



**Profiling Undergraduate Soil Science Education in Canada:
Status and Projected Trends**

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Profiling Undergraduate Soil Science Education in Canada: Status and Projected Trends

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Abstract

Global declines in postsecondary enrollment in soil science programs over the last several decades have been mainly attributed to an overemphasis on the connection with agronomy and production agriculture but recent enrollment increases in the United States suggest change is afoot. To determine if similar trends are occurring in Canada, we inventoried undergraduate soil science course offerings at postsecondary institutions and conducted a survey to assess the status and projected trends in soil science education. We found that 64% of universities and 37% of colleges offer undergraduate soil science courses as part of degrees or diplomas where knowledge of soil science is important (e.g., agriculture, resource management). In Canada there are 149 undergraduate soil science courses taught in universities and 58 at colleges. On average, there are 3.2 courses taught at each university and 1.9 at each college that offer soil science courses. Soil science programs at the University of British Columbia, University of Saskatchewan, and University of Manitoba offer between 8 and 9 soil science courses and represent 17.4% of the national total. Enrollments in all courses across the country are projected to be steady with some anticipated growth, trends that are consistent with those reported in the United States and the Netherlands.

Key words: soil, education, post-secondary, Canada, inventory, trends

Introduction

Soils are an essential component of the biosphere, performing key ecosystem functions and providing the foundation and nourishment for terrestrial food, fiber and biofuel production. As our population continues to grow and our footprint on the planet increases, knowledge of soils is critically important so that they are properly managed to optimize ecosystem function and productivity now and for future generations (Janzen et al. 2011). Despite their important role in society, soils are often an overlooked component of the biosphere. Better awareness about the importance of soil for the general public and imparting the next generation of soil scientists with cutting edge knowledge and tools to ensure the sustainable management of our soils is of utmost importance. Such initiatives have been noted by the United Nations (UN Millennium Project 2005; UN Development Programme 2007), the Intergovernmental Panel on Climate Change (Hartemink 2008), and more recently in the first release of the Status of the World's Soil Resources Report by the United Nations and the Intergovernmental Technical Panel on Soils (UN-FAO and ITPS 2015).

Despite the importance of soils and soils education, declines in undergraduate and graduate enrollment in soil science programs in the United States, Canada, Australia, Netherlands, New Zealand, Kenya, and Tanzania were reported between 1980 and 2005 (Baveye et al. 2006; Collins 2008; Hartemink et al. 2008; Havlin et al. 2010). The declines in enrollments, which reached 50% at some institutions in the United States, were associated with the farm crisis of the 1980s (Barnett 2000) and more broadly across the globe with an overemphasis on the connection to agronomy and production agriculture (McCallister et al. 2005; Baveye et al. 2006; Havlin et al. 2010). In the 1990s, the themes of environment and sustainability were gaining traction with issues like pollution and declining supplies of natural resource coming to the forefront. These issues were fueling students' educational interests. For example, Pepper (2000) documented a shift in enrollment away from soil science and agronomy to environmental science

at the University of Arizona between 1991 and 1997. Enrollments in soil science programs across the United States appear to be increasing, alongside programs such as geology, geography and environmental science increasingly offering soil science courses (Brevik et al. 2014). Though the majority (ca. 58%) of the soil science courses in the United States are delivered by soil science departments, soil science programs account for only a small proportion (ca. 17%) of the total number of programs that include soil science courses in their curriculum (Brevik 2009). This trend may reflect an emerging recognition of the fundamental role that soils play in ecosystem function, global climate, and hydrological cycles beyond the realm of production agriculture and the demand for a more holistic understanding of ecosystem structure and function.

In Canada, the Canadian Society of Soil Science identified revitalization of the discipline of soil science as a priority area in the early 2000s. Since that time, members of the Soil 4 Youth (Krzic et al. 2014), a Canadian collaborative program, have been actively working to integrate soil science into high school curricula in Canada through the development of specific classroom/teaching content and related support material for provincially-mandated learning outcomes that high school teachers are expected to meet. One of the objectives of Soil 4 Youth was to spur awareness of soils at a younger age in hope of increasing subsequent enrollment in soil science courses and programs at the post-secondary level. Building on Soil 4 Youth, the Soil Education Committee was established at the 2014 annual meeting of the Canadian Society of Soil Science with the mandate of enhancing soil science education in Canada at all levels.

Canada is the 2nd largest country in the World by area and its diverse soils (1) support vital natural resources sectors, (2) directly and indirectly influence the quantity and quality of what is regarded as the World's largest freshwater reserve (Environment Canada 2012), and (3) store a substantial amount of carbon that will likely play important roles in climate change-biosphere feedbacks (e.g., DeLuca and

Boisvenue 2012). Despite the vast importance of soils in Canada and reduction of postsecondary soil science programs and/or departments, to our knowledge, there have been no recent comprehensive studies of the state of post-secondary soil science education in the country. Our hypothesis is that soil science offerings and enrollments in post-secondary institutions in Canada show a recent and/or imminent decline keeping in line with the global trend. We tested this hypothesis by assessing the status of post-secondary soil science offerings in Canada through an inventory of the institutions that offer soil science courses, the number of courses offered and their current enrollments. Furthermore, the study will provide a benchmark for future evaluations allowing tracking changes in post-secondary soil science education.

Methods

Our study, conducted in 2015, was carried out in two phases. In *Phase 1* we compiled a list of all universities and colleges in the country and categorized them by province and territory. We searched the website of each post-secondary institution and recorded the city, language(s) of instruction, date founded, undergraduate enrollment and faculties, schools and/or departments that could potentially offer soil science courses as part of their undergraduate curriculum (i.e., soil science, biology, geography, geology/earth science, forestry, agriculture, environmental science, and environmental technology). We excluded civil engineering programs, because they usually focus only on physical properties related to building or subsurface media. We searched the websites of the faculties, schools and/or departments (from here on termed “units”) to identify soil science programs and courses and also searched academic calendars where available. We recorded the course number, name, if the course had a lab section, the course instructor (if available) and the undergraduate coordinator and their contact details. Where the course instructor was known, they were contacted to inquire about student enrollments in their courses. Because the structure of post-secondary education is different in the province of Québec, only soil

program from Québec universities were kept for analyses. Some professional colleges (CEGEP) offer agricultural programs in Québec, but they are predominantly designed to train farmers. The inventory we developed is provided as supplementary data S1.

In *Phase 2* of the study we adapted a survey by the Soil Science Society of America (Havlin et al. 2010), which was designed in cooperation with the Social and Economic Sciences Research Center (SESRC) at Washington State University, Pullman, WA. The survey, conducted using Fluid Surveys (FluidSurveys TM, Ottawa, Canada), included quantitative, categorical questions, and open-ended response questions. In May 2015, an email was sent to the 89 academic units in Canada that offer undergraduate soil science degrees, diplomas, certificates and/or courses inviting them to participate in the online survey. Two days later another email was sent with the survey link. To increase participation, two weeks after the survey link was sent a reminder email was sent to all units that had not completed the survey, reminding them of the survey. The survey was open for one month. The questions included in the survey are provided as supplementary data S2 for universities and supplementary data S3 for colleges.

Results

In Phase 1 we identified 72 universities and 92 colleges in Canada that could potentially offer a soil science course as part of at least one of their curricula. Of these institutions, 64% of universities and 37% of colleges offer at least one course (Table 1). There was notable variation across the country, with a higher than average percentage of institutions offering a soils course in British Columbia and Alberta (in western Canada) and Ontario and Quebec (in central Canada) and a lower than average percentage in Eastern Canada (New Brunswick, Nova Scotia and Prince Edward Island). There was an above- average percentage of universities offering a soils course in the Prairie Provinces of Manitoba and Saskatchewan, but offerings at the college-level in the Prairies were lower. Due to low population

density in northern Canada, there are no universities and only a few colleges in this region, and only one of the colleges offered a soil course (Table 2).

Across Canada, there are 149 undergraduate soil science courses currently being offered in universities, with 66 being introductory and 83 classified as upper level or advanced courses (Table 3). Forty-five percent of university soil science courses are taught in central Canada (Ontario and Quebec), while only 7% are taught in Atlantic Canada. This trend may be reflective of the size of the population (Tables 2 and 4).

Nationally, there are 58 courses being offered at colleges, with 49 classified as introductory and 9 as advanced (Table 3). The majority of soils courses in Canadian colleges are delivered in Ontario (41%) and Alberta (31%), with additional 17% in British Columbia. Less than 5% of college soil science courses of the national total are offered in Maritime Canada and in northern Canada, which again may be reflective of the size of the population (Tables 2 and 4).

Though not all universities and colleges offer soil science courses the majority of the institutions that do tend to offer at least one introductory and one advanced course. On average, there are 3.2 soil science courses taught at Canadian universities that include soil science as part of their programs, with considerable variation across the country (Table 5). Universities in the provinces of Saskatchewan, Manitoba, Quebec, Alberta and Nova Scotia offer more courses than the national average. Universities that offer the greatest number of undergraduate courses include: Université Laval (18), University of Saskatchewan (13), University of Manitoba (13), University of Alberta (10), and the University of Guelph (10). There are, on average, 1.9 soil science courses offered per college in Canada (Table 5), with an above-average number of offerings in Alberta and Manitoba.

Survey: Universities

The survey was sent to 53 academic units at universities that offer soils courses or programs. We had a 58% response rate. Of the units responding, the greatest proportion described their focus as being Geography, Environmental Science, Natural Resource Science, or other (Figure 1). Twelve percent of the responding units offer soil science degrees. All of these units offer Master's and doctoral degrees but only 50% offer undergraduate degrees with a major or minor in soil science. On average there were 54 students enrolled in introductory courses (max=230, min=3, median=39) and 25 students enrolled in advanced courses (max=103, min=3, median=20). Of the units offering undergraduate degrees, 67% reported steady enrollment in their undergraduate programs over the last 10 years, while 33% reported increases of less than 25%. These units expect that enrollments will either remain the same or increase but by less than 25%. Of the units that offer soil science degrees, 40% are, and have been for some time, exclusively soil science departments. Of the units offering soil science degrees, students majoring in programs offered by other units also commonly take their soil science courses. Environmental science majors enroll most often in soil science courses in soil science departments, with healthy subscription from natural resource management, geology, crop science and agronomy (Figure 2).

Recent undergraduate enrollment trends in soil science courses over the last 10 years in Canada have generally been positive. Almost half (48%) of departments offering soil science courses reported that their enrollments were steady over the last 10 years, with 21% reporting increases of <25%, and 10% reporting increases of >25% in enrollments. Decreases of <25% were reported by 21% of the units responding. A shift in the types of majors taking courses towards more environmental science students were reported by 25% of respondents; while 75% of units reported no change in the types of majors taking their courses. Projections for enrollment over the next 10 years were very encouraging. Increases are expected by 37% of respondents, while 63% of respondents expected enrollments to stay the same. Reasons for expected increases vary but a common theme is growing interest in the environmental

sciences and acknowledgement of the importance of soils to society (Table 6). No units expect enrollments in their courses to decrease.

At 71% of the institutions whose representatives responded to the survey, soil science courses are required not just by the respondent's academic unit, but also by majors offered by other units or programs. Approximately half of the respondents (56%) reported no change in the majors requiring soil science course(s) in the last 10 years and 33% were not sure if there had been a change over that time period. There were 11% of respondents reporting additions of majors outside of their units requiring soil science. The majors were environmental science, geology, land reclamation, geography, biology and chemistry.

Based on all the responses, the number of soil science faculty members in each unit offering soil science courses ranges from 1 to 12 (mean = 3; median=1). Most (64%) units reported that the number of soil science faculty members had stayed about the same over the last 10 years. Fifteen percent of units reported declines; 11% reported declines <25% and 4% reported declines of >25%. Increases of <25% and >25% were reported by 11% of respondents for each category. Responses about changes in the number of soil science faculty over the next 10 years were generally positive; 64% expected the number of faculty to stay about the same, with 18% expecting increases, and 18% expecting decreases. The majority (63%) of faculty teaching soil science courses are trained soil scientists (minimum MSc in soil science) and that has remained largely unchanged over the last 10 years. On average, the number of faculty teaching soil science appears stable.

Respondents were positive about the job opportunities in soil science that graduates of their units had during the last 10 years. Though 54% of respondents stated that opportunities were about the same over the time period, 38% felt that opportunities were increasing, and 8% felt that opportunities were

decreasing in soil science. Overwhelmingly, respondents felt that soil science is a good career for a young person; 42% strongly agreed, 39% agreed, and 19% were neutral. When asked to choose three fields that respondents felt had the most future job opportunities for students, environmental science was cited most frequently. Agronomy and land management were also viewed as fields with future job opportunities (Figure 3). The majority of respondents (69%) felt that soil science will continue to be an important discipline in the future, with the remaining 31% feeling that it would be somewhat important. The majority (92%) of units do not assist students with getting internships or co-op placements with soil science employers or organizations, although individual instructors likely play a large personal role.

Survey: Colleges

The survey was sent to 36 academic units in the colleges that offer soils courses or programs. We had a 67% response rate. Of the academic units that responded, the majority had an environmental science focus (Figure 4). Only 12% of units that responded offer a diploma, associate or applied degree, or certificate in soil science. The number of students enrolling in college courses ranged between 30 and 50. Fifty percent of units offering a diploma in soil science reported increases in student enrollment of >25% in these programs over the last 10 years, and 50% of units that responded reported decreases by <25% over the same period. Looking forward, these units projected that enrollment will either increase or stay the same, with increases being driven by job opportunities. There were no soil science units at the college level; all units offering a diploma in soil science were larger units with multiple areas of specialization, and this has always been the case.

Programs focusing on natural resources and environmental management and environmental science were the largest subscribers of soil science courses outside of the academic unit offering the course (Figure 5). Respondents indicated that enrollment has generally increased over the last 10 years in soil

science courses; 31% reported increases of >25%, 31% reported increases of <25%, and 31% reported no change. The majority of respondents (64%) indicated that there have been changes to the programs that include soil science courses and that there have been additions of soil science courses to their programs. Enrollment in the non-soil-science programs that include soil science courses is expected to stay the same (62%) or increase; 31% expect increases of <25% and 8% expect increases of >25%. There were no projections of decreases in programs over the next 10 years. Increases were expected to meet the demand for environmental monitoring, environmental consulting, and agriculture. Increasing interests of students in environmental studies was also cited as a key reason for increased enrollment in non-soil-science programs that include a soils course, as well as greater accessibility to soils courses, as these course are becoming more widely required in programs at Canadian colleges. There were no programs that have dropped a soil science requirement over the last 10 years and 17% of respondents indicated that there have been additions of soils courses to programs in the area of environmental science and environmental management. Over the last 10 years, new courses have been added at 22% of colleges; the majority were introductory courses but there were also additions of courses in soil fertility (1) and soil physics (2).

There was an average of 1.3 soil science faculty at each college, with a median number of 1. The number of faculty ranged from 0 (sessional instructor teaching the course) to 5. These numbers have been stable over the last 10 years with a decrease of <25% reported by 5% of respondents. Respondents expect that these numbers will remain steady over the next 10 years because resources are sufficient to meet the demand for soils courses. There were a small proportion of respondents (6%) who felt that the number of soil science faculty would increase slightly over the next year to meet the growing recognition of the importance of soils in land-use planning. Approximately half (55%) of the faculty members currently teaching soils courses are trained soil scientists (minimum MSc). In general, the

number of trained soil science faculty in Canadian colleges has remained the same over the last 10 years and is expected to stay the same over the next 10 years.

Respondents indicated that job opportunities in soil science or soil science related fields for graduates have remained steady over the last 10 years (59%). Increases in opportunities were reported by 29% of respondents and 12% reported decreases in opportunities. There was variation in opinion as to whether soil science is a good career for a young person; 24% felt strongly that it was, 53% somewhat agreed, 18% were neutral, and 6% somewhat disagreed. Respondents who disagreed felt that soils were only one aspect of the environment and that environmental management requires many skills. They felt that there were few opportunities for graduates with a soil science focus. Environmental science was the top field that respondents felt offered the most future job opportunities for graduates (Figure 6). Agriculture and land management were also fields that respondents strongly felt offered the most future job opportunities for graduates. Most (71%) of respondents felt that soil science will be a very important discipline in the future with only 29% feeling that it would be somewhat important. College units generally do not assist students with finding internships or co-op placements with soil science employers or organizations but again, individual instructors likely play an important role.

Discussion

The majority of soil science courses offered at both universities and colleges are offered in Central and Western Canada. Coincidentally, these are areas with the best integration of soil science into the high school curriculum (Hayhoe 2013, Krzic et al. 2014) and the largest populations. A very different situation can be found in other areas of the country such as Eastern and Northern Canada. There are no universities and just a few colleges in Northern Canada, characterized by a very low population density. Though population density is low, Canada's North is facing unique and significant soil challenges

related to a changing climate. Melting permafrost is placing stress on infrastructure and releasing enormous stores of soil organic matter that have been protected from decomposition by low temperatures. Climate related challenges such as these demand comprehensive soil science training in Canada's North. Despite the lack of courses given in the north, several universities (e.g., McGill, Carleton, Manitoba and others) have active field programs that give students research experience with northern soils, including areas dominated by permafrost. In Eastern Canada there are many undergraduate institutions that could be offering soil science courses that are not. The fact that there is not one soil science course offering at the University of Prince Edward Island or Holland College is surprising, considering that Prince Edward Island has the highest percentage of provincial gross domestic product from agriculture, forestry, fishing and hunting (Table 2). Only a single undergraduate soils course is offered in New Brunswick, and soil science is only taught at the Grenfell campus of Memorial University in Newfoundland. Eastern Canada has a natural resource based economy and sustainable management is a key component for economic prosperity.

In the province of Québec, agronomy is still a trade exclusively reserved to professionals holding a B.Sc. degree in agronomy. Only two universities in the province offer this diploma – Université Laval (in French) and McGill University (in English). They both offer programs strongly oriented towards research in agriculture practices (production systems, fertilization, irrigation, drainage, erosion and soil characterization and conservation). These two universities are historically, and are still continuing to be, the pillars of soil science education in Québec with the highest number of soil sciences courses offered and the largest contingent of faculties teaching those courses. Other universities – Université du Québec à Montréal, Université de Montréal, École Polytechnique de Montréal et Université de Sherbrooke – offer one or two courses in soil science, which are usually a niche within the departments of Geography, Earth Science, and Geology.

Though Ontario offers a relatively large number of soil science courses, there is still room for improvement in post-secondary soil science course offering. For example, at the university-level, key large comprehensive universities with recognized strengths in environmental science, environmental biology, environmental toxicology, physical geography, and landscape architecture do not offer a single soil science course. These include Western University, University of Ottawa, and Ryerson University, collectively with ca. 100,000 undergraduates, or nearly one-quarter of all Ontario university undergraduates. Future efforts from the Canadian Society of Soil Science - Education Committee will include targeted promotion of the importance of soil science to complementary departments at these universities.

On the Prairies, soil science undergraduate education still remains an important aspect of many programs in agriculture, geography, forestry, and environmental science. Both the University of Manitoba and University of Saskatchewan have Departments of Soil Science and offer major or minor specialties in soil science. Other universities and colleges, however, incorporate soil science education through departments that have titles that are more general, and there is a strong soils sub-group at the University of Alberta. Unfortunately, the smaller universities and colleges tend to have limited numbers of academic staff with soil science expertise. The demand for soil science education appears to be on the rise, and most programs have experienced an increase in enrolment over the past few years. There has been a steady and large demand for soil science expertise on the Prairies. The need for land remediation specialists in Alberta has been a major draw for graduates and this has decreased the available work force in agronomy. Although this has been a problem especially for Alberta and Saskatchewan, there has been a shortage of agronomists across the Prairies to fulfill the available jobs, and these agronomists normally require a sound soil science education. The good availability of jobs for B.Sc. graduates with a soil science background has made it difficult to attract these students to graduate

programs, and many graduate programs recruit from other sciences. Overall, the future looks bright as long as upcoming faculty and instructor retirements are replaced.

Even though the number of soil science courses offered in British Columbia is relatively high (15.4% of total number of all soil science courses in Canada), the situation is far from adequate. One of the main concerns is lack of a complete soil science department and/or program at any of the post-secondary institutions in British Columbia. Between 1955 and 1998, the University of British Columbia (UBC), Vancouver was the only institution in the province that had a Department of Soil Science. Since the disappearance of that department other post-secondary institutions in British Columbia have hired soil science faculty members, and currently there are more faculty members across seven universities in British Columbia than at UBC's Department of Soil Science at its peak (i.e., 11 members). At present, number of soil science faculty members at all universities in British Columbia is low, ranging from 1 to 6. Furthermore, coverage of basic soil science sub-disciplines is either non-existent (soil physics), minimal (pedology and soil chemistry courses are only offered at University of Northern British Columbia), or good (soil biology). Despite not being a standard practice in Canada, hiring coordination between institutions could have helped produce a comprehensive set of soil science courses, if not at one institution, at the provincial level at least.

Currently in Canada, soil science courses at post-secondary institutions are most commonly offered by Geography and Environmental Science departments. This is in contrast with the American universities where soil science has traditionally been taught in forestry and agricultural programs (Baveye et al. 2006, Sharik et al. 2012). This also reflects a changing trend in Canada, since in the past soil science courses were also offered mainly through agricultural sciences and/or forestry (Baveye et al. 2006). Students majoring in environmental science are most frequently enrolling in soil science courses and their enrollment is almost double that of majors from natural resource management and agronomy. This

shift reflects a greater interest by students in the roles that soils play in maintaining and enhancing environmental quality.

Even though 89% of respondents agreed (strongly and somewhat strongly) that soil science is a good career choice for a young person, more effort is required to increase the profile of soil science in high school and post-secondary education, so that soil science is seen as a viable career option. In a survey of over 2,000 students at the University of Florida conducted by Collins (2008), the respondents indicated that career opportunities were the most prominent factor in degree selection, but that they (and their parents) knew very little about career paths in soil science.

We began this project expecting to see recent and imminent declines in soil science course offerings and enrollments in Canada, and despite the regional discrepancies, this was not the case. This trend of stable, and occasionally increasing, interest in soil science at the post-secondary level might be a result of Canada already having experienced past declines to a baseline level that will not drop lower; however, our key informants generally see the job market for students with soil science training as robust, perhaps with the caveat that a well-rounded environmental science or natural resource graduate might face more opportunities than a dyed-in-the-wool soil scientist. The observed stable trend of soil science courses warrants further investigation, especially in light of the overall increasing number of postsecondary courses offered across Canada.

A key question is how can we improve the success of educating more soil scientists? The Envirothon program (envirothon.org) has been successful at exposing secondary school students to soils as part of the environment and reaches about 500,000 students across North America. This program is supported by volunteer soil scientists from many federal and provincial agencies as well as academic institutions. At the federal and provincial level, soil science leadership has mostly been through individual efforts in

supporting education and through summer employment. It would be visionary for government agencies to develop long-range outlooks to help train the next generation of soil scientists, especially because experiential learning is needed to work in Canada's forests, grasslands, tundra, and agricultural areas.

Equally important is to consider the needs of the profession of soil science in terms of course offerings. Having established a base of knowledge on the state of soil science education in Canada we are now in a position to evaluate the relevance of our academic offerings to the needs of industry, both agriculture and environmental, where the majority of the professionals trained through our academic programs are employed. Understanding and meeting these needs provides for a healthy profession has implications for agriculture and the environment as sectors of the economy. This should also interest government agencies who could be looked toward to provide more support for professional associations for the continuing education of their members.

Summary and Conclusions

The findings of our study indicate that offerings and enrollments in soil science courses across the country are stable and are expected to stay stable or increase in the coming decade. Institutions offering soil science courses to undergraduates tend to offer more than one course, suggesting that students are able to access more specialized soil science courses to deepen their knowledge. Universities with soil science departments (University of Saskatchewan and University of Manitoba), as well as those that formerly had soil science departments (e.g., the University of Guelph, McGill University, the University of Alberta, and UBC) offer an above-average number of undergraduate courses, but whether institutions that have lost soil science departments still offer a comprehensive suite of courses varies. There has been a shift in the majors enrolling in soil science courses at the agronomic powerhouses of the past (i.e., University of Guelph, McGill University, and UBC) away from agronomy towards environmental

science. We also reported a large percentage of soil science courses being offered by Geography, Geology, Environmental Science and Natural Resource Science/Management departments/programs. Soil science is severely under-represented at post-secondary institutions in Eastern and Northern Canada. Broad efforts should focus on promotion of new soil science courses and curricula in the East and the North, as well as maintaining current courses and curricula in areas already well represented. The introduction of online soil science courses to post-secondary institutions that do not offer soil science as part of their curriculum might be one approach to include and expand soil science courses in Canada.

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For Review Only

Figure captions

Figure 1. Type of units delivering soil science courses in universities in Canada. Values above bars are the actual percentages of respondents. Percentages sum to greater than 100% because respondents were able to indicate multiple specializations.

Figure 2. Type of majors enrolling in soil science courses in Canadian universities. Values above bars are the actual percentages of respondents. Percentages sum to greater than 100% because respondents were able to indicate multiple specializations.

Figure 3. Type of professions that respondents felt offered the best career opportunities in soil science for students graduating from Canadian universities. Values above bars are the actual percentages of respondents. Percentages sum to greater than 100% because respondents were able to indicate multiple specializations.

Figure 4. Type of units delivering soil science courses in colleges in Canada. Values above bars are the actual percentages of respondents. Percentages sum to greater than 100% because respondents were able to indicate multiple specializations.

Figure 5. Type of majors enrolling in soil science courses in Canadian colleges. Values above bars are the actual percentages of respondents. Percentages sum to greater than 100% because respondents were able to indicate multiple specializations.

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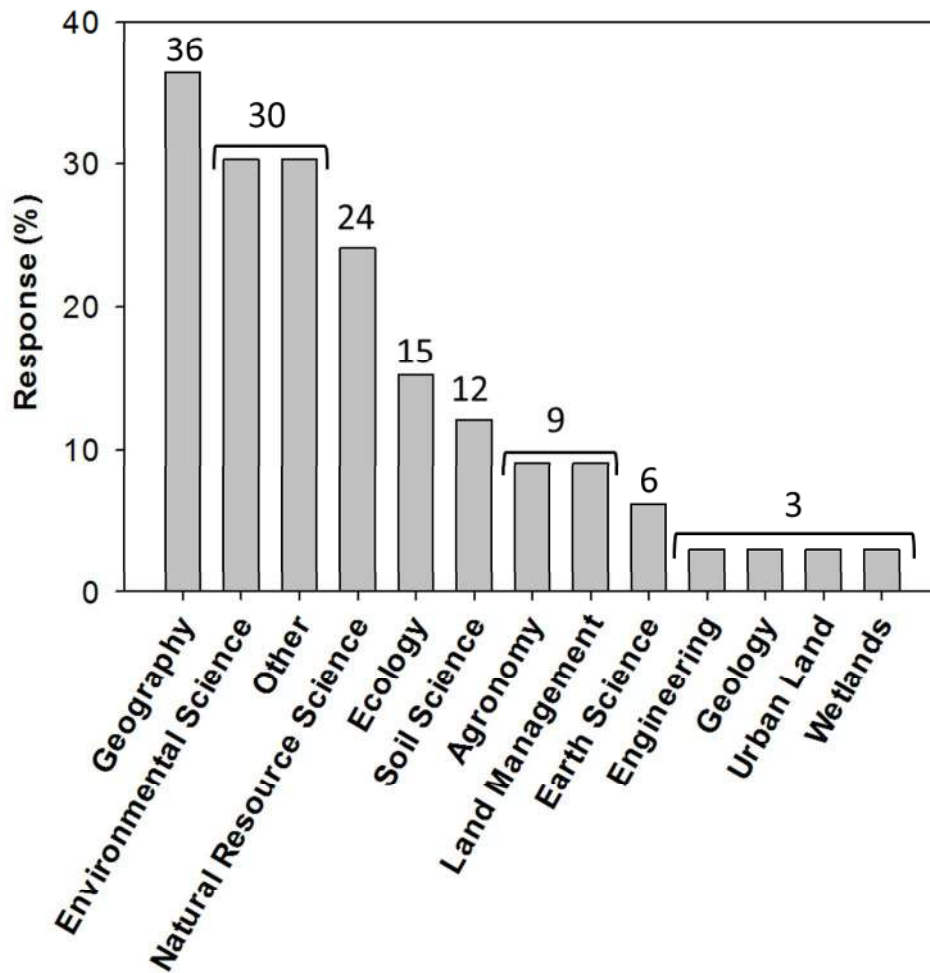


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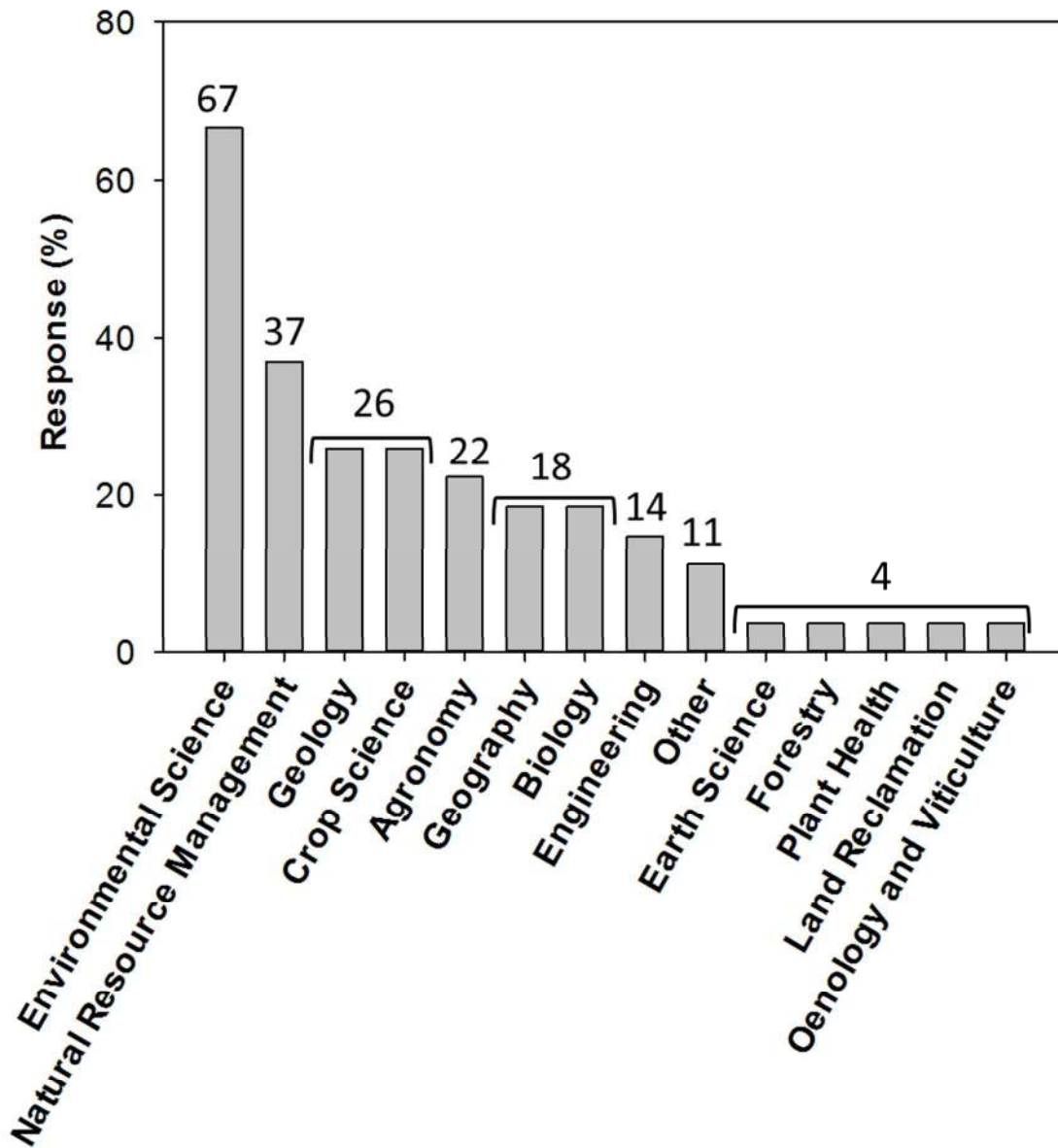


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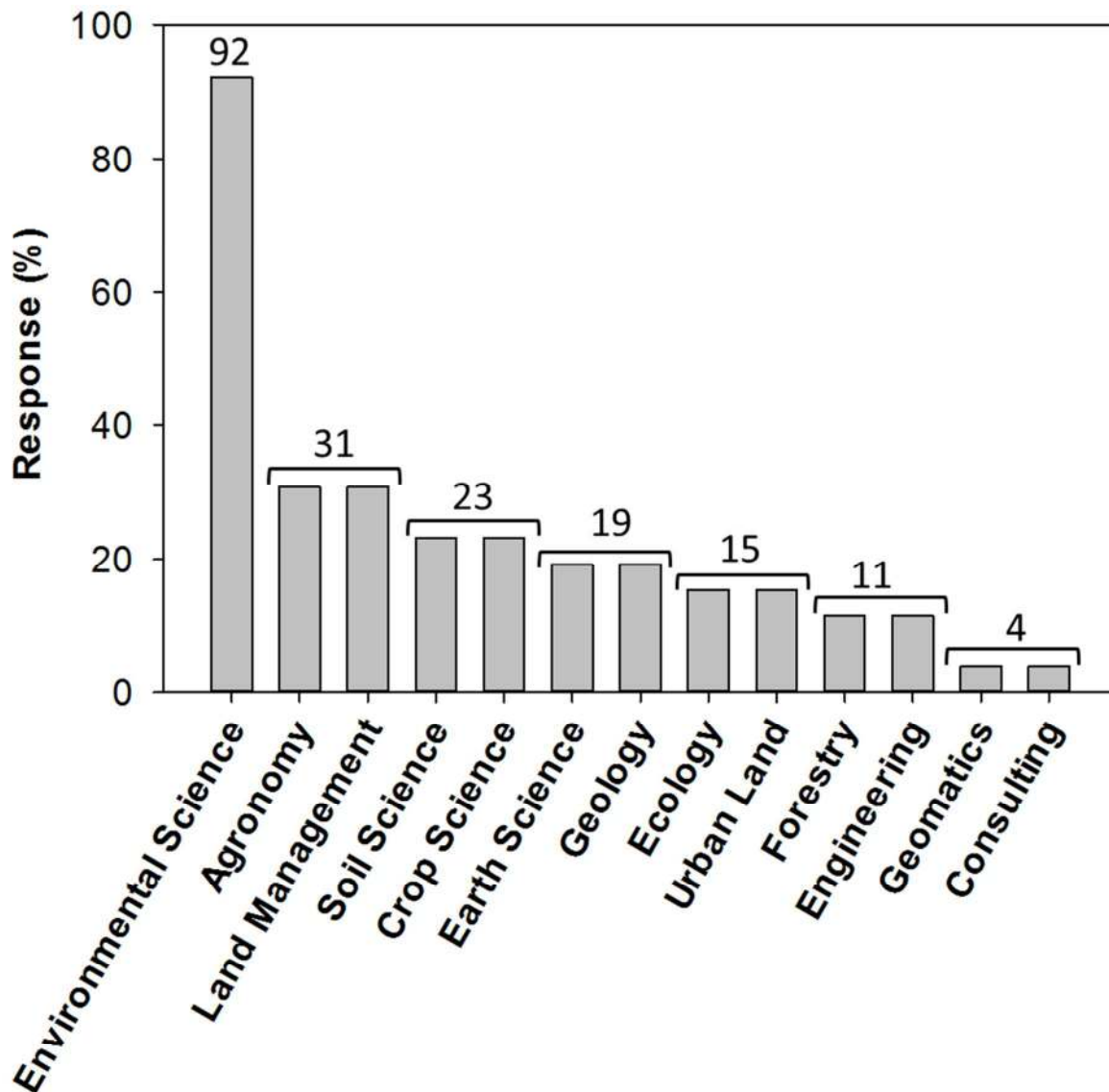


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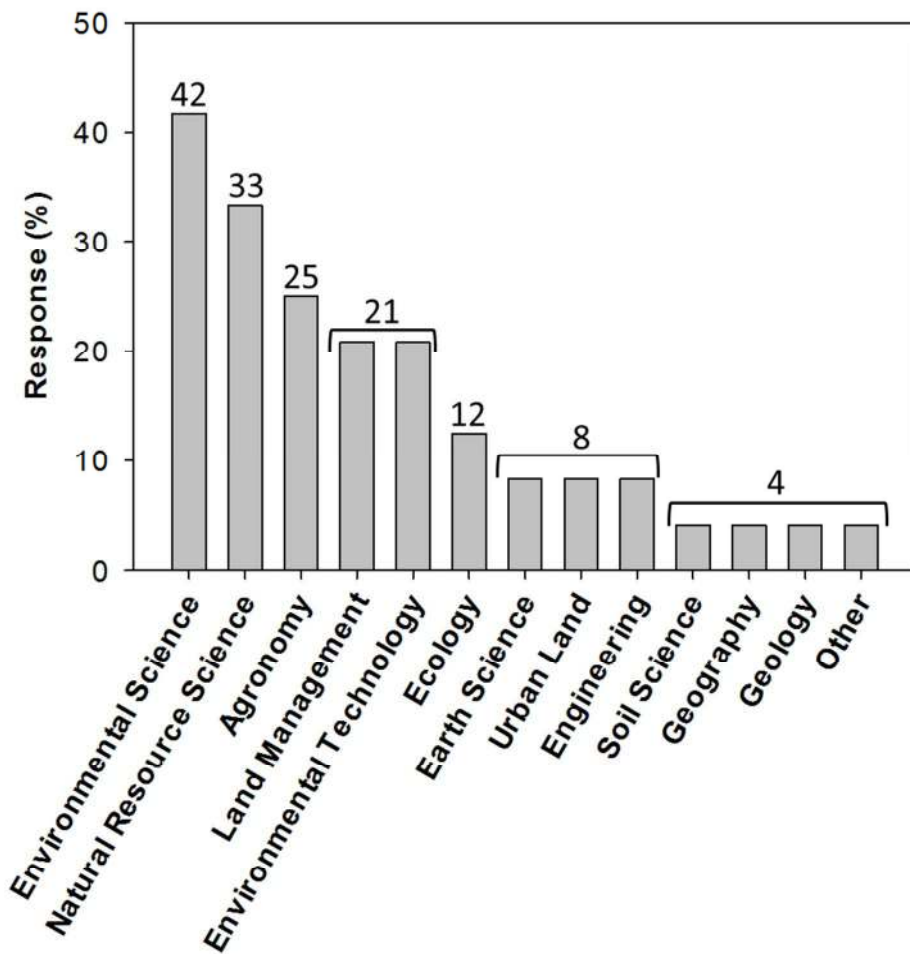


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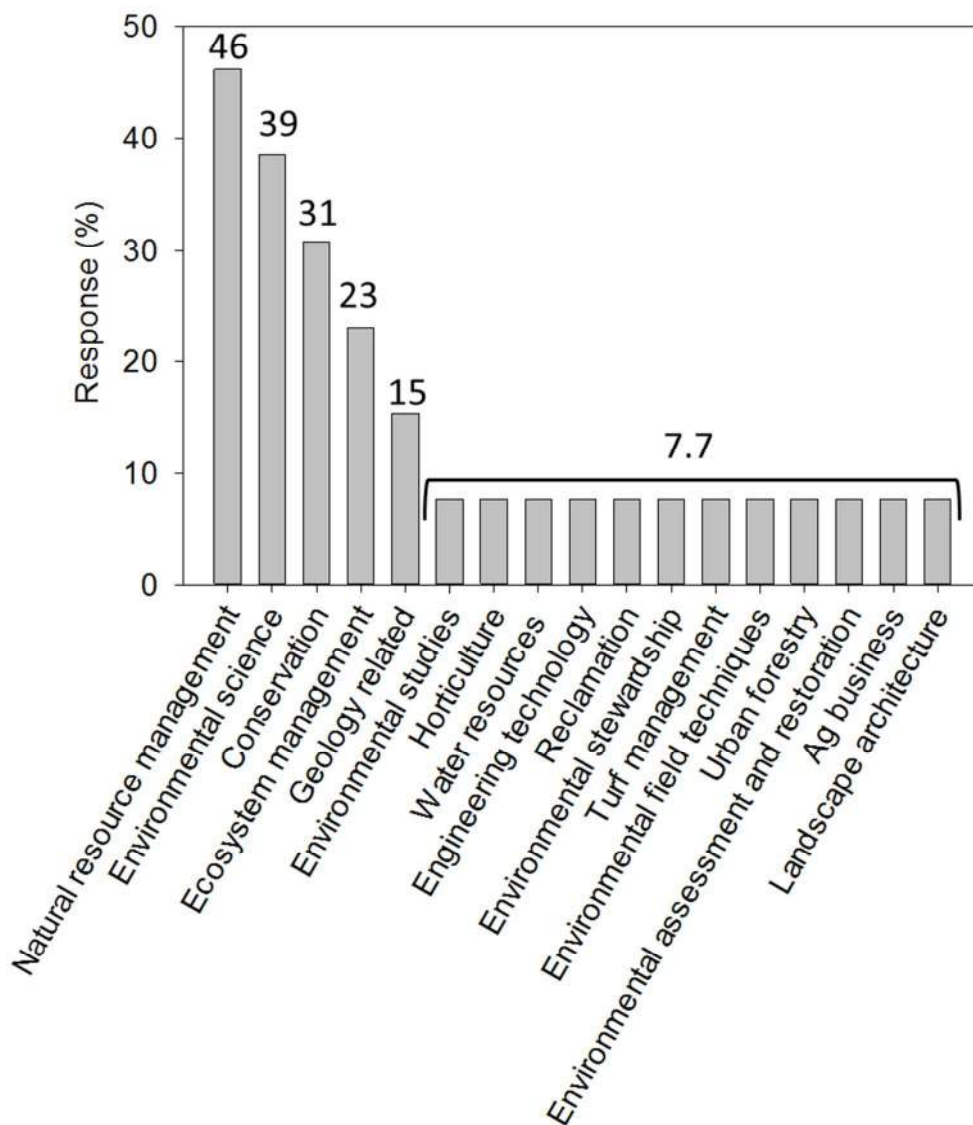


Figure 5. Type of majors enrolling in soil science courses in Canadian colleges. Percentages sum to greater than 100% because respondents were able to indicate multiple specializations.

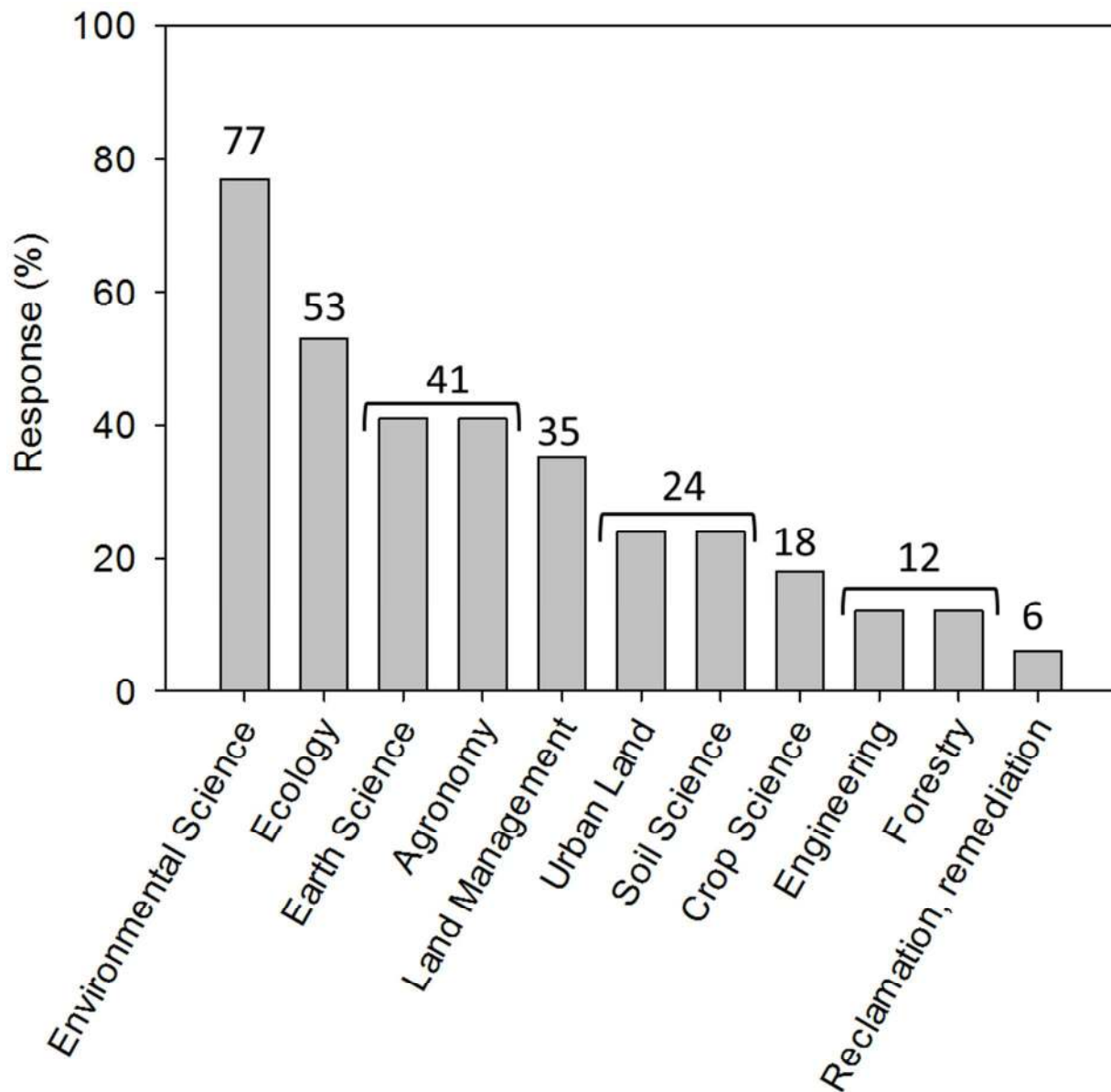


Figure 6. Type of professions that respondents felt offered the best career opportunities in soil science for students graduating from Canadian colleges. Percentages sum to greater than 100% because respondents were able to indicate multiple specializations.

Table 1. Canadian post-secondary institutions with programs that could include soil science courses as part of their curriculum and the percentage of those institutions offering undergraduate soil science courses.

Province or Territory	Total Number of universities with departments that could offer soil science courses	% offering soil science courses	Total number of colleges with departments that could offer soil science courses	% offering soil science courses
British Columbia	11	81.8	13	69.2
Alberta	5	80.0	6	83.3
Saskatchewan	3	66.7	1	100.0
Manitoba	4	75.0	2	50.0
Ontario	22	72.7	22	68.2
Quebec	13	61.5	0	n.a.
New Brunswick	4	25.0	9	11.1
Nova Scotia	7	28.6	17	0.0
Prince Edward Island	1	0.0	1	0.0
Newfoundland and Labrador	2	50.0	16	6.3
Nunavut	0	n.a.	4	0.0
Northwest Territories	0	n.a.	0	n.a.
Yukon	0	n.a.	1	100.0
Total	72	63.9	92	36.9

Table 2. Population (Statistics Canada 2015b), land area (Statistics Canada 2015a), population density and percentage of provincial gross domestic product (GDP) that comes from agriculture, forestry, fishing and hunting across Canada (Innovation, Science and Economic Development Canada 2015) for each province and territory in Canada.

Province	People (2014) in thousands	% of Canadian Population	Land area (km ²)	People (2014) km ⁻²	% of Provincial GDP from Agriculture, Forestry, Fishing, and Hunting
British Columbia	4631.3	13.0	925186	5.01	1.6
Alberta	4121.7	11.6	642317	6.42	1.5
Saskatchewan	1125.4	3.2	591670	1.90	4.9
Manitoba	1282	3.6	553556	2.32	3.1
Ontario	13678.7	38.5	917741	14.90	0.7

Quebec	8214.7	23.1	1365128	6.02	1.5
New Brunswick	753.9	2.1	71450	10.55	2.2
Nova Scotia	942.7	2.7	53338	17.67	2.0
Prince Edward Island	146.3	0.4	5660	25.85	4.9
Newfoundland and Labrador	527	1.5	373872	1.41	1.3
Northwest Territories	43.6	0.1	1183085	0.04	0.5
Nunavut	36.6	0.1	1936113	0.02	0.1
Yukon	36.5	0.1	474391	0.08	0.2
Canada	35540.4	100	9093507	3.91	1.2

Table 3. Number of undergraduate soil science courses at the introductory and advanced level offered at Canadian institutions and their contribution to the national inventory of offerings.

Province or Territory	Universities			Colleges		
	Total number of introductory courses	Total number of advanced courses	% of total	Total number of introductory courses	Total number of advanced courses	% of total
British Columbia	12	11	15.4	10	0	17.2
Alberta	4	12	10.7	11	7	31.0
Saskatchewan	6	9	10.1	1	0	1.7
Manitoba	5	12	11.4	2	0	3.4
Ontario	18	13	20.8	22	2	41.4
Quebec	16	20	24.2	0	0	0.0
New Brunswick	1	0	0.7	1	0	1.7
Nova Scotia	3	5	5.4	0	0	0.0
Prince Edward Island	0	0	0.0	0	0	0.0
Newfoundland and Labrador	1	1	1.3	1	0	1.7
Northwest Territories	0	0	0.0	0	0	0.0
Nunavut	0	0	0.0	0	0	0.0
Yukon	0	0	0.0	1	0	1.7
Total	66	83	100	49	9	100

Table 4. Regional comparison of population and offerings of soil science courses at Canadian universities and colleges. Values are percentages of the national total.

Region	% of National Population	% of National Total of Soil Science Courses Offered at Universities	% of National Total Soil Science Courses Offered at Colleges
Western Canada	24.6	26.2	48.3
Prairies	6.8	21.5	5.2
Central Canada	61.6	45.0	41.4
Atlantic Canada	6.7	7.4	3.4
Northern Canada	0.3	0.0	1.7
Total	100	100	100

Table 5. Average number of undergraduate soil science courses offered at post-secondary institutions in Canada including soil science as a component of their programs.

Province or Territory	Universities			Colleges		
	Introductory	Advanced	Total	Introductory	Advanced	Total
British Columbia	1.3	1.2	2.6	1.1	0.0	1.1
Alberta	1.0	3.0	4.0	2.2	1.4	3.6
Saskatchewan	3.0	4.5	7.5	1.0	0.0	1.0
Manitoba	1.7	4.0	5.7	2.0	0.0	2.0
Ontario	1.1	0.8	1.9	1.5	0.1	1.6
Quebec	2.0	2.5	4.5	N.A.	N.A.	N.A.
New Brunswick	1.0	0	1.0	1.0	0.0	1.0
Nova Scotia	1.5	2.5	4.0	N.A.	N.A.	N.A.
Prince Edward Island	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Newfoundland and Labrador	1.0	1.0	2.0	1.0	0.0	1.0
Northwest Territories	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Nunavut	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Yukon	N.A.	N.A.	N.A.	1.0	0.0	1.0
Total	1.4	1.8	3.2	1.4	0.3	1.7

Table 6. Respondents' opinions for expected increases in Canadian post-secondary soil science courses in the coming decade.

Responses for expected increases in enrollment in soil science courses

- Offering Soil Science courses to Faculties in addition to Agriculture.
 - The role and importance of soil in global food security and environmental issues is going to increase.
 - Our overall programs are showing growth in applications when applications to university are significantly down across the province.
 - The faculty has recently made it a mandatory course for environmental students coming into their degrees. It used to be only the forestry students.
 - Increased interest in degree programming (degrees are <5 years old).
 - Increase in overall enrollment of students in the university in environmental science related courses.
 - Enrollment goes in cycles. In the past 5 years, our enrollment has increased by 25%, but it seems to be part of a cycle of increases and decreases, so over 10 years, the increases and decreases cancel each other out. For the next 10 years, the cause of sustained enrolment increases will be because of increasing enrolment at Universities in general.
 - More students in environmental science and studies will be given the option of taking Soil Science for credit in their program.
 - We have a strong relationship with chemistry/biology/environmental studies and they, like us, are growing. Our department, as well as environmental studies, have initiated three new soil courses for the next three years.
 - Cross listing of courses with earth science department (for APGO* requirements).
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*APGO - Association of Professional Geoscientists of Ontario.