
WORLD HERITAGE NOMINATION – IUCN TECHNICAL EVALUATION

THE JOGGINS FOSSIL CLIFFS (CANADA) – ID No. 1285

1. DOCUMENTATION

- i) **Date nomination received by IUCN:** April 2007
- ii) **Additional information officially requested from and provided by the State Party:** IUCN requested supplementary information on 14 November 2007 after the field visit. The State Party response was officially received by the World Heritage Centre on 31 January 2008.
- iii) **UNEP-WCMC Data Sheet:** 21 references (including nomination)
- iv) **Additional literature consulted:** Dingwall, P., Weighell, T. and Badman, T. (2005) **Geological World Heritage: A Global Framework Strategy**. IUCN, Gland, Switzerland, 51 p.; Gradstein, F.M., Ogg, J.G. and Smith, A.G. (2005) **A Geological Time Scale 2004**. Cambridge University Press; Hook, R.W. and Ferm, J.C. (1988) **Paleoenvironmental controls on vertebrate-bearing abandoned channels in the Upper Carboniferous**. *Palaeogeography, Palaeoclimatology and Palaeoecology*, 63: 159-181; Paton, R.L., Smithson, T.R. and Clack, J.A. (1999) **An amniote-like skeleton from the Early Carboniferous of Scotland**. *Nature*, 398: 508-513; Wells, R.T. (1996) **Earth's Geological History: A Contextual Framework for Assessment of World Heritage Fossil Site Nominations**. IUCN, Gland, Switzerland.
- v) **Consultations:** 10 external reviews. Extensive consultations were undertaken during the field visit with representatives of the State Party; federal, provincial, and municipal county government officials; regional and local authorities; scientists; museums; and the local community.
- vi) **Field visit:** Tim Badman and Wesley Hill, October 2007
- vii) **Date of IUCN approval of this report:** April 2008

2. SUMMARY OF NATURAL VALUES

The nominated property, the Joggins Fossil Cliffs, is located in the northwest of the Province of Nova Scotia, Canada on the eastern shores of the Cumberland Basin of Chignecto Bay, the most northerly arm of the Bay of Fundy. The property comprises 689 ha and is a 14.7 km stretch of sea cliffs, low bluffs, wave-cut platforms and beach. Its northern point is Downing Cove and its southern point is Ragged Reef Point.

The cliffs of the nominated property expose rocks from the Carboniferous period, or "Coal Age", one of the principal divisions of the geological record (354 to 290 million years ago). The term "Carboniferous" was established in relation to the rich deposits of coal from this period in the United Kingdom, and which are also found throughout northern Europe, Asia, and Midwestern and eastern North America. The period has been separated into the Mississippian (Lower Carboniferous) and the Pennsylvanian (Upper Carboniferous) in the United States. In addition to having the ideal conditions for the beginnings of coal, several major biological, geological, and climatic

events occurred during the Carboniferous. One of the greatest evolutionary innovations of the Carboniferous was the amniote egg, which allowed for life on land by the vertebrates (amniotes being the vertebrate group including the mammals, reptiles, dinosaurs and birds). The first amniotes, which resembled small lizards, evolved 340 million years ago. Their eggs could survive out of the water, allowing amniotes to branch out into drier environments. The eggs could also "breathe" and cope with waste, allowing the eggs and the amniotes themselves to evolve into larger forms. The amniotes spread across the globe and were virtually the only land vertebrates at this time.

The rocks of the nominated property are considered to be iconic for this period of Earth's history and are the world's thickest and most comprehensive record of Pennsylvanian coal-bearing strata (318 to 303 million years ago) with the most complete known fossil record of terrestrial life from that time in existence. This includes the remains and tracks of very early animals and the rainforest in which they lived, revealed *in situ*, in an undisturbed geological context, and intact. The cliffs have been mined in the

past for a low grade coal which occurs in thin seams associated with bivalve-bearing limestone and black shale. Some historic fossil extraction was also carried out using mining techniques, but the lower cliff faces are renewed by erosion from the 16.8 m tides of the Bay of Fundy, the highest tides in the world.

The nominated property displays a 15 million year succession of sedimentary layers in the Pennsylvanian Cumberland Group. The 915.5 m thick, 2.8 km long 'Classic Section' of the Joggins Formation, with thin coal-bearing seams of varying thickness, is shown between the younger Springhill Mines and Ragged Reef Formations originally deposited above it (now to its south), and the red beds of the Little River and Boss Point Formations below it (to its north), all tilted at an angle of 21° from the horizontal and running back inland many kilometres.

The exposed fossil assemblages form a remarkable paleoecological archive of a coastal forest of 310 million years ago, where the fossils remain *in situ*, grouped in a combination of three neighbouring ecosystems: estuarine bay, floodplain rainforest and fire-prone forested alluvial plain with freshwater pools. The seams contain the upright fossilized trunks of trees up to 7.6 m high. Within this area, 195 fossil species have been discovered, composed of rainforest and seasonally dry land vegetation, with its vertebrate and invertebrate inhabitants, both terrestrial and aquatic. Evidence of the entire food chain of a primeval terrestrial ecosystem is present. The sea was brackish, populated by an extensive aquatic fauna of annelid shells, bivalves, crustaceans, horseshoe crab-like forms, sharks, ray-like fishes and several species of bony fish.

In 1852, Charles Lyell and William Dawson found the first tetrapod (four-limbed) amphibian and land snails trapped within a buried hollow *Lepidodendrid* tree stump. They were named respectively *Dendropeton acadianum* and *Dendropupa vetusta*. These discoveries, incorporated into the theories of Charles Darwin, led to acclaim for the Joggins Cliffs as the Galápagos of the "Coal Age". In 1859, William Dawson discovered the earliest known reptile, *Hylonomus lyelli*, the ancestor of lizards, dinosaurs and birds, and in 1882, he discovered 25 fossil trees with over two hundred tetrapods of five taxa and more reptiles. Many skeleton remains were found grouped in hollow tree stump-pits. Remains were also found in waterholes in the seasonally dry alluvial plains. Of 66 species of terrestrial fauna, over half are type specimens first or only found at Joggins. 19 of these are amphibian and reptile tetrapods, including the earliest known reptile, and the earliest amniote known.

In total, 96 genera and 148 species of fossils plus 20 footprint groups (ichnogenera) have been found at Joggins, forming the most comprehensive assemblage known of the fossil life of three distinct

paleoecosystems. Reinterpretations of this ancient environment will continue as long as the tides continue to uncover new evidence. Over 900 books and scientific papers have been produced on the property.

In addition, the nominated property has interesting cultural values of national and provincial significance. Its name comes from Mi'kmaq Indian word for a 'place of fish weirs'. Coal was mined in the 17th and 18th centuries by the first French colonists and continued in the Joggins Formation (beside and underlying Joggins village) intermittently from 1847 on, some galleries running underwater into the bay. The gritstone of Boss Point was used for a successful grindstone business in the 19th century. The village of Joggins immediately above the cliffs has always been dependent on coal mining, which ended there only in 1961, leading to local economic decline. Company men and local enthusiasts had long assisted geologists by reporting and saving palaeontological finds and the community remains dedicated to stewardship of the cliffs and uses the area for recreation.

3. COMPARISONS WITH OTHER AREAS

The nomination's comprehensive comparative analysis makes a convincing case for World Heritage listing. It compares Joggins to nine globally significant and comparable "Coal Age" fossil sites, which were selected from a global set of sites based on the quality of their fossil record, using benchmarks derived from IUCN's evaluation of fossil sites. Joggins ranks first in seven of twelve benchmarks and first among the short-listed sites, followed by Sydney (also in Nova Scotia, Canada) and Freeport (Illinois, USA). The analysis identifies the nominated property as the most outstanding example in the world of the "Coal Age" and its terrestrial fauna, notably the earliest amniotes. Additional analysis carried out by the State Party confirms Joggins' status as the most significant known site for evidence of the earliest terrestrial amniotes and early tetrapod evolution. As for all fossil sites, other reference localities exist which contribute elements of the global story not evidenced in the nominated property; however, the comparative analysis makes a compelling case that Joggins best represents the fossil values of the "Coal Age".

The comparative analysis within the nomination also makes thorough reference to the IUCN thematic study on fossil sites and demonstrates that the property meets all of the principles outlined in that study. These include the iconic importance of the property in representing the evolution of the amniote egg and the subsequent ability of vertebrates to colonise the terrestrial world, including the eventual evolution of human life on Earth. A further iconic value is the most complete representation of the "Coal Age" world, and the ecosystems that resulted in vast coal

deposits, whose exploitation in the industrial age has been a major factor in human development as well as having continued resonance through atmospheric pollution and climate change. Additional comparative analysis also notes the significance of the tetrapod footprint record at Joggins which is regarded as the single most extensive known assemblage. IUCN has also evaluated the nominated property against the standard set of ten questions that has been used as the basis for assessing the values of fossil sites since 1996 (see Annex A).

In summary IUCN concludes that:

1) The values of the “Coal Age” represented by Joggins are of Outstanding Universal Value, notably in relation to the iconic values of the evolution of the amniote egg, the early evolution of tetrapods, and the worldwide distribution of vast coal-forming forests.

2) Joggins has the strongest claim to display these values. It has values that equal or exceed values of fossil sites already included on the World Heritage List. It is also superlative in the breadth of values displayed.

IUCN notes these values are complemented by the historic importance of Joggins to the development of seminal geological and evolutionary principles, including as a key site for the work of Charles Lyell and Charles Darwin. This adds further to the compelling case for inscription of Joggins on the World Heritage List.

4. INTEGRITY

4.1 Legal status

The nominated property has protected status under a range of overlapping provincial and municipal laws. It is protected through convergent legislation that includes protective designations, mineral exploration closures, land-use planning and zoning. These include the Provincial Special Places Protection Act, Beaches Act, Minerals Act and the land-use planning and zoning by laws of the Municipality of Cumberland. Some of the legislation appears a little cumbersome in application, and this point is discussed further below. However, the legal status of the property meets the requirements of the Operational Guidelines.

4.2 Boundaries

The property has clearly defined and well thought through boundaries, which are supported by clear maps. The landward and seaward boundaries are tied to the natural processes that maintain the values of the property. The landward boundary is the top of the cliff-face, and in areas where cliffs are not present, the boundary is the most landward point at the back of

the beach. The seaward boundary is 500 m parallel to the top of the cliff or back of the beach. This includes the beach and intertidal area where bedrock “reefs” with embedded fossils extend from the cliffs. The boundary migrates landward with erosion of the cliff-face to accommodate the natural processes of coastal evolution.

The northern boundary at Downing Cove and southern boundary at Ragged Reef Point are defined by prominent coastal landforms. The lateral boundaries are clear and include the whole of the Classic Section with significant older and younger succession that provides context. The boundaries are geologically coherent and justifiable, to the north they include the boundary between the Pennsylvanian and older Mississippian rocks. To the south they include the boundary governed by the structural geology, stopping at a point where the beds begin to dip shallowly so there is little additional geological value added to the section by the rocks beyond Ragged Reef point.

The property is protected by a 20-30 m wide buffer zone landward of the entire length of the property. The buffer zone is relatively narrow, but sufficient to control coastal development which could otherwise threaten the values of the property for at least two generations. The buffer zone is therefore considered adequate. IUCN considers that it would be of benefit to the property for the buffer zones to be extended further, most notably in order to ensure that inappropriate development does not take place.

4.3 Management

Management and conservation of the nominated property is implemented locally through the Joggins Fossil Institute (JFI). The JFI is a registered not-for-profit society and physically located in a newly built Joggins Fossil Centre which will be the science and visitor education centre for the property. The JFI has the principal role of establishing on-site policy and coordinating management for the property. It is governed by an Advisory Board of Directors and advised by a Scientific Advisory Committee, which provides important relationships with scientists from the Nova Scotia Department for Natural Resources, and museum curators from both the Nova Scotia Museum and Fundy Geological Museum, who provide expert support to the work of the JFI.

The JFI provides a strong model of cooperative and community based management for a natural site and has significant political commitment at all levels, including long-term financial commitments to the organisation. The JFI is a relatively new organisation and is still developing. Governance is currently complex, reflecting the range of partners committed to the project, and initially will have a strong connection to the Cumberland Regional Economic Development Association (CREDA). The additional information

provided by the State Party notes a number of key initiatives and activities to consolidate the JFI including the development of a human resources policy and training programme 2008-2012, and the development and implementation of an enhanced financial management system and a long-term fundraising programme. The implementation of these initiatives will consolidate the JFI as an independent and effective organisation in the long term.

Local support for the World Heritage nomination is overwhelmingly positive. This is the result of eight years of investment in engaging the community in the development of the World Heritage nomination. In addition to the protection of the globally significant geological values, World Heritage status is seen as a positive tool for education and community development, providing new economic opportunities for communities which previously relied on coal mining. The JFI and its partners have developed a thorough community involvement and leadership process which is a model for other World Heritage nominations.

The Joggins Fossil Cliffs Management Plan has been developed by the JFI in partnership with government agencies and the local community, and sets out an operating and protection plan, including visitor management, education, visiting scientist, and fossil monitoring programmes. The management system for the property is clearly documented in the nomination.

The key protective measures are operated at provincial level, but can only be effectively implemented through locally based management. An agreement has empowered the JFI to take necessary measures to implement the Beaches Act. A parallel agreement is under discussion to enhance the role of the JFI in implementing the Special Places Protection Act (SPPA) including issuing Heritage Research Permits. This is very important as this is the primary means of regulating/managing the collection and study of the fossils on the site. IUCN considers that the present arrangements for implementing the SPPA could be significantly improved through the conclusion of this agreement as it is highly unlikely that a system based on centrally operated permits, issued from the provincial capital in Halifax (a significant distance from the site), will be sufficiently responsive to management needs.

Almost all (95%) of the property is owned by the Crown (Government of Nova Scotia) from the mean high-water mark seaward to the mean low-water mark. Property landward of the mean high-water mark is owned by those who hold title to land adjacent to the shoreline and is mostly privately owned, except for three large areas that are owned by the Province of Nova Scotia and an additional parcel owned by the Municipality of the County of Cumberland. The JFI and Joggins Fossil Centre are adjacent to the nominated property

and built on land also owned by this Municipality. The involvement of local landowners is therefore a critical dimension to site management, especially in relation to research on *in situ* fossils in the cliffs. Engagement and partnership with local landowners therefore has a very significant priority within the work of the JFI, and includes representation of landowners on the JFI board of directors.

The JFI has a key role in the management of visitors to the property. This is facilitated by the limited access points to the property and the new Joggins Fossil Centre. The Centre is a sensitively designed building with a strong consideration for sustainable building techniques and creative interpretive design. It meets the highest international standards. Such investment is noted by IUCN as particularly important for fossil sites as the values of such properties are not immediately apparent to visitors unless explained. Creation and maintenance of beach access from the Centre is a key issue and requires a sensitively designed solution and ongoing maintenance. The investment in infrastructure is complemented by interpreters who provide first hand communication to visitors on the values of Joggins and on visitor safety.

4.4 Threats and human use

The nominated property comprises an area of an actively eroding sea cliff that is largely inappropriate for development and is legally protected under several provincial and municipal regulations prohibiting development. The beach itself is not suited for any type of development due to the extreme tidal behaviour. Several private residences and properties border the 20 m buffer zone, including one residence inside the buffer zone that is likely to be abandoned and removed at some time in the next 100 years. Whilst potential threats exist from the construction of coastal protection measures to protect private property, this is well regulated by several levels of overlapping legislation, notably at the provincial level through the provisions of the Special Places Protection Act and at the municipal level by the Cliffs and Shoreline Setbacks and the Prohibited Uses and Structures legislation.

The extensive coal mining history of the nominated property has left virtually no economic coal resources intact and does not contain a suitable grade for mining. In addition, there is a "closure" order on mineral rights for the property, reducing the likelihood of further exploitation essentially to zero.

The most significant potential impact on the values of the property is the removal of important fossils, and this threat may be exacerbated by the current legislation which is considered by a number of reviewers to be cumbersome in its blanket protection for both important and common fossils. Reviewers also note the important role played by local people in

the collection of fossils, noting that some of the most important collections, and talented researchers, have come from the local community nearby to Joggins.

The on-site signage is in need of upgrading at the access points to inform the visiting public of fossil collecting restrictions and regulations. Very few individuals possess a Heritage Research Permit for research collecting and public visitation to the site is currently happening virtually unmonitored for collecting. This issue should be addressed through future increased staffing and roving JFI “beach monitors” that will make public contact on a daily basis. The JFI has a clear philosophy regarding the development of their role and policies for fossil collection and this will be an interesting challenge in the establishment phase of JFI and its ongoing role. IUCN considers that this aspect of site management will make a particularly interesting case study of the effectiveness of fossil site management, with the combination of a relatively unknown site, restricted access and strong scientific and management capacity enabling new management techniques to be developed. It will be important that the provincial legislation is managed in a way that empowers JFI to do this, and IUCN encourages the State Party to publicise lessons from the management of fossil collection activities within the property.

IUCN considers the limited threats to the nominated property are well managed at present, and the biggest challenge of the property will be to maintain the level of performance and resources required in the future.

In summary IUCN considers that the property meets the necessary conditions of integrity as set out in the Operational Guidelines.

5. APPLICATION OF CRITERIA

The property has been nominated under criterion (viii). IUCN considers that the nominated property meets criterion (viii) based on the following assessment:

Criterion (viii): Earth’s history, geological and geomorphic features and processes

The “grand exposure” of rocks at Joggins Fossil Cliffs contains the best and most complete known fossil record of terrestrial life in the iconic “Coal Age”: the Pennsylvanian (or Carboniferous) period in Earth’s history. The site bears witness to the first reptiles in Earth history, which are the earliest representatives of the amniotes, a group of animals that includes reptiles, dinosaurs, birds, and mammals. Upright fossil trees are preserved at a series of levels in the cliffs together with animal, plant and trace fossils that provide environmental context and enable a complete reconstruction to be made of the extensive fossil forests that dominated land at this time, and are now the source of most of the world’s coal deposits. The

property has played a vital role in the development of seminal geological and evolutionary principles, including through the work of Sir Charles Lyell and Charles Darwin, for which the site has been referred to as the “coal age Galápagos”.

IUCN considers the nominated property meets this criterion.

6. RECOMMENDATIONS AND STATEMENT OF OUTSTANDING UNIVERSAL VALUE

IUCN recommends that the World Heritage Committee adopt the following decision:

The World Heritage Committee,

1. Having examined Documents WHC-08/32.COM/8B and WHC-08/32.COM/INF.8B2,
2. Inscribes The Joggins Fossil Cliffs, Canada, on the World Heritage List on the basis of criterion (viii);
3. Adopts the following Statement of Outstanding Universal Value:

Values

The Joggins Fossil Cliffs have been termed the “coal age Galápagos” and are the world reference site for the “Coal Age”. Their complete and accessible fossil-bearing rock exposures provide the best evidence known of the iconic features of the Pennsylvanian (or Carboniferous) period of Earth History.

Criterion (viii) – Earth’s history, geological and geomorphic features and processes: *The “grand exposure” of rocks at Joggins Fossil Cliffs contains the best and most complete known fossil record of terrestrial life in the iconic “Coal Age”: the Pennsylvanian (or Carboniferous) period in Earth’s history. The site bears witness to the first reptiles in Earth history, which are the earliest representatives of the amniotes, a group of animals that includes reptiles, dinosaurs, birds, and mammals. Upright fossil trees are preserved at a series of levels in the cliffs together with animal, plant and trace fossils that provide environmental context and enable a complete reconstruction to be made of the extensive fossil forests that dominated land at this time, and are now the source of most of the world’s coal deposits. The property has played a vital role in the development of seminal geological and evolutionary principles, including through the work of Sir Charles Lyell and Charles Darwin, for which the site has been referred to as the “coal age Galápagos”.*

Integrity

The boundaries of the property are clearly defined in relation to logical stratigraphic criteria and include all of the areas necessary to fully display the fossil record of Joggins including the cliff face and foreshore rock exposures, and include both the most fossiliferous strata and younger and older rocks that provide geological context. The inland extent of the property is defined based on the eroding top of the cliffs and this is a fully justifiable and logical basis to cope with the dynamic nature of this coastal property. A relatively narrow buffer zone is defined, which is not part of the inscribed property, but is sufficient to control coastal development which could otherwise threaten the values of the property.

Requirements for Protection and Management

The property has effective legal protection and has the strong support of all levels of government, including in relation to the provision of funding. Some aspects of the legislation, such as for the licensing of fossil collection are cumbersome and would benefit from review, although can be better implemented if site managers are empowered to do so. The site is well resourced, including through the provision of a new visitor centre, and is managed in a way that can be considered to set international standards. The effective process of community involvement and partnerships between scientists, museums and economic interests are also noted, and the biggest challenge of the property will be to maintain the level of performance and resources required in the future.

4. *Notes the very high quality of documentation of the nomination and the process of community engagement in its preparation, over a period of almost ten years, as models in the preparation of nominations and in effective management of World Heritage properties;*
5. *Recommends that the State Party widely publicise the results of its monitoring of fossil resources produced by natural erosion and the development of educational and research collecting policies, which could serve as a model for such management elsewhere.*

Annex A: IUCN Checklist for the Evaluation of Fossil Sites

1. Does the site provide fossils which cover an extended period of geological time (i.e. how wide is the geological window)?

The Joggins Fossil Cliffs record a geological window that spans at least 15 million years of earth history, from the late Mississippian Subsystem (Serpukhovian stage) to early Pennsylvanian Subsystem (Bashkirian to Moscovian stages) of the Carboniferous System.
2. Does the site provide specimens of a limited number of species or whole biotic assemblages (i.e. how rich is the site in species diversity)?

The nominated property represents whole biotic assemblages and the trophic system (the food chain) of the iconic “Coal Age” wetland ecosystem. These assemblages include the most diverse terrestrial vertebrate fauna known from any site of the Pennsylvanian Subsystem. Equally well-represented are aquatic vertebrates (fishes) and invertebrates of both the terrestrial and aquatic realms.
3. How unique is the site in yielding fossil specimens for that particular period of geological time (i.e. would this be the type locality for study or are there other similar areas that are alternatives)?

The nominated property is unique in its record of terrestrial life and has long been recognized as the type locality for the terrestrial “Coal Age” world. Joggins is the best locality for the study of fossil life from this time period *in situ* and within its original environmental context. No other site has provided so much knowledge of the evolutionary paths from primitive terrestrial vertebrates to the major groups of terrestrial amniotes.
4. Are there comparable sites elsewhere that contribute to the understanding of the total “story” of that point in time/space (i.e. is a single site nomination sufficient or should a serial nomination be considered)?

Thorough comparative analysis has demonstrated that there are no Pennsylvanian sites of comparable exposure, paleoecological integrity or completeness as the records of the terrestrial “Coal Age” world at Joggins. As for all fossil sites, however, other localities add specific elements of the global story of life and environments for any given time period.
5. Is the site the only or main location where major scientific advances were (or are being) made that have made a substantial contribution to the understanding of life on earth?

Joggins is the most important site where substantial scientific advances have been made with respect to the terrestrial “Coal Age” world, due largely to the exceptional ecological context it provides for the fossils. Joggins played a seminal role in the development of geological and evolutionary principles. No other locality in the world has provided as much knowledge of the nature of early amniotes, or more informative specimens for linking them to more primitive groups of Palaeozoic tetrapods. Joggins continues to be used as a case study for emerging fields of evolutionary science.
6. What are the prospects for on-going discoveries at the site?

Ongoing discovery at Joggins is a proven certainty and a matter of historic record spanning over 150 years of site investigation. Unlike many other fossil sites, which are of a restricted area (finite sites) or degraded due to weathering (integrity sites), the nominated property will continue to yield new discoveries frequently and on an ongoing basis.
7. How international is the level of interest in the site?

Since it first appeared in the seminal works of Lyell, Darwin and others in the mid-19th century, the unique fossil heritage at Joggins has continued to be of highest international significance. The rich publication record in international journals and by international authors continues to grow, and major research projects are currently in progress. Fossil specimens from the nominated property reside in collections of the world's leading museums and universities.
8. Are there other features of natural values (e.g. scenery, landform, vegetation) associated with the site (i.e. does there exist in the adjacent area modern geological or biological processes that relate to the fossil resource)?

The nominated property comprises a dramatic cliffed shoreline located on the Bay of Fundy. The coast experiences tides that are the highest in the world and result in a large intertidal area being exposed twice a day. The interaction of nature with man in the form of past gritstone production and coal mining is a further interest.

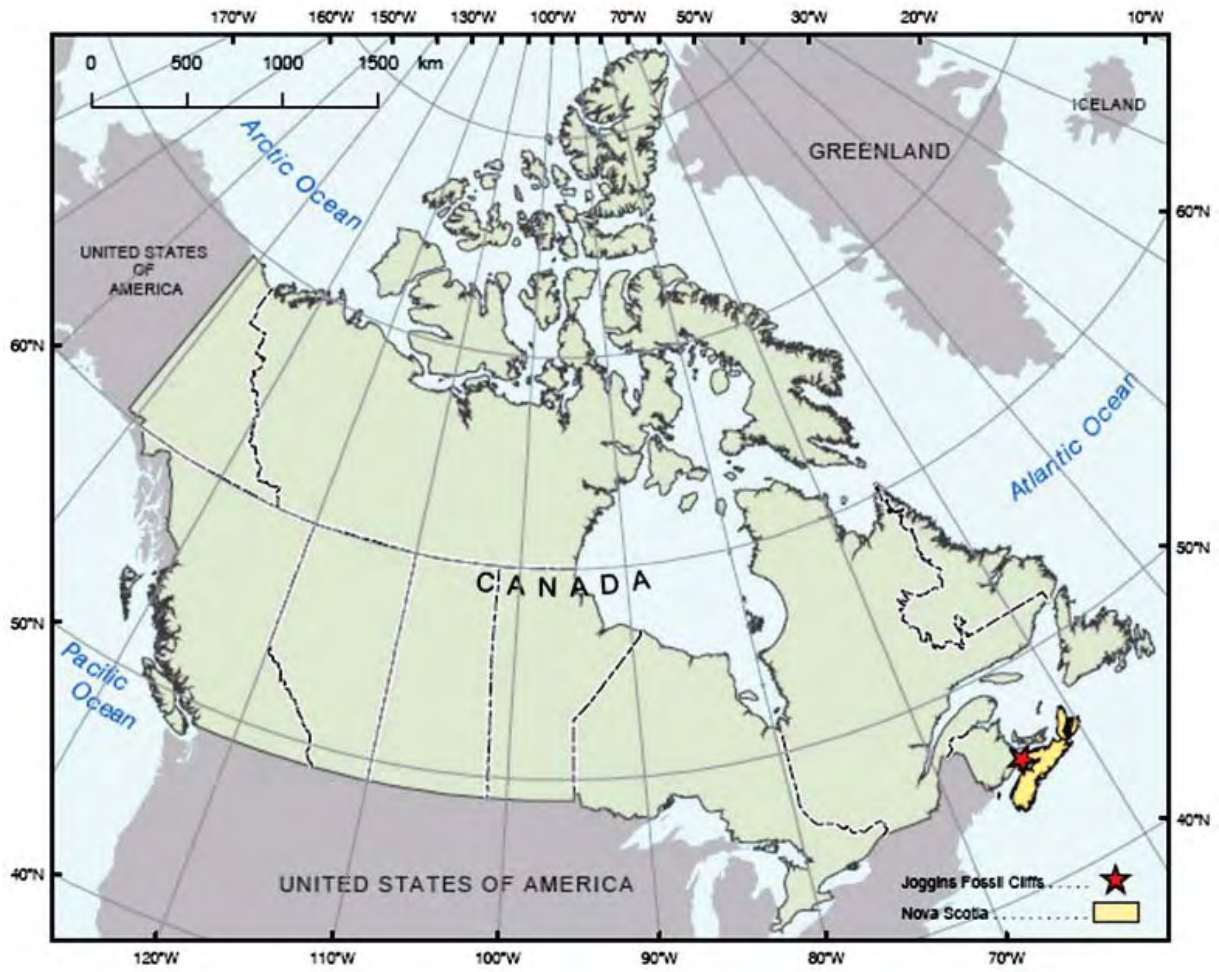
9. What is the state of preservation of specimens yielded from the site?

The state of preservation of the fossils is excellent and preserves *in situ* plants including casts of entire tree trunks up to seven metres in length, cellular structures, and animals ranging from disassembled but complete tetrapod skeletons to fossils completely articulated in three dimensions. Preservation reflects a wide spectrum of environmental conditions that exist in terrestrial ecosystems.

10. Do the fossils yielded provide an understanding of the conservation status of contemporary taxa and/or communities (i.e. how relevant is the site in documenting the consequences to modern biota of gradual change through time)?

The geological record at Joggins reveals the terrestrial ecology of the "Coal Age" world at both landscape and ecological community scales. The outstanding ecological context provided at Joggins has permitted identification of the earliest documented hollow tree guild, which persists today in all forest biomes, as an ancient example of ecological persistence and adaptation of co-evolving animal and plant communities. Joggins was chosen by Charles Darwin in *The Origin of Species* to illustrate simultaneously the persistence of fossil forest communities and the inherent incompleteness of the Earth's fossil record. The apparent resilience of communities at the scale of hundreds of thousands to millions of years in the pre-human world provides a stark contrast to rapid community changes recorded at present, pointing to the significant global impact of human activity on ecosystems.

Map 1: Location of the nominated property



Map 2: Boundaries of the nominated property

