics is not made without reservation on the part of some of the SSC membership, since many feel that the separation of the current institutes, both geographic and in research focus, has left them removed from many of their benefits. However, if a Statistical Science

[10] The *Statistical and Applied mathematical Sciences Institute* (SAMSI) is part of the Mathematical Sciences Institutes program of the Division of Mathematical Sciences at the National Science Foundation (see http://www.samsi.info/). The *National Institute of Statistical Sciences* in the U.S.A. was established in 1990 with the mission to identify, catalyze and foster high-impact, cross-disciplinary and cross-sector research involving the statistical sciences (See http://www.niss.org/).

[11] There is some history of collaborative relationships involving the statistical sciences and the mathematics institutes. The NPCDS (National Program in Complex Data Structures) was funded in 2003 as a joint initiative of NSERC and the three mathematics institutes and with the Mathematical Sciences institutes, it was moved to the MRS program in 2007.

Institute can be formed with little additional infrastructure cost by sharing current space and staff, we believe it can help coordinate research activities in statistics, contribute to the training of high level HQP, and more effectively manage the programs directed at Statistical Science and its applications nationally. If carefully managed, the physical location of the institute (e.g. Fields, PIMS, CRM) should not be an impediment to its national presence, if sponsored programs and activities are located in all regions of the country.

5. New initiatives and directions

Much of the attention of this brief has been how to accommodate the collaborative nature of the statistical sciences within NSERC and the importance to all of science and engineering research of doing so. Providing support for the large number of graduate students and early career researchers in the statistical sciences is an investment with returns far beyond Statistical Science, in other sciences, in the economy, and in the general understanding of data. We have suggested in this brief that two initiatives, a *National Statistical Science Institute* with significant collaboration among mathematics and related sciences and a special supplement to the DG for the costs of HQP would contribute to enhancing collaborative research and technology transfer.

6. Summary

Of fundamental importance to continuing statistical research, innovation and technology transfer in Canada is a viable peer-adjudicated discovery grant program at NSERC, with funding decisions and priorities determined by researchers in the relevant Statistical Sciences. In order to maintain and enhance these objectives, we propose:

- That the inequities in discovery grant funding across different Evaluation Groups for projects of similar research costs be remedied.
- That additional funds be made available to the EG for the costs of an *HQP supplement*. These supplements would be adjudicated by the same panel that handles the discovery grant and dedicated to the support of HQP.
- That NSERC support the formation of a *National Statistical Science Institute*, which shares infrastructure and staff with one or more of the math institutes, to encourage and support methodological and cross-disciplinary research involving the statistical sciences.

Appendix 1. Average Discovery Grants in the Mathematical Sciences in 1992 dollars

Year	Total Math Sciences	Number grants	Average DG, Math Sciences	Average DG in $ 1992
2010	$11,574,172	601	$19,258.19	$13,889.67
2009	$11,346,837	616	$18,420.19	$13,521.41
2008	$13,118,873	626	$20,956.67	$15,429.30
2007	$13,820,414	644	$21,460.27	$16,174.63
2006	$13,671,129	648	$21,097.42	$16,241.13
2005	$13,335,699	612	$21,790.36	$17,110.45
2004	$13,541,276	632	$21,426.07	$17,196.87
2003	$11,690,916	595	$19,648.60	$16,063.09
2002	$10,927,755	552	$19,796.66	$16,630.57
2001	$11,288,357	579	$19,496.30	$16,748.15
2000	$10,927,423	541	$20,198.56	$17,789.56
1999	$12,411,007	586	$21,179.19	$19,160.50
1998	$13,279,029	642	$20,683.85	$19,036.99
1997	$11,455,576	617	$18,566.57	$17,258.48
1996	$12,050,066	650	$18,538.56	$17,511.83
1995	$12,171,825	681	$17,873.46	$17,148.72
1994	$10,588,757	673	$15,733.67	$15,420.07
1993	$10,808,251	686	$15,755.47	$15,466.99
1992	$9,857,516	636	$15,499.24	$15,499.24

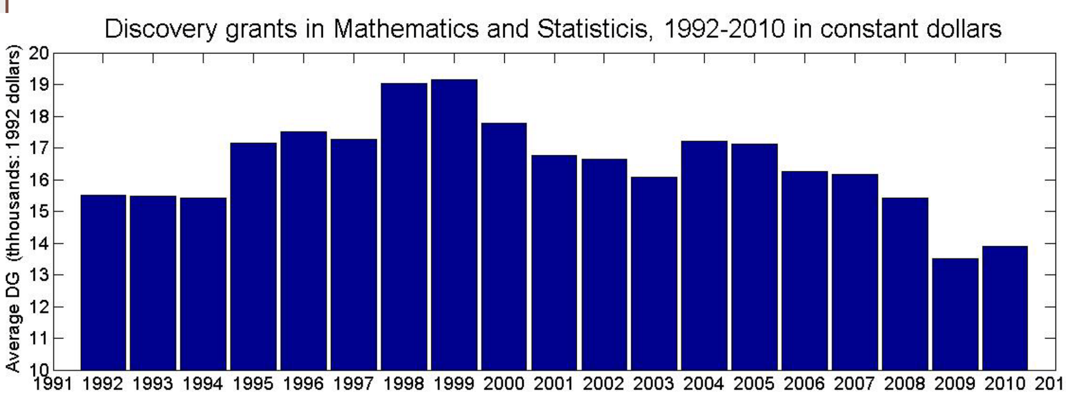


Table 1 and Figure 1. **Average Discovery Grants 1992-2010 in constant (1992) dollars**
(inflation data taken from http://www.rateinflation.com/consumer-price-index/canada-historical-cpi.php?form=cancpi and grant data from Table 3, prepared by David Wehlau, in http://ghoussoub.wordpress.com/2011/02/18/20-years-of-nserc-funding-for-discovery/)

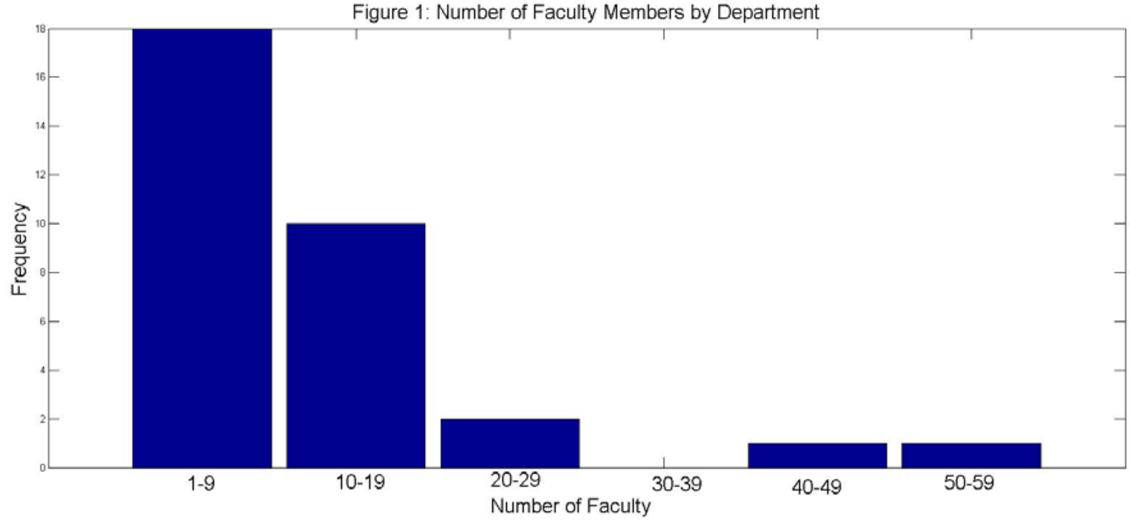
Appendix 2. Dynamics of the Statistical Sciences: A Survey of Canadian Departments

Prepared by Louis-Paul Rivest and the Research Committee of the Statistical Society of Canada

Introduction

This report uses data gathered using a questionnaire sent to departments of Statistics, Mathematics and Biostatistics in Canadian Universities. A total of 33 questionnaires were returned, 27 come from regular Mathematics and Statistics or Statistics departments while 6 were from “service” departments, 5 in faculties of medicine and one in a business school (HEC in Montréal). The respondents are given

Figure 1: Number of Faculty Members by Department



at the end of this report.

Figure 1 gives an histogram for the number of faculty members in 2010. The three large departments are the Dalla Lana School of Public Health at the University of Toronto (51 faculty), the Department of Statistics and Actuarial Science of the University of Waterloo (42 faculty) , the Department of Statistics and Actuarial Science of the University of Western Ontario (20.5 faculty). The fourth largest department is the Department of Statistics and Actuarial Science of Simon Fraser University with 20 faculty members in 2010. These four departments house 38% of the 2010 Statistics faculty members surveyed. The 28 other departments in the survey all have fewer than 16 statisticians each.
To present the findings it is convenient to distinguish three types of department, the *Small* mathematics and statistics departments with less than 10 statistics faculty members (n=16), the *Large* departments with 10 statisticians or more (n=11) and the *Service* departments (n=6) identified above. This classification done with 2010 data is relatively stable in time. Using data obtained from the year 2000, the only changes would be that 3 *large* departments would be classified as *small*.

Age distribution and research support of faculty members and changes for the 2000-2010 period

Table 1 gives the 2010 age distribution of statistics professors and the 2000 and 2010 figures. Globally there was a 25% increase in faculty members for the 33 departments surveyed in the period

2000-2010. Two thirds of this growth occurred in *large* departments; indeed the three largest Statistics and Actuarial Science departments (Simon Fraser, Waterloo, and Western) are responsible for nearly half of the increase in Statistics faculty members.

Table 1. Total number of Statistics faculty members in 2000 and 2010 and 2010 age distribution

Department	2010 Age distribution				2010 total	2000 Total	Increase
	<40	[40,49)	[50,59)	60+			
Service	20%	41%	27%	12%	84	68	24%
Large	29%	29%	27%	15%	181.5	132	37.5%
Small	27%	26%	22%	25%	90.25	84	7.4%
Total	26%	31%	26%	17%	355.75*	284	25.3%

* Non integer numbers are associated with cross appointments

Table 1 reveals that the Statistics faculty members in the smaller groups are typically older, with nearly half of them above 50 years old. This agrees with the previous observation that the growth in Statistics faculty occurred in the large and in the service departments. Table 1 shows a trend towards the concentration of statisticians out of smaller departments.

Table 2 looks at the proportion of faculty with NSERC support in the 33 departments surveyed. This proportion is stable over a 10 year period. It is much smaller in the so called *service* departments since they mostly represent biostatisticians in faculties of medicine where other sources of funding are available. This questionnaire did not permit evaluating the impact of recent changes at NSERC in the method for adjudicating grants.

Table 2. Proportion of Statistics professors with NSERC grants in 2000 and 2010

Department	2010 total	2010 NSERC	Percent	2000 Total	2000 NSERC	Percent
Service	84	40	48%	68	31	46%
Large	181.5	146.5	81%	132	107	81%
Small	90.25	71.25	79%	84	65	77%
Total	355.75*	257.75*	72%	284	203	71%

* Non integer numbers are associated with cross appointments

Table 3 looks at the total funding obtained from various sources. *Service* departments are not included for a lack of reliable data. It shows that the NSERC discovery grant program is still the major source of funds for research in Statistics. It account for nearly 50% of the support money. The second most important category, “Other”, stands for industrial contribution and money from other agencies such as CIHR. Nearly 50% of the total amount (1 179) comes from a single university, namely Waterloo; this entry might change in future years. In 2010, the large departments represent 67% of all faculty members and 71% of all research support showing a stable per faculty basis.

Table 3. 2010 Funding in Thousands of Dollars from Various Sources for Statistics and Mathematics and Statistics departments (n=27)

Department	NSERC Disc	NSERC Other	MITACS	Other	Prov	Univ	Total
Large	2778	607	286	1950	350	383	6354
Small	1264	266	45	483	240	255	2553
Total	4042	873	331	2433	590	638	8907

Graduate students supervision

The questionnaire also highlights a substantial increase in the supervision of graduate students; Table 3 shows that graduate student supervision has nearly doubled both at the Masters and at the Ph. D. levels over a 10 year period. The important increase, in the large departments, is associated with the increase in numbers of statistics professors in these departments. Thus we also look at this data on a per faculty basis.

Table 4. Comparison of 2000 and 2010 enrolment in Masters and Ph. D. programs by type of departments

	Masters			Ph. D.		
Department	**2000 Enr.**	**2010 Enr.**	**Increase**	**2000 Enr.**	**2010 Enr.**	**Increase**
Service	26	59	127%	23	32	39%
Large	134	316	236%	90	187	103%
Small	88	119	35%	46	60	40%
Total	248	494	99%	159	289	82%

Table 5 and 6 make the questionable assumption that graduate student supervision is the sole responsibility of NSERC discovery grant holders. It highlights that the load has increased between 2000 and 2010. Roughly speaking, in 2010 the average NSERC grant holder in Statistics has 2 Masters and one Ph. D. students enrolled in a Statistics or Mathematics and Statistics program. Of course, this does not account for supervisory activities in subject matter areas and these figures underestimate the involvement of statisticians in the training of highly qualified personnel.

Table 5. Comparison of the 2000 and the 2010 Masters supervision load for NSERC grant holders

Department	2000 Masters	2000 NSERC	Load	2010 Masters	2010 NSERC	Load
Service	26	31	0.84	59	40.0	1.47
Large	134	107	1.25	316	146.5	2.15
Small	88	65	1.35	119	71.25	1.67
Total	248	203	1.22	494	257.75	1.92

Table 6. Comparison of the 2000 and the 2010 Ph. D. supervision load for NSERC grant holders

Department	2000 Ph.D.	2000 NSERC	Load	2010 Ph.D.	2010 NSERC	Load
Service	23	31	0.74	32	40.0	0.80
Large	90	107	0.84	187	146.5	1.27
Small	46	65	0.71	60	71.25	0.84
Total	159	203	0.78	289	257.75	1.12

Evident Trends in Survey

The development of actuarial sciences and financial statistics

An interesting finding of the survey is the growing importance of actuarial sciences and financial statistics. Over a ten year period the cohorts of undergraduate actuarial students have experienced a steady growth that has benefitted the departments that house them, especially Waterloo, Western and

Montréal. Six of the 27 departments surveyed report initiatives geared at actuarial sciences. The growing importance of this area is also reflected by the emergence of new research topics in actuarial sciences and financial statistics. In the 2010 NSERC data base most of the 40 researchers found under the applied probability keyword work in this area, as compared to only a handful in 2000.

New initiatives in biostatistics

Several Statistics and Mathematics and Statistics departments are becoming involved in the training of students in biostatistics. Indeed 4 of the 27 departments surveyed highlighted their participation in graduate programs in biostatistics. Thus biostatistics training is not the sole responsibility of biostatisticians in medicine faculties. This suggests a societal need for statistical expertise in medical research.

Limitations of the survey

There was some difficulty in defining a statistics professor. Should a probabilist in a Mathematics and Statistics department be counted? What about somebody with a statistics degree in a medicine faculty that applies to CIHR for research support? Is a fellow of the SOA involved in the training of actuarial students a statistician? Some kind of involvement with the SSC was proposed as a defining criterion. The responses provided in the questionnaire were used as provided. The NSERC searchable data base was used to fill some gaps for the 2000 data, see
http://www.outil.ost.uqam.ca/CRSNG/Outil.aspx?Langue=Anglais

The survey did not cover actuarial schools that were separate from mathematics and statistics departments; this is the situation at Manitoba and Laval for instance. Among the respondents there is only one business school (HEC Montreal) so statisticians working in this area might be underrepresented. Some statisticians were missed, from the NSERC data base the numbers of 2010 grantees can be estimated at about 360, only 258 are accounted for in this survey.
The 2000 financial data was so scarce that this report does not provide any summary. Data about undergraduate students was highly variable; in some universities it included actuarial science students, some departments could not disentangle mathematics and statistics students. No attempt was made to summarize this data.

list of respondents

"*Service*" departments: School of Population and Public Health UBC, HEC Montréal, Department of Epidemiology Biostatistics and Occupational Health McGill, Queen's School of Public Health, Saskatchewan School of Public Health, Dalla Lana School of Public Health University of Toronto

"*Large*" departments[12]: Alberta, UBC, Calgary, Carleton, Guelph, Manitoba, U. De M. , Simon Fraser, Western, York, Waterloo.

"*Small*" departments: Acadia, UBC Okanagan, Brock, Dalhousie, Laval, McGill, Memorial, Moncton, UNB St John, Ottawa, UQAM, Queen's, Saskatchewan, Sherbrooke, Victoria, Windsor.

[12] The Statistics department at the University of Toronto has subsequently submitted data which will be incorporated in a future revision of this report.

Appendix 3. Restructuring GSC 14: Submission from the Statistical Sciences NSERC Liaison Committee

We propose that a new Broad Area Panel, or Group, be established, with the working title: Statistical and Quantitative Interdisciplinary Sciences, composed of the former GSC 14 with portions of the Interdisciplinary GSC and other NSERC areas involving quantitative research.

Researchers in all areas of science, especially the physical sciences, now routinely record massive amounts of observational and experimental data. This in turn requires their techniques to take on statistical characteristics, and requires the development of new statistical methodology. Statistical Science is a relatively new discipline, a frontier area which is evolving as a cross-cutting science to address these scientific challenges.

We see many important benefits to the creation of such a panel:

1) Proposals in all aspects of quantitative science, both methodological and applied, would be considered by the same panel.

2) The group would be a focal point at NSERC for integrated quantitative research and highlight truly interdisciplinary work.

3) The group would retain all aspects of the Statistical Sciences in a single panel, reflecting the evolution of the discipline of statistics as a collaborative quantitative science.

4) This would avoid a return to the outdated view of Statistical Sciences as a sub-discipline of mathematics like algebra, functional analysis or combinatorics.

5) The Sedra Report recommends that cross-council activities be developed as new initiatives. There is great interest in the statistical community in these cross-council efforts, and the Group we are proposing could play a leadership role in this.

6) This structure would reduce the difficulties faced by NSERC in the evaluation of certain interdisciplinary quantitative applied areas. These difficulties were an important part of the rationale for the current restructuring of NSERC evaluations.

Statistical and Quantitative Interdisciplinary Sciences

As a recent NSF report[13] noted: "statistics is inherently an interdisciplinary science. … united through a common body of knowledge and a common intellectual heritage…". As our community has been discussing the positioning of statistical science in the context of the Discovery Grants re-organization, it has become clear that the links to computer science are at least as strong as those to mathematics, but more importantly that there are also many areas of applied statistics with links to other research areas. For example, biostatistics has close ties to the Life Science Group, environmental statistics has

[13] Lindsay, B.G., Kettenring, J. and Siegmund, D. (2003) *Statistics: challenges and opportunities for the twenty-first century.* http://www.stat.psu.edu/~bgl/nsf_report.pdf.
Accessed on June 30, 2008.

close ties to Ecology, and also to Geosciences, some areas of actuarial science are close to operations research, while others are closer to mathematics.

It is important to note however that there is a core of the discipline that cuts across all these areas, and most statistical scientists have a research program that combines development of core statistical methodology with one or more areas of application. Separating the core from the applied areas would be very limiting for the development of both aspects of statistical science.

These issues are reflected in the reactions of various members of our community to the current proposed Group combining Mathematics and Statistics. As NSERC staff is aware, there is considerable opposition within our community to this proposal, and many in the community feel that it would be preferable to be in a Group with Computer Science and Operations Research. Biostatistics, a major sub-area of Statistical Science, would certainly be an uneasy fit with Mathematics: Karen Kopciuk from U Calgary wrote: "I also strongly support aligning ourselves with computer scientists, if we need to be included with another discipline. In my case, there is an active group of mathematical biologists at the University of Calgary but it is the bioinformatics researchers with whom I interact. I have much more in common with them than with any of the work being carried out by the mathematicians yet we all share a lot of common application areas".
On the other hand, probability would not be a good fit with Computer Science: Martin Barlow of UBC summarized the view of the probability group when he wrote "We don't want Probability Theory to be split up (as at present) between different panels. There are mixed views on whether Probability Theory would be better placed in Mathematics or Statistical Science, but it is nearly unanimous that we don't want to be with CS".

At the National Science Foundation statistics is within the Directorate of Mathematical Sciences (DMS), which essentially funds the 'core' of statistical theory and methodology, while many other statisticians are funded through programs in Biology, Information Science, Engineering, Geological and Environmental Science, Social and Economic Science and Physical Science. While this is functional, it is clear from the NSF report that it is not viewed as optimal for the development of statistical science.
In any case there is not enough critical mass in Canada to be able to parcel up the statistical sciences into 'core' and 'applications' following the NSF model, without essentially losing the coherence and shared intellectual heritage of the discipline.

Our committee has been discussing the restructuring exercise extensively over the past year, and quite intensively since the final report of the Sedra committee was released. We have consulted with the broader statistical science community by email using d-ssc@ssc.ca, which reaches members of the Statistical Society of Canada, by email to the email list used by Judie Foster to request input, which reaches many current and former members of GSC-14, and by email to several of our colleagues, including colleagues in probability and in actuarial science. We also established a public wiki page, where all the relevant documents were posted, and invited comments on that page from the community. NSERC staff presented the conference model to several groups at the Annual Meeting of the Statistical Society of Canada, including the Board of Directors, the Chairs of Departments, and at an open meeting. The Liaison committee met by conference call with Judie Foster and Rawni Sharp on June 26, 2008. There is very strong support for a separate Group for Statistical Science, and the supporting emails received over the past weeks are attached to this proposal. Professor Stephen Fienberg of Carnegie-Mellon University sent an unsolicited formal letter, which is also attached.

Research units

Attached is a set of proposed units for the Group. The blocks attempt to divide the statistical sciences into relatively large, relatively homogeneous groups of topics. It should be noted however that there is no widely agreed on subdivision of past and current statistical research into well defined sub-areas, and that most statistical scientists work on theory, methods, and applications, in varying proportions both among scientists and, for a given scientist, at various times within her career.

The applied units were created with a view to relevant areas now covered by the Interdisciplinary GSC, isolating those we felt had significant statistical aspects. In order to ensure the necessary expertise for evaluation of these areas, it will be necessary to expand Panel Membership outside the field of Statistical Science.

There are two units formed from actuarial science, financial mathematics and probability. Probability is a somewhat special case, in that applications in this area are currently divided somewhat arbitrarily between 3 GSCs, pure and applied mathematics (336/7) and statistical science (14). As noted above, Probability Theory should be in a single Group, which would either be Mathematics or the newly proposed Group, and further consultation will be needed. Our feedback indicates that Actuarial Science researchers are relatively comfortable within GSC 14 and would remain with the Statistical Sciences.

Submitted by

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