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INTERNAL REPORT

ASSESSMENT OF THE ECONOMIC IMPACT OF ACTIVITIES RELATED TO THE MMIDSR

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TABLE OF CONTENTS

TABLE OF CONTENTS
TABLE OF CONTENTS
TABLE OF CONTENTS
TABLE OF CONTENTS
TABLE OF CONTENTS

Table of contents

LIST OF

TABLES

FIGURES

TABLES

FIGURES

TABLES

FIGURES

TABLES

FIGURES

TABLES

FIGURES

TABLES

FIGURES

TABLES

FIGURES

TABLES

FIGURES

List of tables and figures

INTRODUCTION

The Observatoire du Mont-Mégantic (OMM), which was founded in the late 1970s, saw ambient light pollution levels double in its first two decades of operation, threatening its purpose and practicality. As the 1990s drew to a close, people in the region around Mont-Mégantic started organizing to fight for the preservation of the dark sky. Since 2002, numerous light pollution-reducing measures have been implemented, from prevention measures to lighting regulations. Thanks to these measures, in 2007 the Mont-Mégantic International Dark-Sky Reserve (MMIDSR) became the world's first International Dark-Sky Reserve certified by the International Dark-Sky Association (IDA), which is dedicated to preserving the integrity of the night sky. The MMIDSR's territory encompasses 19 municipalities in Le Granit regional county municipality (RCM), the 14 municipalities in Le Haut-Saint-François RCM and the city of Sherbrooke.

In December 2020, the MMIDSR steering committee granted a research contract to the Institut de recherche et d'informations socioéconomiques (IRIS) to assess and evaluate the economic impact of MMIDSR's dark-sky protection and interpretation efforts.

IRIS proposed a study combining two methodologies for calculating the economic impact of these efforts, one based on spending and investment by the park and actors in the core zone of the MMIDS, and one based on a calculation of tourism spending as determined by a literature review validated by interviews with key stakeholders in the region. Economic impact will be assessed on a yearly average basis and over a decade.

To accomplish this, IRIS used the most recent data from the Institut de la statistique du Québec cross-sector model (ISQ) and Statistics Canada's input-output model

This report aims to quantify the direct and indirect impact of MMIDSR-related spending within the reserve and in the province of Quebec in general. We will then describe the non-economic impact of the MMIDSR's activities that do not contribute directly to the GDP but help maintain the region's reputation as a dark-sky place throughout the world.

This report has two main sections. The first section, Methodology, explains the processes and concepts used in this report. The second section describes the results of the research, broken down by geographic zone in the MMIDSR.

CHAPTER 1

CHAPTER 1
CHAPTER 1
CHAPTER 1
CHAPTER 1
CHAPTER 1
CHAPTER 1
CHAPTER 1
CHAPTER 1
CHAPTER 1

CHAPTER 1

Methodology

We would like to start out by presenting the methodology used in this report and the working hypotheses we selected.

1.1 Concepts and definitions

Economic impact calculation models are projections of returns on new investments or spending in the economy. Statistics Canada (StatsCan) and the Institut de la statistique du Québec (ISQ) assess the economic impact of past investments, broken down by industry, to calculate multipliers that can be used to estimate the impact of new spending. These models can be used to estimate the direct and indirect impact of investments or new spending on job creation, added value (GDP), income tax collected at different government levels and parafiscal charges (QPP, HSF, QPIP, EI). Both long-term and short-term impacts can be estimated.

We use this method to calculate the economic impact of ongoing activities carried out by stakeholders of the MMIDSR, especially dark-sky activities undertaken by the Parc national du Mont-Mégantic (PNMM). With that information, we are able to estimate the economic impact of this spending for future years. We also estimate the potential impact of future dark-sky investments that result in new instances of spending. For example, when the PNMM invests in its Sommet project[a], economic activity is generated thanks to infrastructure construction projects in the short term and an expanded range of park activities in the long term.

Short-term impacts generally occur during the early phases of a project, when infrastructure is being built. Long-term effects are usually tied to regular spending.

To determine economic impact, we will calculate the direct and indirect impacts of dark-sky promotion activities within the MMIDSR. Direct effects include variations in GDP, job numbers[b] and imports related to meeting the newly created demand. For example, when new facilities are built, materials need to be purchased and new jobs are created. Indirect impacts measure changes attributable to purchases made by secondary industries in response to the new demand in the industries that are directly affected.This includes purchases made at all stages of the supply chain, as each purchased item requires the production of inputs. For example, if the park purchases construction materials, then the supplier will incur additional expenses and hire more staff. All these effects will tend to increase GDP, job numbers and imports of raw materials.

This report measures economic impacts solely within the province of Quebec. It bears noting that all calculations are estimates based on the statistical data collected by the ISQ. There is always a degree of uncertainty in this type of data set, but this exercise enables us to paint a sufficiently accurate and valid picture of the MMIDSR's economic impact.

Studies of the economic impacts of tourism generally focus on tourism spending in a given region. This is generally calculated based on average spending in an area over a certain period of time. While this approach gives a decent portrait of how tourists spend their money, it does not account for the impact of investments or regular spending by organizations that maintain tourist attractions or, in our case, observatories that benefit from the dark-sky reserve but are not necessarily tourist attractions themselves.

Our study relies on a two-pronged methodology. First, we will calculate the economic impact of current yearly expenditures and planned investments within the dark-sky core zone of the MMIDSR. The core zone consists of the Parc national du Mont-Mégantic and the Observatoire du Mont-Mégantic (OMM), affiliated with the Institut de Recherche sur les Exoplanètes (iREx).

Second, we will assess the economic impact of tourism spending in the area surrounding the MMIDSR, which includes Le Haut-Saint-François RCM, Le Granit RCM and the city of Sherbrooke. This area is divided into zones 1, 2 and 3, based on their distance from the core zone. We also include spending by entities that directly benefit from the dark-sky reserve, but that are situated outside the core zone, such as the Bishop's University Observatory

a An ongoing plan to upgrade the hiking, lodging and astronomic potential at the summit of Mont-Mégantic.

b Jobs are measured in full-time equivalents (FTE).

in Sherbrooke. Figure 1 shows the spatial relationship of the core zone to outer zones 1, 2 and 3.

Finally, we will combine the results of both calculation methods to obtain the final results presented later in this report.

1.2 Methodology for calculating the impact of investments and spending within the core zone of the MMIDSR (method 1)

To accurately assess the economic impact for the core zone, we worked with representatives from the PNMM (including the ASTROLab museum) and the OMM/iREx to understand their dark-sky-related operating expenses. To paint a full picture of their activities, we needed to quantify the jobs and salaries of these organizations and their ongoing expenses in various industries.

Therefore, we used surveys to assess the dark-sky-related spending of the representatives of these entities. The surveys were sent out in spring and summer 2021 and contained questions about:

- The jobs and salaries of permanent and temporary staff with dark-sky-related functions
- Revenue sources and expenses of each entity, itemized by industry sector identified by the ISQ as related to dark sky initiatives[a].

The survey responses represent the direct impact of core zone spending for an average year. It should be noted that for the sake of accuracy, 2019 data was selected as the reference, so as to avoid any anomalies caused by the health crisis that started in 2020[b].

a When jobs or expenses could not be classified as entirely related to dark-sky initiatives or the MMIDSR, we consulted with our partners to define a jointly accepted percentage of total working time. For example, we determined that 50% of the salary of a PNMM administrative employee could be factored into our calculation, because around half of the staff are assigned to sky observation tasks.

b Given that 2020 was a near-record year for the PNMM and 2021 has been similar according to partial data, our results may be interpreted as conservative.

FIGURE 1
MMIDSR territor

SOURCE : MMIDSR.

Table 1 (p.12-13) presents the breakdown of operating expenses for the PNMM and OMM.

Total expenditures by these organizations amounted to $3,702,960. This represents the total direct economic impact of PNMM and OMM activities.

1.2.1 Calculating the indirect impact of the core zone of the MMIDSR

After spending numbers were broken out by sector, we measured the indirect impact in terms of jobs and added value, including salaries and parafiscal employee benefits. To this end, we developed an economic impact evaluation model based on the ISQ's cross-sector model. This model uses a two-stage calculation. The first stage measures the impact felt directly by primary suppliers, businesses that have business relationships related to dark-sky activities with stakeholders in the core zone. This stage generates the most local impacts, since the majority of these businesses are physically close to the core zone. In our case, we know that 100% of purchases made by the PNMM and OMM were made locally, in Quebec.

The second stage measures indirect impacts and concerns secondary suppliers. Indirect impact refers to the impact of stakeholder activities on their primary suppliers, i.e., the business relationships between the primary suppliers and their own business partners in the context of dark-sky promotion and protection activities. This second type of impact is less significant than the first, and local impacts are more difficult to determine.

The selected model also calculates income tax and parafiscal charges deducted from the wages and benefits of partner businesses' workers. This is done by estimating the number of jobs by dividing total wages and salaries of a sector by the average compensation in the sector. Then, the model estimates taxable income, taking into account source deductions[a]. The provincial and federal income tax tables are applied, including adjustments such as tax credits and surtaxes as appropriate. The model can therefore be used to allocate the tax revenue generated according to the two levels of government, taking into account certain average deductions.

As for parafiscal charges, they should theoretically not be considered when calculating government revenue. The sums allocated to parafiscal charges are contributions to social security programs, intended for specific uses at a later date. However, they allow us to evaluate the impact of MMIDSR core zone activities. In Quebec, parafiscal charges include the contributions to the Health Services Fund (HSF) Québec Parental Insurance Plan (QPIP) and the Québec Pension Plan (QPP). At the federal level, the model accounts for the Employment Insurance (EI) fund. Note that the ISQ cross-sector model does not account for taxes on corporate profit or property taxes.

Our model also calculates indirect taxes paid by partner companies to both levels of government. Indirect taxes take two forms: taxes on products and taxes on production. The first type includes payments made by individuals or groups when buying goods and services, such the Quebec Sales Tax (QST) , the federal Goods and Services Tax (GST), federal excise duties and Quebec-specific taxes, such as on lodging or tobacco. The second type is related to the production of goods and services. Examples are payroll taxes, capital gains tax, business tax and so on.

1.2.2 Other PNMM and OMM projects

Following this initial assessment of core zone impacts, we conducted interviews with the relevant employees from the two entities about investments planned between 2021 and 2031. Together, we estimated the future expenses and revenue for these projects.

Through these interviews, we determined that four projects (three of which are confidential) will be undertaken by 2031. Table 2 shows a breakdown of these projects.

We can conclude that each of these projects will have an impact on the local and provincial economy. These impacts are included in our calculation.

Considering the limited quantity of data and projections available from the stakeholders, we chose to use a model based on Statistics Canada's input-output multipliers[1] to evaluate the economic impact of the investment plans. To estimate job creation and salaries, we distributed the estimated budgets by industry[2]. See Table 3 for this breakdown.

Therefore, from our model, we can estimate the short-term economic impact of these projects, which will then be integrated in the timeline found later in this document.

These projects will have an impact on the PNMM and OMM's recurring operating expenses in the years following their implementation. For example, the PNMM will hire additional staff to work on the Sommet project,

a The income tables used here are found in the appendix.

TABLE 1

Breakdown of 2019 operating expenses related to PNMM, ASTROLab and OMM activities, by ISQ industry classification

No	Code	Product	$K	No	Code	Produit	$K
22	113C00	Firewood	40.0	208	3324B0	Metal tank (heavy gauge) manufacturing	2.2
47	221100	Electric power generation, transmission and distribution	126.5	209	332500	Hardware manufacturing	1.1
48	221200	Natural gas distribution	6.7	211	332700	Machine shops, turned product, and screw, nut and bolt manufacturing	3.3
50	221320	Sewage treatment facilities	5.6	213	332AA0	Cutlery and hand tool manufacturing	2.2
59	23B007	Other institutional buildings	16.7	214	332AB0	Metal valves and fittings	3.3
83	31151A	Dairy product (except frozen) manufacturing	3.3	215	332AC0	Ball and roller bearing manufacturing	3.3
92	311810	Bread and bakery product manufacturing	3.3	217	332AE0	Metalwork products	4.4
95	311910	Snack food manufacturing	7.8	218	3331A0	Agricultural and garden machinery manufacturing	3.3
99	312110	Soft drink and ice manufacturing	1.1	219	3331B0	Logging, construction and mining machinery manufacturing	2.2
111	31B001	Men's & women's clothing	53.3	220	333200	Industrial machinery manufacturing	2.2
116	31B006	Other leather products	1.1	221	333300	Commercial and service industry machinery manufacturing	166.5
134	322220	Stationery product manufacturing	1.1	222	333413	Industrial and commercial fan and blower and air purification equipment manufacturing	1.1
137	32229C	Other converted paper product manufacturing	1.1	223	33341A	Heating equipment and domestic refrigeration equipment manufacturing	3.3
139	323A00	Printed products	3.3	224	333500	Metalworking machinery manufacturing	2.2
142	32411A	Gasoline	26.6	225	333611	Turbine and turbine generator set unit manufacturing	2.2
147	32411F	Lubricants & other refined petroleum products	6.7	226	333619	Other engine and power transmission equipment manufacturing	1.1
162	325500	Paint, coating and adhesive manufacturing	1.1	227	333910	Pump and compressor manufacturing	3.3
163	325610	Soap and cleaning compound manufacturing	5.6	229	333990	All other general-purpose machinery manufacturing	2.2
165	325900	Other chemical product manufacturing	2.2	230	334100	Computer and peripheral equipment manufacturing	20.0
168	32612A	Plastic construction materials	8.9	238	334A00	Audio and video equipment manufacturing	12.2
172	326193	Motor vehicle plastic parts manufacturing	2.2	240	335120	Lighting fixture manufacturing	1.1
173	32619A	Other plastic products	1.1	241	335210	Small electrical appliance manufacturing	1.1
174	326210	Tire manufacturing	6.7	242	335220	Major appliance manufacturing	1.1
175	326220	Rubber and plastic hose and belting manufacturing	2.2	243	335311	Power, distribution and specialty transformers manufacturing	2.2
205	332321	Metal window and door manufacturing	1.1	244	335312	Motor and generator manufacturing	1.1
206	332329	Other ornamental and architectural metal product manufacturing	1.1	245	335315	Switchgear and switchboard, and relay and industrial control apparatus manufacturing	2.2

Numbers rounded to the nearest thousand. Sum of elements may differ from total.

SOURCE : IRIS compiled data

TABLE 1

Breakdown of 2019 operating expenses related to PNMM, ASTROLab and OMM activities, by ISQ industry classification

No	Code	Product	$K	No	Code	Product	$K
246	335910	Battery manufacturing	1.1	359	517A00	Telecommunication fixed services	5.6
248	335930	Wiring device manufacturing	2.2	360	517B00	Telecommunication mobile services	5.6
249	335990	All other electrical equipment and component manufacturing	3.3	362	517D00	Internet access fixed services	4.4
257	336310	Motor vehicle gasoline engine and engine parts manufacturing	1.1	363	518000	Data processing, hosting, and related services	4.4
258	336320	Motor vehicle electrical and electronic equipment manufacturing	1.1	364	519B00	Web advertising	1.1
260	336340	Motor vehicle brake system manufacturing	1.1	365	519C00	Other information services	1.1
261	336350	Motor vehicle transmission and power train parts manufacturing	4.4	378	5241C0	Automobile insurance services	1.1
262	336360	Motor vehicle seating and interior trim manufacturing	2.2	379	5241D0	Home insurance services	12.2
264	336390	Other motor vehicle parts manufacturing	2.2	391	532100	Automotive equipment rental and leasing	4.4
272	336900	Other transportation equipment manufacturing	5.6	393	532D00	Other consumer goods rental	1.1
283	339930	Doll, toy and game manufacturing	16.7	404	5417A0	Scientific research and development services	33.3
285	339950	Sign manufacturing	1.1	405	541800	Advertising, public relations, and related services	52.2
286	339990	All other miscellaneous manufacturing	1.1	416	561500	Travel arrangement and reservation services	2.2
312	481A00	Air transportation	11.1	417	561600	Investigation and security services	1.1
326	487000	Scenic and sightseeing transportation	35.5	418	561700	Services to buildings and dwellings	16.7
327	485300	Taxi and limousine service	1.1	419	561A00	Other services to buildings and dwellings	6.7
334	488400	Support activities for road transportation	8.9	420	562000	Waste management and remediation services	4.4
337	491000	Postal service	4.4	443	713A00	Other entertainment and leisure service	21.1
342	5111B0	Periodicals, printed and electronic	1.1	444	721100	Traveler accommodation	10.0
343	5111C0	Books, printed and electronic	12.2	447	722A00	Catering services	20.0
345	5111E0	Newspaper advertising	2.2	448	722B00	Alcoholic beverage services	2.2
346	5111F0	Magazine and periodicals advertising	1.1	449	811100	Automotive repair and maintenance	36.6
348	511200	Software publishers	6.7	450	811A00	Other automotive repair and maintenance	22.2
356	515A00	Radio advertising	11.1	452	812300	Dry cleaning and laundry services	10.0
357	515B00	Television advertising	2.2	454	812930	Parking lots and garages	3.3
						Total goods expenditure	**1011.02**
						Salaries and fees before taxation	**2691.8**
						Total expenditure	**3703.0**

Numbers rounded to the nearest thousand. Sum of elements may differ from total.

SOURCE : IRIS compiled data

who will then contribute to the local economy. After analyzing the various projects, we concluded that only the Sommet project would lead to additional recurring expenditures that impacted the economy; other projects have additional economic impacts in their implementation years. We estimated the additional recurring expenditures of the Sommet project at $230,000 starting in year 6 of the plan. We estimated that the additional yearly expenses of completed projects were in line with the breakdown in Table 1.

1.2.3 Economic impact of the iREx

The Observatoire du Mont-Mégantic (OMM) is a world-class institution jointly administered by Université de Montréal and Université Laval. It includes the Laboratoire d'astrophysique expérimentale (LAE), which has facilities on both university campuses, and the telescope on the summit of Mont-Mégantic in the Estrie region of Quebec

The OMM telescope is used for vital astrophysics research and is an exceptional training tool, especially as a testbed for new techniques and prototyped instruments. The LAE designs cutting-edge instruments for both large ground telescopes and space telescopes. The OMM is closely associated with the Institut de Recherche sur les Exoplanètes (iREx), a working group of approximately 45 professors, researchers and graduate students. The iREx pays out salaries and expenses that impact the economy within the MMIDSR, but primarily have an impact elsewhere in Quebec. However, as a leading-edge astronomy institute, it is only natural that its work is dependent on and greatly improved by the existence of the MMIDSR. It seems logical to account for the impact of iREx spending in the MMIDSR economic impact calculation for Quebec. Figure 2 distinguishes the respective elements of the OMM and iREx.

After discussions with OMM and iREx representatives, we determined that the iREx's MMIDSR-related spending has the equivalent impact of eight full-time employees on Quebec's economy. The exact payroll figures will not be disclosed here for confidentiality reasons. All this data was added to our model.

TABLE 2

Current and planned dark-sky projects in the MMIDSR core zone

Organization	Name	Brief description	Timetable	Costs
PNMM	Sommet project	Infrastructure renovation, new visitor lodging, stargazing terrace construction, construction of an auditorium dome for astronomy presentations, renovation of the existing observatory, including a new telescope	2020 to 2023	$4.9M
Other projects		Renovation and expansion of existing structures	Btwn. 2021 & 2026	$3.5M
Total				$8.4M

SOURCE : IRIS compiled data

TABLE 3

Breakdown by industry of expenditures related to MMIDSR core zone projects between 2021 and 2031

	Cost $M*	Industry code (NAICS)
Sommet project		
Consulting fees	0.9	BS5413
Mountain refuge renovation	1.2	BS23B and BS23D
Astronomy/education area	1.8	BS23B
Civil engineering work	0.5	BS220
Outdoor landscaping	0.2	BS113
Equipment	0.2	BS23D
Road maintenance	0.2	BS23D
Project 1		
Consulting fees	x	BS5413
Work	x	BS23B
Project 2		
Consulting fees	x	BS5413
Sanitation buildings	x	BS23B
Wastewater treatment	x	BS220
Infrastructure	x	BS23B
Furnishings and equipment	x	BS3A0
Project 3		
Engineering work	x	BS23C
Manufacturing	x	BS3A0

*Costs written as 'x' are confidential.

SOURCE : IRIS compiled data.

1.2.4 Core zone timeline

We developed the timeline in Figure 3 to plot our economic results over a 10-year period in the core zone.

The figure shows the yearly operating expenses of the PNMM and OMM and the onetime expenses of various projects. For example, for the four-year Sommet project, we assume the total investments will be evenly split four ways across years 2 to 5. Then, those investments lead to new recurring yearly expenditures in years 6 to 10.

The sum of the calculated impacts for each case allows us to determine the complete yearly economic impact of the dark-sky protection and promotion initiatives in the MMIDSR.

1.3 Methodology for calculating the impact of activities in MMIDSR zones 1, 2 and 3 (method 2)

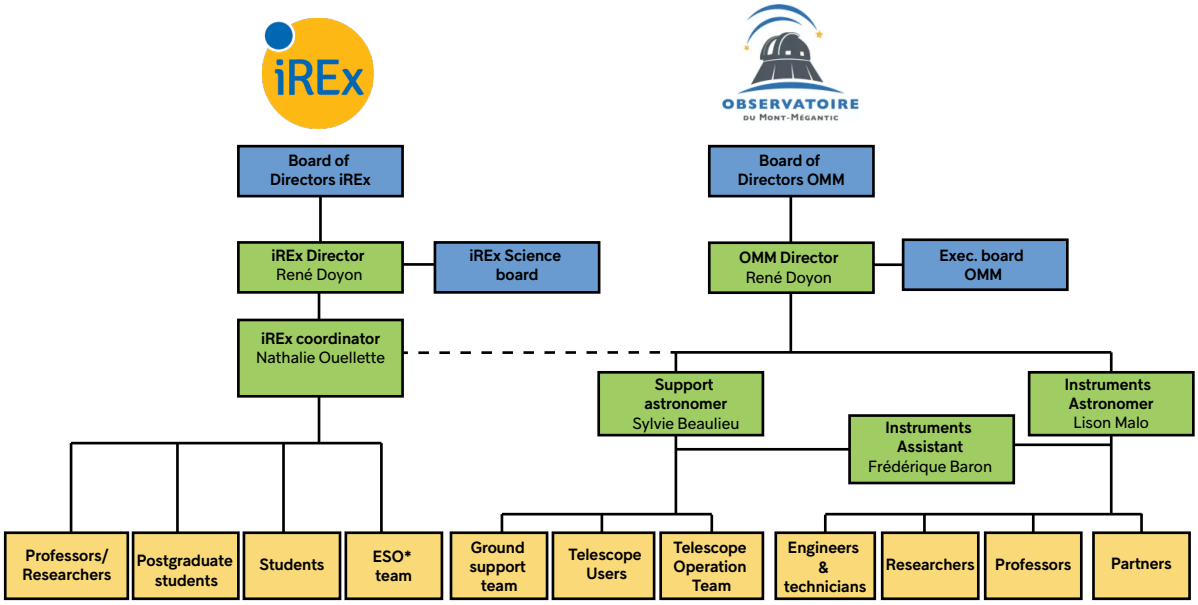
The methodology used to calculate the economic impact of tourism was inspired by two models: the 2019 study *Dark sky tourism: Economic impacts on the Colorado Plateau Economy by David Mitchell and Terrel Gallaway* [3] and the 2013 study by Ekos Limited on Scotland's Galloway Forest Park, *Dark Sky Park Report: Economic Impact and Potential*[4]. These two studies estimate the number of tourists who visit national parks for their dark skies. Visitor numbers are multiplied by an estimate of average daily spending to calculate the local economic impact. The researchers polled the visitors at the entry gates of international dark-sky parks to determine the number of tourists particularly drawn to the parks by the low level of light pollution.

In our case, this method enables us to measure the economic impact of all dark-sky spending. We feel our method is more precise than those of Ekos Ltd. and Mitchell & Gallaway, as it includes the actual figures for tourist spending and investments made by the core zone partners. This method proves useful for determining the impact of dark-sky tourism in the MMIDSR zones 1, 2 and 3. While we did not do a survey of all visitors to the MMIDSR and their spending, many public institutions do compile such information. We reached out to representatives of Tourism Eastern Townships, Le Granit RCM, Le Haut-Saint-François RCM and Destination Sherbrooke to compile data from several studies on the economic impact of tourism within MMIDSR zones 1, 2 and 3.

Of course, visitors to the MMIDSR territory are not there just for the dark sky. Therefore, we needed to estimate what proportion of tourism revenue is attributable to the MMIDSR. We communicated with multiple partners from the tourism industry in the MMIDSR in order to estimate the proportion of tourists primarily or partly drawn to the area by the MMIDSR dark-sky preservation. We also used the data provided by the tourism ministry of Quebec to guide our evaluation. Once the total economic impact of dark-sky-related tourism was determined, we subtracted the spending of the PNMM to avoid double counting. Finally, we added the economic impact of the Bishop's University observatory, located in zone 3.

Figure 4 shows the method used to calculate economic impact in zones 1, 2 and 3.

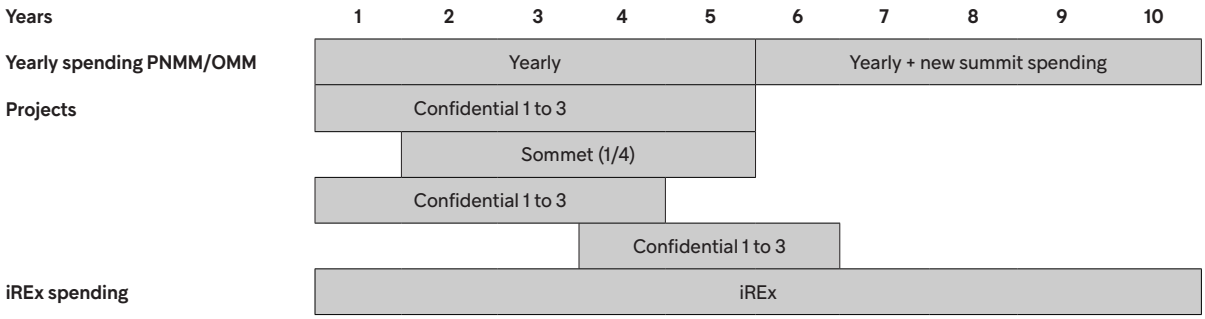
FIGURE 2
iREx and OMM organization chart



*ESO: Education and Scientific Outreach.

SOURCE : IREx-OMM.

FIGURE 3
Timeline used to calculate the economic impact of the MMIDSR core zone



Please note that confidential projects might not necessarily be implemented over the entire time interval shown here. That interval is presented here to give a general idea of the projects' schedule.

SOURCE : IRIS compiled data.

1.3.1 Step 1: Literature review

To understand tourism spending in Le Granit and Le Haut-Saint-François RCMs, we obtained access to the data on tourism revenues in a radius of 40 km from the core zone per RCM, from 2008 to 2017[5]. We used these numbers to calculate the average yearly tourism revenue for the two RCMs. To ensure the representativity of the tourism spending per RCM used in our model, we averaged it over a 10-year period. We concluded that average yearly tourism spending is $12.9M for Le Haut-Saint-François RCM and $27.0M for Le Granit RCM.

For the city of Sherbrooke, we drew our information from the study *Analyse de l'impact économique du Tourisme à Sherbrooke*, conducted by Raymond Chabot Grant Thornton in May 2019[6]. Since this is a recent two-year study, we consider it to be particularly useful for our report. Page 38 of the analysis states that an estimated 27% of the 3,256,000 visitors to Sherbrooke were tourists[7], for a total of 879,120 unique tourist visits. In 2017, 40.5%[a], of tourists in the Eastern Townships were leisure tourists. If we apply this percentage to the 879,120 tourists above, we can estimate that 365,044 leisure tourists visited the city of Sherbrooke[b]. According to the Ministry data, each tourist spends on average of $142.91 per stay in the Eastern Townships[8], which means that total leisure tourism spending in the city of Sherbrooke is around $50.9M.

We concluded that the tourism spending in zones 1, 2 and 3, including the core zone, is approximately $90.8M[c] per year.

a Please note that the Quebec ministry of tourism classifies four types of tourism: leisure, business and conference, family visits and other. We concentrate on leisure tourism, even though other visitor types may also enjoy the advantages of the MMIDSR's dark sky. We consider this choice to be the conservative option. See *Le tourisme au Québec en bref-2017* updated August 12, 2020, online www.quebec.ca/tourisme-et-loisirs/services-industrie-touristique/etudes-statistiques/faits-saillants-tourisme-quebec/tourisme-en-bref-2017, accessed on August 4, 2020

b For a city like Sherbrooke where business and family tourism make up a large percentage of total tourism numbers, we took into account only leisure tourism spending. This decision is different from the choice made in Le Granit and Le Haut-Saint-François RCMs, where leisure tourism is more common.

c For lack for available information, these numbers do not account for tourist spending on renting chalets or Airbnb accommodations in the region. These categories are not included in our calculation, even if it seems acceptable to assume such lodging is important in the MMIDSR area. On this point, our evaluation remains prudent and conservative.

1.3.2 Step 2: Calculating dark-sky tourism spending

Of course, not all tourism spending is directly related to the night sky. Therefore, we established a ratio of tourism spending associated with astronomy, outdoor or camping activities related entirely or partially to the MMIDSR for each RCM. We conducted interviews on tourist behaviour with various representatives from the following organizations: the PNMM, Destination Sherbrooke, Le Granit RCM, the Centre local de développement Haut-Saint-François, Tourisme Mégantic, Tourism Eastern Townships, Cégep de Sherbrooke (for the dark sky oasis project), the Club d'astronomie de Sherbrooke, Camping Aventure Mégantic, Aux Berges de l'Aurore inn and the Baie-des-Sables tourist station. These interviews enabled us to determine the percentage of tourism that is related to the dark sky protection efforts. Considering that several of the stakeholders had an economic interest in safeguarding the MMIDSR, we took a conservative and prudent approach to our calculations, in order to avoid overestimating the economic benefits of the dark-sky reserve.

For Le Granit and Le Haut-Saint-François RCMs, the interviews revealed that a significant portion of tourism dollars are spent on outdoor nature activities. In addition, many of the region's local tourism boards prominently feature dark-sky activities in their marketing campaigns. The dark, starry sky is promoted via marketing materials for the Route des Sommets, the Ose le Haut local marketing initiative, stargazing activities, "sleep under the stars" experiences and the region-wide scale model of the solar system centred on the OMM.

Many of our interviewees estimated tourism spending at between 30% and 50%. Again out of prudence, we chose to use the more conservative 30%. Since the accommodation owners we met are business partners of the PNMM, it makes sense that a greater than usual proportion of their clients visit for the starry sky. A 50% ratio across the board was thus deemed exaggerated. Interestingly, a survey of 29 businesses by the Société d'aide au développement des collectivités (SADC) du Haut-Saint-François noted that 31% of respondents said that the primary reason for the tourists' visit was the PNMM[a].

Based on this information, we believe our estimate that 30% of tourism in Le Granit and Le Haut-Saint-François RCMs is motivated by dark-sky activities is quite credible.

This percentage is lower for the city of Sherbrooke. Despite some city projects dedicated to preserving the night sky and the presence of the Club des astronomes amateurs de Sherbrooke, the tourism economy in the city is less reliant on outdoor and stargazing activities. After discussions with tourism partners in the city, it was decided, again as a precaution, to use the conservative figure of 1% of tourism spending in the city for its contribution to the regional draw of the night sky, with the understanding that this is only a marginal contribution.

1.3.3 Step 3: Subtracting PNMM-related impacts

Since spending in the PNMM derives from tourists with an interest in astronomy, we suppose a significant

a Internal documents provided to IRIS after interviews.

FIGURE 4

Steps in the calculation of dark-sky tourism spending in MMIDSR zones 1, 2 and 3

Step 1	Step 2	Step 3	Step 4	Step 5	Resulting economic benefits of the MMIDSR
Literature review of economic impact studies provided by Le Granit MRC, Le Haut-Saint-François RCM and Destination Sherbrooke	Determine the proportion of dark-sky tourism spending via interviews and data provided by Tourisme Québec per RCM or urban area	Subtract PNMM spending	Calculate all economic impacts	Add impact of Bishop's Univ. observatory	Combine core zone and zones 1, 2 and 3 impacts

SOURCE : IRIS.

portion of dark-sky spending in the MMIDSR is due to the existence of the park. One can assume that many of the visitors interested in stargazing spend some amount of money in the park. To avoid double counting and to remain conservative in our estimates, we chose to subtract spending in the PNMM from the total dark-sky tourism numbers for zones 1, 2 and 3. Out of respect for the confidentiality of the participants, we will not reveal this amount.

Table 4 presents the results of the tourism spending calculations.

In total, we estimate that close to $10.8M are spent by tourists interested in dark-sky activities in zones 1, 2 and 3 of the MMIDSR.

1.3.4 Step 4: Calculating economic impact

We used the StatsCan input-output model and the ISQ cross-sector model to calculate the economic impact of all dark-sky tourism spending in zones 1, 2 and 3. In our calculation, we assumed that tourism spending is distributed as follows: accommodation and food services—80% [a], arts, entertainment and leisure—20%[b].

1.3.5 Step 5: Adding the impact of the Bishop's University observatory

Though the OMM, situated in the heart of the MMIDSR, is the primary astronomical facility in the region, Bishop's University also operates an observatory, and its staff collaborates with the OMM. BU hires faculty members and students to observe the sky in the MMIDSR. This spending has both direct and indirect economic impacts. After discussions with BU representatives, it was agreed that the data used to calculate their impact would remain confidential, but that the results would be integrated in the overall assessment of economic impact. This method prevents readers from deducing the BU observatory's budget while still allowing for an accurate calculation.

Finally, after this last step, we can assess the impact of tourism spending in zones 1, 2 and 3 of the MMIDSR along with the impact of BU's astronomy program.

a NAICS CODE BS720.

b NAICS CODE BS710.

TABLE 4

Tourism spending data used to calculate the economic impact of zones 1, 2 and 3 of the MMIDSR

	Tourism spending ($M)	Ratio	Total ($M)
Le Granit RCM	27	30 %	8.1
Le Haut-Saint-François RCM	12.9	30 %	3.9
City of Sherbrooke	50.9	1 %	0.5
Sub-total	90.8		12.5
PNMM spending			1.7
Dark-sky tourism spending data for zones 1, 2 and 3			10.8

SOURCES : Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC Haut-Saint-François*, 1 p. for years 2008 to 2017; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC du Granit*, 1 p. for years 2008 to 2017; Raymond Chabot Grant Thornton, *Analyse de l'impact économique du Tourisme à Sherbrooke*, May 2019, 64 p. online www.destinationsherbrooke.com/Fichiers/34095boc- 94e4-e511-80d6-00155d00750b/Sites/8d44bd82-e200-e611-80d9-00155d00750b/Documents/rapport-impacttourismesherbrooke.pdf. Data compiled and processed by IRIS.

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Economic impact

2.1 Core zone of the MMIDSR

Table 5 shows the calculation of economic impacts in the core zone in an average year with no additional projects. This includes the dark-sky-related impact of a baseline year for the PNMM and OMM (iREx included). We began by assessing the core zone. We chose to differentiate the baseline economic impacts stemming from the yearly operating expenses of dark-sky organizations from those caused by planned investments over the next decade. We then assessed the total impact, both for each individual year and for the whole period.

Table 5 shows that during an average year before the first stirrings of the Sommet project and other plans, dark-sky protection and promotion activities in the MMIDSR sustain 51 direct jobs and 6.7 indirect jobs, for a total of 57.7 full time equivalent positions.

In terms of GDP, these activities have an annual impact of more than $3.6M ($3M direct, $0.6M indirect). The Government of Quebec receives more than $400,000 and the Government of Canada close to $300,000 from income tax and various other taxes. Employees and employers contribute close to $500,000 in Quebec parafiscal charges and $100,000 in federal parafiscal charges.

We also added the anticipated impact of all planned projects to be implemented in the core zone over the next decade[a]. Table 6 shows these numbers.

As we can see, when considered as a whole, the major dark-sky projects in the MMIDSR core zone will create 38.3 direct and 39 indirect jobs in the next decade, for a total of 77.3 non-recurring jobs. These positions will mostly be in consulting, engineering and non-residential construction. It bears repeating that these are short-term, one-time hires. However, once the Sommet project is completed, it will have a recurring economic impact starting from year 6.

The impact on GDP for those projects is estimated at $6.6M ($3.8M direct and $2.7M indirect). Through income and other taxes, the Government of Quebec should receive $0.7M and the Government of Canada $0.4M. Employees and employers are expected to contribute parafiscal revenues of $0.5M for Quebec and $0.1M for Canada.

As explained earlier, some projects will add to the PNMM's operating expenses, especially the Sommet project and its associated extra salaries once completed[b].

TABLE 5

Yearly impact of PNMM and OMM operating expenses for Quebec (in FTE and $K)

	Direct	Indirect	Total
Jobs (FTE)	51.0	6.7	57.7
GDP	$3,025.0	$640.0	$3,664.8
Provincial income tax	$378.1	$27.5	$405.5
Provincial parafiscal charges	$418.5	$44.8	$463.3
Federal income tax	$263.1	$17.4	$280.5
Federal parafiscal charges	$418.5	$44.8	$463.3

SOURCES : Cross-sector ISQ model, *Table*, 20180430-1-1-2014G-2018H (2017G); StatsCan, *Table 36-10-0113-01 Input-output multipliers, provincial and territorial, summary level*; StatsCan, *Table 14-10-0064-01 Employee wages by industry, annual*; Marc-André Gauthier, *L'amortissement hypothécaire au Québec — Données sociodémographiques en bref*, ISQ, February 2016, vol. 20, no 2, p. 14, online, bdso.gouv.qc.ca/docs-ken/multimedia/ PB01614FR_dembref2016T01F00.pdf; ISQ, *Impact économique pour le Québec d'une tranche de 100 M$ de dépenses courantes des ménages au Québec*, 2021, Data compiled and processed by IRIS.

a This ensures the confidential nature of some future investments, as agreed to with partners, while allowing us to assess their economic impact.

b Estimated at $230,000 per year.

Table 7 shows the sum of the economic impacts related to the night sky in the MMIDSR core zone over a decade, including total spending, recurring and non-recurring, of the PNMM, OMM/iREx and their projects.

Table 7 also shows that the combined dark-sky economic activities in the MMIDSR core zone create or maintain the equivalent of 568 direct and 105 indirect positions, for a total of 673 jobs.

We can estimate that the impact on GDP will be close to $45M ($34.6M direct and $10.1M indirect). From income tax and other revenue, the Government of Quebec is expected to collect close to $5.2M and the Government of Canada, close to $3.6M. Employees and employers will contribute more than $5.7M to Quebec and more than $1M to Canada in parafiscal charges.

Table 8 presents the average annual economic impact of the dark-sky reserve in the MMIDSR core zone, based on the data in Table 6.

Together, the average yearly dark-sky economic activities in the MMIDSR core zone create or maintain the equivalent of 57 direct and 10.5 indirect jobs each year, for a total of 67.5 jobs.

It can be estimated that the average yearly impact on GDP will be close to $4.5M ($3.5 M direct and $1M indirect). Overall tax revenue will be close to $0.4M for the Government of Quebec and $0.3M for the Government of Canada. Parafiscal contributions from employees and employers are estimated at close to $0.6M for Quebec and more than $0.1M for Canada.

TABLE 6

Economic impact of all major core zone projects over a ten-year period for Quebec (in FTE and $K)

	Direct	Indirect	Total
Jobs (FTE)	38.3	39.0	77.3
GDP	$3,886.2	$2,727.0	$6,613.2
Provincial income tax	$270.5	$422.1	$6,92.7
Provincial parafiscal charges	$270.4	$267.0	$537.4
Federal income tax	$195.7	$249.3	$445.0
Federal parafiscal charges	$59.7	$61.4	$121.1

SOURCES : StatsCan, *Table 36-10-0113-01 Input-output multipliers, provincial and territorial, summary level*; StatsCan, Table 14-10-0064-01 *Employee wages by industry, annual*; Marc-André Gauthier, *L'amortissement hypothécaire au Québec — Données sociodémographiques en bref*, ISQ, February 2016, vol. 20, no 2, p. 14, online, bdso.gouv.qc.ca/docs-ken/multimedia/ PB01614FR_dembref2016T01F00.pdf; ISQ, *Impact économique pour le Québec d'une tranche de 100 M$ de dépenses courantes des ménages au Québec*, 2021, Data compiled and processed by IRIS.

TABLE 7

Total economic impact of the MMIDSR core zone over a ten-year period for Quebec (in FTE and $M)

	Direct	Indirect	Total
Jobs (FTE)	568.1	104.7	672.8
GDP	$34.59	$10.11	$44.70
Provincial income tax	$4.17	$1.01	$5.19
Provincial parafiscal charges	$4.98	$0.76	$5.74
Federal income tax	$2.98	$0.58	$3.56
Federal parafiscal charges	$0.87	$0.14	$1.01

SOURCES : Cross-sector ISQ model, Table, 20180430-1-1-2014G-2018H (2017G); StatsCan, *Table 36-10-0113-01 Input-output multipliers, provincial and territorial, summary level*; StatsCan, *Table 14-10-0064-01 Employee wages by industry, annual*; Marc-André Gauthier, *L'amortissement hypothécaire au Québec — Données sociodémographiques en bref*, ISQ, February 2016, vol. 20, no 2, p. 14, online, bdso.gouv.qc.ca/docs-ken/multimedia/ PB01614FR_dembref2016T01F00.pdf; ISQ, *Impact économique pour le Québec d'une tranche de 100 M$ de dépenses courantes des ménages au Québec*, 2021, Data compiled and processed by IRIS.

2.2 Zones 1, 2, and 3 of the MMIDSR

The methodology described earlier in this paper allows us to estimate the average yearly economic impact of dark-sky tourism in Le Haut-Saint-François RCM, Le Granit RCM and the city of Sherbrooke, including the impact of the BU observatory. Table 9 presents the results of our calculations.

Tourism in MMIDSR zones 1, 2 and 3, combined with spending by the BU observatory, creates on average 37.8 direct and 10.9 indirect jobs, for a total of 48.7 jobs.

The impact on GDP can be estimated at close to $9M ($5.7M direct and $3.2M indirect). Direct and indirect taxation will net the Government of Quebec close to $0.3M and the Government of Canada close to $0.2M. Parafiscal contributions by employees and employers are estimated at close to $0.3M for Quebec and close to $0.1M for Canada.

We also assessed these impacts over a ten-year period, as shown in Table 10. Over a decade, approximately 377.5 direct and 109.1 indirect jobs will be created, for a total of 486.6 jobs.

The GDP impact is estimated at $89.8M ($57.5M direct and $32.3 M indirect). The Government of Quebec will collect close to $2.8M in income and other taxes and the Government of Canada close to $1.7M. Employee and employer parafiscal contributions are estimated at close to $3M for Quebec and close to $0.7M for Canada.

TABLE 8

Average annual economic impact attributable to the dark-sky reserve in the MMIDSR core zone (in FTE and $K)

	Direct	Indirect	Total
Jobs (FTE)	56.8	10.5	67.3
GDP	$3,459.20	$1,010.80	$4,469.99
Provincial income tax	$417.40	$101.48	$518.83
Provincial parafiscal charges	$498.20	$76.00	$574.18
Federal income tax	$297.80	$57.72	$355.56
Federal parafiscal charges	$87.20	$13.98 $	$101.17

SOURCES : Cross-sector ISQ model, *Table, 20180430-1-1-2014G-2018H (2017G)*; StatsCan, *Table 36-10-0113-01 Input-output multipliers, provincial and territorial, summary level*; StatsCan, *Table 14-10-0064-01 Employee wages by industry, annual*; Marc-André Gauthier, *L'amortissement hypothécaire au Québec — Données sociodémographiques en bref*, ISQ, February 2016, vol. 20, no 2, p. 14, online, bdso.gouv.qc.ca/docs-ken/multimedia/ PB01614FR_dembref2016T01F00.pdf; ISQ, *Impact économique pour le Québec d'une tranche de 100 M$ de dépenses courantes des ménages au Québec*, 2021, Data compiled and processed by IRIS.

TABLE 9

Average yearly economic impact of MMIDSR zones 1, 2 and 3 (in FTE and $K)

	Direct	Indirect	Total
Jobs (FTE)	37.8	10.9	48.7
GDP	$5,748	$3,235	$8,983
Provincial income tax	$221	$57	$278
Provincial parafiscal charges	$180	$114	$293
Federal income tax	$125	$49	$174
Federal parafiscal charges	$43	$24	$67

SOURCES : Cross-sector ISQ model, *Table, 20180430-1-1-2014G-2018H (2017G)*; *StatsCan, Table 36-10-0113-01 Input-output multipliers, provincial and territorial, summary level*; StatsCan, Table 14-10-0064-01 *Employee wages by industry, annual*; Marc-André Gauthier, *L'amortissement hypothécaire au Québec — Données sociodémographiques en bref*, ISQ, February 2016, vol. 20, no 2, p. 14, online, bdso.gouv.qc.ca/docs-ken/multimedia/ PB01614FR_dembref2016T01F00.pdf; ISQ, *Impact économique pour le Québec d'une tranche de 100 M$ de dépenses courantes des ménages au Québec*, 2021; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC Haut- Saint-François*, 1 p. for years 2008 to 2017; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC du Granit*, 1 p. for years 2008 to 2017; Raymond Chabot Grant Thornton, *Analyse de l'impact économique du Tourisme à Sherbrooke*, May 2019, 64 p., online destinationsherbrooke.com/Fichiers/34095b0c-94e4-e511-80d6-00155d00750b/Sites/8d44bd82-e200-e611-80d9-00155d00750b/Documents/rapport-impacttourismesherbrooke.pdf, Data compiled and processed by IRIS.

2.3 Total economic impact of the MMIDSR

We used our calculation of the economic benefits in the core zone of the MMIDSR and zones 1, 2 and 3 to assess the total economic impact of the dark-sky reserve.

Table 11 presents the yearly average of the results.

It can be estimated that all dark-sky activity in the MMIDSR creates or maintains 94.6 direct and 21.7 indirect jobs, for a total of 116.2 jobs annually.

The impact on GDP is close to $13.8 M ($9.5M direct and $4.2M indirect). The Government of Quebec is expected to bring in close to $0.8M from income and other taxes and the Government of Canada more than $0.5 M. The employee and employer parafiscal contributions are estimated at around $0.9M for Quebec and around $0.2 M for Canada.

Table 12 shows the total impact of these activities over a decade. This table also shows that over 10 years, the total combined economic activities related to the dark-sky reserve in the MMIDSR are expected create or maintain the equivalent of 945.6 direct jobs and 216.8 indirect jobs for a total of 1,162.4 jobs.

It bears reminding that this measurement takes into account the entirety of the activities of the PNMM, OMM, iREx, along with construction projects in the

TABLE 10

Economic impact of MMIDSR zones 1, 2 and 3 over a ten-year period (in FTE and $M)

	Direct	Indirect	Total
Jobs (FTE)	377.5	109.1	486.6
GDP	$57.5	$32.3	$89.8
Provincial income tax	$2.2	$0.6	$2.8
Provincial parafiscal charges	$1.8	$1.1	$2.9
Federal income tax	$1.3	$0.5	$1.7
Federal parafiscal charges	$0.4	$0.2	$0.7

SOURCES : Cross-sector ISQ model, *Table, 20180430-1-1-2014G-2018H (2017G)*; StatsCan, *Table 36-10-0113-01 Input-output multipliers, provincial and territorial, summary level*; StatsCan, Table 14-10-0064-01 *Employee wages by industry, annual*; Marc-André Gauthier, *L'amortissement hypothécaire au Québec — Données sociodémographiques en bref*, ISQ, February 2016, vol. 20, no 2, p. 14, online, bdso.gouv.qc.ca/docs-ken/multimedia/PB01614FR_dembref2016T01F00.pdf; ISQ, *Impact économique pour le Québec d'une tranche de 100 M$ de dépenses courantes des ménages au Québec*, 2021; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC Haut- Saint-François*, 1 p. for years 2008 to 2017; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC du Granit*, 1 p. for years 2008 to 2017; Raymond Chabot Grant Thornton, *Analyse de l'impact économique du Tourisme à Sherbrooke*, May 2019, 64 p., online destinationsherbrooke.com/Fichiers/34095b0c-94e4-e511-80d6-00155d00750b/Sites/8d44bd82-e200-e611-80d9-00155d00750b/Documents/rapport-impacttourismesherbrooke.pdf, Data compiled and processed by IRIS.

TABLE 11

Annual total of the average yearly economic impact of dark-sky-related activities in the MMIDSR (in FTE and $K)

	Direct	Indirect	Total
Jobs (FTE)	94.6	21.7	116.2
GDP	$9,553.1	$4,245.3	$13,798.4
Provincial income tax	$638.0	$158.8	$796.8
Provincial parafiscal charges	$677.7	$189.7	$867.4
Federal income tax	$423.0	$106.3	$529.3
Federal parafiscal charges	$130.2	$38.3	$168.5

SOURCES : Cross-sector ISQ model, *Table, 20180430-1-1-2014G-2018H (2017G)*; StatsCan, *Table 36-10-0113-01 Input-output multipliers, provincial and territorial, summary level*; StatsCan, Table 14-10-0064-01 *Employee wages by industry, annual*; Marc-André Gauthier, *L'amortissement hypothécaire au Québec — Données sociodémographiques en bref*, ISQ, February 2016, vol. 20, no 2, p. 14, online, bdso.gouv.qc.ca/docs-ken/multimedia/PB01614FR_dembref2016T01F00.pdf; ISQ, *Impact économique pour le Québec d'une tranche de 100 M$ de dépenses courantes des ménages au Québec*, 2021; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC Haut- Saint-François*, 1 p. for years 2008 to 2017; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC du Granit*, 1 p. for years 2008 to 2017; Raymond Chabot Grant Thornton, *Analyse de l'impact économique du Tourisme à Sherbrooke*, May 2019, 64 p., online destinationsherbrooke.com/Fichiers/34095b0c-94e4-e511-80d6-00155d00750b/Sites/8d44bd82-e200-e611-80d9-00155d00750b/Documents/rapport-impacttourismesherbrooke.pdf, Data compiled and processed by IRIS.

core zone, tourism activity and BU observatory operations.

We can estimate that, for the ten-year period, the impact on GDP will be close to $138M ($95.5M direct and $42.5M indirect). Overall, direct and indirect taxes should yield the Government of Quebec close to $8.7M and the Government of Canada close to $5.3M. Parafiscal contributions by employees and employers should reach approximately $8.7M for Quebec and $1.7M for Canada.

TABLE 12

Ten-year total of the economic impact of dark-sky-related activities in the MMIDSR (in FTE and $M)

	Directs	Indirects	Total
Jobs (FTE)	945.6	216.8	1,162.4
GDP	$95.5	$42.5	$138.0
Provincial income tax	$6.4	$1.6	$8.0
Provincial parafiscal charges	$6.8	$1.9	$8.7
Federal income tax	$4.2	$1.1	$5.3
Federal parafiscal charges	$1.3	$0.4	$1.7

SOURCES : Cross-sector ISQ model, *Table, 20180430-1-1-2014G-2018H (2017G)*; StatsCan, *Table 36-10-0113-01 Input-output multipliers, provincial and territorial, summary level*; StatsCan, Table 14-10-0064-01 *Employee wages by industry, annual*; Marc-André Gauthier, *L'amortissement hypothécaire au Québec — Données sociodémographiques en bref*, ISQ, February 2016, vol. 20, no 2, p. 14, online, bdso.gouv.qc.ca/docs-ken/multimedia/PB01614FR_dembref2016T01F00.pdf; ISQ, *Impact économique pour le Québec d'une tranche de 100 M$ de dépenses courantes des ménages au Québec*, 2021; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC Haut- Saint-François*, 1 p. for years 2008 to 2017; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC du Granit*, 1 p. for years 2008 to 2017; Raymond Chabot Grant Thornton, *Analyse de l'impact économique du Tourisme à Sherbrooke*, May 2019, 64 p., online destinationsherbrooke.com/Fichiers/34095b0c-94e4-e511-80d6-00155d00750b/Sites/8d44bd82-e200-e611-80d9-00155d00750b/Documents/rapport-impacttourismesherbrooke.pdf, Data compiled and processed by IRIS.

2.4 Other impacts associated with the MMIDSR

It should be noted that many other positive impacts are associated with dark-sky preservation efforts in the MMIDSR. Ready access to nature and an exceptional living environment for residents are significant boons on their own. Two other crucial impacts of a high-quality starry sky are without a doubt scientific progress and dissemination of knowledge. Based on our research and interviews, we would like to note the following elements that in themselves create qualitative added value for the region's reputation and the dissemination of scientific knowledge across Quebec:

- More than 25,000 tourist visits to the ASTROLab each year
- More than 3,000 student visits to the PNMM each year
- More than 400 scientific articles published in respected journals since 2014
- More than 2,100 conferences held in schools and libraries since 2018, in person or online
- More than 90 public talks on exoplanets and the night sky given since 2018
- Nearly 100 basic astronomy talks given in schools and libraries since 2018
- Close to 50 TV interviews since 2018
- Close to 100 radio interviews since 2018
- More than 100 media articles written
- 10 events held each year by the Club des astronomes amateurs de Sherbrooke

The dark sky is only a minor draw for tourists visiting Sherbrooke, despite the city's international reputation for its leadership in eco-lighting best practices. However, there is every reason to believe that the Oasis de Ciel étoilé project and the numerous projects led by the MMIDSR team in Sherbrooke will result in the growth and notoriety of dark-sky tourism in coming years. The Oasis de Ciel étoilé project, in particular, is currently in the process of being certified as an Urban Night Sky Place by the International Dark Sky Association (the MMIDSR's certifying body) and could eventually become a tourist destination on its own. As a result, it is still too early to estimate tourism numbers or to expect significant investments in the development of this project. Astrotourism, a sector as yet modestly developed in Sherbrooke, and ongoing projects have significant potential to boost the economic impact of the MMIDSR's dark sky in the near future and, in so doing, consolidate the region's reputation as the astronomical hub of Quebec.

CONCLUSION

Calculating the economic impact of activities, spending and investments related to the dark sky over the MMIDSR offers valuable insight into the significance of the Reserve for the local economy.

As calculated, the MMIDSR maintains on average more than 116 positions (FTE) and has an impact on GDP of close to $14M, distributed between the core zone, Le Haut-Saint-François RCM, Le Granit RCM and the city of Sherbrooke, which translates into a non-negligible fiscal contribution to Quebec and Canada. Recall that we chose to be conservative in our calculations, such as by excluding chalet and Airbnb rental data and other tourism categories within the RCMs and city of Sherbrooke. Even so, this report undeniably shows that tourist activities in the MMIDSR are a major driver of tourism in the region and that the ongoing preservation of the protected area has clear economic benefits. In addition, the existence of the Reserve promotes stargazing outside its borders, and other RCMs also enjoy economic benefits thanks to the Reserve. It is also important to consider that there are countless other benefits to quality of life that we will not go into here. That being said, from our interviews, we cannot overlook the MMIDSR's contribution to the progress of astronomy, as demonstrated, for example, by the more than 400 scientific articles published since 2014 by the OMM, iREx, PNMM, BU observatory and others.

Since 2007, the region has made a concerted effort to apply best practices in lighting to enable scientific research at the OMM, preserve the nocturnal environment, improve residents' quality of life and promote dark-sky tourism. Planned investments in one-time projects and the addition of new recurring investments will help bolster the MMIDSR's contribution to the local tourism economy and preserve this unique territory and the economic benefits provided by the beauty of the night for future generations.

End notes

1 Statistics Canada, Table 36-10-0113-01 *Input-output multipliers, provincial and territorial, summary level.*

2 We used the following tables: Statistics Canada, Table 14-10-0064-01 *Employee wages by industry, annual*; Marc-André Gauthier, *L'amortissement hypothécaire au Québec — Données sociodémographiques en bref*, ISQ, February 2016, vol. 20, no 2, p. 14, online, bdso.gouv.qc.ca/docs-ken/multimedia/PB01614FR_dembref2016T01F00.pdf; ISQ, *Impact économique pour le Québec d'une tranche de 100 M$ de dépenses courantes des ménages au Québec*, 2021.

3 David Mitchell & Terrel Gallaway, "Dark sky tourism : economic impacts on the Colorado Plateau Economy, USA", Tourism Review, vol. 74 , no. 4, 2019 p. 930-942, online, bearworks.missouristate.edu/cgi/viewcontent.cgi?article=1007&context=articles-chpa.

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5 Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC Haut-St-François*, 1 p. for years 2008 to 2017; Tourism Eastern Townships, *Synthèse des recettes touristiques totales : MRC du Granit*, 1 p. for years 2008 to 2017.

6 Raymond Chabot Grant Thornton, *Analyse de l'impact économique du Tourisme à Sherbrooke*, May 2019, 64 p., online, www.destinationsherbrooke.com/Fichiers/34095b0c-94e4-e511-80d6-00155d00750b/Sites/8d44bd82-e200-e611-80d9-00155d00750b/Documents/rapport-impacttourismesherbrooke.pdf.

7 *Ibid., p. 38.*

8 *Le tourisme au Québec en bref-2017*, updated August 12, 2020, online, www.quebec.ca/tourisme-et-loisirs/services-industrie-touristique/etudes-statistiques/faits-saillants-tourisme-quebec/tourisme-en-bref-2017, page visited August 4, 2020, calculations by the authors.

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