Final Report

Skills Needs in the Resource-Based Sectors in Atlantic Canada

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Executive Summary

The "Knowledge Economy" is considered to include research and development intensive industries and advanced services, while the resource-based sectors are regarded as medium or low knowledge activities. This paper sets out to redress this misconception. While the resource-based companies do not undertake extensive research or development, over the past two decades they have adopted increasing amounts of advanced technology in order to maintain a competitive advantage in an increasingly competitive global marketplace, often by focusing on new value-added products. This has placed an increasing emphasis on skills in these sectors.

In Atlantic Canada, the resource-based sectors are the mainstay of the economy, being the largest contributors to the overall regional exports. The resource-based sectors that have been examined are agriculture, the fishery including aquaculture, forestry, mining and the oil and gas sector. There has been considerable effort to diversify the region's economic activity around the wealth generated by the resource-based sectors, but as yet this has not happened to any great extent.

Atlantic Canada has the means to meet the increasing demand for skilled workers in the resource sectors. Universities and colleges have established programs that provide the training necessary for those entering these sectors. Many of these programs have been in existence for a considerable time while others are recent additions to meet emerging needs. The post-secondary system appears to have established a rapport with the sectors to ensure that the programs are meeting the sectors' changing needs.

The major skills issue for these sectors is the current low skilled portion of the workforce. Workers who entered the workforce with low skills require significant upgrading of skills to meet the demands of an increasingly technology-oriented workplace. Each sector has faced specific problems in this area and mechanisms are now in place to provide workplace training to improve the situation. A series of sector human resource councils have been formed during the 1990's to determine the skills needs of each sector, the barriers to upgrading skills and the mechanisms to provide appropriate skills training, usually in workplace settings.

The oil and gas sector is an exception to this as it is new, and has placed an emphasis on skills from the start. It is also the only sector that might face a skills shortage in the future, depending upon the growth of the sector over the next ten years. If this were to occur it would not relate to training but to experience, as the sector places a great importance on using experienced workers in certain high skilled functions. The environment industry has been included in this paper because of the important support role it plays for most of the resource-based sectors. The environmental industry has experienced a high growth rate over the past decade. It has a high requirement for skilled workers,

but has managed to meet the demand for skills that the high growth rate has placed upon it. Again, this is due to a large extent to the excellent training programs that exist in the region. There is also an active human resources council that is working to ensure appropriate accreditation and provide the necessary training where required.

In general the resource-based sectors have fostered a degree of co-operation and communication between the various stakeholders that enables them to establish the priorities for training needs and move to provide the necessary programs to meet these needs. A concern that the paper identifies is the present reduction in support for continued development of workplace training programs for various sectors. While the human resource councils were established and funded in the early 1990's to deal with these issues, currently funding is being reduced and the concern is that reduced funding will affect program delivery.

Finally, the paper provides a brief discussion of an horizon issue, namely sustainable development. While the concept of sustainable development has been promoted during the past decade, it is now beginning to assume an important role in the management of most resources. It is predicted that sustainability will be a dominant issue for resource managers in the next century. As yet, training in the concepts of sustainable development has not reached those who will be requiring this knowledge. Further, at this stage there is a paucity of training programs in this subject in Atlantic Canada. New skills are required to deal with this issue and workers in the resource-based sectors will need to acquire skills such as communicating with the public and understanding the ecosystems in which they work.

1.0 Skills, Knowledge, and Innovation Dynamics in Resource-Based Economies

Discussions about the "Knowledge Economy" almost always emphasize research and development-intensive industries and advanced services, treating older industries (those with medium or low research and development intensity) as relic or legacy economies that are destined to decline. There are a number of problems with this perspective which prevent us from identifying and fully pursuing knowledge-intensive, high value-added development opportunities in Atlantic Canada.

The first is that considerable evidence, historical as well as contemporary, regarding the development potential of staple or extractive economies does seem to support the view that economies based primarily on natural resource extraction experience great difficulty becoming diversified, higher value-added activities. Those economies that are able to make the transition appear to be the exceptions to the rule.

The second problem is that it is fundamentally inaccurate to regard resource or extractive industries as low-skill endeavours. These industries, although they do not conduct high levels of research and development internally, have undergone substantial modernization by purchasing and incorporating innovations from a variety of research and development intensive supplier industries and by maintaining networks of relationships with a science and technology infrastructure. However, conventional innovation indicators do not capture the innovation dynamics of the resource-based industries (or other innovation-using industries) well enough to permit an in-depth assessment of the specific learning aptitudes or disabilities of these industries.

The third problem is that of conceptualizing and operationalizing sustainable development. This is a problem that affects us all, but the environmental dimensions of natural resource-based economies are immediate and proximate in the affected regions. Natural resource-based economic development raises the challenge of learning from natural capital: how to recognize natural capital, how to value it, how to manage it, and how to replenish it. This is a challenge that the resource-based economies cannot ignore, but it also may provide knowledge-based development opportunities that allow value to be added to natural resources. Furthermore, even though the long-term trend of industrial civilization may be away from use of natural materials and toward the use of human-made materials, the environment provides basic life-support services that must be protected.

The following sections sketch out some ideas regarding the nature of these three problems, and provide some elements of a response. The overall argument is that sustainable development in a resource economy cannot possibly happen in the absence of a wide range of skills, learning, and knowledge that must be nurtured and monitored as carefully as we are nurturing and monitoring the skills, learning, and knowledge that we hope may lead us to a post-industrial "knowledge economy".

1.1 The Staples Trap

With the exception of some oil-exporting countries and a few others, national income is inversely related to the degree of income derived from export of raw or semi-processed natural resources. This is because, in many cases, while possession of natural resources may provide an immediate competitive advantage, the technologies to extract and distribute them have improved so immensely that increase in demand for commodities can be satisfied very quickly by bringing new supply on stream. Markets for commodities are notoriously volatile. Moreover, prices for commodities have displayed a long term downward trend since the end of the last century. A high degree of specialization in resource extraction for export earnings is undesirable because commodity producers are vulnerable to the "cost-price squeeze" produced by new suppliers in the Third World, cost factors related to technological change, resource depletion, environmentally- or biologically-determined resource cycles (Clapp 1998), environmental surprises and in some cases collapses of living resources, and reduction in demand due to substitution.

Atlantic Canada's place in the global division of labour is characterized by extreme specialization in resource extraction and processing. Table 1 provides information about the major export industries in the region, which account for about 90% of export earnings. As Table 1 indicates, at least 81% of the region's export earnings are processed or semi-processed natural resources. Exports from the forestry and forest products industries are the single largest source of revenue, providing 30% of export earnings between 1994 and 1998. Energy, fish and fish products, and mining are other significant sources of export earnings. In the case of petroleum-based energy, the region imports some of the raw resource, processes it, and exports it. Non-natural resource-related manufacturing accounts for about 9% of earnings. The only technology-intensive industry in the top 25 export industries from the region is aircraft and aircraft parts, accounting for 0.35% of export earnings between 1994 and 1998. The other major manufacturing export earners are medium or low-technology industries, including rubber and plastic products, tires, tubing, railroad rolling stock, construction and mining equipment, and non-ferrous metal products. The region's top exported products include preparations of non-crude petroleum, crude petroleum, newsprint, lumber, iron ores and concentrates, various kinds of paper, various kinds of wood-pulp, tires, frozen lobsters, crabs, shrimp, potatoes, fish fillets, zinc ore, and salmon. About two-thirds of Atlantic Canada's exports go to the United States.

Resource regions can derive prosperity from their natural resources in two ways (Freudenberg and Gramling 1998). The first involves capture and re-investment of the revenues from extraction or harvesting, which are temporally limited in the case of non-renewable resources and, in principle, sustainable in the case of renewable resources. These revenues come from jobs and wages, taxes, profits, and fees. The volatility of the resource economy gives it a "boom and bust" personality that often requires the migration of skilled workers from one extraction site to another. When the boom is over, revenue declines and local economic activity spirals downward.

Table 1: Exports from Atlantic Canada, classified by Industry Group (source: Strategis and Statistics Canada)

Industry group(1)	Percentage of all exports from Atlantic Canada, 1994-1998	Value in millions of Canadian dollars
Forestry and forest products (2)	30.05	15,987
Energy (3)	19.62	10,437
Fish and fish products (4)	17.63	9, 381
Mining (5)	10.31	5,484
Manufacturing (6)	8.88	4,725
Agriculture (7)	3.36	1,786
Remaining industries	10.15	5,400

1. The Standard Industry Codes (SIC) Numbers (four digits) are given for those sectors included in each grouping.
2. Includes newsprint industry (2712), sawmill and planing products industry (2512), pulp industry (2711), coated and treated paper industry (2791), paperboard industry (2713), and building board industry (2714).
3. Includes Refined petroleum products industry (3611), conventional crude oil and natural gas industry (0711), and private electrical power systems industry (4911).
4. Includes fish products industry (1021) and saltwater fishing industry (0311).
5. Includes iron, silver-lead-zinc, potash, and gypsum mines, and the peat industry.
6. Includes tire and tube industry (1511), railroad rolling stock industry (3261), other rolled, cast, and extruded non-ferrous metal products industries (2999), other rubber products industries (1599), construction and mining machinery and materials handling equipment (3192), aircraft and aircraft parts industries (3211), and other plastics industries n.e.c. (1699).
7. Includes frozen fruit and vegetable industry (1032) and potato farms (0138).

The second way to capture benefits from resource extraction is through ancillary investments in infrastructure and the development of upstream linked industries that supply equipment and services, and downstream linked industries that add value to the resource. The development of linked industries has been an expectation of resource-led development since Harold Innis showed how the

Canadian staple economy led to new economic activities, although the paradigmatic case of linkage development is the way that eighteenth-century British coal-mining regions attracted a wide range of other industries (ibid.). However, it is not easy to find more recent compelling examples of development of diversified upstream and downstream linkages around a non-renewable natural resource. Part of the reason is that linkages may share the fate of the resource industry: when it declines, they do too. The depletion of easily accessible resources has pushed extractive activities to remote regions which cannot maintain transformation or support services once the original resource is depleted. In the case of renewable resources such as agriculture and forestry, cases of local upstream and downstream linkages seem to be easier to find.

Interest in linkage capture in resource regions has its parallel in the world of advanced technology: the search for agglomeration economies or "clusters" is characteristic of policies to promote knowledge-intensive development. Innovative activity concentrates in agglomerations of firms and institutions because of the lower transaction costs and lower costs of information access that occur when innovation system actors are in physical proximity to each other. The innovative geographical locations go by different names, depending on the size and configuration of players and the identity that they have assumed - clusters, filières, innovative milieux, districts, silicon valleys, local innovation systems, etc. There are two features that make their extrapolation to Atlantic Canada problematic. First, they nearly always are centered around an urban location. Few rural or resource-based clusters or innovation systems have entered the pantheon of paradigmatic innovative locations that are so eagerly emulated. Second, they nearly always involve manufacturing or advanced technology industries, although presently researchers are beginning to study innovation systems and innovative agglomerations that form around advanced services such as the entertainment industry, financial services, or tourism. Natural resource-based innovation complexes are not well known. The agricultural biotechnology complex in Saskatoon is perhaps the most spectacular example in Canada of the recent accumulation of highly knowledge-intensive institutional assets that bring research and development to bear on problems of management and exploitation of a natural resource.

It is unfortunate that so little is known about the linkage and clustering behavior of firms in Atlantic Canadian resource-based industries. The 1997 study by Nordicity for the Atlantic Canada Opportunities Agency (ACOA), on "prospects for growing knowledge-based industrial clusters in Atlantic Canada" is one of the few attempts to examine Atlantic Canadian resource industries from the perspective of innovation agglomerations. The report examines six regional clusters, of which four have some or all of their roots in the resource sector: geomatics, aquaculture, ocean technology, and food processing. The recurring problems in expanding these clusters are: the small size of firms; marketing and management skill deficits; and bottlenecks in the financial support system. In the case of aquaculture, ocean technology, and food processing, weak local market demand , weak local downstream linkages, and absence of championship and leadership activities are problems. In the

case of the food processing cluster, observed problems are the high degree of vertical integration of the larger firms, with few cross-linkages within the cluster and few startups of new, small firms. The geomatics industry cluster shares problems of management, export marketing, and financial support with the others; it has also developed a dependency on local public markets that has sheltered it from international competition.

In summary, current understanding of the ways that knowledge is produced and diffused throughout an economy emphasize the need for interconnectedness and linkages among a variety of public and private actors in an innovation system. In the case of regions whose economy is resource based, the need for linkages is regarded as an essential step in the movement toward added value and diversification, without which resource exploitation will breed poverty and a level of environmental degradation that represents at the end of the day a subsidy to the importers of the resources.

1.2 Innovation Dynamics in Resource Economies

We have no idea how well we are doing in Atlantic Canada in terms of our economic, institutional, and social capability to use natural resources wisely for sustainable development because all of the report cards on the emergence of a "knowledge economy" in the region focus on indicators that measure advanced technological industries.

Some researchers in Europe are using data from regional innovation surveys to identify the real dynamics of innovation in existing industries, not just the industries that are regarded as most research and development intensive. These data show that growth is spread among many sectors, including ones that conduct little or no research and development themselves such as food products, furniture, and services. Innovative firms are ones that introduce new products or services; the inter-industry diffusion of technology and access to an industry knowledge base are key factors in the capacity of non research and development-performing firms to generate growth. Smith (1999) has mapped the knowledge base of the Norwegian offshore industry and demonstrated that it consists of dozens of advanced techniques that derive their reliability and effectiveness from dozens of scientific and technical knowledge bases that are provided by many public and private teaching and research institutions. He argues that "the growth trajectories of the advanced economies rest far more on such sectors as engineering, food, wood products, vehicles and so on, than on allegedly radical new 'growth' sectors as information technology or biotech.... Growth is based, primarily, not on the creation of new sectors but on the internal transformation of sectors which already exist" (Smith 1999).

A less optimistic view is provided by a long research tradition in Canada that has examined technological behaviour in the resource sectors and found that firms are failing to meet the challenge "to change themselves from producers of a few bulk commodities whose profitability depends on

cost minimization into diversified and flexible manufacturers that serve a wide range of geographical markets and whose profits stem from value maximization" (Hayter 1996: 101). Typically, Canadian resource industries have proven to be very dynamic in implementing process innovations to increase the efficiency of harvesting and primary transformation operations, but less dynamic in product innovations which would diversify and add value to the resource. The case of the forest products industry is illustrative. The Canadian forest sector spends only a quarter to a third as much, in relative terms, on research and development as its international competitors. However, the industry has aggressively invested in improved production machinery and process technologies. Between 1985 and 1995, capital expenditures in the Canadian forest products industry averaged 23 percent of total manufacturing capital spending in Canada, higher than for any other manufacturing industry in the country (Industry Canada 1996). The wood products sector introduced state-of-the-art equipment and gained high labour productivity levels, making Canadian softwood lumber and wood-based panels producers internationally competitive. Canadian pulp mills improved their productivity and cost competitiveness during the early 1990's through upgrading of mills and skills and closing of older plants. The result has been improved performance but reduction in employment.

Many of the technological requirements proposed to the forest sector in its Technology Road Map (Industry Canada 1998a) illustrate points made earlier about the propensity of the industry to innovate through incorporation of new process innovations embodied in capital equipment, often associated with new information technology applications. Numerous improvements to existing technologies would improve harvesting, transportation, and silviculture operations. In addition, "breakthrough" technologies are identified in the areas of robotics and automation, lightweight materials, global positioning systems, training simulators (required because of the rapidly increasing complexity of forestry equipment), artificial vision, environmentally friendly fluids, computer-assisted decision support tools, soft footprint technologies, voice- and data-acquisition and transfer systems, operator-machine interface systems, and remote sensing. This list reveals a technological sensitivity in the forest sector emphasizing increased efficiency and selectivity and decreased environmental impact. The list of technologies suggests sophisticated demand for innovation on the forest sector side, itself not a major performer of research and development. The proposed technological improvements have obvious importance for the upskilling of workers in the forest sector. Most of the proposed technological improvements are unrelated in any obvious way to new forest product development but rather to improvement in the management and harvesting of the resource. However, the Wood-Based Panel Products Technology Road Map (Industry Canada 1998b) identifies a wide range of desirable product and process innovations, including process controls, dryers, adhesive and adhesive application systems, additives, pressing and forming systems, lamination, environmental controls, and non-veneer product developments. Great potential exists for innovation in highly designed materials based on forest biomass and improvements in wooden construction system. Current thinking is that innovation is as important in the laboratory and the mills, as that being done in forest management.

In summary, we have presented evidence concerning the technological behaviour of the resource sectors. They appear to be technologically dynamic, active adopters of improved technologies which embody new knowledge, although they are not strong research and development performers themselves. They are more oriented to process than to product innovations. The new technologies have generally resulted in reduced employment, greater competitiveness, and greater need for specialized skills among workers. In some instances, such as the wood products industry of the forest resource sector, or aquaculture within the fishery, new technology and an emphasis on value added products has led to improved productivity. This improved productivity has resulted in expansion, with a resultant net increase in employment and economic output. Furthermore, we may surmise, but cannot demonstrate on the basis of available information, that the Atlantic Canadian resource industries, like other dynamic mature industries, are embedded in networks that provide them access to knowledge bases in public and private support institutions.

2.0 The Resource Sectors as Knowledge Users

Having presented the argument that the resource sectors in Atlantic Canada (and elsewhere) have become knowledge-based it is necessary to consider how these sectors have managed to cope with the demands that the associated skills needs has placed on these sectors. The remainder of this paper will deal with this in two parts, namely a review of how the sectors have coped over the past decade with the emerging knowledge-based skills needs and then provide some thoughts on an emerging issue which has already been introduced: sustainability.

There are a number of issues related to the increased knowledge dependence of the resource sectors over the past two decades that have required ongoing attention with respect to skills needs. These issues are not only related to changing knowledge requirements, but are also structural in nature. These will be addressed in reviewing how each sector has set about managing change. In addition it is worth examining the parallels and divergences that occur between the natural resource sectors and the knowledge-based sectors in terms of the skills needs, how these occur and how the needs are being addressed.

An examination of the Atlantic Canadian employment figures, as depicted in Table 2, over the last decade indicate that the resource-based sectors workforces have largely remained stable or decreased. There has been fluctuations within each sector relating to cycling of resource commodity demand, with decreases in the early 1990's tracking the economic downturn that was experienced during that period. Within sectors there are variations that relate to changes in technology, adoption of new technologies and changing emphasis on value added products. This is illustrated in Table 2 by the three entries relating to the forestry sector. Forestry and logging varied somewhat through the decade, but remained essentially unchanged. Paper manufacturing declined initially with the

decreased demand, but then did not recover to the 1988 levels as new technologies increased productivity but not overall output. Wood products manufacturing declined with the economic downturn, but then increased substantially as the move to value added products expanded market demand, both within the region and beyond (ACOA). The increase in employment for oil and gas extraction is related to the recent development of offshore oil and gas reserved off the coasts of Newfoundland and Nova Scotia.

Table 2. Employment trends in Atlantic Canada by Resource-based Sector, for the Decade 1988 to 1998 (source: Strategis and Statscan)

Industry Sector	Employment (000's)		
	1988	1994	1998
Agriculture	20.2	18.5	19.1
Fishing, Hunting and Trapping	27.3	27.7	23.9
Forestry and Logging	11.7	10.4	11.7
Paper Manufacturing	16.7	11.8	13.0
Wood Product Manufacturing	9.1	6.5	11.4
Mining and Mix Mining	12.6	9.4	9.8
Oil and Gas Extraction	0	0	2.4

It can be seen that the demand for labour in the resource sectors has generally not increased. However, as the following discussion will indicate, this does not mean that the skills demands within these sectors has remained static. On the contrary, as has been argued already, there is a growing demand for more skilled workers within all the resource-based sectors, as these sectors adopt knowledge-based technologies.

Sustainability will present a paradigm shift for the resource sectors in the first decade of the twenty first century that will affect how workers in these sectors are trained and managed that will be as great as any seen during the preceding twenty years when the focus has been on technological innovation for process efficiency. How the resource sectors will prepare for this change will be discussed in the last section of this paper, as well as what new skill sets will be required to deal with this emerging issue.

2.1 Agriculture

Agriculture is the third largest employer of the natural resource sectors in Atlantic Canada. Farms are essentially small businesses, usually family operated and employing few workers. Many agricultural workers will not have received related post-secondary training. However, demands for knowledge-based skills in agriculture are growing. This includes both farm-based skills, where issues of productivity, farm safety and management are important, to the processing of food products, where there is considerable emphasis on quality and hygiene as food safety becomes increasingly important. Environmental issues are also receiving much attention as the demands increase for farms to manage waste issues and maintain the sustainability of their resources (land and water).

Many farmers have little formal training in business management skills. Operating a farm is in essence operating a small business and the usual principles that apply to the successful small business apply to farms. There has been an effort to provide training programs for farmers in small business management. Farm safety has until recently not received much attention, but is an important concern for an occupation where accident levels are relatively high. In addition, there are specific skills required to handle food products. As health regulations change, there is a need for farmers to stay current with the requirements for safe food handling.

Farming activities can interact with the surrounding environment, often in a negative way. Improper waste management practices have led to problems with surrounding communities and regulators. Improved waste management practices, for example, often result not only in a cleaner environment, but also in economic benefits to the farmer. Land management practices, which ensure the long term quality of soils and prevent erosion, are also an issue.

Atlantic Canada has a number of university and college programs which provide training to the agriculture and food processing sector. Most of these are established programs that have served the region for a long time. Further, there are well established links between these programs and the industry organizations and government agencies. This ensures that the programs being offered are relevant to the needs of the sector.

Amongst the degree programs that are offered in Atlantic Canada, Dalhousie University, in conjunction with the Nova Scotia Agricultural College, offers an engineering degree with an emphasis in agricultural engineering, or in food and bio-process engineering. The Nova Scotia Agricultural College offers a science degree in agriculture with emphasis on either agricultural chemistry, soil science or agribiology. This college also has a bio-environmental engineering centre which undertakes various research projects related to agricultural needs in the region and serves to train graduate students in agricultural engineering. Dalhousie University also has a program in food science which encompasses the processing of all agricultural products and also seafood. This

program includes an emphasis on food safety and hygiene, which is a major concern for the food industry at present as quality is a key market factor. The Atlantic Veterinary College trains veterinarians for the region and also undertakes numerous research projects. (Programs cited here, and for the other resource-based sectors, are meant to provide examples of the post-secondary activity in the region and are not an exhaustive listing of all post-secondary programs in Atlantic Canada.)

Holland College has a number of diploma and certificate programs including a program to train technicians in the maintenance of farm machinery. Farm machinery has become very complex and requires sophisticated maintenance programs. This course includes maintenance of computer controlled accessories. While the above is not a comprehensive listing of all the programs in Atlantic Canada, it serves to illustrate that there is adequate capacity to meet the present demands for skilled workers entering the workforce force in this sector.

Apart from the programs offered at universities and colleges, there are a number of extension programs that are offered through co-operation between these institutions and provincial federations of agriculture. An example of a co-operative program that delivers information to the industry is the "Atlantic Canada Food Processors Guide". This is a joint product of the Prince Edward Island Food Technology Centre and the Atlantic Agri-Products Competitiveness Council, which includes all the provincial agriculture agencies. This guide provides information on food safety, as well as the promotion and marketing of products.

The combination of post-secondary and industry association courses appears to be meeting the current needs of the sector to create a new skills pool and upgrade the skills of those workers already employed in the sector.

2.2 Fishery

The fishery is the second largest employer amongst the resource sectors in Atlantic Canada. While it has high employment, much of this employment, particularly in harvesting and food processing has traditionally required low skill levels. The fishery has also been subject to substantial economic cycling, in part as a result of demand side fluctuations and more recently by supply side difficulties related to mis-management of the resource.

These resource problems may suggest that the fishery, and particularly harvesting, is not an area where new technology and new skills would be required. It is in part the efficiency that technology has provided which has led to supply problems for certain fish species (for example, northern cod).

However, it is the current supply-side difficulties that are driving fish harvesters to seek retraining. There is a national effort, with strong roots in Atlantic Canada, to seek to establish national occupational profiles which will lead to the professionalization of fish harvesters. The Canadian Council of Professional Fish Harvesters (1998) is the leading force to implement this important step. While it is likely that some categories of current harvesters will be grand-fathered out of any requirement to acquire qualifications for professional status, a major retraining program is beginning.

The focus of this program will be more efficient operations, emphasizing the proper use of equipment, monitoring of catches and the release of non-targeted species. Use of modern navigational equipment and increased emphasis on marine safety will also be a part of the program. As with agriculture, the need for better business skills, and the computerization of many business processes is an important part of making professional harvesters more proficient and competitive.

Finally, as management of the fishery changes and greater emphasis is placed upon conservation of stocks, it is becoming necessary for harvesters to become more aware of the resource that they harvest and how each species is related within the ecosystem. This encourages harvesters to play a role in the sustainable use of this resource. Harvesters will in the future work more closely with resource managers to determine and allocate quotas that will maintain stocks and protect the long term sustainability of the resource.

Training programs to bring about the professionalization of fish harvesters are being put in place at present. The responsibility for this will be assumed by the professional body, the Canadian Council of Professional Fish Harvesters, with assistance from various colleges and other training institutions around Atlantic Canada.

The move to professionalize fish harvesting and to emphasize the sustainability issue is relatively new. Programs are being developed by the Canadian Council of Professional Fish Harvesters (1998) and many of these programs will be delivered as extension programs through universities and colleges, probably in rural areas or the workplace. As yet there is not an extensive number of programs being developed within the post secondary system to meet these needs. An example of such a program is the one developed by the Marine Institute of Memorial University, which offers an advanced diploma in fisheries development that focuses on providing skills in fisheries management, including resource management and business skills.

Fish processing, like harvesting, has undergone changes over the past several years, often driven by similar needs to those of harvesters, namely, how to survive in a supply-side crisis. As there have been fewer fish to process, the move has been firstly to other species, often requiring the adoption of new technologies. More importantly, there has been a shift to additional processing to add value to fish products being sent to market. The move to value added products is being achieved through increased knowledge. Fish plant workers, especially management, have to be aware of those issues

which affect the quality of fish, as high quality product is required for sale to high end markets. The National Seafood Sector Council (NSSC), has been established to address the need for additional training. NSSC brings together employers, labour, trade associations, and universities and colleges to work toward creating a strong, prosperous seafood processing industry with a well-trained and productive workforce (J. Oehling, pers. comm.). It has identified the training needs of the industry and developed courses to meet these needs. The NSSC has already establishing a series of training courses aimed at all aspects of the seafood industry, from quality, to waste management, to sanitation and hygiene issues. The courses it runs are aimed at all plant workers and all courses are offered through training partners in each province. All the Atlantic provinces have participating colleges (Marine Institute, Memorial University of Newfoundland; Nova Scotia Community College - Shelburne Campus, Nova Scotia School of Fisheries; Holland College, PEI; University of Moncton, New Brunswick School of Fisheries, St. Andrew's College)

As well there are a number of universities and colleges offering degrees and diplomas in food science and food technology with a focus on seafood. For example, Marine Institute of Memorial University offers advanced diplomas in food safety and food technology. These programs produce graduates who are skilled in the chemistry, microbiology and processing of foods, particularly seafood, and also provide the requisite management skills to allow these graduates to either assume leadership roles in the industry or to start their own businesses. The supply of graduates from these programs appears to be ahead of demand at this time and graduates often leave the region to find employment.

It can be seen that there are changing needs for skills in both harvesting and seafood processing, and that these skills needs are being driven by changes in the industry, in part from the introduction of technology changes, in part from external pressures related to supply issues and in part due to the need to better understand and nurture the environment in which this sector operates. As is the case with agriculture, the emphasis falls on retraining an existing workforce and providing more knowledge for these workers so that they can be more productive and be able to take better care of the resource on which their livelihood depends. The present balance of post-secondary training and on the job training being developed by industry associations in conjunction with colleges, has the capacity to meet the changing skills needs of the sector. Ongoing efforts will be required to continuously update these programs to stay abreast of new technical requirements driven by regulatory demands and the push to produce value added products.

A third facet of the fishery which has emerged within the past ten to twenty years as a major component is aquaculture. Aquaculture is rapidly expanding worldwide and has shown a growth rate of more than 67% over the past decade in Canada. The industry employed about 6,000 workers in Canada at the beginning of 1998 and its landed value of fish had then reached $300 million, representing 17% of Canadian seafood production (Davis 1998). Atlantic Canada accounts for just under half of the Canadian production, with the biggest concentration being in New Brunswick

(24%) and Prince Edward Island (14%). There is also a significant knowledge-intensive supporting infrastructure and supplier service in Canada which produces annual revenues of approximately $300 million.

The continued growth of the aquaculture industry is dependent upon a number of factors including the ability to open new areas of coastline for aquaculture development, the addition of other species suitable for farming, the effective management of environmental impacts and the development of new markets for aquaculture products. The latter is particularly important as other countries, such as Chile, are presently ahead of Canada in their aquaculture production of some species such as Atlantic salmon and are competing strongly in the North American market (Cormier, 1998). If the Canadian aquaculture industry can meet these challenges, then it is possible that it could see a doubling of its size between 1997 and 2000. If this rate of growth were to occur then there would be a potential skills gap created in Atlantic Canada for trained aquaculturists.

At present there is a reasonable balance between supply of skilled workers and the demand within the industry. There are a number of colleges and universities within Atlantic Canada that are training graduates with the necessary skills to maintain the current level of activity and allow for growth. Should the predicted doubling of the industry occur then the current training facilities may not be able to keep pace with demand and a skills gap could occur. However, there are a number of concerns existing at present which may delay this growth. These include restrictions on making new areas available for aquaculture development and environmental concerns. The latter are prevalent in British Columbia, but are also restricting expansion in Atlantic Canada.

In 1996 Human Resources Development Canada (HRDC) established a Sectorial Partnerships Initiative with the Canadian Aquaculture Industry Alliance (CAIA) in which HRDC contributes $952,000 over a three year period to support an Aquaculture Industry Human Resources Council. This Council will undertake activities to support the industry through the upgrading of skills for current production workers and managers in the aquaculture industry, ensure balanced educational and practical training for new workers in the industry and ensure that there are adequate academic training programs for the industry.

CAIA has recently published an *Aquaculture Career and Training Directory* (CAIA, 1997), which contains information on education and training institutions and their aquaculture programs. Atlantic Canada is well represented in this inventory and there are universities and colleges in all four provinces offering degree and diploma courses in a range of aquaculture related activities. These activities range from aquaculture medicine and fish health (Atlantic Veterinary College) to diplomas in aquaculture technology and seafood processing technology (Holland College). The Marine Institute of Memorial University offers a Graduate Diploma in Aquaculture to approximately 15 graduate students each year. The course includes topics on biology, fish health and diseases, engineering, marketing and business issues. Graduates of this program are employed across Canada

and many find employment beyond Canada. Many educational institutions also have extension services which offer training courses in rural communities, plus a range of vocational and industry oriented short courses. Another example is Dalhousie University's Bachelor of Engineering program which has an emphasis on aquaculture. Several other universities and colleges in the region offer similar programs. In general the aquaculture sector in Atlantic Canada is well served in terms of its training needs at this point in time.

CAIA released a report entitled *"Canadian Aquaculture Industry Profile and Labour Market Analysis."* in March 1999. This report contains an up-to-date assessment of the sector and its potential. Its outlook for growth in the sector is not as optimistic as previous reports, as it suggests that there is a slowing in the salmon markets, due to intense competition from Chile, Norway and Alaska, particularly into the United States market. This competition is driving the salmon producers to examine value added product and there is a major initiative under-way to explore this opportunity. This will require salmon aquaculture workers to improve their seafood processing skills, as well as placing more emphasis on issues such as quality management, sanitation and hygiene. It is also anticipated that there will be an increase in mechanization in both producing and processing, in order to reduce costs. This will require aquaculture workers to acquire skills in equipment operation and maintenance. The report indicates that growth in the salmon industry is not expected to be significant through the next two to three years. However, shellfish aquaculture is expected to show growth as there is less competition from other countries. Thus, employment growth is anticipated in shellfish aquaculture.

Overall, there will also be a need for aquaculture managers to acquire more sophisticated marketing skills to research consumer needs and the market environment to better understand how to develop successful products, in appropriate packaging, at prices that meet consumer needs, at a profit. Significant change is expected in skill levels within the aquaculture industry, if it is to continue to compete successfully. A higher percentage of aquaculture workers will require higher skill levels.

The demand for skilled aquaculture workers is being met by those already in the industry who are acquiring experience, by the steady supply of graduates from universities and from entry level workers at the lower end of the skills levels. The latter are readily recruited, as most aquaculture facilities are located in rural areas where unemployment is relatively high and there is a plentiful supply of those willing to work and be trained on the job.

2.3 Forestry

Forestry has been a mainstay of the Atlantic Canadian economy since the region was first settled. Forestry is the largest source of employment in Atlantic Canada and forest products are the largest export commodity in the region. The similarity to the fishery includes the types of employment and

the role that technology has played in changing the sector. Forestry is subject to economic cycles and as such suffers from uncertainties in demand. The forest sector has experienced a growth cycle through the mid-nineties, which is now slowing down as supply overtakes slumping demand for products such as newsprint. This has placed pressure on the sector to institute efficiencies, become more cost effective and where possible focus on value added products. As in other industries, this is achieved by the introduction of technology to increase efficiency and reduce labour costs.

The resultant effect on employment has been a decrease for the pulp and paper industry and little change in the logging industry, while the wood products industry has increased employment as it has expanded through a greater focus on value added products (see Table 2). Mechanized harvesting is now common place and has largely displaced the traditional logger. The modern logger is required to operate sophisticated, computerized equipment, and to have a high level of training in the operation and maintenance of this equipment. Modern pulp and paper mills are highly automated, with all equipment operated by process controls. Sawmills are highly mechanized, and use computer controls to determine the best cuts from a piece of timber. New emphasis on value added products, such as flooring and furniture, focuses on quality and places a strong emphasis on technology to be competitive in the export markets (ACOA). Without technical advances, the sector would not be able to compete in the highly competitive export markets which is essential for its continued viability.

This need to increase productivity to compete globally requires ongoing research and development. As new ways are found to improve wood and energy use and develop value added products through advanced manufacturing processes, the demand for new knowledge-based skills in the workplace increases. Forest product companies need to complement their investment in sophisticated technology with investment in training and education of their workforce. Both the wood products and paper manufacturing industries have experienced some difficulties in recruiting highly skilled specialists. This problem is more prevalent in remote areas, where it is difficult to attract skilled workers.

Programs are being developed in Atlantic Canada to meet these challenges. Again, there are programs within the university and college system that meet many of the sector's needs. An example is the college system in New Brunswick which is developing programs to link with the National Advanced Wood Processing Centre. New Brunswick Community College - Miramichi offers programs in natural resource vocational training which focus on the harvesting and management of forest resources. The University of New Brunswick has a Faculty of Forestry and Environmental Management, offering a Bachelor of Science degree in Forestry and a Bachelor of Science degree in Forest Engineering. These programs prepare graduates to work in complex situations where an understanding of societal demands regarding the present and future status of the resource is an integral part of decision making. The program offers students the opportunity to obtain practical work experience. Université de Moncton offers forestry education at its Edmundston campus. The

Nova Scotia Community College offers a program in forestry resources which provides knowledge in harvesting, silviculture and related production activities. The Woodworking Centre of Excellence in Campbellton, New Brunswick operates as a component of the New Brunswick Community College and offers two programs in woodworking processing techniques and woodworking technology. Graduates from these two programs serve the wood products industry and initial retention of these graduates in Atlantic Canada appears to be high.

Sustainability of forest resources is a focus of the forest resources technician program offered by the Corner Brook campus of College of the North Atlantic (CONA). This program is attached to the Centre for Forestry and Environmental Studies which is involved in studies on sustainability in the forestry sector. CONA also offers the only program to train pulp and paper technologists in Atlantic Canada. This program prepares workers to assume entry level positions in paper mills which are highly mechanized. There is a strong emphasis on process controls which are common place in a modern pulp and paper mill, but which are also applicable to a number of other industrial processes.

As is the case with the fishery, reducing environmental impacts and the concept of sustainability of the resource are emerging issues. In the forestry sector, pollution prevention, particularly from sawmills and paper mills has been a significant issue. This has led to the introduction of increased levels of technology to control and eliminate environmental problems. Environmental employment in the sector has increased and there is an ongoing need to keep workers current with the latest developments in this area (Van Mirbach, 1999.Pers. Comm.)

Forest resource management that seeks to balance the harvesting of wood with its ability to regenerate has become a major issue for the sector. This has meant that both forest managers and loggers must acquire the knowledge to manage the forest. Sustainability is the responsibility of all forest workers if this resource is to be maintained for future generations. The required knowledge is not limited to harvesting and silviculture practices, but includes the need to understand soil management, water quality and wildlife.

Programs are being developed for delivery to forestry workers to provide them with this knowledge. An example of this is the collaborative program between the Centre for Forest and Environmental Studies, the Western Newfoundland Model Forest and a number of industry partners. This program will develop training programs for environmental awareness and environmentally sensitive woods practices (Robinson, 1999. Pers. Comm.). Another example is the forestry program at University of New Brunswick, which includes training for managers in how to deal with publicly sensitive issues, which requires skill such as communications and public relations.

While the demand for skills in the forest industry in Atlantic Canada has increased over the past decade, the post-secondary system, plus the development of on the job training programs, appears to have kept pace with the demand. In some cases, graduates are leaving to seek employment elsewhere, probably as a result of there being insufficient opportunities in the region. On the job upgrading of skills will continue to be an issue for the forestry sector, as it is for the other resource-based sectors and will require continued attention and support.

2.4 Mining

Mining in Atlantic Canada, and indeed in Canada, has been in decline for several years now. The pace at which mines are closing, due to both depletion of reserves and the low price of minerals, exceeds the rate at which new mines are being developed. As operating mines struggle to maintain a competitive edge, they decrease operating costs by decreasing their workforce. This is being achieved by introducing further technology to an already technology-driven sector.

Mining activity includes exploration, extraction of ore, milling, concentrating, smelting, refining and processing minerals. All of these activities are present in Atlantic Canada. While there has been a recent upsurge in exploration activity as a result of the discovery of nickel in northern Labrador, even exploration activity is presently down from its high of three to four years ago.

The mining sector is faced with similar difficulties to those confronting the fishing and forestry sectors, namely an aging workforce, little expansion and few opportunities. Its response appears to be lagging behind that of the other sectors, who are already advanced in establishing training programs for its workforce. This may be reflective of the difficulties the mining sector has faced with declining markets, mine closures and declining metal prices.

A study of skills needs in the mining industry, done in 1993 resulted in the establishment of the Mining Industry Training and Adjustment Council (MITAC) in 1996 (Price Waterhouse, 1993). MITAC, which consists of mining companies and labour, is developing training materials in the areas of health, mine safety and the environment, technology change and the retraining of the current workforce. HRDC has provided funding to MITAC to develop and administer a Training Infrastructure Program. This program is establishing workplace training committees to examine issues such as the role of workplace training, barriers to training and a needs analysis of workplace training. A major priority of the Training Infrastructure Program is to develop a wide range of training courses to address the training needs of mine workers. The overall focus of these training courses will be higher quality, greater cost efficiency and adaptability and improved employability. MITAC has dealt with a number of fundamental issues that confront mature sectors that have significant workforce training needs. These include the quality of training and the transferability of training from one workplace to another. By establishing protocols for the development and delivery

of training MITAC has ensured that all training programs will be accredited and accepted within the industry. It is presently developing training programs for underground mining that will be aimed at workers with low skill levels in the industry (Pelletier, 1999. Pers. Comm.).

Atlantic Canada does have several post-secondary programs to meet the needs of the mining sector. Dalhousie University offers Bachelor of Engineering programs in both mining engineering and metallurgical engineering. Both of these programs are co-operative programs, allowing students to obtain practical work experience. These are the only degree level programs in mining in Atlantic Canada. The University College of Cape Breton offers diploma courses for mining overman and examiner and in mineral technology. This is reflective of the strong mining influence that has pervaded the Cape Breton region as mining has been a mainstay of the local economy. College of the North Atlantic offers a mineral technician diploma at its Bay St. George campus. This program focuses on both mining and mineral exploration, preparing graduates for field exploration programs as well as being able to function in the technological environment of an operating mine. Many universities also offer programs in earth sciences/geology which serve as a valuable basis for work in the mineral exploration and mining area. Overall, there are numerous ways in which prospective workers in mining and mineral exploration can acquire the skills necessary to function in the mining sector. The issue for the mining sector is not the production of new skilled workers, but the upgrading of the skills of the existing workforce. This is particularly relevant for those workers who entered the workforce as unskilled workers and are now attempting to cope with an increasingly technology oriented workplace.

2.5 Oil and Gas

Oil and gas is the new resource sector in Atlantic Canada. As such it does not face many of the problems that confront the other resource sectors, such as aging workforce and low initial skills levels. The oil and gas industry is knowledge-based and demands a high skill level of all its workers. At present there are two producing fields in Atlantic Canada, Sable Island and Hibernia, with a third development, Terra Nova, presently under construction and due to begin production in 2000.

The Canadian Association of Petroleum Producers (CAPP) represents most of the companies focused on exploration, development and production of oil and gas in Canada. It has recently opened offices in Halifax and St. John's. CAPP is concerned that the growing demand for highly skilled workers required to operate offshore production facilities will place stress on the available human resources, leading to a skills gap. The association has therefore commissioned a study of the

situation in Atlantic Canada regarding the future skills needs of the industry . This study is focused only on the demand side and will be available in the second half of 1999 (Diamond, 1999).

The study will include three potential production scenarios that are based on potential crude prices over the next ten years, and therefore determine future offshore development. These three scenarios range from the current status quo, to the addition of one more production platform, to the addition of two more platforms and extensive exploration. While the results are not available yet, there is a strong likelihood that the third scenario may result in significant skills gaps within the sector.

Meeting these possible skills gaps will be a challenge. The oil and gas sector, in its production phase, is not a particularly big employer by resource sector standards. However, its demand for a high level of training and experience means that it cannot readily fill positions. In general, the feeling is that the level of training in Atlantic Canada for the sector is very good. Several university and college programs are addressing the types of skills that are required for both offshore work and the onshore support for the production platforms. The industry is satisfied with the training that is being provided and does not look for specialized programs. However, along with training, there is a need for considerable experience.

An example of this is the position of instrumentation technician on a production platform, which is a very demanding position. These people are expected to maintain the performance of the platform under all operating conditions. Downtime and production losses are very expensive, so technicians are expected to have a high level of relevant workplace experience to complement their training. This experience is obtained by working in the industry. Usually at least ten years of experience is required for a position such as an instrument technician on a production platform.

Even accommodations technicians require a high level of training and experience as most of these people have responsibilities for emergency response and health and safety. While it is relatively easy to acquire the training, it is often necessary to move to other locations to obtain relevant experience. It is this experience that is the issue. New engineering graduates are often sent to other areas such as Alberta after being hired to acquire this experience in producing oil fields. The same applies to geologists, geophysicists and petro-physicists.

The oil and gas sector is aware of the problem surrounding the issue of skills and is addressing it by encouraging suitably trained Atlantic Canadians to acquire experience elsewhere so that they can return to assume these responsible positions in the future.

2.6 Environmental Industries

The environment sector is not a resource sector. However, it is included in this discussion as it plays such a key role in the management of the resources sectors. The environment sector has established a synergy with the resource sectors that has grown over the past decade as more focus has been placed on the ability of these sectors to manage the resource in a sustainable manner. A key driver

for change in the resource sectors has been the need to adapt to changing environmental requirements. The environmental industries sector is knowledge intensive, having a high number of highly trained workers. The majority of workers in this sector have post-secondary training.

The environmental sector has become involved not just in the management of the physical resource but in dealing with the range of socio-economic issues that surround the resource extraction processes. As it has diversified into these areas it has shown rapid growth in Canada. In 1996 there were estimated to be approximately 150,000 workers in this sector (Davis, 1998). In Atlantic Canada it was estimated that approximately 5,600 workers were employed by 900 environmental companies, which in turn produced annual revenues of $540 million. This indicates a sizeable sector, comparing favourably with the computer and related services sector that produced revenues of approximately $350 million in 1996 (expressed in 1992 dollars). Many companies in the environmental sector have experienced annual growth in excess of 10% per year for over a decade (CCHREI, 1999).

If the growth level in the environmental industry is to be sustained then the need for well-trained knowledge workers is crucial. Fortunately, over the past decade universities and colleges have responded to these skills needs and there have been a number of programs put in place throughout Atlantic Canada to meet the growing demand for skilled workers. HRDC has assisted in establishing the Canadian Council for Human Resources in the Environment Industry (CCHREI). This organization has assessed the potential skills needs of the sector and determined which skills, such as hydro geology, environmental management and air quality management, might be in short supply. A significant focus of CCHREI has been on establishing certification programs for workers in the environmental sector. This includes the accreditation of environmental programs in universities and colleges. Certification has become an important issue for the environment sector as many companies performing environmental management and auditing functions are moving to adopt recognized standards of performance such as ISO 14000. Certification of workers is essential for this, as well as for issues such as liability insurance.

Environmental needs are changing rapidly, driven by changing legislation, emerging environmental concerns and demands on industry to meet more stringent standards. Concepts such as sustainability, which were virtually unheard of fifteen years ago, have become dominant forces for change. These factors require that workers in the environment sector are constantly upgrading skills. Along with universities and colleges, the provinces have formed provincial environment industry associations which offer courses for workers needing to upgrade skills or acquire new skills. For example, the New Brunswick Environmental Industry Association is offering its members training in Risk-Based Corrective Training to provide these members with the knowledge required to address sites that may be contaminated with petroleum products (NBEIA, 1999). This type of course is invaluable as workers in the environment sector seek to stay current in an area where technology is changing rapidly.

In Atlantic Canada a number of new post-secondary programs in both universities and colleges have been established over the past decade to meet the demand for trained entry level workers. There is now a good supply of these workers, with a variety of skills to meet the demand. Difficulty is still experienced in obtaining experienced workers in this sector, especially those with management skills. Overall, the skills needs of the environment sector are being addressed by existing programs and there do not appear to be any major problems emerging at this stage. As will be discussed later in this paper, the issue of sustainability is predicted to play in increasing role in the resource-based sectors. Expertise in sustainable development is not readily available at present, either in Atlantic Canada or elsewhere. There are moves to incorporate sustainability concepts into current programs and establish new, focused programs, but these are relatively new.

3.0 Atlantic Canada Themes from the Resource Sectors

The preceding review of the resource sectors in Atlantic Canada provides a basis for comparing these sectors with the emerging sectors. The emerging sectors, such as information technology have identified problems associated with the supply of needed skills. In some instances there may be gaps between the supply of skills and the demand, leading to constraints on growth. As stated at the beginning of this paper, there are two overriding issues that have contributed to potential skills gaps in the emerging sectors, namely rapid growth and extensive technological change. The emerging sectors are evolving rapidly and creating a need to continuously increase and update the knowledge base on which the economic activity of these sectors depends.

An examination of the resource sectors shows that to a greater or lesser extent, the technology being employed by these sectors is undergoing significant change. The need to reduce costs to remain competitive globally has forced all the resource sectors to adopt new technology at an unprecedented rate. Thus, there are similarities between resource and emerging sectors. In many instances the technologies being adopted by the resource sectors stem from developments in the emerging sectors such as the IT sector, the environment sector or the biotechnology sector. Thus, the changes that are occurring are interrelated to those taking place in the knowledge-based sectors. In some instances, such as the employment of information technology in the resource sectors, there may be direct competition for skilled workers between knowledge-based companies and resource-based companies.

While traditionally the resource sectors were not considered to require many knowledge-based skills, this situation has changed significantly and knowledge has now become a key factor in maintaining a competitive advantage in global markets. The need for knowledge-based skills provides a similarity with the emerging sectors. There is an ongoing need to provide adequate training, to

anticipate in which directions these needs will move and to create liaisons between the trainers (universities, colleges, governments and industry organizations), the employers and labour to ensure that training is meeting the requirements of the sectors.

When we examine how training is being delivered to the sectors, and to whom, then differences between the resource and emerging sectors become apparent. Knowledge-based sectors are new sectors, usually made up of companies formed recently, with young, skilled workforces. Often these companies have a high number of workers with post secondary training, who are accustomed to concepts of life long learning. Management is a problem in these sectors, due to shortages of workers with enough experience to assume management responsibilities. Managing rapid technology change is a relatively recent phenomenon, and the managers that have these skill sets are often difficult to find.

Conversely, resource sectors have usually been operating for a considerable period of time, and the majority of the workforce have many years of service and little experience with the technological changes that are taking place. As technology is incorporated into the workplace, these workers have to undergo considerable upgrading of skills and many have been displaced from the workforce as a result of this. While there are established management practices in the resource sectors, management often has little experience in managing this type of change and thus requires an upgrading of skills in how to manage technological change. This includes the management of people in a changing work environment.

Another difference between emerging and resource sectors is labour. Resource sectors have traditionally been unionized. It is unusual to find an knowledge-based sector that is unionized at this stage in their development. This factor can be both positive and negative for the resource sectors. There are examples of unions resisting technological change to protect jobs (in instances where technology may displace existing workers) or to protect aging workers who may find retraining difficult. On the other hand, unions have provided a co-operative conduit for training workers, where management/union partnerships have been formed to facilitate training. The human resource sector councils have worked to establish partnerships between management and labour to ensure co-operative delivery of training programs.

While the above provides a summary of the differences between the emerging and resource sectors, there are also considerable differences between the various resource sectors, which also influence how skills needs arise and are dealt with. The distinction between those resources which are renewable (agriculture, fishery and forestry) from those which are not renewable has already been mentioned.

Other differences include the types of companies that exist within the sector. Agriculture includes a very large number of small enterprises (farms) while forestry companies and mines tend to be large, with large workforces. There are constraints on retraining programs in small enterprises as

retraining may require scarce human resources to be away from the workplace. Thus, special considerations are sometimes required to design training programs for these workers. Some sectors such as the fishery have new industries (aquaculture) emerging within them, changing the overall skills requirements of that sector. In the case of the oil and gas sector, this is a new sector in Atlantic Canada demanding high skills levels for its workforce. The sector has recruited a highly skilled and well trained workforce and feels that the training facilities within Atlantic Canada are adequate to meet its future needs. However, it is focused on building a workforce that has the experience to complement its basic educational requirements

A final observation on skills in the resource sectors pertains to the organizations that have been established to manage the requirements of change. There has been a realization that change was happening within the sectors during past decade. As these sectors have established mechanisms for exchanging information on these issues, programs were put in place to prepare for and handle this change. HRDC and other government agencies have played a part in examining the impacts of change and determining how the change could be managed. Unlike knowledge-based sectors, where there is often a concern that universities and colleges should be assuming an active role in providing the training, these sectors have often established human resource councils which have gone about building consensus, dealing with accreditation issues, preparing training programs to upgrade the skills of existing workers and ensuring that university and college programs have been upgraded or introduced to meet the skills needs. To date training has been successful, with financial input from the industries, labour and governments. The federal government, which assisted in setting up these structures, and has supported them over the past decade, is now gradually withdrawing its financial support. There is a concern that without this continued support these structures will be less successful in meeting the demands for ongoing, quality skills upgrading programs that are being experienced throughout Canada.

Communications between the various stakeholders appears to be more consistent, enabling the trainers to receive needed information on skills requirements and to plan programs to address these. There is also more co-operation on delivery of these programs which provides flexibility in providing training where it is most needed. For all the resource sectors, universities and colleges have long established programs catering to the needs of these sectors. These programs have been upgraded over the past several years to accommodate the changes taking place and to stress new technologies that are being deployed in these sectors. More recently there has also been emphasis placed on management, particularly in sectors such as agriculture and the fishery, where previously little attention was paid to this important aspect of the industry.

While this may serve to provide a brief outline of the resource sectors as coping with their skills

needs in a changing technology driven world, this should not give rise to complacency. There are ongoing challenges that will continue to confront these sectors as they move into the twenty first century. This paper ends with a brief outline of one such challenge, namely sustainable development.

4.0 New Skill Sets Required for Sustainable Development

What skills are required to attain sustainable development in a resource-based economy? The idea that we want to put forward here is that any society that can learn to derive a decent living from its natural capital that is sustainable over the long term will necessarily have developed useful, complex skills and knowledge bases. These can form the basis for tradeable services.

The concept of sustainable development has a variety of meanings which determine the ways that the concept can be translated into practice. A composite definition shows the complexity of the concept: sustainable development is "a process of achieving human development in an inclusive, connected, equitable, prudent, and secure manner" (Gladwin, Kennelly and Krause 1995). In this definition, inclusiveness means that sustainability must go beyond environmental efficiency to encompass human and environmental systems in the present and in the future. Connectivity means that the systemic relationships among problems must be understood. Equity means that the costs of environmental or social inefficiencies must not be passed onto others without compensation. Prudence means that the design principles for human intervention must include precaution, safety margins, and safeguards. Security means that there should be no net loss of ability of natural and social systems to renew themselves; i.e. that natural and social carrying capacities should not be exceeded (ibid. pp. 878-880.).

The transition from principles to practice will not be simple. It is exceedingly difficult to measure the economic value of such values of sustainable development as inter-generational equity or environmental quality.[1] The amount of individual and social learning required to meet the specifications of sustainable development, however they are defined, is staggering. It is important that Atlantic Canada begin to identify the kinds of learning that are required, the ways that this learning can be improved, and the ways that this learning and the skills it entails are distributed in the region's knowledge infrastructure.

Evolutionary economists distinguish between innovation at the level of the firm, the production system, the technology system, and the techno-economic paradigm. Incremental innovations are

[1] For a recent project on sustainability indicators in Atlantic Canada see Colman (1998).

minor cumulative changes continuously occurring in firms, adding up over time to significant improvements in productivity and efficiency. There are many indications that the extraction, harvesting, and processing technologies adopted by Atlantic Canadian firms in the resource sectors over the past decade have improved the environmental efficiencies of the firms while at the same time improving their competitiveness through increases in energy efficiency, decreases in wastage, and diminishment of environmental impacts of harvesting and processing (although the increased volume of resource extraction may have raised the overall level of environmental impacts).

Radical innovations are discontinuities in the production system that "are usually the result of deliberate research and development in enterprises and/or in university and government laboratories" (Freeman 1992). Nylon, a new material, is an example. Another example might be the development of composite materials for the wood-based panel products industry.

Changes of "technology system" are the result of clusters of radical innovations that create "far-reaching changes in technology, affecting several branches of the economy, as well as ultimately giving rise to entirely new sectors." Synthetic materials and the associated manufacturing techniques are examples. Technological revolutions, or change of "techno-economic paradigm," are "new technology systems which have such pervasive effects on the economy as a whole that they change the style of production and management throughout the economy" (Freeman 1992). The introduction of electricity or networked interactive multimedia (the Internet) are examples.

A great deal of recent attention has been devoted to thinking about the ideal characteristics of an environmental sustainable industrial techno-economic paradigm. For example, Lovins, Lovins and Hawken (1999) propose four shifts in business practice that will require new skills, attitudes, and production technologies: radical decrease in the wastage of natural resources (water, energy, minerals, other raw materials) through whole-systems redesign; shift to biologically inspired production models through closed-loop systems, move to a solutions-based business model by providing services rather than products; and reinvest in natural capital. These are suggestions that are directed to firms as producers of goods/services and as consumers of inputs.

A knowledge base for management of sustainable resource environments has to be much more extensive than the internalized skills and routines in firms. It would have to include knowledge of the biological, physical, and systems behavior of the ecosystem, and also include knowledge regarding the production and use of management and diagnostic tools, institutions of governance, and design and operation of policy instruments. It would have to include skills for capacity building, training and extension, planning and management, impact assessment, environmental economics, and information and decision support.

Among professional knowledge workers in the resource sector, required skill sets are specified by their educational institutions, professional associations, and employers, However, it is important

to note that the evolution of desired skill sets has paralleled that of knowledge workers in the advanced technology sectors: in addition to core technical or scientific skills, professional forestry workers, for example, require quantitative analytical skills, interpersonal skills, and philosophical skills (Erdle 1998). The general areas of competence for a professional forester are: "comfort in woods, apply operational practices, understand values, communicate, interact with people, structure problem solving, supervise effectively, manage a work unit, commit to lifelong learning" (Devlin 1998).

Undoubtedly many elements of this knowledge base already exist in Atlantic Canada, but little is known about the supply of, or demand for, skills in this area of the region's own version of a "knowledge economy". Yet much of the region's useful intellectual capital lies in this direction, and the region's potential environmentally-oriented techno-economic paradigm requires further development of such skills and knowledge in order to fully exploit the opportunities in this region to learn from its own natural capital. In sum, the skill set that revolves around the sustainable use and management of natural resources is surely a significant component of a "knowledge economy" and is as significant for Atlantic Canada as are the skill sets that revolve around the use and management of advanced technologies in other regions of the country.

5.0 Conclusions

Observers of lagging Canadian productivity are concluding that our reliance on our low-tech industries and resource sector are absorbing disproportionate amounts of public attention in the form of subsidies and transfer payments. Comments a recent article on the impoverishment of Canada in the Financial Post:

> "The Canadian economy is stuck in the past. We continue to be far too reliant on traditional resource companies and low-tech manufacturing. These relics of a bygone era are protected by government subsidy. Nowhere is government research and development funding more out of line with the rest of the world than in the resource sector. More than 13% of all government research and development expenditure goes to the agriculture, forestry, and fisheries sectors in Canada, compared with 2.4% in the U.S. and 2.6% in Germany. Over the past decade, the U.S. has boasted a 182% surge in real output growth in the electrical and electronics sector - better known as the high-tech industry. In Canada, growth in the high-tech sector was 70% weaker. A similar pattern is evident in machinery - another high-value-added manufacturing sector. Where we did lead the U.S. was in the growth of relatively low-tech sectors such as furniture and food output." (Cooper 1999)

As a region that is particularly committed to resource-based development, Atlantic Canada cannot afford to be indifferent about the prospects and pitfalls of using its natural capital to build a knowledge-intensive economy. If it is possible to develop a regional innovation system that finds a path to sustainability through application of science and technology to management, knowledgeable extraction, and imaginative transformation of natural resources, then this region should endeavour to be the pioneer. The alternative is to succumb to the resource curse with its declining terms of trade, market volatility, slow growth rates, and eventual decline of the region.

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