INTRODUCTION
To report on the current status of cartographic education in Canada, educational organizations were requested to identify what they felt to be the major influence, directions and current activities in the profession. Questionnaires were distributed to universities and colleges, including geography, surveying, forestry, engineering, geology, and computing science departments. Forty responses were received of which seven represented colleges or polytechnics and 33 were from university departments. Of the university responses, 28 were geography departments and five were from other fields. There responses in support of the National Report are greatly appreciated.

Geography Departments Responding

Brandon University
Brock University
Carleton University
Concordia University
Lakehead University
Laurentian University
McGill University
McMaster University
Memorial University of Newfoundland
Mt. Allison University
Queen’s University
St. Mary’s University
Simon Fraser University
University of Alberta
University of British Columbia
University of Guelph
Université de Laval
University of Manitoba
University of Ottawa
Université du Quebec a Chicoutimi
University of Regina
University of Saskatchewan
Université de Sherbrooke
University of Victoria
University of Waterloo
University of Western Ontario
University of Windsor
Wilfrid Laurier University

James W. Darlington
Alun Hughes
S. Prashker, C.E. Earl
Jacqueline M. Anderson
B.A.M. Phillips
G.O. Tapper
R. Norman Drummond
G.M. MacDonald

Robert J. Rogerson
Steven Bell
Gerald McGrath
Bob McCalla
R. Hayter
Val Naronha

Brian Klinkenberg
Janet Mersey
Jean Ravenel
Micha Pazner
David Douglas

Majella J. Gauthier
H. Schlichterman, D. Gauthier
M.R. Wilson
Michel Rheault
C. Peter Keller
Len Gueike

Ronald M. Butler

C. Grant Head
Other University Departments

Lakehead University
  School of Forestry
St. Francis Xavier University
  Department of Geology
University of Calgary
  Department of Surveying Engineering
University of New Brunswick
  Department of Surveying Engineering
University of Toronto
  Department of Survey Science

Grant Mitchell
Brendan Murphy
Vincent B. Robinson
Y.C. Yee
Gordon Gracie

Colleges

Algonquin College
  Surveying and Mapping Program
College of New Caledonia
  Forestry Department
Humber College of Applied Arts & Technology
  Technology Division (Surveying)
Niagara College of Applied Arts & Technology
  Survey Program
Nova Scotia College of Geographic Sciences
  Cartography Program, GIS Program
Ryerson Polytechnical Institute
  School of Applied Geography
Sir Sandford Fleming College
  Cartography Program

R. Proulx, E. Starchuck
Roberta Dunsmore
Ken Wilson
T. McGuiness
John Belbin, Robert Maher
Douglas Banting
Christopher S. Yu

The questionnaire was designed with two primary topics in mind. Firstly, what courses were given along with an assessment of the supply and demand situation for graduates; and secondly, what in the respondent's opinion were the effects of the technological trends toward computer techniques. As far as possible we wished this national report to be an expression of the topics and concerns of the respondents to the questionnaire. The main questionnaire items are listed below. Responses were evaluated under: Geography Departments; Other University Departments; and Colleges.

Programs:
Please enumerate any programs you have that lead to some specialization in cartography. If possible state the current and anticipated future (i.e., next 4 years) situations with respect to:

a) enrolment;
b) market demand for graduates;
c) collaboration (cooperative projects, etc.) with outside agencies and other departments;
d) funding for these programs;
e) technology used (e.g., changes from manual to computer methods). If possible give an outline or list of cartography-related courses required in the program.
Courses:
As far as possible, without duplicating your comments about programs, enumerate courses in cartography/map use. Enumerate the current and anticipated future situation with respect to:

a) enrolment;
b) market demand for the skills being taught;
c) collaboration with outside agencies/departments;
d) technology used.

Resources:
Please describe the basic resources available to you, within your department or outside, for teaching or performing research on map preparation/use/interpretation. Estimate future changes in these resources:

a) research directions;
b) faculty/student involvement;
c) funding;
d) changes in research interests.

Technology:
There appears to be a significant trend toward computer automation of the map preparation process and also the spatial data manipulation/GIS activity. Do you perceive this to be a true statement in general and in your field of interest in particular? How do you see your organization responding to this trend? Do you anticipate in general more research, resources, computer software, manpower, or funding being committed to this emphasis over the next four years?

Final Comments:
Please add any final comments you may have about research or teaching directions that in your opinion are, are not, or should be addressed within Canadian educational institutions, and what types of clients or employers will be interest in our graduates or our research activities.

UNIVERSITY GEOGRAPHY DEPARTMENTS

Levels of Activity in Cartography

In practice it was not possible to distinguish between the answers given to the questions under programs and the answers given to the questions under courses, so the results for these two questions have been merged. In addition, where possible, courses were classified as manual cartography, computer cartography, or remote sensing. Nevertheless, due to the open-ended character of the questions, considerable difficulty was encountered with absolute categorization of the courses. For example, it is unclear in many cases whether or not respondents considered courses in air-photo interpretation or remote sensing to be part of a cartography program. Some respondents mentioned these courses, others did not. In many cases it was also unclear whether course titles represented full-year courses or half-year courses. Where respondents stated that new or planned courses in a particular topic were being introduced, these have been included. Frequently, when new or planned courses were mentioned, these were new computer courses. Since the number of courses offered by a particular department seems to be related to the number of faculty involved, responses to the
question of faculty numbers have also been included. Nevertheless, these responses frequently do not state whether staff numbers represent full-time faculty only, or include sessional part-time faculty, and/or technical support staff. Occasionally, faculty numbers for the department were given. An attempt was made to distinguish between graduate and undergraduate programs. Course totals, however, include both graduate and undergraduate courses.

An attempt was made to assess the cartographic involvement for each of the 28 departments submitting replies. For the purposes of this breakdown air-photo interpretation or remote sensing courses were excluded. On this basis the number of cartography oriented courses varied from zero to eight or more. Departments are classified into those having low, medium or high involvement in cartography. It must be emphasized that since brief course titles or outlines may have been incomplete, undoubtedly some misclassification of courses or programs has taken place.

Two departments have a low involvement in cartography, giving either zero or one course in the subject. Nineteen universities fall in the medium category giving two to four courses with nine of these providing three courses in cartography. Seven universities fall in the high category offering five or more courses; three of these being classified as very high having eight or more courses available.

Predictably the result is much like a normal distribution, with a mean of three. The high category, (Alberta, Carleton, Laval, Memorial, Queen's, Simon Fraser and Western Ontario) in general coincides with those universities on the questionnaire that specifically mention graduate programs; (Sherbrooke, the other university that mentions graduate level programs, has a very strong emphasis on remote sensing). Not surprisingly, the number of cartography courses is closely related to the presence of a graduate program. Also, the number of cartography courses offered is related to the number of full-time faculty. Universities with a high involvement in cartography have typically two to four (usually three) faculty members whose specific involvement is in cartographic issues.

In the medium category, typically one faculty member teaches the two, three, or four cartography courses available, although this figure is sometimes confused by the overlap of aerial photography or remote sensing courses and interests with those of cartography. Approximately four of the seventeen universities in this category have a second faculty member, perhaps sharing cartography and/or remote sensing duties. Universities in the low category have no faculty members specifically concerned with cartography.

Thus, the norm for Canadian geography departments is for one faculty member to teach three courses. Sixteen of the 28 responding departments mention at least one course in aerial photography or remote sensing. Eleven of these responses are from departments falling in the medium cartographic involvement category, so it is probable that, either separately or in cooperation, another faculty member will be covering air-photography and remote sensing subjects.

In keeping with the particular concern of this questionnaire with trends and technology, course titles were examined to determine the extent of involvement with computing techniques. Four of the responding departments provide no such courses, 12 departments provide one, and eight departments offer two courses in computer-assisted cartography. Four departments offer three or more computer oriented courses. Those departments providing three or Wore courses at any level in computer cartography or geographic information systems are those departments showing a high course involvement in cartography in general and in addition possessing a graduate program. Where a single computing course is offered, it is typically entitled "Automated Cartography" or an equivalent whereas those departments offering a second course frequently entitle it "Geographic Information Systems" (GIS). Most respondents referred to GIS as an extension to "Automated Cartography", although it must be em-
phasized that there are significant differences. In particular, automated cartography is concerned with the production of maps as final products, whereas in GIS applications maps are heavily used as input to the system, for subsequent analysis. Nevertheless, with the increasing use of spatial data structures in both approaches, and perhaps database management systems also, some of the technical distinctions may be decreasing.

In summary, of the three cartography courses offered in the average university environment, one will probably be automated cartography. The other two courses - when not labeled “Introductory Cartography” and “Advanced Cartography” may well be labeled “Cartographic Theory and Design” and “Cartographic Production”, depending on the availability of darkrooms and equipment and/or a cartographic services division.

Courses and Programs

The first main question in the questionnaire concerned both individual courses and whole programs: enrolment; market demand for graduates; collaboration with outside agencies or departments; program funding, and technology used. Responses to individual questions varied from 50% to 75%.

Enrolment figures proved difficult to generalize, primarily due to departmental policy. Where introductory cartography constitutes a required course within the degree program, enrolment can be 100 or more in that course, independent of the availability of higher level courses. The numbers quoted in responses vary from a maximum of 300 to a minimum of 20 in some small departments. Enrolment dwindles in subsequent years with the highest level undergraduate courses having 5 to 35 students, but typically with an enrolment of 15. On the basis of a few individual comments it is clear that in several cases these last figures result from enrolment restrictions - due to equipment availability. Thus, the enrolment figures of between 5 and 35 students may represent student demand, perhaps based on perceptions of employment opportunities, or else these figures may represent limitations in the potential throughput of individual geography departments. If this is the case actual demand for the course may indeed be significantly higher. This matches comments mentioned by several respondents - that available university resources cannot meet the market demand for students skilled in computing techniques.

The general response concerning market demand is that it is high for graduates, with the additional comment that much of the growth in demand is for graduates with experience in automated cartography and/or geographic information systems. Where current market demand is assessed as fair to poor it is sometimes stated that future market demands will be heavily in the field of computer automation.

In response to the question about technological development in university cartography courses and programs, nine departments stated that they were planning to, or had recently completed, the installation of microcomputer labs for teaching automated cartography. Three departments stated that expansion in teaching computer cartography was not currently possible due to enrolment limits in these courses, primarily due to the non-availability or limited number of microcomputers or graphics terminals and equipment.

Under the heading of collaboration with other departments or organizations, 12 responses were received. Inevitably there is some confusion between collaboration with outside agencies in the process of presenting undergraduate or graduate courses, and collaboration with these agencies in the pursuit of graduate or faculty research. Nevertheless, 10 responses indicate that collaboration exists with various government agencies; some of them federal, some provincial, and some municipal. Five responses mention working with other university departments, including biology, geology and other earth sciences and urban planning departments. Lakehead University mentions involvement in GIS activity through the Computer Assisted Resource Inventory Systems unit at the university. (A separate questionnaire
was received from the Forestry Department at the university involved with this program). The University of Alberta was unique in its specialization programs: one in survey science run in collaboration with the Department of Civil Engineering; and, one in Geo-information Processing, run jointly with the Department of Computing Science. Two departments mentioned collaboration with private industry.

On the basis of these responses, out of 28 geography departments replying to the questionnaire, it is clear that collaborative efforts need further promotion. At least within the teaching context, collaboration and field trips to government agencies should be more extensive than are in fact specified in the questionnaire. That only five departments mentioned cartographic collaboration with other university departments leaves a great deal to be desired. While earth sciences departments are the most commonly mentioned, far too few even of these are involved.

Resource Availability

Here questions were concerned with staff and faculty; laboratories and darkrooms; computer hardware, and computer software. Discussion of the number of faculty has already been dealt with, and also the basic description of the levels of cartographic involvement of particular departments. Where other staff are mentioned by respondents, in most cases this appears to represent support staff involved in cartographic production for internal or external users.

On the basis of individual responses to the question about laboratories, darkrooms and equipment available, departments are placed in four categories. Category “A” can handle full color reproduction up to the proof stage. Category “B” can handle black and white reproduction and printing and have a process camera available. Category “C” can handle black and white reproduction but there is no process camera available. Category “D” involves almost entirely manual drafting facilities. Of the respondents four are placed in category “A”, three in category “B”, and four in category “C”. The remainder are assumed to be in category “D”.

It is also of interest to compare a department’s graphical resources with their response to the question concerning external contacts and collaboration. More than half of the laboratories in categories “A” and “B” belonged to departments reporting significant external collaboration, whereas only a third of the departments in categories “C” and “D” expressed any external collaboration involvement. Cooperative activity with external agencies is one factor in improving internal resources and equipment.

Hardware

We now turn to the availability of computer hardware and software for cartography education. In terms of computer hardware, personal computers of one type or another have become associated with computer cartography and geographic information systems in most installations. Only three of the departments responding did not mention personal computers. The number varies from 1 to 20 or more, with several organizations reporting personal computer or microcomputer laboratories, in some cases being shared with some other departments. Fifteen of the respondents have digitizers and/or plotters (or occasionally optical scanners) available. Several departments stated that microcomputers will be procured in the near future. In addition, some mentioned that limited access to microcomputer labs has had the effect of limiting course enrolment in computer cartography or geographic information systems courses.

This raises an issue not restricted to geography departments or computer cartography. The availability of microcomputers for developing computer cartography application is not purely a function of the number of microcomputers purchased, it is also a function of the number of hours in the day when they are available for student use. Universities vary widely
in their reaction to the problem of after-hours microcomputer availability (assuming no supervision is available in the evenings). Thus, if practical experience suggests that unrestricted access to microcomputers does not cause significant problems, then a small number of these machines may satisfy a significant number of students. This is the usual situation for access to main computer terminals. However, where vandalism, or irresponsible use such as software piracy, are perceived to be problems with the result that the machines may only be used when staff supervision is available, then even a large number of microcomputers in a laboratory may provide extremely limited access to students taking computer cartography courses. This is further degraded by the fact that program compilation and data throughput may be extremely slow, requiring waits of thirty minutes or more for results to be produced, again reducing the apparent availability of computing equipment for training in computer cartography applications. Computer cartography is particularly troublesome in this way, since frequently large amounts of data must be handled, slowing throughput time considerably.

Most departments mention availability of computer access and use of the main-frame university computer or central minicomputer cluster. Few departments mention specific graphics terminals or workstations, but recent developments in microcomputers reduce this distinction. A few departments mention access to minicomputers, e.g., VAX, that appeared to be distinct from the university main-frame and may be part of a departmental resource. The apparent move from central mainframe computer usage to microcomputer laboratories for graphics applications of this sort raises questions about the financial ability of university programs to train students in computer cartographic techniques demanding significant hands-on experience.

Software
Departmental responses to a request for information about available computer cartographic software fall into three categories. Category “A” includes traditional mainframe mapping packages, e.g., Surface II, SYMAP, GIMMS, DISSPLA, SASGRAPH, etc. In general, with the notable exception of GIMMS, these are not specifically cartography packages (concerned with automation of cartographic processes), or geographic information systems, of the kind required by students for future employment. In fact, most of the computer packages mentioned are more properly considered computer graphics than computer cartography. Indeed, a few questionnaire responses appeared to be uncertain of the distinction between the two.

The second category of software mentioned is intended for microcomputer use. The most common names include AutoCAD, MAP, and “Macintosh Software”. With the exception of the MAP package these programs are predominantly microcomputer graphics.

Only nine responses mention significant cartographic software, whether their own or commercial packages such as ARC/INFO. However, several departments mentioned software development of their own.

If “hardware is what you have, software is what you do”, then most courses in automated cartography merely use fairly simple software to produce fairly simple maps. Encouraging exceptions to this are the relatively widespread use of the GIMMS and MAP software packages, which permit meaningful manipulation of map information. Clearly, the development of mapping software or the serious use of large-scale mapping systems is limited to a small number of departments. With the exception of Regina and Lakchead Universities, who mentioned access to commercial GIS systems, the development of software for automated cartography or geographic information systems appears to be restricted to a small number of departments, primarily those in the “high involvement in cartography” category. It is hoped
that other departments will see the benefits since mere use of existing packages gives little understanding of underlying spatial processes.

Nevertheless, based on the software mentioned, most departments highly involved in cartography (five or more courses, two or more faculty) are actively involved in software development, problem analysis and algorithm development - in other words, developing methodology. Departments in medium category of cartographic involvement are primarily using methods or technology developed elsewhere, and only a few of these are providing training in systems directly related to subsequent employment possibilities. There is a significant gap here between demand and supply.

Research

Questions under this heading concern research directions, faculty and student involvement, funding and changes in research interests. The most useful information comes from a discussion of current and proposed research directions. Nine departments mention "traditional" cartographic issues. Examples of these are historical cartography, map design, map use, map learning, map communication, map perception, together with atlas development, land use and multivariate analysis. Four departments specifically target remote sensing as a research emphasis. This topic is frequently inextricably mixed with the topic of cartography, especially computer cartography. Twelve departments, nearly 50% of the total, focus on computer applications in automated cartography or geographical information systems as their specialization in research. In some instances, this is just the recognition of trends; in other cases, specific automated cartography or geographic information issues are mentioned. Examples include: digital terrain models; raster/vector conversion problems for specific applications; modeling and optimization; cartographic data structures for use in automated cartography or geographic information systems; automated cartography or geographic information systems development; digitizing problems; GIS applications, and GIS use in teaching. For half of the Canadian geography departments, research in cartography is becoming equated with research in computer cartography or geographic information systems.

Conclusions

All respondents to the questionnaire agreed that there is a significant trend toward automation of the map preparation process and that spatial data manipulation and GIS activity are increasing.

OTHER UNIVERSITY DEPARTMENTS

One forestry department responded to the questionnaire as a result of it’s involvement with a commercial geographic information system. Lakehead University has been active in the implementation of GIS in forestry resource inventory work in collaboration with the Ontario Ministry of Natural Resources. They have both undergraduate and graduate work in GIS.

Three replies were received from survey science or survey engineering departments. While there are significantly fewer such departments in Canada than there are geography departments, their activity in cartography, automated cartography and GIS is significant. The University of Calgary provides significant undergraduate and graduate education in surveying engineering, including digital mapping and land information systems. They also are active in continuing education in those fields. In cooperation with the provincial government they have established a professorship in digital mapping and spatial data management. Faculty and graduate students are actively involved in basic and applied research of interest to government and industry. The University of New Brunswick (Fredericton) provides undergraduate and graduate degrees in cartography and digital mapping. Research topics include
conventional and digital mapping techniques, cartography, GIS, photogrammetry, remote Sensing, and image processing. They have active involvement with private industry and government. Twelve graduate students are enrolled in cartography related programs, and they also provide a certificate in mapping, and a graduate diploma in land information management. They have five cartography courses, three of them digital, together with photogrammetry and remote sensing courses.

The department of survey science, Erindale Campus, University of Toronto, is also extremely active in cartography. They provide undergraduate and graduate programs, as well as special training courses of varying lengths, and external consultative services. Current undergraduate enrolment is 100, with an expected increase to 150 in the near future because market demand for their graduates is high. Four courses that might be classified as cartography are given, excluding photogrammetry and remote sensing. Two of these courses are computer related. Research directions include surveying methodology, remote sensing, and land information systems. Much of the funding for this research comes from federal or provincial sources. More research is anticipated in digital mapping, image processing, spatial information systems, and land information management. A new institute for land information management in surveying is being established.

Conclusions

Surveying departments appear to be extremely active in both the theoretical development and conventional aspects of cartography. Their activity in GIS and LIS is likely to increase in the next few years. They appear to be successful in obtaining funding and cooperate actively with government and private industry. Their support of short- and medium-term non-degree courses is particularly interesting. It is clear that their influence will be felt even more strongly in the field of cartography over the next few years. Additional effort needs to be spent in encouraging other applications-oriented disciplines to become more involved with cartographic issues, especially computer cartography and spatial data handling.

COLLEGES

Seven colleges or polytechnics replied to the questionnaire. Three of these train technicians or technologists in surveying or forest resources. The New Caledonia's forest resource program instructs in surveying, air-photo, and landsat imagery analysis, and aerial mapping for environmental or forestry mapping and planning purposes. They collaborate extensively with industry and provincial agencies, and estimate that market demand is significantly in excess of the 30 to 40 students who graduate each year. Niagara College provides a two-year survey technician program with no separate cartography courses. Humber college provides training from one to three years in duration for aerial survey technicians, survey technicians and technologists, and hydrographic technologists. Their cartography course involves darkroom work as well as use of microcomputers and plotters. They expect to emphasize micro-computer skills more in the future, and expect fair to good demand for their graduates.

Three colleges that specialize in cartography-based programs replied to the questionnaire: Algonquin, Nova Scotia College of Geographical Sciences, and Sir Sanford Fleming College. Sir Sanford Fleming provides two- and three-year cartography diplomas. There is some collaboration with government agencies, and overall they find an excellent demand for their graduates along with an excellent international reputation as a result of the many national and international cartographic awards which their students receive. Laboratory facilities include the ability to produce color proofs, and they have access to several minicomputers along with a large number of microcomputers. Software systems available to them include RAMs, Geobase, and Dipex systems. In response to the trend toward computer automation in mapping, their cartographic technology programs, with enrolment of approxi-
mately 100 students, have been extensively revised to prepare graduates for the anticipated changes in the workplace. In addition to cartography, a new GIS technology program was initiated, also with a very high demand for graduates.

The Nova Scotia College of Geographical Sciences provides courses in both cartography and GIS. Their diploma in cartographic technology is a one-year 2,400 hour intensive program. Market demand for their graduates has been excellent: since its inception in 1962 only four years have produced less than full employment for graduates. Cartography courses are also offered in the planning, survey, and remote sensing programs. Laboratories and darkrooms are available up to and including color proof facilities.

The college’s one-year 2,400 hour GIS programmer/applications specialist diploma will expand from 14 to 24 students in 1987. Extensive individual cooperative projects with government or industry are provided for each student. Several minicomputers and microcomputers and extensive computer graphics equipment are provided. Cartographic or GIS software includes ARCANFO, Strings, and CARIS on minicomputers, along with PC ARC/INFO, MAP, and SPANs on microcomputers. Research on data structures, data transfer standards and image processing GIS integration is actively pursued. While current computer resources are excellent, significant additional funding may not be forthcoming.

Algonquin College provides two- and three-year training programs in cartography. The College presents an integrated mapping course in which the graduate is required to know surveying, photogrammetry, air-photo interpretation, remote sensing, traditional cartography, digital cartography, GIS, and reprographics. Their darkroom and laboratory resources are capable of producing color proof products, and they have photogrammetric equipment, an ACDS four-station system with software, plotters, a digitizing table, and access to college computer facilities for other computing resources. They expect and see a significant trend toward computer automation.

Similarly, the CEGEP de l’Outaouais and the CEGEP Limoilou offer three-year diploma programs, including automated cartography.

Ryerson Polytechnical Institute, School of Applied Geography, emphasizes GIS applications in their undergraduate cartography courses. They have a Synercom GIS system, and feel that there is a high market demand for people able to analyze spatial data.

Conclusions

The college system has provided and continues to provide the traditional cartographic training required by government and industry. Student job placement remains high, but some difficulty is encountered in finding the financial resources to purchase the expensive equipment to provide for the expected trends in automated cartography and geographic information systems. While there is considerable skepticism whether computers can do everything as well and as efficiently as is claimed for them, there is little doubt that automation will continue to increase and student training must be provided. The same pressures occur here as in the university environment: significant demand for their graduates over the next few years, especially those with computer expertise. At the same time however, government funding for equipment, student seats, or staffing, tends to be limited. There must be an improved policy for student training in this field. Conflicting signals of expanding demand and shrinking funds will produce at best confusion and at worst wholesale withdrawal of educational institutions from an exciting, vital and nationally significant field of activity.

OVERALL CONCLUSIONS

The picture emerging from this is surprisingly consistent and this review has clarified as a national trend what may have been believed to be individual local problems. Business is booming, especially in the process of automation, and most educational institutions are concerned about ensuring the development of faculty expertise, enhancing computer resources or appropriate computer software, or all three, in order to respond as they would like to the opportunity. While many of the traditional cartographic skills need to be preserved, it is important that new developments be actively pursued, in a subject vital to the nation’s interest - the collection and presentation of the information on which we must base our decisions.