

**Development of a Fossil Impact Management Process and Guidelines for  
BC: Jurisdictional Review and Smart Practices**

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*It isn't easy to become a fossil...First, you must die in the right place. Only about 15 percent of rocks can preserve fossils, so it's no good keeling over on a future site of granite. In practical terms the deceased must become buried in sediment, where it can leave an impression, like a leaf in wet mud, or decompose without exposure to oxygen, permitting the molecules in its bones and hard parts (and very occasionally softer parts) to be replaced by dissolved minerals, creating a petrified copy of the original. Then as the sediments in which the fossil lies are carelessly pressed and folded and pushed about by Earth's processes, the fossil must somehow maintain an identifiable shape. Finally, but above all, after tens of millions or perhaps hundreds of millions of years hidden away, it must be found and recognized as something worth keeping.*

- Bill Bryson, 2003, p. 321-322

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## **EXECUTIVE SUMMARY**

The objective of this project is to develop draft guidelines for paleontological impact assessments in British Columbia. The client for this project is the Land Tenures Branch of the Ministry of Forests, Lands, and Natural Resource Operations (FLNRO). Significant fossils need protection, as they are rare, fragile, and important in terms of their scientific and educational value.

There is no systematic paleontological impact assessment process in place in British Columbia. This report represents the first steps towards identifying a systematic paleontological impact assessment process for utilization in British Columbia. The report provides information to assist FLNRO in developing such a process, and contains a literature review, jurisdictional scan (i.e., Alberta, California, San Diego, New Mexico, South Africa, South Australia, Abu Dhabi, and Mongolia), case studies (Alberta and Western Australia) and results from a survey of paleontologists and paleontological resource managers.

### **Methods**

This project utilized a four-part methodology that allowed for a large amount of information to be compiled, compared, evaluated, and utilized. The literature review aimed to identify smart practices related to paleontological resources, while the jurisdictional scan, looked to examine what practices were in place across various jurisdictions. The case studies provide greater detail about practices and experience in other jurisdictions. The survey was designed to tap into expertise that could inform the drafting of the final guidelines for British Columbia. All data for this report were qualitative in nature, and analyzed to identify potential smart practices.

### **Findings**

The literature review, jurisdictional scan, case studies, and survey yielded information on smart practices for paleontological resource management. The literature review focused on paleontological resource management practices from government and organizational literature, as well as professional conference papers, while the jurisdictional scan examined how other jurisdictions assess significance, protect fossils, and the process for determining when an impact assessment is necessary. The case studies provided lessons learned from the experiences of Alberta and Western Australia, and the survey portion of this report collected the expertise of paleontological resource managers and professional paleontologists.

The paleontological impact assessment (PIA) process is similar across the jurisdictions analyzed. PIAs are triggered by activities that disturb bedrock. Many jurisdictions include a preliminary scan, often in the form of a desktop study (e.g., literature review, consultations with museums regarding fossil collections, consultation of geological maps,) in combination with preliminary fieldwork.

If the preliminary review indicates the potential for fossils, or fossils are discovered, more in depth investigation is required, conducted by a qualified paleontologist (e.g. formal education and extensive experience). The paleontologist is responsible for determining significance with regards to fossil discoveries. If significant fossils are discovered, the

paleontologist recommends mitigation and monitoring plans. Monitoring could include the use of on-site paleontologists during excavation.

### **Options and Recommendations**

Two options were proposed for consideration for this project:

- **Option 1: *Most Stringent*.** This option is based on international smart practices and provides the highest level of protection, though at the cost of greater time and resources. Option 1 mirrors the findings as discussed above. Any project that disturbs bedrock must undergo a series of investigations conducted by qualified paleontologists. This option is resource intensive, and may increase delays to a project. Unfortunately, this option depends heavily on the availability of paleontologists. However, it would provide the greatest protection to significant paleontological resources.
- **Option 2: *Less Stringent*.** This option relies heavily on paleontological resource monitoring during the development of a project, based on the findings of a preliminary desktop study. Option 2 is less resource intensive than Option 1, and would reduce delays to projects, unless significant paleontological resources are discovered.

Option 1 involves more work up front, but less work down the road; Option 2 will require less work up front, but potentially more work further down the road. However, if no resources are found during development, then Option 2 would save time and money. Option 2 is viable but would most likely be criticized by the paleontological community as significant paleontological resources could still be jeopardized by project developments. Option 1 is recommended as it is most in line with smart practices from other jurisdictions. The practices identified are time tested and have the support of the scientific community. There is nothing particular about British Columbia's geography that could prevent the adoption of equivalent practices.

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## **ABBREVIATIONS**

APEGBC	Association of Professional Engineers and Geoscientists of British Columbia
BCPA	British Columbia Paleontological Alliance
BLM	Bureau of Land Management
CEQA	California Environmental Quality Act
EAO	Environmental Assessment Office
MFLNRO	Ministry of Forests, Lands, and Natural Resource Operations
HIRAs	Historical Impact Resource Assessment(s)
LTB	Land Tenure Branch
PCRs	Preliminary Culture Review(s)
PIAs	Paleontological Impact Assessment(s)
SAHRA	South Africa Historical Resource Assessment
SVP	Society of Vertebrate Paleontology
USDA	United States Department of Agriculture



## **PART ONE: SETTING THE STAGE**

# 1. INTRODUCTION

Most people may associate paleontology with dinosaur bones. However, paleontological resources are more than just dinosaur bones. They can be trace fossils (e.g., preserved animal footprints), vertebrate fossils (i.e., animals with a spine) and invertebrate fossils (i.e., animals without a spine), coprolites (i.e., well preserved feces), and paleobotanical fossils (e.g., plants). Paleontological resources offer a glimpse into the history of life on Earth. Without them, we would not be able to understand how life has evolved, and interacted over time. Unfortunately, paleontological resources are finite and non-renewable. Despite having been preserved for extensive periods of time, fossils are not immune from destruction (Hone, 2013, *The World's Fossils Are Going Extinct*). In sum, fossils are rare, fragile, have scientific value and are in need of protection in British Columbia.

The primary research question of this report is how the Government of British Columbia could address the issue of protecting significant paleontological resources through a formal impact assessment process. In other words, the aim of this project is to develop paleontological impact management guidelines and processes for British Columbia based on the smart practices identified through the research. With regards to smart practices Bardach (2000, p. 71) notes the need to identify successful solutions from other jurisdictions, and examine why they are effective. Therefore, smart practices are effective practices that have worked elsewhere and could be adopted or adapted for use in British Columbia.

This research examines the conditions under which Paleontological Impact Assessments (PIAs) should be conducted. The purpose of this project is to identify smart practices for conducting PIAs. Specifically, the objectives of this project are to undertake research and develop options to inform the guidelines on the following matters: 1) who would be qualified to conduct PIAs, 2) the process for conducting PIAs, 3) how to determine if an area has a high probability of having paleontological resources, 4) mitigation strategies to protect significant paleontological resources, 5) which monitoring systems could be in place for mitigation strategies, and finally, 6) strategies for ensuring industry support and compliance.

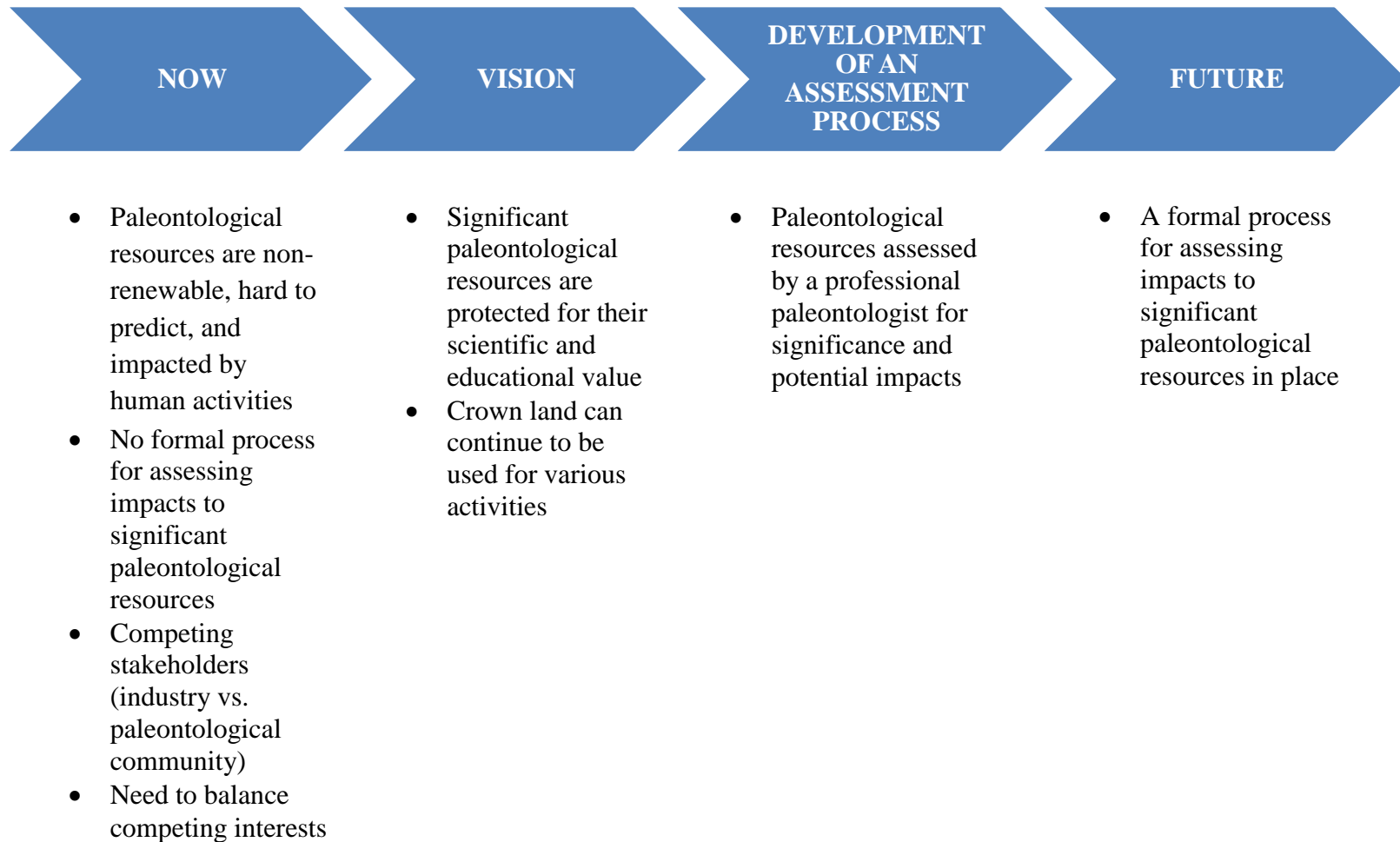
The client for this project is the Land Tenures Branch (LTB) of the British Columbia Ministry of Forests, Lands, and Natural Resource Operations. The LTB seeks to ensure that the allocation and management of Crown land offers the greatest benefits for British Columbia (LTB, 2013, *Crown Land in British Columbia*). It is also responsible for implementing the provincial Fossil Management Framework, which includes managing impacts on fossils from other activities (LTB, 2013, *Fossil Management in British Columbia*).

Fossils were once considered mineral resources, but through legislative changes in 2005 enacted by the BC government, they are now considered land resources. This has resulted in the recognition of the need to manage the resource, and a better framework to do so. The Fossil Management Framework was established to address the issues of fossil ownership, collection and uses, and fossil protection (LTB, 2013, *Fossil Management in BC-Collection and Uses*). The Province also conducted stakeholder consultations to help guide the development of fossil management in British Columbia (LTB, 2010, *Fossil Management Framework Consultation Summary Report*). The government is implementing its Fossil Management Framework. It includes legislative, regulatory, and policy tools that the

Province is using to manage BC's fossils, and establish the priority of fossil use in BC. It also includes establishing Paleontological Impact Assessment (PIA) guidelines. Currently, the land application process and the Environmental Assessment Office (EAO) process do not systematically include PIAs. Only fossil or fossil sites that have been designated under the *Heritage Conservation Act* are protected under the act (Government of British Columbia, 2013, Heritage Conservation Act)

## Conceptual Framework

Figure 1- Conceptual Framework.



Paleontological resources are non-renewable and human activities can impact (damage or destroy) these resources. However, it is possible to protect these resources from human activities.

Currently, British Columbia does not have a formalized system in place for protecting paleontological resources. Until recently, fossils were considered minerals, and as such, did not necessarily receive protection. This research addresses this problem. The questions guiding the research process address what elements and information are needed to implement a paleontological impact assessment process.

There are numerous stakeholders involved in the issue of protecting significant fossils in British Columbia. These stakeholders include other levels of government, industry, First Nations, the BC Paleontological Alliance, the Association of Professionals Engineers and Geoscientists of British Columbia, and British Columbians themselves.

The vision guiding this project is a commitment to the protection of significant paleontological resources for their scientific and educational value. In the future, paleontological resources will be given due consideration while ensuring that Crown land can continue to be used for various activities.

An ideal assessment process would see paleontological resources assessed by professional paleontologists for significance. If the resources were deemed significant professional expertise would inform mitigation and monitoring efforts to ensure that these resources are protected for their scientific and educational value.

### **Report Structure**

This report has been structured into three sections: *Setting the Stage*, *Digging Up the Facts*, and *Moving Forward*. The first section, *Setting the Stage*, is an introductory section that includes the introduction, background, and methodology. Section two, *Digging Up the Facts*, includes a literature review, jurisdictional scan, case studies, and survey results. Section three, *Moving Forward*, discusses the findings, lists options, provides recommendations, discusses implementation, and provides an overall summary of the report.

## **2. BACKGROUND: BC APPROACH TO PROJECT DEVELOPMENT AND PALEONTOLOGICAL NEEDS**

This section will provide contextual information regarding current activities on Crown land, stakeholders, the paleontological community within British Columbia, and government efforts to date to protect significant paleontological resources.

### **Crown Land Activities**

Crown Land comprises 94% of British Columbia. The activities that occur on Crown Land are varied and many of these activities have the potential to impact paleontological resources. Research has demonstrated that any activity that impacts bedrock has the potential to impact paleontological resources. The following program areas could have the potential to impact paleontological resources: aggregates and quarry materials, agriculture, communication sites, grazing, industrial, log handling, mining, oil and gas, residential, roadway, utilities, and wind power (LTB, 2013, Crown Land Uses). In designing a paleontological impact assessment it is necessary to understand the types of activities currently occurring on Provincial Crown Land. It should be noted that the activities listed above are not exhaustive, but may represent threats to paleontological resources, depending on where they occur.

### **Stakeholders**

Industry stakeholders will be numerous given the types of activities that can impact paleontological resources. Oil, gas, and mining industries are likely major stakeholders, but other industries that involve land disturbing activities are also important given how fragile fossils are. Public stakeholders are also important to consider. Beyond the general public which benefits from the protection of significant paleontological resources in terms of educational and scientific information, two organizations come to mind as important public stakeholders: The Royal BC Museum, and the British Columbia Paleontological Alliance. Other public stakeholders within BC could include universities, and other museums. Key government stakeholders also need to be considered. Beyond the Ministry of Forests, Lands, and Natural Resource Operations, the Ministry of Environment, the Ministry of Energy, Mines, and Natural Gas, and the Ministry of Aboriginal Relations and Reconciliation are also important government stakeholders. Some Crown corporations that may be interested in paleontological resource management in the Province would include the Oil and Gas Commission, and BC Hydro.

Another important stakeholder is the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). This association regulates the geosciences profession within British Columbia. Paleontology is often considered a sub-discipline of geology, and therefore may be subject to APEGBC oversight. This may be an obstacle to the government's ability to determine qualifications for professional paleontologists as paleontology is a multi-disciplinary field that encompasses more than simply geology.

### **British Columbia's Paleontological Community**

In addition to industry stakeholders, a major player in British Columbia with regards to paleontology, is the British Columbia Paleontological Alliance. This organization is comprised of both professional and amateur paleontologists. Further, the British Columbia Paleontological Alliance has worked with the Province of BC in the development of the fossil management framework. They have worked to lobby the government for greater

fossil protection. Currently, there are no formal qualifications for paleontological consultation within British Columbia. Qualifications in other jurisdictions for paleontological consultants often consist of extensive experience, and at least a graduate level education.

### **Government Efforts to Date**

In 2004, the Province of BC conducted a jurisdictional review of fossil management; as a result the Government endorsed a series of fossil management principles (LTB, 2013, Fossil Management in BC). These principles recognized fossils and fossil sites as important heritage resources and gave an order of priority for fossil management and use (e.g., science, natural heritage, education, commercial use). Fossils were once considered mineral resources, but through regulation made in 2005 under the *Mineral Tenure Act* that excluded fossils from definition of "mineral" under the Act, they are now considered land resources. This has resulted in the need to manage this resource. Government then worked successfully to define "fossil" under the *Land Act*.

In 2010, Government undertook public consultation with stakeholders to develop the fossil management framework. This consultation requested input on fossil management components such as fossil collection and use, custodianship, fossil definition, export, impact prevention, information management, legislative authority, protection of significant fossils, protection of significant fossil sites, and reporting of fossil discoveries.

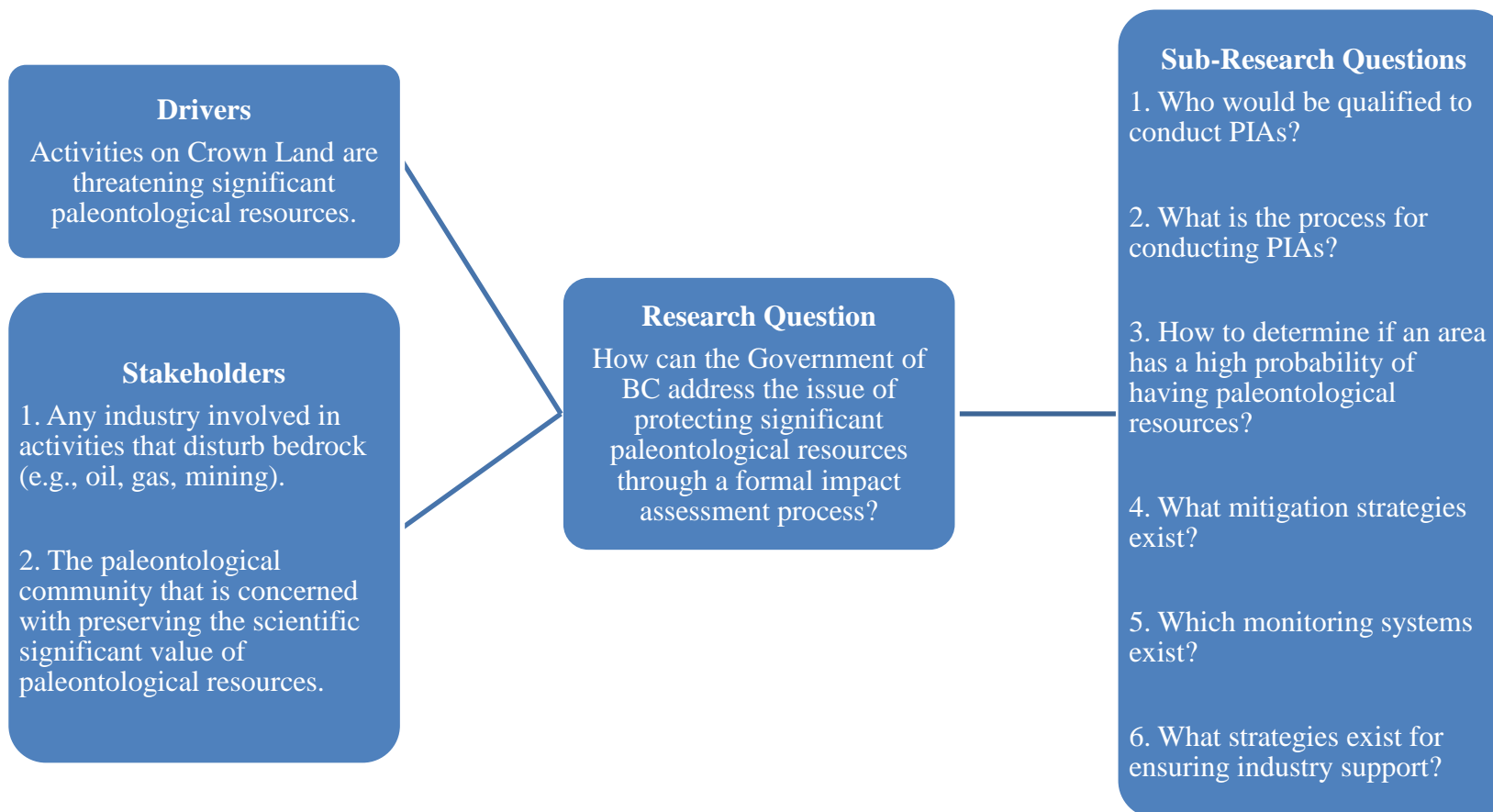
Currently, the land application process and the Environmental Assessment Office (EAO) process do not systematically include PIAs. Fossil or fossil sites that have been designated under the *Heritage Conservation Act* are protected under the Act (Government of British Columbia, 2013, Heritage Conservation Act). The Province of BC recently protected a significant fossil site in British Columbia under heritage designation, the McAbee Fossil Beds Heritage site. Fossils and fossil sites found within a provincial park or protected area are also protected.

This report builds on this previous research and expands on the prior interjurisdictional scan as conducted by the Fossil Management Review Technical Working Group in 2004. This research will help to fill in previously identified information gaps in the area of fossil impact prevention (e.g., who should conduct paleontological impact assessments, what paleontological impact assessments should include, when are paleontological impact assessments needed, how is paleontological significance determined).

### **Conclusion**

There are many different activities that take place on Crown land that could be threats to paleontological resources. There are both intergovernmental and external stakeholders that have an interest in British Columbia's paleontological resource management approach. Likewise, there is a paleontological community within British Columbia that would have an interest in this work. The government has taken steps to protect significant paleontological resources, and this report adds to the current work being done.

Figure 2- Developing the Research and Sub-Research Questions.



### 3. METHODOLOGY

The methodology for this project has four elements. A four-part methodology is helpful as it allows for a large amount of information from various sources to be compiled, compared, evaluated, and utilized. The components of the project are as follows:

*Literature review.* This section focuses on paleontological resource management. This literature review was conducted primarily via online sources (e.g., government and organizational). Paleontological research papers from conferences were also consulted, as well as literature resources as suggested by the respondents of the survey, after the initial literature review was conducted. Most journals related to paleontology are primarily scientific in nature. No sub-field of paleontological journals dedicated to assessment and mitigation was uncovered. Within the survey, participants were asked to provide links to any resources or information that they were aware of. Several participants noted that literature related to the field of paleontological resource management is scarce. Suggested literature from survey respondents included Bureau of Land Management guidelines, and conference proceedings from the Conference of Fossil Resources. While the literature in this field is limited, the available literature was very useful given the expertise of the authors, and the experience of the government organizations producing the material.

*Jurisdictional scan.* Information on how other jurisdictions a) define significance, b) protect fossils, and c) determine which projects required impact studies was gathered. This information was then compared and analyzed to identify smart practices. The following jurisdictions were included in this report: Abu Dhabi, Alberta, California, Mongolia, New Mexico, San Diego, South Africa, South Australia, and the United States (BLM & SVP). These jurisdictions were selected for analysis based on how extensive and novel the information was related to paleontological resource management. All of these jurisdictions have in place systematic processes for assessing paleontological resources and mitigating impacts.

*Case studies.* Two jurisdictions were included in the case studies section of this report: Alberta and Western Australia. The Alberta case study provides a wealth of information on the assessment of paleontological significance, while the Western Australia case study provides information on what a paleontological impact assessment process could look like, and the lessons learned therein.

*Survey.* One hundred paleontological resource management experts from various jurisdictions around the world were surveyed to gain insight and information into the field of paleontology. Although survey requests were sent all over the world, the majority of those experts who responded were located in North America. I received completed responses from 10 of those 100 experts contacted. Due to confidentiality concerns, specific locations and identifying information have not been included in this report.

#### *Limitations and Delimitations*

Some government agencies are reluctant to provide particular information due to the desire to keep the location of paleontological resources confidential. Therefore, not all information is readily available online or in print. Specifically, one limitation of this project is the lack of information readily available that directly relates to Paleontological Impact Assessments (PIAs). However, there was enough information to create solid draft

guidelines for PIAs from the jurisdictional scan. Another limitation lies in the fact that my subject knowledge of paleontology is limited. This limitation was addressed by surveying experts in the field of paleontology and paleontological resource managers.

A further limitation can be seen with the small number of survey responses. Although 100 experts were contacted, only 10 experts completed the survey. Despite the small number of participants, the uniformity of responses across a large variety of jurisdictions indicates that the information being provided is reliable. The lack of variance in the responses indicates that there is a consensus on the issues being surveyed.

### **Conclusion**

The methodology that was used in this report is qualitative in nature, and includes a literature review, jurisdictional scan, case studies, and a survey. By using a variety of information sources in combination, smart practices were identified and analyzed. These smart practices can help to inform the BC process.





## **PART TWO: DIGGING UP THE FACTS**

## **4. LITERATURE REVIEW**

Initially, the literature review was intended to look at literature regarding environmental assessments, impact assessments, and paleontological smart practices for assessment and mitigation. While some applicable information regarding mitigation was available, information about environmental assessments and impact assessments relevant to the topic were not identified.

The research question, how the Government of British Columbia could address the issue of protecting significant paleontological resources through a formal process, informed the search, and examined when paleontological impact assessments should be conducted, who is qualified to conduct them, what they should contain, and what mitigation strategies exist. An extensive search using the following keywords was undertaken: geoheritage, geosites, geology, geological, fossil(s), paleontology, paleontological in combination with environmental impact assessment(s), mitigation, management, and smart practices. Various combinations of these keywords were used to locate relevant material.

### **How Can Paleontological Resources Be Assessed For Significance?**

The issue of assessing paleontological resources for significance is contentious, as subjectivity is unavoidable (Beat & Hanna, 2009, p. 3; Kuizon, 2006, p. 99). Subjectivity will always exist in assessing significance, but criteria have been developed for assessing these resources. One criterion for significance could be based on scientific value, which is defined as the “contribution and importance to the history of life on Earth, (i.e., specimen-based significance), or its value as a type specimen or stratigraphic indicator, (i.e., context-based significance)” (Kuizon, 2006, p. 99). Significance may also be assessed on the basis of museum value, which considers the quality of preservation, uniqueness, and completeness of the paleontological resource.

Kuizon (2006) outlines the scientific criteria used by the USDA Forest Service for assessing fossils. The USDA Forest Service assesses fossils either by specimen or by context.

Specimens are considered scientifically significant if they:

- represent a newly discovered taxon
- are rare
- are vertebrate
- are well preserved
- are unique
- exhibit soft tissue preservation
- have cultural importance

Contextually, fossils are scientifically significant if they provide “taphonomic, ecological, environmental, behavioural, cultural, or evolutionary information” or if they enhance understanding of “the stratigraphic, chronological and or geographic range of a taxon or functional paraphyletic group” (Kuizon, 2006, p. 100). The USDA Forest Service criteria are very comprehensive.

Another way to look at paleontological significance is to determine what is not significant and work backwards from there (Foss, 2009, p. 120). Foss (2009) provides in his definition, characteristics that demonstrate when a paleontological resource is not significant (p. 121). A paleontological resource is not significant if it lacks context, physical integrity (e.g., erosion), or is not useful for research (p. 121).

### **When Should A Paleontological Impact Assessment Be Conducted, And Who Should Bear the Cost?**

Gore (2009) notes that surface disturbing activities in jurisdictions managed by the USDA Forest Service require paleontological consultants to assess potential impacts (p. 28). Furthermore, proponents are required to bear the costs of hiring the consultant, salvaging the fossils, and arranging transportation and curation of the fossils (p. 28). Similarly, Alberta legislation states that any projects that impact bedrock may require the company to perform a paleontological “impact assessment and/or monitoring” (Hysuick & Spivak, 2009, p. 32).

### **How To Determine If An Area Has A High Probability Of Having Paleontological Resources?**

Alberta has a tracking system to record all areas in which paleontological resources have been found. This information is used to identify paleontological resource potential in adjacent areas (Hysuick & Spivak, 2009, p. 32). Alberta previously relied on “paper, topographical maps, and grid overlays” (p. 32), but recently introduced an ArcGIS system to identify information about paleontological resources. Alberta has also incorporated information from the Alberta Royal Tyrell Museum fossil collections into the system (p. 32). This information is used to help consultants identify impacts to paleontological resources. The province has assessed the geological formations within Alberta to understand the paleontological resource potential of the province, and has incorporated this information into the ArcGIS system (Hysuick & Spivak, 2009, p. 32-33).

### **What Are The Stages Of Paleontological Resource Management?**

Fremd (1994a) recommends that all sites should be inventoried; which includes conducting literature reviews, and examining museum collections for information on previously collected fossils in a given area. This information can be used for predicting paleontological resource locations, especially when considering types of rock formations (i.e., fossiliferous). It is also recommended that areas be surveyed systematically, and documented with photographs (p. 63).

Significance, as determined by Fremd (1994a), is based solely on scientific value (p. 63). He believes that people who specialize in the study of that particular paleontological resource should determine significance. Management options include taking no action, monitoring sites for damage, restricting access, excavation, and documentation (p. 63-64). This is a resource intensive approach, but it ensures that significant paleontological resources are protected. Fremd (1994b) has also developed a process for determining when a paleontological resource should be recovered or left in situ (p. 65). This process has been designed with Federal parks in mind, but is generally applicable.

When paleontological resources are discovered, an assessment needs to be made as soon as possible to determine if salvaging is required (Fremd, 1994b, p. 65). Delay in action may jeopardize the paleontological resource, and it may be impractical to salvage some

paleontological resources if they are too large, or inseparable from the rock formation (p. 65). Not all paleontological finds are of equal significance. However, fossils are often fragile and are susceptible to weathering and erosion among other threats. As soon as a paleontological resource is uncovered it needs to be assessed by a professional for significance.

Fremd (1994b) believes that insignificant paleontological resources should not be collected and curated but left in place (p. 66). Once again, this system was designed for a Federal park. If a paleontological resource has been deemed insignificant, but would be impacted by a proposed project, perhaps amateur paleontologists should be allowed to collect in order to have the fossils preserved rather than destroyed. Amateur paleontologists should not be permitted to work on significant paleontological finds unless supervised by qualified paleontologists or a certification program is created. There is the danger that they could do more harm than good. Fremd (1994b) believes that until the proper financing, equipment, and methodology are in place, its best to focus on stabilizing paleontological resources until they can be removed and documented properly (p. 66).

### **What Mitigation Strategies Are Available To Protect Significant Paleontological Resources?**

The following strategies have been recommended for mitigating impacts to paleontological resources. A leading researcher in geoh heritage, Murray Gray, recommends that “wherever possible, preserve *in situ*. Otherwise remove for curation” (Gray, 2008, p. 291). The benefit of preserving fossils *in situ* is that contextual information is not lost. Where the paleontological resource is located, and what other paleontological resources surround it, are just as valuable to paleontologists as the paleontological resource itself.

According to Gray, minor methods for conserving fossils include: permitting, supervision, and signage (2008, p. 291-292). He notes that major methods for conserving fossils include: secrecy, physical restraint, reburial, excavation/curation, benevolent ownership, legislation, policy, site management, and education (p. 291).

#### *Major Methods:*

- *Secrecy* involves keeping paleontological site locations confidential, and offers protection from theft and vandalism. This is a common strategy for protecting paleontological sites (Gray, 2008, p. 291).
- *Physical barriers* are also important for protecting paleontological sites (Gray, 2008, p. 291). Florida Heritage recommends that fences only be used in monitored areas; otherwise, fencing may draw unwanted attention (Florida Heritage, 2005, p. 14).
- *Reburial* prevents access, conserves the sites, and allows for future study (Gray, 2008, p. 292). The Florida Heritage guide acknowledges the usefulness of reburial to protect important sites from vandalism and theft (Florida Heritage, 2005, p. 15).

The other major mitigation strategies include benevolent ownership, legislation, and policy development (Gray, 2008, p. 293-294). However, the concept of benevolent ownership is not applicable in the BC context as the Crown retains ownership over paleontological resources. Gray (2008) emphasizes providing training to land managers; this is important as land managers may not be familiar with paleontological resource management, as it is not well established (p. 294-295).

### *Minor Methods:*

- *Permits* are used to control access to paleontological sites. Most jurisdictions use permits for fossil collection or scientific study.
- *Supervision* is effective at protecting paleontological sites. It could involve site checks, or full-time security guards of the paleontological sites. However, this is not a common option due to costs.
- *Signage* helps “to dissuade potential transgressors from intruding into and/or damaging sites” (Gray, 2008, p. 291). The obvious downside to signage is that it could potentially make it a target by identifying the location of the paleontological resources. Vandalism and theft are major issues with paleontological resources (CBC News, 2012, Irreplaceable Dinosaur Fossil Destroyed at Alberta Dig Site). The Florida Guide for best management practices notes that the use of signs should depend on location (Florida Heritage, 2005, p. 14). The general rule is that if the location is accessible there should be signage. If the location is inaccessible, there should not be signage as it is best not to draw attention to sites in remote locations where they are not protected.

Florida has taken a unique approach in regards to signage. They discuss the possibility of planting poison ivy and other similar plants, or even using beehives to protect important sites while also putting signs noting these dangers. This technique is referred to as *camouflaging*, and can work as an effective deterrent. Individuals will typically avoid the dangers on the signs, and therefore will avoid damaging important sites.

### *Management Options*

Kirkland and Foster (2009), in their discussion of the management of paleontological resources note, that “all paleontological localities are not equal” (p. 19). Different localities require different management approaches. For example, paleontological sites that contain “isolated bones, teeth, and... skeletons” (p. 19) can be managed by “excavation, stabilization, and curation” (p. 19). In contrast, “areas with dense concentrations of individual sites require comprehensive and long-term management” (p. 19). This information is useful for determining which fossils should be preserved *in situ*, or salvaged.

### *Documentation and Awareness*

While not contributing to the protection of the paleontological resources itself, documentation can ensure that the valuable information about the paleontological resource is not lost forever. Technology such as, “photogrammetry, ground-based LIDAR and Ground Penetrating RADAR” are capable of documenting paleontological resources (Matthews, Noble, & Breithaupt, 2006, p. 129). Once the paleontological resource has been documented virtually it can be studied long after it has been damaged or destroyed by human activity or erosion. Documentation can also be resource-type specific. For example, where fossil tracks are concerned, a qualified individual can make moulds of the tracks without damaging the original tracks (Milner, Ferris-Rowely, & Kirkland, 2006, p. 146). Breithaupt (2009) recommends that tracks be preserved in place, and protected by fencing or covering. Further, technology has allowed for three-dimensional preservation of track sites (p. 91).

In sum, there is no one-size fits all approach to the mitigation or management of paleontological resources. The options presented above are not meant to be used exclusively, but rather, can be used in combination depending on the circumstances and

resources available. It is best to consult with paleontological experts in determining both mitigation and management strategies. Depending on the type of paleontological resource and its significance, different strategies or combinations of strategies may be utilized. In the case of insignificant paleontological resources little to no management or mitigation may be required. However, if a paleontological resource has been deemed significant a greater level of active management and mitigation would be required.

### **Which Monitoring Systems Could Be In Place For The Mitigation Strategies?**

Not only are fossils finite and fragile, their distribution is also hard to predict, as it is not uniform (Santucci, Kenworthy, & Mims, 2009, p. 189). This makes paleontological resource management even more challenging. Documentation is not only a mitigation strategy, but can also contribute to monitoring. Santucci et al. (2009) recommends that baseline information be collected, as this information is essential to the development of monitoring plans. This type of information includes “site description, photography, and some level of mapping” (p. 189). Photography, both close up and high-level, can be used to capture changes to paleontological resources over time. Photographs of the area can be compared so that the impacts of erosion and human activity can be documented and mitigated. Santucci et al. (2009) also recommends assessing threats to paleontological resources and incorporating this information into monitoring plans (p. 189).

#### *Monitoring*

Santucci et al. (2009) believe that the process of envisioning the desired future condition of paleontological resources is beneficial for guiding monitoring and mitigation (p. 190). An example of a vision statement is provided below (p. 190):

Paleontological resources and their associated geologic context are maintained *in situ* in a stable environment and are in good condition with little or no potential for degradation or impairment by artificially accelerated natural processes or direct human impacts. Similarly, the scientific and educational values are unimpaired and are also preserved in good condition.

Monitoring requires an understanding of what activities impact paleontological resources. Natural weathering, erosion, and human activities are a major threat to these resources. Natural processes can also contribute to the discovery of paleontological resources by increasing surface exposure (Santucci et al., 2009, p. 190).

#### *Natural Threats and Monitoring*

Paleontological resources may be at greater risk depending on location. Santucci et al. (2009) note that freezing and thawing cycles can contribute to the weathering and erosion of fossils (p. 190). Areas with a higher number of “24-hour periods per year when the temperature fluctuates above and below freezing” would experience higher rates of erosion and weathering (p. 191). These areas may require more frequent monitoring.

As discussed by Santucci et al. (2009) the rate and intensity of various types of precipitation may determine the amount of monitoring required for the paleontological resource (p.191). Further, humidity, wind, hydrological factors, geological factors, and biological factors can all impact paleontological resources. Human activities can also impact paleontological resources especially ground disturbing activities (p. 192). Santucci et al. (2009) recommend that all assessments include an evaluation of human access to the

resource area and how this access may (even unintentionally) adversely impact fossils (p. 192).

### *Tiered Monitoring Approach*

Santucci et al. (2009) outline a comprehensive tiered approach for monitoring paleontological resources. Approaches are categorized according to cost and technical requirements (p. 193). The table addresses threats to paleontological resources and identifies methods for monitoring, the expertise needed (i.e., volunteer or scientist), required special equipment, approximate cost, personnel requirements, and labour intensity for each approach. This is a very useful chart, and has been included below for reference.

Table 1- Summary Of Paleontological Resource Vital Signs And Monitoring Methods.

TABLE 1. SUMMARY OF PALEONTOLOGICAL RESOURCE VITAL SIGNS AND MONITORING METHODS

Vital signs and methods	Expertise	Specialized equipment	Cost*	Personnel	Labor intensity <sup>†</sup>
<b>Erosion (Geologic Factors)</b>					
Repeat photography	Volunteer	No	\$	Individual	Low
Erosion stakes	Volunteer	No	\$	Individual	Low
Technology-enhanced	Scientist	Yes	\$\$\$	Group	High
<b>Erosion (Climatic Factors)</b>					
Climatic records	Volunteer	No	\$	Individual	Low
Repeat photography	Volunteer	No	\$	Individual	Low
Technology-enhanced	Scientist	Yes	\$\$\$	Group	High
<b>Catastrophic Geohazards</b>					
Geologic assessment	Volunteer	No	\$	Individual	Low
Digital mapping	Scientist	Yes	\$\$	Group	Medium
Technology-enhanced	Scientist	Yes	\$\$\$	Group	High
<b>Hydrology/Bathymetry</b>					
Repeat photography	Volunteer	No	\$	Individual	Low
Digital mapping	Scientist	Yes	\$\$	Group	Medium
Technology-enhanced	Scientist	Yes	\$\$\$	Group	High
<b>Human Access/Public Use</b>					
Repeat photography	Volunteer	No	\$	Individual	Low
Digital mapping	Scientist	Yes	\$\$	Group	Medium
Technology-enhanced	Scientist	Yes	\$\$\$	Group	High

\*Cost (in US\$) = <\$1,000; \$\$ = \$1,000 to \$10,000; \$\$\$ = >\$10,000.  
<sup>†</sup>Labor intensity: low = <few hours; medium = <full day; high = >full day.

Retrieved from Santucci et al. (2009, p. 193)

### *Volunteer Support*

Volunteer monitoring is an option. Public land managers may lack resources to dedicate to paleontological monitoring. Volunteers contribute to paleontological resource management by “increasing the capabilities of agencies to monitor sites, and to document new localities” (Milner, Ferris-Rowley, & Kirkland, 2006 p. 146-148). The site stewards monitor paleontological sites for erosion, vandalism, and theft (p. 149). The researchers advocate using volunteers to search for paleontological resources, and for recording localities (p. 149).

The Denver Museum of Nature & Science has developed the Paleontological Certification Program. This seven-course program qualifies individuals to participate in active fossil research conducted by the museum (Denver Museum of Nature & Science, Paleontological Certification Program, 2013). Individuals are required to take two core courses: an overall introduction to paleontology and an introduction to regional geography. Electives include courses on curation, evolution, vertebrate paleontology, invertebrate paleontology, paleobotany, sedimentology and stratigraphy, as well as lab and field methods. Completion

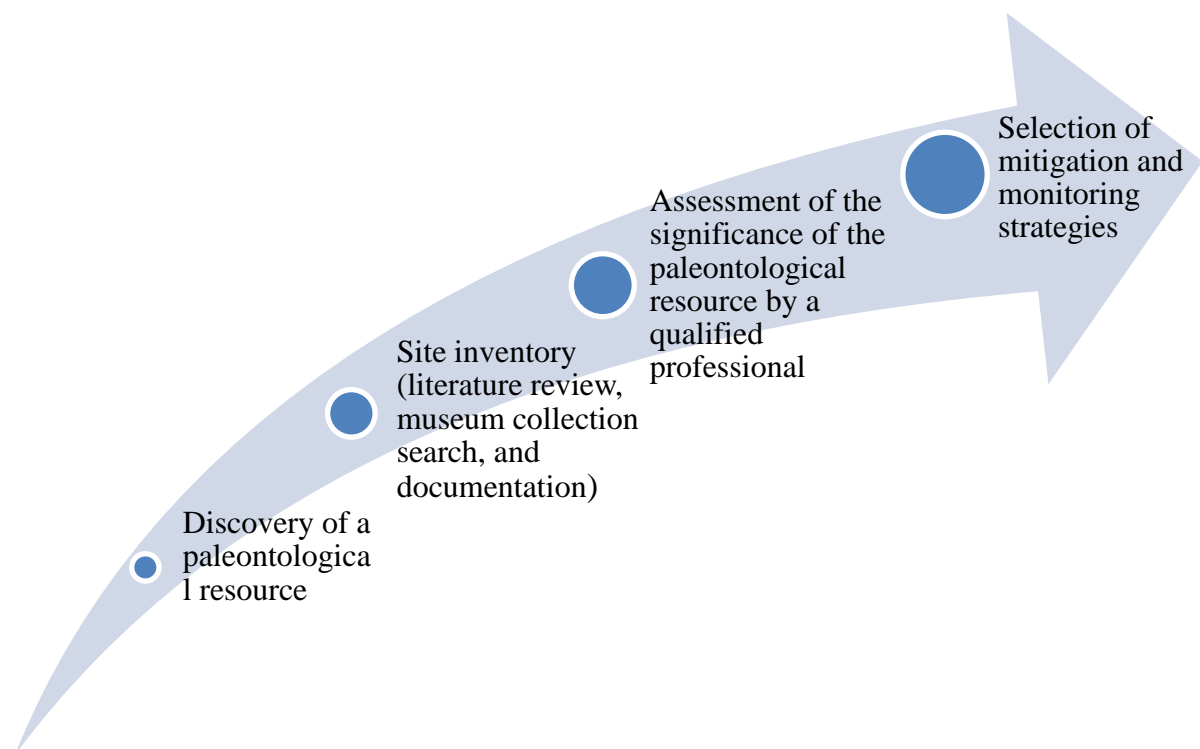
of the program takes two to four years. To date, there have been about 300 graduates (MSN, Giving Back: A Penchant for Paleontology, 2013). The program has salvaged many significant fossils that would have been destroyed. For example, construction was halted on a dam building project for 51 days to allow the museum to recover 6000 significant ice age fossils with the help of 200 volunteers.

In sum, the monitoring of paleontological resources can take many forms. Monitoring can be conducted by professional paleontologists, or by volunteers with sufficient training. The various means that can be employed to monitor paleontological resources can range in cost. The monitoring systems that are utilized depend on the resources available and are context dependent. Monitoring allows for government to identify any significant changes, which may impact paleontological resources, and it allows government to take action when necessary.

### Conclusion

While literature is limited in the field of paleontological resource management, the above findings provide useful and practical information regarding how paleontological resources can be assessed for scientific significance, when paleontological assessments should be implemented, how the location of paleontological resources can be predicted, and the available mitigation and monitoring strategies that exist.

Figure 3- Paleontological Resource Management.



The following table provides a general overview of the lessons learned from the literature review.

Table 2- Literature Review Summary.

Assessing Significance	<ul style="list-style-type: none"> <li>• Scientific significance can be assessed in many ways.</li> <li>• The USDA Forest Service provides comprehensive criteria for assessing scientific significance.</li> </ul>
Triggers	<ul style="list-style-type: none"> <li>• Paleontological impact assessments should be conducted when bedrock is impacted.</li> <li>• Proponents often bear the costs of PIAs, monitoring, and mitigation.</li> </ul>
Potential	<ul style="list-style-type: none"> <li>• Information about past discoveries can be used to predict paleontological resource potential through a tracking system or database(s).</li> </ul>
Resource Management	<ul style="list-style-type: none"> <li>• The stages of paleontological management include: site inventory, significance assessment, and selection of management options.</li> <li>• Under certain circumstances paleontological resources should be left in place.</li> </ul>
Mitigation	<ul style="list-style-type: none"> <li>• Depending on the type of paleontological resource and its significance, different strategies or combinations of strategies may be utilized.</li> </ul>
Monitoring	<ul style="list-style-type: none"> <li>• Monitoring can be conducted by professional paleontologists, or by volunteers with sufficient training.</li> <li>• The various monitoring strategies range in cost.</li> </ul>

## 5. JURISDICTIONAL SCAN

The following is a jurisdictional scan regarding paleontological impact assessments, and information related to paleontological resource management. The jurisdictions selected for inclusion in this report were chosen based on the robustness and availability of information.

The jurisdictions selected (Abu Dhabi, Alberta, California, Mongolia, New Mexico, San Diego, South Africa, South Australia, and the United States (BLM & SVP) deal specifically with requirements for conducting impact assessments. In order to avoid repetition of common practices, jurisdictions were excluded that only addressed permitting requirements (i.e., China, Florida, India, New Zealand, Nova Scotia, Nunavut, Ontario, Peru, Spain, United Kingdom).

The following jurisdictional scan details the impact assessment process of the selected jurisdictions, and are arranged according to the usefulness of the information. The following table highlights the common features of each of these jurisdictions, while a table at the end of this section highlights those features unique to each jurisdiction.

Table 3- Jurisdictional Scan Summary Highlighting Common Smart Practices And Approaches.

<b>Jurisdiction</b>	<b>Bedrock Disturbance Trigger For PIA</b>	<b>Graduate Degree in Paleontology or Equivalent Required</b>	<b>Preliminary Assessment Process Conducted</b>	<b>Vertebrate Fossils Considered Significant</b>
United States: SVP	YES	YES	YES	YES
United States: BLM	YES	YES	YES	YES
Alberta	YES	YES	YES	YES
California	YES	YES	YES	YES
San Diego County	YES	YES	YES	YES
South Africa	YES	YES	YES	YES
South Australia	YES	YES	N/A	YES
New Mexico	YES	YES	N/A	YES
Mongolia	YES	YES	YES	YES
Abu Dhabi Emirates	N/A	N/A	N/A	N/A

### **United States: Society of Vertebrate Paleontology (SVP): The Gold Standard**

The Society of Vertebrate Paleontology (SVP) is an international organization, and its mitigation guidelines have been designed to operate with the United States' federal legislation in mind (SVP, 2010, p. 1). The impact mitigation guidelines address impacts from land development on paleontological resources. The SVP guidelines are considered “the standard against which the adequacy of all paleontological resource impact assessments and mitigation programs are judged” (Fisk & Reynolds, 2009, p. 77). The

guidelines were designed to be utilized universally. The SVP notes that they are applicable to “local city, county, regional, state, and federal agencies” (2010, p. 1).

In order to protect fossils the SVP recommends conducting initial assessments to identify paleontological resources that may be impacted by proposed developments. Once this has been accomplished, a mitigation strategy needs to be developed and implemented. SVP options include preservation of the site and the salvage of paleontological resources while ensuring that “contextual data” is preserved (2010, p. 1).

#### *SVP Guidelines*

The SVP impact assessment guidelines include:

- A literature review of “paleontological, geological, geotechnical, and environmental literature” as this could provide information about significance and location of paleontological resources (2010, p. 5).
- A record search of relevant institutions (e.g., museums) to identify existing information (e.g., previous fieldwork and specimen collection in the area).
- A field investigation by a qualified paleontologist to determine the potential for paleontological resources.
- A report by the paleontologist (and investigating team) outlining the potential impacts and mitigation strategies.

The SVP recommends that the land management agency use the information above in determining what mitigation requirements are necessary. The SVP also recommends that as part of all mitigation plans a repository agreement be established to ensure the proper storage of any paleontological finds. Further, project staff should be briefed by a paleontologist on the importance of fossils, and procedures for handling unintended finds (e.g., stop work until the area can be assessed by paleontologists).

#### *Paleontologist Qualifications (SVP)*

Depending on the classification of the geological unit, different qualifications are required for monitoring excavation (SVP, 2010, p. 6). The SVP requires that geological units with high or unknown potential require monitoring by paleontologists during excavation. Other lower classifications as determined by paleontologists can be monitored by non-paleontologists with training (e.g., construction workers, engineers).

SVP qualifications for paleontologists include the following:

- peer-reviewed publications.
- “demonstrated competence in field techniques, preparation, identification, curation, and reporting in the state or geologic province in which the project occurs” (SVP, 2010, p. 10).
- a minimum of two years experience supporting a Project Paleontologist.
- a minimum of two years experience in relation to administration and project management.
- a graduate degree in paleontology or geology.

The SVP considers experience and regional knowledge as more important than a graduate degree. The SVP has also established guidelines for paleontological resource monitors. Once again, experience is given more weight than education. The SVP note that they prefer

a Bachelor's degree in paleontology or geology, but lower educational attainment may be acceptable with the right mix of experience.

#### *Determining Paleontological Potential*

The SVP system determines paleontological potential by examining the potential of individual paleontological units. The classifications used by the SVP include “high”, “undetermined”, “low”, and “no potential” (SVP, 2010, p. 1-2).

- *High potential* - geological units with potential for significant fossils or trace fossils (e.g., dinosaur footprints). The unit must have the potential to produce abundant and/or significant fossils. These units can include “sedimentary formations and some volcanoclastic formations, and some low-grade metamorphic rocks...and sedimentary rock units (e.g., middle Holocene and older, fine-grained fluvial sandstones, argillaceous and carbonate-rich paleosols, cross-bedded point bar sandstones, fine-grained marine sandstones, etc.)” (SVP, 2010, p. 1-2).
- *Undetermined potential* - geological units with this classification require field studies to determine paleontological potential.
- *Low potential* - geological units with no documented history of paleontological discoveries. This classification can be assigned through desktop studies that examine literature and published and/or unpublished paleontological surveys.
- *No potential* - geological units that are unlikely to produce any paleontological resources. The SVP lists “high-grade metamorphic rocks and plutonic igneous rocks” in this category (SVP, 2010, p. 2).

In determining an area's potential for paleontological resources the SVP suggests conducting a detailed review of “pertinent geological and paleontological literature, geological maps, and records in fossil locality databases of paleontological specimens deposited in institutions” (SVP, 2010, p. 3). This research is useful in determining paleontological potential, however, the SVP notes, that if an area's potential cannot be assessed in this way, then a field study is required. Both the area of study and the surrounding areas need to be examined for paleontological resources because other areas may have the same geological units, only better exposed.

It is difficult to determine the distribution of fossils. While certain geological units may be fossiliferous, fossil distribution varies. To overcome this obstacle the SVP recommends that paleontologists develop and utilize Paleontological Resource Potential Maps to aid decision-makers (SVP, 2010, p. 2).

#### *Determining Significance*

Significant paleontological fossils are defined by the SVP as vertebrate fossils, rare invertebrate fossils, and trace fossils (2010, p. 11). Particular attention is paid to “taphonomic, taxonomic, phylogenetic, paleoecological, stratigraphic, and/or biochronological information” (SVP, 2010, p. 11). Measures to rate the significance of paleontological resources are provided by the SVP (e.g., biostratigraphic, chronological, paleoecological, taphonomic, and taxonomic attributes).

#### *Mitigation*

In terms of mitigation strategies, the SVP notes that companies should have either a paleontological monitor on site, or have arranged for a paleontologist to develop mitigation programs if paleontological resources are discovered by accident (2010, p. 3). The SVP

recommends that in areas with high paleontological potential salvage operations commence early to avoid delaying construction. Under the SVP system, the proponent's ability to financially support mitigation measures is not a factor in determining how extensive required mitigation measures will be (2010, p. 3).

Mitigation practices under the guidelines include "pre-project survey and salvage, monitoring and screen washing during excavation to salvage fossils, conservation and inventory, and final reports and specimen curation" (SVP, 2010, p. 1). The SVP has established a list of recommended mitigation strategies. These include surveying prior to "earth-moving", monitoring excavations, salvaging, preparation of fossils for curation, data collection, and reporting (SVP, 2010, p. 3-4).

### **US Bureau of Land Management (BLM): Geological Units Determine Potential**

The Bureau of Land Management (BLM) of the United States' Department of the Interior is concerned with managing and protecting paleontological resources on Federal Public Lands to ensure that the scientific and educational benefits are protected. Specifically, the BLM recognizes "paleontological resources found on public lands...constitut[e] a fragile and non-renewable scientific record of the history of life on earth" (BLM, 1998a, p. 66). The BLM believes in preserving the scientific and educational value of fossils. Proponents bear the costs of undertaking monitoring and mitigation efforts for all vertebrate fossils (BLM, 1998b, p. 9). An initial scoping process is undertaken to identify if the area under consideration has the potential for paleontological resources. If potential exists then a paleontologist undertakes further study, if "surface disturbing actions are proposed for such lands" (BLM, 1998b, p. 6).

The BLM had previously developed a paleontological classification system that incorporated three conditions. While a newer system exists (see below), the old system is worth examining as it provides an alternative perspective on how rock types can be classified. However, with respect to the other aspects of the assessment process, the BLM is relying on the old Handbook and Policies until new policies can be developed (BLM, n.d., Paleontology Policy and Guidance).

#### *Old BLM Classification System*

- *Condition 1* - an "area is known to contain vertebrate fossils, or noteworthy occurrences of invertebrate or plant fossils" (BLM, 1998b, p. 7).
- *Condition 2* - the area contains geologic characteristics that have "high potential" for paleontological resources (BLM, 1998b, p. 7). Under this condition, fossils have been discovered in the same geological units elsewhere. This condition relies on past information to predict the presence of paleontological resources.
- *Condition 3* - encompasses areas with low potential based on geological characteristics such as "surficial geology, igneous or metamorphic rocks, extremely young alluvium, colluvium, or aeolian deposits, or the presence of deep soils" (BLM, 1998b, p. 7).

Bedrock is the key to determining impacts to paleontological resources. If bedrock is disturbed or exposed, paleontological resources may be impacted. Therefore, it is necessary to determine at what depths bedrock occurs, in order to determine impacts to paleontological resources (BLM, 1998b, p. 7). The threshold used by the BLM for

determining what qualifies as a surface disturbance is anything beyond 1-square meter (p. 7).

#### *New BLM Classification System*

The Potential Fossil Yield Classification (PFYC) System has replaced the old BLM classification system. This system is based on the notion that “the probability for finding paleontological resources can be broadly predicted from the geologic units present at or near the surface” (BLM, 2008, p. 1). The PFYC system makes use of geological mapping to assess the potential for paleontological resources. This classification system is based on “the relative abundance of significant localities” containing paleontological resources (BLM, 2008, p. 1). The PFYC system is a baseline tool that helps to determine the potential for paleontological resources, and is designed to help evaluate the need for further assessment.

The classification system rates paleontological potential from low to high (BLM, 2008, p.1).

- Class 1 - very low paleontological potential in geological units that are igneous or metamorphic, or are Precambrian or older. Geological units that receive a Class 1 classification generally do not require paleontological assessment or mitigation.
- Class 2 - low paleontological potential in sedimentary geologic units that are unlikely to contain significant paleontological resources. The need for conducting assessment or mitigation is unnecessary.
- Class 3 - moderate or unknown paleontological potential in geological units that are “fossiliferous sedimentary...where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential” (BLM, 2008, p. 2). These particular types of resources are often “poorly studied and/or poorly documented” (p. 2). Class 3 requires field studies to determine paleontological resource potential. This class is divided into two types: moderate potential (Class 3a), and unknown potential (Class 3b).
- Class 4 - high paleontological potential in geological units where the potential for significant fossils is great. This classification system is divided into two parts: Class 4a and Class 4b. Class 4a incorporates areas with exposed bedrock (e.g., no soil or vegetative cover) susceptible to actions that disturb the surface. Class 4b deals with bedrock with high potential that is protected by soil and vegetative cover. Protective layers may lower the risk of erosion and damage from human activities. Geological units that have been assigned a Class 4 classification require paleontological monitoring while construction activities take place.
- Class 5 - very high paleontological potential in geological units known for containing significant fossil resources, and are at risk from project impacts. This class is divided into two parts: Class 5a and Class 5b. Class 5a involves exposed bedrock (e.g., no soil or vegetative cover). Class 5b is defined as bedrock with high potential, and soil and/or vegetative cover. These protective layers have the potential to reduce impacts. This classification requires field studies, but mitigation is often necessary throughout the project (BLM, 2008, p. 3).

In general, any activity that has the potential to disturb bedrock will require that more attention be given to conducting impact assessments and monitoring. However, the categorization is not 100% accurate. Even if an area has previously received a low

classification, there is a possibility that significant fossils may still exist (Temme, Thomas, Masters, & Sandau, 2009, p. 75).

#### *Current BLM Practices Until A New System Is Developed*

The BLM process involves conducting a literature review on “published and unpublished work on the paleontology of the area or geologic unit(s) to be impacted” (BLM, 1998b, p. 8). Institutions that house paleontological resources are also consulted to determine if specimens in their collections have originated from the area of study, or surrounding areas. A professional paleontologist, who may or may not make recommendations for further investigation, evaluates this information (e.g., a paleontological field survey) (p. 8).

In a field study, a professional paleontologist is contracted to identify paleontological resources within the study area, and to develop recommended mitigation strategies (p. 8). Field surveys involve pedestrian surveys (i.e., on foot) of locations where paleontological resources may be expected. Field studies also include the sampling of surface fossils. The information gathered helps to determine mitigation strategies and aid decision makers (p. 9).

After completing a field study, a report is required that includes the following (BLM, 1998b, p. 9):

- A description of each geological unit
- A discussion of the paleontological resources
- A list of institutions contacted and references consulted
- Locality forms and/or other appropriate scale maps showing fossil localities identified during the formal analysis
- Mitigation recommendations

A BLM paleontologist reviews this report, and in order for work to commence on a project, this report must be approved. Further, this report becomes property of the BLM. Information about paleontological resource locations contained in these reports is not released to the public to protect the paleontological resource(s).

The BLM has identified several alternatives when it comes to mitigation (p. 10):

- Salvaging paleontological resources
- Representative sampling
- Avoidance of paleontological resources

Mitigation and monitoring plans must include information on how extensive paleontological resource collection will be, how frequently monitoring will occur “for each geological unit/area impacted”, and an agreement for specimen recovery and storage (proponent bears the cost of storage) (BLM, 1998b, p. 10). Activities involving paleontological resource management such as “survey, identification, evaluation, and mitigation” need to be undertaken by a qualified paleontologist (BLM, 1998b, p. 13)

#### *Paleontologist Qualifications (BLM)*

A qualified paleontologist is defined as an individual who has (BLM, 1998b, p. 13-14):

- Professional instruction in a field of paleontology relevant to the work proposed (vertebrate, invertebrate, trace, paleobotany etc.)
- A graduate degrees in any of the following acceptable disciplines: paleontology, geology, biology, botany, zoology, or anthropology so long as the focus is on the study of paleontology
- At least 24 months under the guidance of a professional paleontologist who has the necessary educational qualifications listed above
- Demonstrated experience in paleontological collection, analysis, and reporting, as well as, administrative capabilities for paleontological projects
- Reliability and the ability to produce publications (e.g., “theses, research reports, scientific papers”)

The BLM process also allows for students to conduct paleontological work under the supervision of a qualified individual.

#### *Other Considerations*

The BLM process currently requires researchers arrange a willing repository in order to receive a research permit (1998b, p. 15). Information is required about all individuals involved in carrying out paleontological work, including any information about the qualifications discussed above (1998b, p. 24). In addition, the BLM requires information about the affiliated organization(s) (e.g., consulting firm) conducting the paleontological impact assessment (p. 25). This information includes a history of past projects, government contracts, reports, publications, permits, and experience. The BLM notes that where new organizations are involved, “lack of an organizational history will not be the principal factor in evaluating an application” (BLM, 1998b, p. 25).

#### **Alberta: Rigorous Requirements for Conducting Paleontological Work**

Alberta utilizes a different approach. In Alberta, paleontological and archeological assessments fall under the Historic Resource Impact Assessment (HRIA) process administered by Alberta Culture. The *Historical Resources Act* requires that paleontological resources be considered prior to development activities. Impact assessments are initiated when the Province of Alberta believes proposed activities may damage or destroy historical resources such as fossils. The Province maintains a listing of historic resources (including paleontological resource) and their heritage value (Alberta Culture, 2013, Listing of Historic Resources). The listing is available as an excel spreadsheet and as a ArcGIS Shapefile. The proponent pays for a professional paleontologist to perform the impact assessment in the potential impact area, which results in a report on potential impacts. The proponent is required to avoid, or mitigate the impact to historical resources (Alberta Culture, 2013, Historic Resources Impact Assessments). The assessment area is not limited only to the area that would be directly impacted, but includes surrounding areas (Government of Alberta, 2013, p. 14).

#### *Permitting Process and Requirements*

Permits for conducting paleontological research and assessment work are issued under the Archaeological Research Permit Management System by Alberta Culture's online permitting system (Alberta Culture, 2013, Archeological Research Permit Management System). Permits are required in order “to excavate for the purpose of carrying out a

paleontological research project, a paleontological survey or a mitigative research project relating to paleontological resources” (Government of Alberta, 2008, p. 2).

Permit holders must perform all work in accordance with professional practices. Permit holders must catalogue all resources discovered (p. 5). Alberta requires that the permit holder submit a report outlining the number of discoveries made, and the extent and geological characteristics (age and location) of the paleontological resources found (p. 7-8). The reports are reviewed by government paleontologists. Alberta makes a distinction between collection and mitigation studies. In essence, paleontological permit holders conducting mitigation work are generally not allowed to collect paleontological resources without further government permission (p. 8). The Government of Alberta maintains a list of heritage resource consultants (e.g., paleontology, archeology), but does not necessarily endorse them; the list is also not exhaustive.

#### *Permit Qualifications*

Alberta’s paleontological permit qualifications are stringent, and include the following requirements (Government of Alberta, 2008, p. 4):

- The submission of a curriculum vitae (with reference to educational background, publications, affiliated institutions, pertinent experience etc.).
- A postgraduate degree in paleontology
- Supervised field training (paleontological surveying and excavation)
- Training in either paleontological curating or laboratory analysis
- The applicant also must have undertaken a comparable paleontological study

If an applicant does not meet these qualifications, it is up to the discretion of the Minister to determine if the applicant receives a permit (p. 4). Supervised students conducting work required for post-graduate studies may also receive a permit (p. 4).

#### **California: Uniqueness Alone Does Not Equate To Significance**

California has a robust system in place for dealing with paleontological resources. The California Environmental Quality Act (CEQA) requires that paleontological resources be considered prior to development activities. Responsibility for ensuring compliance has been devolved at the county level, and is included in various county land use plans. There are some differences between counties in how the paleontological component of CEQA is administered (California Department of Transport, 2007, Local Agencies). Fossils that are unique, and the locations where fossils are abundant, diverse, and well preserved are afforded protection under CEQA (Scott & Springer, 2003, p. 4-5).

#### *Criticism of CEQA*

A major criticism of CEQA has been the emphasis on unique fossils as the only important type of fossils (Scott & Springer, 2003, p. 5). As Scott and Springer (2003) discuss this is a problematic viewpoint, as other paleontological resources are important even if they are not unique (p. 5). Further, the emphasis of paleontology is not confined to making unique discoveries but rather examining the evolution and interaction of life. In the opinion of Scott and Springer (2003) focus on uniqueness is counterproductive in terms of advancing paleontological knowledge. Defining uniqueness is problematic, as this would require “extensive study that is generally beyond that which can be performed in the field” (Scott & Springer, 2003, p. 5)

The application of the uniqueness criteria can also be problematic depending on how stringent the definition is interpreted (Scott & Springer, 2003, p. 5). These researchers argue that if the definition of uniqueness is applied too stringently, scientifically significant fossils may not receive protection.

#### *Proposed Definition of Significance*

Scott and Springer (2003) propose a definition of scientific significance. Under this proposed guideline, a paleontological resource can be considered significant if “one or more of the criteria” are met (p. 6). The criteria states that fossils that contribute data about evolution, timing of geological events, biological interactions, or are threatened be considered scientifically significant. As with other guidelines, Scott and Springer (2003) believe that significance can ultimately only be determined by qualified paleontologists (p. 6). The authors note that if a paleontological resource can be precisely identified, then it has the potential to be significant.

#### **San Diego County: Specific Triggers and Monitoring Requirements**

San Diego County has developed guidelines for determining significance of paleontological resources. Under the CEQA checklist proponents are asked whether their project would “directly or indirectly destroy a unique paleontological resource or site” (County of San Diego, 2009, p. 1-3). San Diego defines unique paleontological resources as meeting one of the following criteria: local or regional exemplar, evolutionary knowledge contribution, and/or unique assemblage.

#### *Geological Maps and Predicting Paleontological Resources*

Using geological information “it is possible to reasonably predict whether paleontological resources might be present” (County of San Diego, 2009, p. 12). San Diego uses a paleontological predictive map to identify the likelihood of paleontological resources being impacted by a project. Essentially, they look at the project site location and compare it to a map of paleontological and geological information to see if there is any reason for concern. This is the first step in the review process.

San Diego County has already combined existing geological maps and knowledge of previous paleontological resource discoveries to assess the paleontological potential of geological units within the county (2009, p. 12). Field studies are still required as these predictive maps can only show potential for paleontological resources, but cannot accurately determine distribution.

#### *Impacts to Paleontological Resources*

The County of San Diego has identified activities, which commonly impact paleontological resources. These activities are described as altering “subsurface geological formation(s)” (County of San Diego, 2009, p. 14). Those activities that have been identified as commonly threatening paleontological resources include “grading, excavation, trenching, boring, [and] tunnelling” (p. 14). In particular, San Diego County has identified excavation as the most commonly damaging activity.

San Diego County has identified activities involving earth movers such as bulldozers, front-end loaders, track hoes, and trucks as having the potential to significantly impact paleontological resources during extensive excavation that disturbs “massive amounts of soil and bedrock” (County of San Diego, 2009, p. 14). San Diego County has also identified indirect threats to paleontological resources. A primary threat is erosion.

Therefore, in assessing a proponent's impact to paleontological resources within an area the cumulative effects of activities that may enhance the rate of erosion need to be considered in relation to the paleontological resources present.

#### *Paleontologist Qualifications*

The County of San Diego has established qualifications for paleontologists. High levels of education (Ph.D. or M.S. in paleontology or a closely related field), experience, and local paleontological knowledge and knowledge of techniques are required (p. 19).

#### *Mitigation*

San Diego County has identified common mitigation requirements. Premier amongst them is the requirement that onsite monitoring occurs during excavation activities. The County of San Diego requires paleontological monitors for sites of high or moderate paleontological potential where excavation is "equal to or greater than 2500 cubic yards (County of San Diego, 2009, p. 16). Anything less than 2500 cubic yards that has been classified as high or moderate still requires monitoring, but does not require a professional paleontologist to monitor. It is important to note that regardless of whether fossils are discovered or not, the proponent is required to submit a report detailing their findings or lack thereof (p. 23).

#### **South Africa: Assessment of Areas Surrounding Project Area Are Important**

Law requires paleontological impact assessments whenever paleontological resources may be impacted (SAHRA, 2007, p. 5). The documents that outline the standards for paleontological reports note that paleontological impact assessments are required where "sedimentary strata or gravels" are disturbed (SAHRA, 2007, p. 5).

#### *Paleontological Impact Assessments*

Paleontological impact assessments involve an initial literature review (i.e., desktop study) followed by a cursory field study (Almond, 2011, p. 7). Geological maps are consulted to determine the paleontological potential of geological units within the study area (p. 7). Furthermore, the paleontological potential of geological units can be determined in part through consultation with institutions to determine if specimens have been previously collected from this area, or if there is previous research in the area of concern or surrounding areas (p. 7). The level of impact is determined based on the potential for paleontological resources in a particular geological unit, in combination with the scale of development in terms of "bedrock excavation" (Almond, 2011, p. 7).

A more in depth paleontological field survey is required when geological units have been identified as having moderate to high potential for paleontological resources (p. 7). Some sampling may be required as part of this assessment. While it may seem counterintuitive for paleontologists to examine areas outside the development area, Almond (2011) states that because most paleontological resources are hidden beneath the surface, paleontologists may have to examine areas where "better exposure of the same formation" exist (e.g., riverbanks, road cuts) (p. 7). This is an important consideration for land-use decision-makers to note so they do not view a report as incomplete since it may not focus specifically on the area under development. Almond (2011) also identifies conditions where paleontological resources may be impacted. The general consensus is that construction involving the exposure of fresh fossiliferous bedrock is often the cause of impacts to these resources (p. 8).

### **South Australia: Potential Permitting System and Compliance**

In 2004, the Government of South Australia assembled the Fossil Working Group to draft a discussion paper titled *Fossil Protection in South Australia*. The purpose of the discussion paper was to discuss the protection of significant fossils (Fossil Working Group, 2004, p. 3). The authors of the paper noted that South Australia has “no legislative or other measures that stipulate specific requirements for fossil protection” (Fossil Working Group, 2004, p. 3). Besides the discussion paper there is no other information available pertaining to the Fossil Working Group. It is unknown if anything resulted from their work.

#### *Contents of the Discussion Paper*

The discussion paper notes the importance of leaving certain fossils in place or *in situ*. Protecting the fossils in place allows for the study of fossil ecology (Fossil Working Group, 2004, p. 5). South Australia aimed only to protect significant fossils (p. 7). In their discussion of which fossils could or should be protected, the Fossil Working Group identified potential criteria. The Fossil Working Group concluded that greater protection should be afforded to “specific fossil material [that] may only be obtained from one known location and may therefore be very rare and valuable” (Fossil Working Group, 2004, p. 7). Other factors such as the level of preservation may also factor into consideration regarding protection.

#### *Potential Permitting System*

The Fossil Working Group also contemplated the creation of a permitting system for the collection of fossils for educational and scientific purposes, which in itself is not unique. What is novel however, is the notion of implementing a tracking system database (possessor, location collected, other information) to allow for “future scientific and educational purposes” (Fossil Working Group, 2004, p. 8). In the absence of a tracking system valuable fossils could be lost. The working group identified one potential obstacle that South Australia would have to overcome: compliance. Arguably, it would be difficult to enforce compliance in any jurisdiction without allocation of specific resources that may not be available (p. 8). The issue of compliance will have to be considered further.

### **New Mexico: A Significance Criteria Worth Considering**

Several significance criteria were used by the New Mexico Bureau of Mines and Mineral during the 1980s, as part of a paleontological inventory conducted Resources (1985, p. 1). The criteria are as follows:

#### *Paleontological Resource Types*

New Mexico grouped the different types of paleontological resources into three categories, vertebrate, invertebrate, and paleobotanical in order to assess significance (1985, p. 10). Although examples in these categories are not exhaustive, the criteria applies to vertebrates (e.g., complete skull and/or jaw, articulated or complete skeleton, concentration of vertebrate material, unique or rare occurrence, intimate association with the paleo environment), invertebrates (e.g., good to excellent preservation of shell material, concentration of diverse material, unique or rare occurrence, intimate association with the paleoenvironment, stratigraphic sequence), and paleobotanical material (e.g., well preserved plant material of any kind, petrified wood, fossil stumps, intimate association of fossil plant and animal materials) (p. 10).

### *Significance Criteria*

The state of New Mexico devised a set of criteria pertaining to the significance of paleontological resources. The paleontological resources were assessed for their contribution to both floral and faunal lists, and the “systematics of the group or groups discovered” (New Mexico Bureau of Mines and Mineral Resources, 1985, p. 10). Further, the paleontological resources were assessed for the way in which they contribute to an understanding of the anatomy and function of the organism discovered. The ability for the paleontological resource to contribute to the knowledge of the “biostratigraphy, paleoecology, or taphonomy of the occurring organisms” was also assessed (New Mexico Bureau of Mines and Mineral Resources, 1985, p. 11). Lastly, the paleontological resources were assessed in terms of their educational significance and museum potential use (p. 11).

### **Mongolia: Industry and Government Working Together**

Mongolia demonstrates the importance of industry and government cooperation in addressing threats to paleontological resources. The Ministry of Education, Culture, and Science has an approval process in place to determine cultural heritage significance (Oyu Tolgoi Project, 2012, B12: p. 6). However, there do not seem to be policies in place that require mandatory paleontological impact assessments. The mining project, Oyu Tolgoi, a joint venture between Rio Tinto and the Government of Mongolia has plans in place to address paleontological resources. Oyu Tolgoi recognizes that “one of the first things impacted by the activities of a mining company are essentially archeological and paleontological findings” (Oyu Tolgoi, 2012, Interview with D. Amarbayasgalan, p. 1). In order to protect paleontological resources, they conduct paleontological surveys prior to any construction work, and if paleontological resources are discovered during construction or mining, operations must cease. Their workers receive training in how to treat paleontological findings and training occurs at 6-month intervals. In Mongolia, companies are responsible for all excavation costs, and for arranging transportation and proper storage of paleontological resources. Rio Tinto, one of the co-operators of the project, has developed its own heritage management system, and this may warrant further investigation.

### *Oyu Tolgoi Process*

In undertaking cultural heritage studies, the Oyu Tolgoi Project hires professional paleontologists (Oyu Tolgoi Project, 2012, B12: p. 3). During the course of these cultural heritage studies, professionals prepare inventories, impacts from the project, and study and document the resources they encounter. This combines elements of a literature review and fieldwork. As Mongolia does not have formal guidelines in place for determining the value of cultural heritage resource items, the project has to rely on expert opinion (B12: p. 14). Oyu Tolgoi “is exploring ways to facilitate protection of the fossil heritage” (Oyu Tolgoi Project, 2012, B12: p. 24). Interestingly, they are looking at the model used by the Society of Vertebrate Paleontology as a template.

Oyu Tolgoi has developed “chance find procedures”, that are “designed to ensure the safety, integrity, and proper handling of any previously undocumented [paleontological] objects” (Oyu Tolgoi Project, 2012, D13: p. 6). These procedures apply to regular employees, as well as contract workers, and subcontractors (D13: p. 6). Under the chance findings procedure, new discoveries trigger a stop to “all earth-moving works” and require the proper authorities be notified (Oyu Tolgoi Project, 2012, D13: p. 6). The procedure also requires a buffer zone be created around these new discoveries to avoid any potential

damage, and then the discovery is assessed by “a competent and qualified specialist representing the professional institution in the relevant field” (Oyu Tolgoi Project, 2012, D13: p. 6). If excavation is required it has to be supervised by a qualified paleontologist (D13: p. 6). All finds are required to be properly documented. The language around who should conduct assessments in the Mongolian document is particularly good language in that it ensures that relevant expert opinion helps shape decisions around paleontological resources.

### **Abu Dhabi Emirates: A Challenge of Lack of Expertise and Enforcement**

The United Arab Emirates has recently started researching how to protect paleontological resources. In 2004, the Abu Dhabi Emirates conducted an overview study on the paleontological and archaeological resources within this jurisdiction. Compiling information of existing knowledge of paleontological sites helps to determine when and where paleontological impact assessments might be necessary. While little information is available about this jurisdiction, Abu Dhabi is dedicated to protecting cultural and heritage resources from the rapid pace of development that the United Arab Emirates is currently undergoing (Mesbah, 2011).

#### *Challenges*

Like many jurisdictions, the United Arab Emirates and the Emirate of Abu Dhabi, lack formal measures for fossil protection. At the same time, development is a major threat to fossil sites (Beech, 2007, p. 32). The United Arab Emirates faces many challenges when it comes to paleontology that other jurisdictions share. In particular, there is a lack of educational opportunities available within the country for studying paleontology. Beech (2007) notes that paleontology is “not a priority in the current educational system and there are no economic incentives for entering this field” (p. 33). As with education, employment opportunities are also limited. This has resulted in a lack of qualified individuals in the United Arab Emirates (Beech, 2007, p. 33). The United Arab Emirates have also highlighted other challenges related to ensuring that fossil sites are protected. For one, at the time, there was no monitoring of important sites. Monitoring and enforcement efforts were limited to signage and fencing (2007, p. 37).

Technically, under the current law of the United Arab Emirates, fossil resources should be considered as part of an Environmental Assessment, but there is no way to ensure enforcement (2007, p. 41). The Government of Abu Dhabi has established the Abu Dhabi Authority for Culture and Heritage to protect Abu Dhabi’s cultural heritage resources, which include paleontological resources. The Historic Environment Branch of this organization is responsible for conducting Preliminary Culture Reviews (PCRs). PCRs are required as part of the environmental assessment process, and are required for developmental projects (Mesbah, 2011).

#### *PCR Process*

The PCR process is generally comprised of desktop studies and site surveys. First, applicants must submit project information and a map of the development area. The government is responsible for determining whether any further investigation is required. If further investigation is required then the proponent bears the cost of having the Historic Environment Branch undertake additional research (Abu Dhabi Culture & Heritage, 2013).

## **Conclusion**

The above jurisdictional scan has covered international practices related to paleontological resource management. Table 3 provides a summary of the key findings. The jurisdictions included in the scan were included based on the strength of their paleontological resource management practices. The jurisdictions share many similarities regarding how paleontological resources should be managed. These jurisdictions outline how paleontological impact assessments should be conducted, and by whom. The jurisdictions also outline mitigation practices, and potential problems with implementing a paleontological impact assessment process.

Table 4 - Jurisdictional Scan Summary Highlighting Uniqueness And Differences In Practices And Approaches.

US Society of Vertebrate Paleontology (SVP)	<ul style="list-style-type: none"> <li>• The SVP guidelines are considered the "gold standard" for paleontological impact assessments.</li> <li>• The guidelines are universally applicable and include criteria for recommended stages of assessment, qualifications, significance determination, and monitoring and mitigation options.</li> </ul>
United States: Bureau of Land Management (BLM)	<ul style="list-style-type: none"> <li>• The BLM system provides in-depth information on how geological units can be classified.</li> <li>• The BLM system provides useful information on the educational and experience requirements for paleontologists.</li> <li>• The BLM outlines report contents for paleontological impact assessments.</li> </ul>
Alberta	<ul style="list-style-type: none"> <li>• Provides useful qualification criteria for paleontological work.</li> <li>• Provides listing of Historic Resources.</li> <li>• Created a GIS system for tracking paleontological resources.</li> </ul>
California	<ul style="list-style-type: none"> <li>• Criticisms of CEQA identified an overemphasis on uniqueness for determining significance.</li> <li>• The critics of CEQA identified important alternative significance criteria that address the concerns with uniqueness.</li> </ul>
San Diego County	<ul style="list-style-type: none"> <li>• San Diego County provides an informative definition for uniqueness (i.e., significance).</li> <li>• This jurisdiction highlights the importance of geological maps in predicting paleontological resources.</li> <li>• San Diego County provides information about what activities can impact paleontological resources.</li> <li>• San Diego County also provides a specific trigger for requiring monitoring.</li> </ul>
South Africa	<ul style="list-style-type: none"> <li>• South Africa outlines when paleontological impact assessments should be conducted and how they should be conducted (i.e., what steps).</li> <li>• South Africa highlights the importance of bedrock disturbances.</li> <li>• South Africa identifies the importance of considering the areas surrounding the project area when assessing potential impacts to paleontological resources.</li> </ul>
South Australia	<ul style="list-style-type: none"> <li>• Identified one possible criterion for when fossils should be protected (i.e., if they are rare and valuable).</li> <li>• Permitting system &amp; tracking of paleontological a useful technique for paleontological resource management.</li> <li>• The issue of compliance was raised and warrants further consideration.</li> </ul>
New Mexico	<ul style="list-style-type: none"> <li>• New Mexico provides useful examples of the various paleontological resources which warrants consideration.</li> <li>• New Mexico's significance criteria are informative.</li> </ul>
Mongolia	<ul style="list-style-type: none"> <li>• Oyu Tolgoi demonstrates the importance of training for workers and for having stop work procedures in place.</li> <li>• Oyu Tolgoi has taken a novel approach in requiring subcontractors to follow the established procedures rather than limiting these procedures to regular employees.</li> <li>• This jurisdiction highlights the importance of relying on expert opinion.</li> </ul>
Abu Dhabi Emirates	<ul style="list-style-type: none"> <li>• The United Arab Emirates highlight some of the issues that may occur in implementing a paleontological assessment process such as lack of expertise, and lack of enforcement.</li> </ul>

## 6. CASE STUDIES

The following case studies, Alberta and Western Australia, were selected for the information they provide with regards to how significance could be determined (Alberta), and what a paleontological impact assessment process may look like in terms of its elements, and potential problems that could be encountered (Western Australia).

### **Alberta: How Consultants Determine Significance**

What follows examines the contents of Historical Resource Impact Assessment (HRIAs) from Alberta. Particular attention will be paid to the types of individuals involved in conducting paleontological resource impact assessments and their credentials. The types of projects requiring impact assessments will also be noted, alongside the methodology of the assessments, activities that have noted potential to damage paleontological resources, recommended mitigation measures, and proposed management plans.

#### *Background*

These first two assessments involve mining projects. The consultants noted that fossils would be destroyed during mining operations, as some fossils would be contained in the limestone (FMA Heritage Resource Consultants, 2008, p. i). However, they argued that most of these fossils would be invertebrate (i.e., without a spine), and therefore would be considered less rare and unique in comparison to vertebrate fossils (p. i). This information could potentially be useful in helping to determine which fossils would warrant greater protection. The consultant provided information about how to define medium to high heritage value; for them these would include exceptionally preserved fossils, or previously undiscovered fossils.

The consultants warned that mining activities would continuously destroy low value fossils, but also that the mining activities could potentially lead to the discovery of high value fossils (p. ii). Given the potential impacts to fossil resources, the paleontologists recommended developing a protocol to address fossil discoveries during mining. Samples should be taken as mining exposes new areas with the potential for paleontological resources, and paleontologists should visit occasionally to examine new areas and any fossils recovered by workers (p. iii). The consultants also recommended an education program for workers on the importance of fossils, how to recognize fossils, and what procedures to follow when they find fossils (p. iii).

#### *Qualifications*

The consultants involved included an individual with a Bachelor of Science degree assisting a professional paleontologist who has a Ph.D. in the field. The project involved the use of a GIS analyst, the main paleontologist, and an individual with a Master of Science degree (p. iv). This information provides a baseline account of who may be involved in the paleontological impact assessment process. The report includes a background section on regional stratigraphy and paleontology. In order to evaluate the importance of this section, an individual would need to be well versed in the field of paleontology due to the technical nature of the report.

#### *Methodology*

The paleontologist was able to identify areas with potential paleontological resources through the examination of various maps (i.e., bedrock/surficial geology maps), drilling

program results, and through a literature review. The paleontologist also made use of the paleontological database of the Royal Tyrell Museum (FMA Heritage Resource Consultants, 2008, p. 14). The area under review by the paleontologist included the immediate project site and adjacent areas (p. 15). Paleontological consultants can identify cumulative effects that the project may have on the surrounding paleontological resources. Alberta has included this requirement in its regulations. The paleontological consultant also examined the potential for paleontological resources in a regional context.

### *Significance*

The significance of the paleontological resources at each horizon (e.g., layer of rock) was determined by the following criteria: “abundance of material, quality of preservation, diversity, rarity of taxa, aesthetic value, taxonomic value, and geographic or stratigraphic value” (p. 18). Values for each of these criteria were assigned (e.g., on scale of 1-10), and those values were compiled to form an overall “Heritage Value” (low, medium, or high) (p. 19).

*Abundance of material* was rated from low (1) to high (10), with a score of 1 representing “not abundant”, and a score of 10 representing “abundant”.

*Quality of preservation* was determined on a scale of 1-10 again, with “1” being poor, and “10” being excellent (p. 19). The consultants note that this value is a “useful indicator of how much scientific information can be obtained from a site” (p. 19). Specifically, a fossil rating low on this scale (i.e., 1) is “recognized as a fossil, but not identified to a lower taxonomic level”, while a fossil rating high on this scale (i.e., 10) “allows for accurate identification of the fossil plus other scientific information” (p. 19).

*Site diversity* is determined by the number of species at each horizon (FMA Heritage Resource Consultants, 2009, 19). The consultants state that a rating of “1” represents only one type of species, while a rating of “10” represents four or more species (p. 19).

The *rarity of taxa* is provided on a scale of “1” common (i.e., 10 or more localities), to “10” rare (i.e., 1 or few localities) (FMA Heritage Resource Consultants, 2008, p. 19). The rarity of taxa is defined as the “scientific value attached to fossil types that are rarely found” (p. 19).

*Aesthetic and public value* was defined by the consultants as the ability of a layperson to recognize a specimen as a fossil (FMA Heritage Resource Consultants, 2008, p. 19). The scores ranged from low (e.g., cannot be recognized) to high (e.g., intriguing for an individual). This rating is also based on educational and economic value.

The next scale addresses the *taxonomic value* of the fossil resource (FMA Heritage Resource Consultants, 2008, p. 19-20). This scale is from “1” (i.e., taxon is already well known) to “10” (i.e., the taxon is not known) (p. 19-20). Specifically, a score of “1” means the discovery will not add to the scientific literature as the resource is well documented, while a score of “10” means that there is limited information on the resource, and it “will add to the scientific knowledge base” (p. 19-20).

The final scale, *geographic or stratigraphic value*, refers to whether or not a fossil site contributes to the “scientific knowledge based on distribution of fossils” (p. 20). A score of “1” represents that the site has been studied before; a score of “10” represents that the site has not been studied before.

### *Conclusion*

The criteria provided are useful. Each criterion is given equal weight in the determination of the overall significance value.

### **Western Australia: The Benefits of a Blind-Peer Review Process**

Fossils in Western Australia are protected under the *Environment Protection and Biodiversity Conservation Act* (1999) at the Commonwealth level, and at the State level by the *Conservation of Land Management Regulations* (2002) (Government of Western Australia, 2010, Section 4, p. 18). There does not appear to be any specific trigger for conducting an assessment of paleontological resources in Western Australia.

In the case of the Browse LNG Precinct proposal, the proponents, the Government of Australia and the Government of Western Australia, willingly undertook a strategic assessment report that examined potential impacts to paleontological resources. While there appears to be no formal government policy outlining triggers for paleontological assessment, the strategic assessment report for the project outlined activities that could potentially impact paleontological resources. These activities included “clearing, drilling, piling, earthworks, dredging, and operation” (Government of Western Australia, 2010, Section 4, p. 18).

### *Lessons Learned*

In assessing the impact of the proposal, the government hired Dr. Mikael Siverson, the Curator of Paleontology at the Museum of Western Australia to conduct the first assessment (McCrea, Lockley, Haines, & Draper, 2011, p. 86). Dr. Mikael Siverson’s area of research was not dinosaur tracks (McCrea, Lockley, Haines, & Draper, 2011, Appendix 5), but rather “Cretaceous Lamniform Sharks” (Perrella, 2010). Dr. Siverson based his assessment of significance on whether or not the fossil prints were of museum quality (McCrea et al., 2011, Appendix 5). He concluded that they were not. Another paleontologist disagreed with Dr. Mikael Siverson’s findings and criteria for assessing significance, and the government responded by seeking further expert opinion.

The situation described above offers three valuable lessons:

- There is a need to consider the type of paleontologist conducting an assessment; many subfields of paleontology exist. Ideally, an appropriately qualified expert who specializes in the particular paleontological resource being assessed should conduct the paleontological assessment.
- In defining significance, emphasis should not be placed strictly on the level of museum quality of the paleontological resource. Museums are often not the best place for paleontological resources as they often suffer “severe constraints on space and other resources” (McCrea et al., 2011, Appendix 5).
- The scientific value of paleontological resources are often most valuable in their original position. Scientists can gain valuable information not just from the paleontological resource itself, but also through the study of the paleontological resource in the context of its surroundings.

Additional expert opinion came from Canadian Richard T. McCrea, the Curator of Paleontology at the Peace Region Paleontological Research Centre. It is important to note that in this case, the Australian government still relied on Mr. McCrea’s expertise despite having a Masters in Science of Paleontology, rather than a Ph.D. The remaining three

individuals involved in conducting the assessment had Ph.D.'s in various fields (McCrea et al., 2011, p. V).

### *The Australian Experience*

While there is no formal paleontological impact assessment process in place, the Australian protection agency set out clear guidelines for how they wanted this particular site assessed. The proponent was required to gather information in order to identify potential impacts to the paleontological resources. If potential impacts were identified then the proponent had to provide the Environmental Protection Agency (EPA) with “any plans the proponent has to deal with such material to avoid, mitigate, manage, or offset any potential impacts” (McCrea et al., 2011, Appendix 1).

In order for the proponent to gather the information, they required a ground survey conducted by qualified experts. By insisting on this requirement, Australia encountered a lack of readily available expertise. The EPA notes, “there is a limited pool of experts in Australia (or elsewhere) that would have the expertise or would be available to undertake such a survey (McCrea et al., 2011, Appendix 1). This may also prove to be a serious obstacle to determining the appropriate qualifications for conducting paleontological Impact assessments (PIAs).

### *Process Requirements*

The EPA requirements set out in its draft scope of work may prove useful as they are more or less universally applicable. The agency required a ground survey and the use of “professionally recognized search and document techniques” (i.e., GIS location, high resolution photographs) (McCrea et al., 2011, Appendix 1). In addition to using GPS to track location and high-resolution photos to document their findings, the team that conducted the assessment also created 3D images through photogrammetry and anaglyphs. The EPA was very specific about what components the final report was to include. The report was to include background information on the survey, a methods section, a results section, and conclusions supported by evidence. The report also examined the significance of the paleontological sites.

### *Peer Review*

The quality of the assessment was assured through the use of peer review. The EPA required that both the study design and the final report be peer reviewed. Two versions of the report were prepared, one with confidential information concerning the location of paleontological resources, and one for public consumption with information about the location removed. This information was removed in order to protect the sites (McCrea et al., 2011, Appendix 1). The peer reviews themselves provide a useful source of information. The peer review process was designed to be flexible so as to allow the reviewer the ability to make suggestions for improving the process (McCrea et al., 2011, Appendix 5). One anonymous peer reviewer of the Browse LNG Precinct proposal suggested that field teams be comprised of a geologist, surveyor, and a paleontologist. These suggestions were ultimately incorporated into the study methodology. The study required the expertise of paleontologists, a field survey geologist, and a geomorphologist. Both the geologist and geomorphologist were selected for their local and regional expertise. This information is useful in determining the qualifications required for conducting PIAs. The peer reviewer also stressed the importance of allocating sufficient time for completing the required task adequately (McCrea et al., 2011, Appendix 5). Lastly, the peer reviewer

noted the need to share the full assessment (with information on location left in document) with qualified individuals in order to facilitate further scientific study.

*Report Content*

In concluding their report, the survey team included a basic overview of threats to paleontological resources: neglect, natural erosion, industrial activity, and human activity (McCrea et al., 2011, p. 49). These are all factors that could be considered in developing mitigation strategies. Interestingly, they note that industrial activity can be both destructive as well as beneficial in terms of exposing paleontological resources. The assessment team also offered suggestions on possible mitigation strategies that could be employed. These include documentation, recovery, and mould making. In documenting the paleontological resources they suggest paleontologists and geologists conduct a complete scientific survey. Recovery would involve collecting representative samples to be stored in institutions capable of properly caring for them.

**Conclusion**

These two jurisdictions provide information that is essential to consider with regards to paleontological impact assessments. Alberta addressed the issue of determining significance, while Western Australia provides solid guiding practices for conducting paleontological impact assessments. Both jurisdictions offer valuable information.

The following table provides a general overview of the lessons learned from the case studies.

Table 5 - Case Studies Summary.

Alberta	<ul style="list-style-type: none"> <li>• Significance can be assessed according to various criteria, such as abundance, quality of preservation, diversity, rarity, esthetic and public value, and geographic value.</li> <li>• Determining an overall value of significance can be challenging given the subjective nature of the assessment process.</li> </ul>
Western Australia	<ul style="list-style-type: none"> <li>• Western Australia provides information on what would constitute a PIA, and also raises the issue of ensuring that paleontological impact assessments are conducted by subject experts.</li> <li>• Western Australia introduces the concept of using a blind-peer review system for assessing paleontological impact assessments.</li> </ul>

## **7. SURVEY FINDINGS**

One hundred paleontologists and paleontological resource management experts from various jurisdictions around the world were contacted. The majority of those experts who responded were located in North America. The survey had a 10% response rate. Knowledge of geology and palaeontology were common to these experts. Some individuals had worked in paleontological resource management at the state or provincial level, while others worked as paleontological resource consultants. Many of the experts were vertebrate paleontologists, and one invertebrate paleontologist was surveyed. Most of the individuals surveyed had fieldwork experience related to paleontological resource management. The following is a summary of the responses from participants to the paleontological resource management survey.

### **Triggers for Paleontological Impact Assessments**

Respondents indicated that paleontological impact assessments should be conducted whenever fossil vertebrates or paleontologically sensitive bedrock will be disturbed, or can be conducted at the request of a company (e.g., pipelines, right-of-ways). In the United States, at the Federal level, they are currently working out the circumstances that would require assessments. However, participant three notes, “some level of assessment should be done for any land action. One respondent noted that it is also important to conduct paleontological impact assessments in known fossils sites or areas that have paleontological potential (e.g., paleontologically sensitive bedrock).

Most participants agreed that disturbance of bedrock was a sufficient condition for triggering paleontological impact assessments. Some noted that fossil resources might also be contained under shallow alluvium. Further, the Bureau of Land Management (BLM) Potential Fossil Yield Classification (PFYC) system was identified as a useful tool by participant three. However, participant three also notes that fossils can occur in unexpected places. Paleontological sensitive bedrock may also be “obscured by Quaternary deposits”. Therefore, participant five recommends that assessments should be conducted in this case. Participant six noted that the need for an assessment should be made by a trained paleontologist.

### **Qualifications For Conducting Paleontological Impact Assessments**

In regards to who would be qualified to conduct paleontological impact assessments, the respondents favoured a graduate degree or equivalent in the subjects listed in the question provided to participants (i.e., palaeontology, geology, biology, zoology, anthropology, and botany so long as there has been a specialization on palaeontology). Experience with significant fieldwork was also considered necessary. Participant five in particular recommended a background in geology. Further, participant five noted that a specialization in anthropology was seen as not sufficient to conduct the work. Participant six, in addition to fieldwork, recommended experience in a paleontological lab and curating specimens.

Some individuals thought that some experience assisting or conducting paleontological impact assessments was useful. The BLM system requires three to four years of fieldwork, but participant two notes that this a stringent requirement. Participant two may believe that this is too stringent a requirement, as it is hard to gain opportunities to gain experience in this field. It is important to note that the type of paleontological resource being mitigated

may require specialized expertise. Participant five stated that a minimum of five years of experience is required to conduct paleontological impact assessments.

All of the respondents agreed that scientific value followed by educational value should be the top indicator of significance. The respondents note that the significance should be assessed by a qualified paleontologist, and that there is some subjectivity involved.

### **Elements Of A Paleontological Impact Assessment Report**

Nine out of the ten participants agreed that the report content should contain maps, literature review of unpublished/published documents, an overview of geological units and corresponding paleontological elements, identification of potential impacts, mitigation strategies, and/or monitoring recommendations. Participant one also recommended that there should be an agreement with a nationally recognized repository. In addition to survey results and monitoring recommendations, Participant two notes that it is important to include geological/paleontological history (e.g., previous discoveries) and background of the area. Participant two also includes “regional geological maps and stratigraphic column”, and recommends that photos, GPS coordinates, and stratigraphic information is kept confidential. Many of the elements discussed in the survey question were encapsulated in participant five’s response. Participant five acknowledged that these are “considered standard elements of reports for most jurisdictions” but Participant five warns against a universal template. Participant six provided a benchmark for determining whether or not a paleontological impact assessment has sufficient information. These criteria can be summed up as follows: “a paleontologist who has never seen a site/project area...can assess potential impacts on paleontological resources and make reasonable recommendations regarding the preservation and protection of those paleontological resources”. Participant six has also provided recommendations for minimum standards for the contents of paleontological impact assessments. Much of this information has been discussed already.

### **Impact Activities To Paleontological Resources And Mitigation Strategies**

The following activities were identified by survey participants as having potential impacts on paleontological resources: any bedrock disturbing activity, pipelines, mining, roads, cellphone towers, oil well pads, housing developments, engineering projects on rivers, erosion control projects, railways, transmission lines, seismic investigations, wind and solar power developments, oil and gas explorations, forestry, residential and commercial developments, water projects, gravel pits, bridge installations, and/or excavation projects.

Of the sample mitigation strategies provided in the question (i.e., avoidance, monitoring, recovery, sampling), respondents viewed most of them as acceptable strategies. Participant one notes that recovery and sampling require a qualified person and an appropriate repository. Participant three notes that avoidance is typically preferred, but is not always an option. Further, participant three warns against sampling because fossil locations are often random. Participant five advocates against avoidance because it allows for scientifically significant fossils to weather or erode. In participant five’s opinion, recovery makes use of the work done to conduct the paleontological impact assessment, whereas avoidance could lead to the work going to waste. Participant five notes however, that clients should be able to choose between salvaging and avoiding the area. Participant six notes that while avoidance is preferable, it is not always an option because of “time constraints and/or budgetary reasons for the developer”. Participant six provides mitigation strategies gravel pits, roadwork and bridges, power lines, oil and gas developments, mines, railway work,

residential and commercial developments, and water lines. Avoidance being the most common mitigation strategy for these project types.

### **Recommended Literature**

The BLM guidelines, the Conference of Fossil Resources, and select individuals were suggested for further consultation. In terms of recommended literature, participant five noted, “no such documents currently exist to my knowledge”. This demonstrates the lack of available literature on this subject matter.

The following is a list of recommended literature as suggested by survey participants.

- Bureau of Land Management (BLM) Manuals and Guidelines
- Conference of Fossil Resources Papers/Reference Material
- Alberta Historical Resources Act
- Best Practices in Mitigation Paleontology (working title)
- Agency-Specific Management Guidelines
- Society of Vertebrate Paleontology (SVP)

The Bureau of Land Management Manuals and Guidelines provide a comprehensive overview of qualifications for paleontologists, monitoring and mitigation strategies, and categories of geological units for determining paleontological potential (BLM, 1998b). The Conference of Fossil Resources are held regularly, and the conference allows paleontological resource experts an outlet for sharing the latest developments in the field. Conference papers are collected in order to disseminate information about paleontological resource management (see fossilresources.org). The Alberta Historical Resources Act outlines legislative requirements for conducting paleontological work in Alberta (see Alberta section in jurisdictional scan). The Best Practices in Mitigation Paleontology is a forthcoming article that was recommended by one of the participants. It is not currently available. The agency-specific management guidelines would include organizations like the BLM and the SVP. Finally, the SVP guidelines have been developed by paleontological experts to be universally applicable.

### **Conclusion**

Survey experts provided a means of confirming that the findings of the other sections were valid. The information provided by the experts aligns with the information from the literature review, jurisdictional scan, and case studies. Having experts share their knowledge of paleontological resource management was important for aiding in the development of the draft guidelines for British Columbia as information on paleontological impact assessments and resource management is limited. Further, the experts surveyed have a passion for paleontology, and are motivated to see paleontological resources protected.

## **PART THREE: MOVING FORWARD**

## 8. DISCUSSION

The following information outlines the findings of the literature review, jurisdictional scan, and the survey. The information has been organized in terms of general findings and specific implications for British Columbia. The first section, *Pulling The Findings Together*, discusses permitting, the stages of paleontological impact assessments, significance of paleontological resources, impact prevention, mitigation, preservation, reporting, and predictability. The second section, *Implications for the BC Process*, addresses stakeholder engagement, qualifications, assessment triggers, and useful tools.

### **Pulling The Findings Together**

#### *Permitting Is The Norm*

Based on the research most jurisdictions require some form of permit for conducting paleontological work within their jurisdiction. Qualifications also vary by jurisdiction. Paleontological Impact Assessments (PIAs) are triggered when a project or activity may disturb bedrock.

#### *PIAs Are Generally Conducted In Stages*

The preliminary stage often involves a review of relevant literature, survey of institutional collections, review of geological maps, and potentially a cursory field survey conducted by a paleontological resource consultant hired by the proponent. After analyzing the information collected during the preliminary stage, the paleontological resource consultant makes a recommendation in regards to the need to conduct any further study. If no potential impacts are identified by a paleontologist then no further investigation is required. If paleontological resources are discovered that may be threatened, then paleontological resource consultants are hired by the proponent to determine the significance of the paleontological resource, identify impacts, and propose mitigation strategies. Some jurisdictions also require chance find procedures.

#### *Assessing Paleontological Resource Significance Is Subjective*

Significance of paleontological resources can be determined by assessing aesthetic value, educational value, scientific value, economical value, rarity, uniqueness, abundance, public interest, and fossil type. Assessments are unavoidably subjective and it is difficult to determine the proper weighing of these categories as this ultimately depends on the goals of the organization and/or jurisdiction responsible for the resource. As survey respondents note, scientific value should be given priority in determining significance, followed by educational value.

#### *Protecting Fossils From Human and Non-Human Impacts*

Impacts can be both direct and indirect, and any activity that disturbs bedrock (e.g., road construction, pipeline development, and mining) has the potential to directly impact paleontological resources. The natural environment (e.g., humidity, wind, hydrological factors, geological factors, and biological factors) can also impact paleontological resources. Human activity may enhance these natural processes (i.e., increased rates of erosion). The research suggests that natural processes as well as human activity should be considered in an impact assessment. It is important to protect significant fossils from all possible threats, not just from human activity.

*Mitigation: Best Handled With Protocols And Monitoring*

Many mitigation strategies exist including avoidance, monitoring, recovery, sampling, signage, secrecy, and reburial (n.b., reburial is controversial and may damage paleontological resources). The most important mitigation strategy is the development of discovery protocols and the use of paleontological monitors. Project workers are provided with training about fossils, how to recognize them, and what to do if they are discovered. A qualified individual, either a paleontologist or a geologist, also monitors excavations.

*In Situ Preservation As Default; Documentation Second Best*

Most sources are in agreement regarding the importance of leaving paleontological resources *in situ* as the contextual information surrounding the resources is often scientifically the most valuable information provided by a discovery. When *in situ* preservation is not possible sufficient efforts need to be made to ensure adequate documentation of the site. Proponents always bear the cost of paleontological documentation, salvaging, transportation, and site management. Proponents must also make arrangements for an institution to accept discoveries. Monitoring can be accomplished through the use of technology and human supervision (e.g., scientist or volunteers depending on the circumstances). Photography is common practice for monitoring and documenting impacts to paleontological resources.

*Reporting And Decision Making: Capacity And Expertise Essentials*

The land management agency ultimately determines which mitigation and monitoring strategy should be implemented. Reports submitted to land management generally include maps, literature review of unpublished/published documents, an overview of geological units and corresponding paleontological elements, identification of potential impacts, mitigation strategies, and/or monitoring recommendations. This information aids the land management staff in the decision making process. If land management staff lack the knowledge and/or experience in the field of paleontological management, then a blind peer-review system can be implemented similar to what is used in Western Australia.

*Predictability Is Possible: Judgment Still Required*

It is possible to indicate which areas have high probability of containing paleontological resources. Some jurisdictions use GIS systems to track past discoveries and to integrate this information with geological maps. Furthermore, only certain types of rock are known to contain fossils. Both the BLM and SVP have comparable systems for classifying the paleontological potential of an area. As the research notes, geological maps are useful in determining potential but they cannot be depended on because fossils may be found in locations other than bedrock.

Paleontological resource distribution is not uniform. Therefore, even if certain bedrock has high potential for paleontological resources there is no guarantee that paleontological resources will be contained within that specific area. Areas of the same bedrock may contain different paleontological resources and may also differ in terms of distribution. As a result, paleontologists need to make the final call regarding area potential on a case-by-case basis.

Overall, the findings show that bedrock is an important determinant of fossil locality, but it is not the only source of paleontological resources. Paleontological expertise is essential to any paleontological impact assessment process, as there is unanimous agreement that the

significance determination, and the monitoring and mitigation strategies need to be developed by paleontological experts. As the needs of each paleontological site will differ, various combinations of mitigation and monitoring strategies will need to be utilized depending on the context specific requirements. There is consensus throughout the literature and from the respondents as to the importance of paleontological resources and the need for their protection.

### **Implications for the BC Process**

The section below outlines important considerations that could be considered when developing paleontological impact assessment guidelines for British Columbia.

#### *Stakeholder Engagement and Alternative Expertise*

Industry support is essential to any paleontological impact assessment process. The vast number of activities that can impact paleontological resources makes it difficult to select which industries should be consulted. Compliance will be a major issue in any paleontological impact assessment process. Identifying paleontologically sensitive areas and developing monitoring and management strategies are exercises in futility if there is no follow through. It may be in the interest of industry to avoid reporting paleontological finds due to project delays and increased costs. Ignorance about paleontological resources could lead to their unintentional destruction. Project workers will need to be educated about paleontological resources and what to do if they encounter them. It will be necessary in any paleontological assessment to develop educational materials and courses with the help of government, industry, and the paleontological community.

There is also a need to ensure that First Nations are consulted with regards to the development of the paleontological impact assessment process. This is particularly important with respect to determining significance. First Nations may offer an alternative perspective about the significance of a paleontological resource.

The Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) may have a monopoly on the regulation of paleontology through the Engineers and Geoscientists Act. Under the Act, the "practice of professional geoscience" is defined as:

reporting, advising, acquiring, processing, evaluating, interpreting, surveying, sampling, or examining related to any activity that is (a) directed towards the discovery or development of oil, natural gas, coal, metallic or non-metallic minerals, precious stones, other natural resources or water, or the investigation of surface or sub-surface geological conditions and (b) requires the professional application of the principles of geology, geophysics, or geochemistry (Government of British Columbia, 2013, Engineers and Geoscientists Act).

Paleontology, although a multidisciplinary field, could conceivably fall under this definition. If this situation continues, individuals from outside the discipline of geology may not be able to practice as paleontological consultants. This situation could limit the number of potential paleontological consultants in the province. Although, there are benefits from utilizing an established regulatory body. The government could consider advocating APEGBC to allow for some exemption for other disciplines. This issue needs further research as APEGBC could limit the provincial government's control over establishing qualifications. Negotiation on the issue of qualifications between the province,

APEGBC, and the British Columbia Paleontological Alliance is essential to resolve the qualification questions and to determine which organization will certify qualifications.

*Determining Qualifications; Expanding The Pool of Experts*

Determining the qualifications that would be best suited for BC would require a thorough survey of all paleontological expertise within the province. Some of this information may be available through APEGBC, but not every paleontologist would consider themselves a geoscientist as they may come from other academic disciplines. It is necessary to identify the paleontological expertise available within BC to ensure that there is a sufficient number of qualified professionals. This survey could collect information about the education and experience levels of BC paleontologists. This is necessary to ensure the professional standards are not set too high by the government.

There is a danger in setting the qualifications too high. Alberta for example has very stringent requirements (e.g., graduate level education, supervised field training, training in curating or laboratory analysis, and experience in conducting comparable paleontological studies) that individuals must have received a permit to conduct paleontological research. Alberta has left the ultimate decision to grant permits up to the discretion of the Minister. This ensures flexibility in permitting.

If the permitting requirements are too stringent the province may artificially and unnecessarily limit its pool of qualified professionals. On the other hand, setting the bar too low is also dangerous, as incompetent individuals may end up doing more harm than good if they receive permits to conduct paleontological research. As noted, Alberta also provides the opportunity for students to receive permits under the guidance of a qualified paleontologist. This is a practice that would be beneficial in the BC context as it contributes to the growth of the profession within BC.

If insufficient expertise is available at the provincial level then the government may consider fostering the growth of the paleontological community through education. The establishment of a paleontological certificate program similar to the Denver Museum of Natural History would help to create a solid foundation for professional paleontologists. This certificate program would also help to tap into the amateur paleontological community as those with a interest in paleontology would now have an outlet for their passion and a chance to learn more about the field.

BC is fortunate geographically in that two nearby jurisdictions (Alberta and California) currently require paleontological impact assessments. BC may initially be lacking in terms of BC-based paleontological consultants, but in the meantime could utilize expertise from outside jurisdictions. To expand on this point the qualifications needed could depend on the type of assessment being conducting. Desktop studies and records searches could be conducted from outside BC by qualified paleontologists. The downside to relying on paleontological expertise from outside of BC, however, would be increased costs for the proponent.

Rather than limit the granting of permits to only individuals with graduate degrees in paleontology, it would be wise to broaden the scope to include other disciplines such as geology, biology, zoology, anthropology, and botany so long as there has been a specialization in paleontology. Making exceptions for individuals with relevant experience or regional knowledge of paleontology could also be beneficial. Archeologists should not be granted paleontological permits or be retained as paleontological impacts assessment

consultants as the disciplines are very different. Paleontological impact assessment reports produced by archeologists should also not be accepted by government unless fossilized human remains are involved. This practice is in line with the principles identified in the jurisdictional scan and literature review. Only individuals with the appropriate expertise for a particular type of resource are qualified to conduct valid paleontological impact assessments. Qualification requirements may need to be reduced based on circumstances so that project development delays are avoided.

#### *Assessment Triggers*

BC should consider including in its land act applications a question that asks “Does the proposed activity on Crown Land have the potential to disturb bedrock (either unexposed or exposed)?”. While there are other localities which can contain fossils, it is not a comprehensive trigger, it is a starting point. Perhaps the question could be expanded to inquire if a proponent knows of any paleontological resources that may be impacted by the project.

#### *Useful Tools: Maps, Guides, Repositories*

Tools that can guide stakeholders could also be developed. It may be a useful undertaking for BC to create a database or a map that outlines where paleontological resources have been found, or are suspected. These would include a map of paleontological sensitivity and the creation of a database of previous paleontological discoveries. In order to commence both projects, a literature review of all paleontological scientific publications discussing past discoveries could be undertaken. Likewise, museum collections could be examined to gather information about their place of origin within BC. This step would help to paint a paleontological picture of the province.

It may also be useful to address the storage of paleontological discoveries. In order for current museums to handle the influx of paleontological resources they would require increased funding and space. Alternatives will have to be investigated. One such alternative could be to allow private individuals with the proper storage to act as custodians (not owners) for finds. Industry could also be required to care for, or ensure the proper care for finds on their project sites. Paleontological finds could also be lent out to other jurisdictions provided that they can be stored properly.

#### *Other Considerations: Reporting and Enforcement*

Further discussion is needed to determine the required content of paleontological assessment reports. Consideration is needed regarding where these reports will be submitted and who will be responsible for reviewing the contents to ensure that the reports are of sufficient quality.

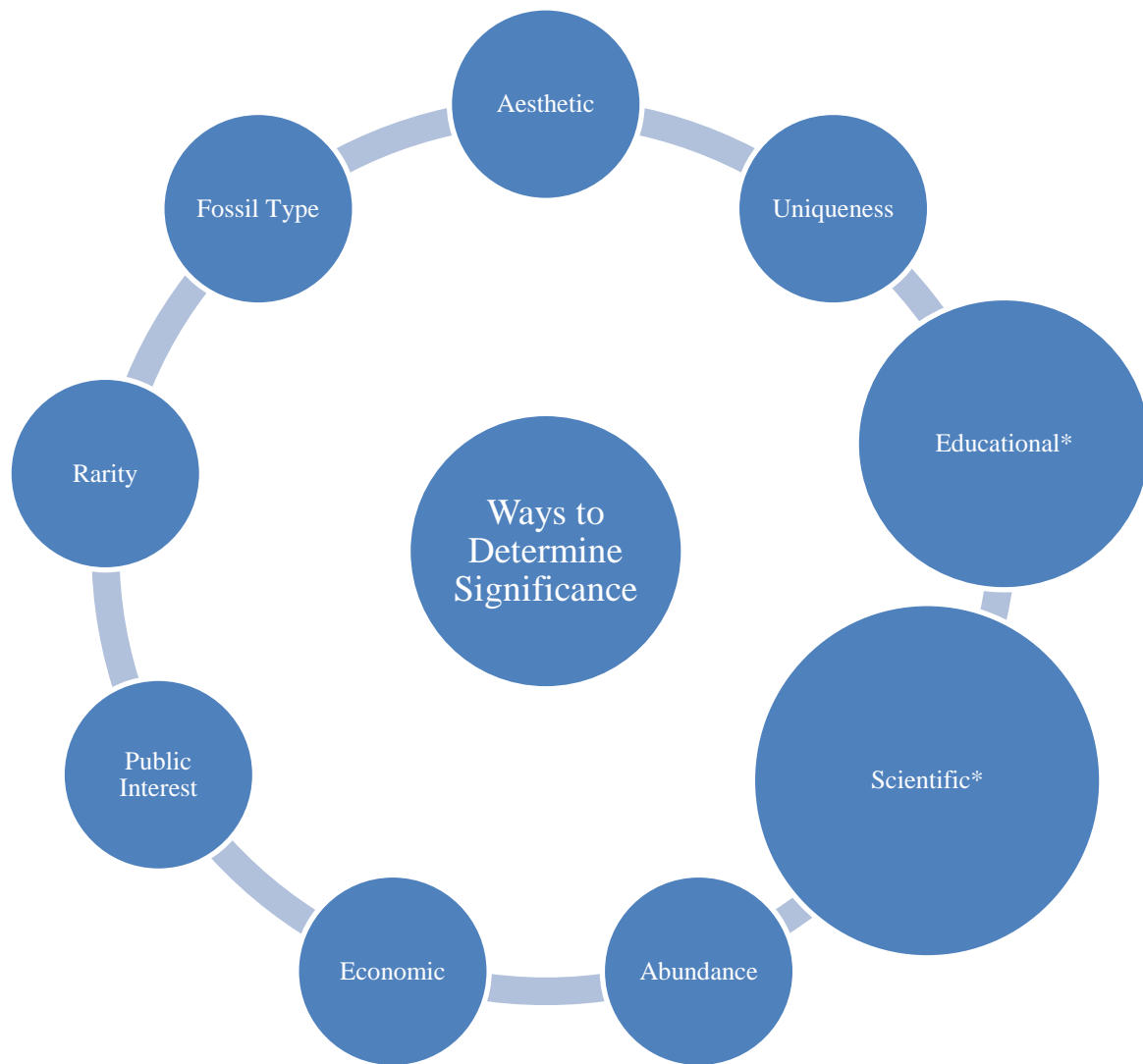
The question of enforcement is also important at the implementation stage. Can industry be relied on to self-regulate? What penalties will exist for those that damage significant paleontological resources? Will the consequences be sufficient to deter damage and destruction to paleontological resources?

#### *Overall Conclusions*

There are many outstanding issues that will need to be addressed before a paleontological impact assessment process could be operationalized. There are opportunities to learn from the practices of other jurisdictions that could ease the development process. The importance of consultation with stakeholders cannot be underestimated, especially, consultation with APEGBC. Paleontology could potentially fall under their bailiwick. This will need legal

assessment because if APEGBC continues to be the regulatory body for geosciences, and paleontology is considered within the domain of geology, then the government's ability to consider other qualifications from disciplines outside of geology will be restrained. Ultimately, implementing the nuts and bolts of paleontological impact assessments can be achieved. The challenge lays in adapting this process to the BC context.

Figure 4- Competing Significance Criteria For Paleontological Resources.



\*There are many competing criteria for determining significance. Scientific value followed by educational value are the two leading criteria endorsed by the paleontological community.

## 9. OPTIONS AND RECOMMENDATION

The following options are designed to address the need for a systematic system of assessing impacts to paleontological resources in BC. Many activities that take place on Crown land in BC can impact paleontological resources. Currently, assessments are made on a case-by-case basis. These options would allow for the creation of mitigation and monitoring strategies to help protect significant paleontological resources.

The options were assessed based on:

- Effectiveness
- Feasibility
- Speed of Implementation

*Effectiveness.* How effective will the option be at ensuring that significant paleontological resources are protected? An effective option under this criteria should increase the number of significant paleontological resources that are protected.

*Feasibility.* How feasible will the option be to implement? Feasibility includes both the cost of implementation, and maintenance of the paleontological impact assessment process. Feasibility can also be measured in terms of stakeholder support. Stakeholders could believe that requirements are too costly both in terms of time and resources (i.e., industry), or not sufficient in terms of the protection provided (i.e., paleontological community).

*Speed of Implementation.* How immediate can the paleontological impact assessment process be operationalized? Activities are occurring each day on Crown land that can impact significant paleontological resources. The sooner that an impact assessment and mitigation/monitoring program can be implemented the sooner that significant paleontological resources can be protected.

### **Option 1: PIA Draft Guidelines (Most Stringent)**

Paleontological Impact Assessments (PIAs) may be required as part of the environmental assessment process for large projects triggering the requirements of the Environmental Assessment Office under the Ministry of Environment or as part of the Crown land application process. Any project that disturbs bedrock requires that a PIA be conducted. In order to conduct PIAs in BC, a permit granted by the Ministry of Forests, Lands, and Natural Resource Operations, is required.

#### *Permitting Qualifications*

In order to receive a permit an individual must possess a graduate degree in paleontology or a related discipline such as geology, biology, zoology, anthropology, and botany with sufficient specialization in paleontology. If an individual does not possess a graduate degree in paleontology or a related field, equivalent experience or knowledge of paleontological curation, vertebrate paleontology, invertebrate paleontology, paleobotany, geology, and demonstrated paleontological field experience is required to receive a permit. These factors will be considered on a case-by-case basis and the applicant bears the onus of proving they are qualified.

Evidence of knowledge or experience may include academic publications on paleontology, past involvement in paleontological impact assessments in a supporting role, or an endorsement from the BC Paleontological Alliance or Royal BC Museum. Students may

also receive permits if a qualified paleontologist supervises them, and the permit is needed to fulfill course requirements. Archaeologists are not qualified to conduct PIAs and should not be retained by proponents to conduct paleontological investigations.

#### *Assessment Process*

Any project that disturbs bedrock must include a preliminary paleontological assessment to determine the project area's paleontological potential. Preliminary assessments include a literature review, examination of past paleontological research in the area, a survey of institution collections to establish if specimens have previously been collected from the project area or surrounding area(s), an examination of geological maps by a qualified paleontologist/geologist to determine potential.

If the preliminary assessment does not turn up conclusive evidence then a field survey will be required, especially wherever geological maps indicate that geological features are known or have potential to contain paleontological resources. If paleontological resources are encountered at any time during the development of a project, the proponent must retain a qualified specialist with subject knowledge about the particular resource. This is in order to assess significance and potential impacts caused by the environment, or by the project. This may require consultation with various experts depending on the number and type of paleontological resources encountered. The research conducted in this report indicates that vertebrate and trace fossils are considered significant. However, other paleontological resources may be considered significant on a case-by-case basis.

Submitted reports must include maps, high resolution photographs, literature review of unpublished (e.g., other impact assessments) and published documents, an overview of geological units and corresponding paleontological elements, identification of significance, potential impacts, mitigation strategies, and/or monitoring recommendations. The methodology employed in conducting the impact assessment must also be submitted prior to conducting an impact assessment. Reports are subject to a blind peer-review process, where reports are assessed by other paleontological resource experts without know who conducted the report. Information regarding the locality of paleontological resources is considered confidential. The reports themselves are not to be shared with the public in order to prevent vandalism and theft of significant paleontological resources.

#### *Proponent Requirements (Mitigation and Monitoring)*

Proponents are required to comply with the mitigation and monitoring strategies recommended by the paleontological consultant and endorsed by Ministry staff. These may include: avoidance, documentation, monitoring, recovery, sampling, signage, secrecy, and reburial. Significant paleontological resources should generally be maintained in the natural environment. If this is not possible, adequate documentation of the site is required. Proponents always bear the cost of paleontological documentation, salvaging, transportation, and site management. Proponents must also make arrangements for an acceptable institution to accept discoveries.

All project proponents must provide education and training to workers informing them how to properly identify paleontological resources discovered in the course of construction or development. Project areas that have high paleontological potential require that a qualified paleontological monitor (e.g., paleontologist/geologist) be present during any new activities that disturb bedrock. If new discoveries are made, work must stop until a qualified

paleontologist can assess significance of the discovery. If the paleontological resource is significant an impact assessment and mitigation plan must be undertaken.

#### *Advantages*

This option encompasses the findings of extensive research regarding paleontological impact assessments, monitoring, and mitigation strategies. The practices detailed in the option are widely practiced across various jurisdictions. The details of this option have been informed by the experiences of other jurisdictions, and have included solutions to problems faced in those jurisdictions. There is a definitive structure to this option, and this option provides clear guidance to proponents and government. This option is likely to garner support from the paleontological community given its robustness.

#### *Disadvantages*

One main disadvantage of this option is that it will be costly to implement. Implementation would require extensive consultation with industry stakeholders, the paleontological community, government ministries, and the Association of Professional Engineers and Geoscientists of British Columbia. An additional disadvantage is that there may not be sufficient paleontological expertise in terms of numbers of paleontologists within BC. This will make it difficult for industry and others to comply with the guidelines. Industry may oppose the implementation of these guidelines as it could increase costs in terms of project delays and the expenses incurred from salvaging, monitoring, and mitigating impacts. There is also the issue of the storage of paleontological finds, as BC would need to expand the number of repositories available.

#### *Evaluation: Effectiveness, Feasibility, Speed of Implementation*

In terms of effectiveness, this option would ensure that significant paleontological resources are protected to the greatest extent possible. The requirements under this option are very stringent, and would utilize a vast array of paleontological expertise to ensure that resources were properly assessed, and that the most effective techniques were utilized to protect significant resources. Enforcement of the paleontologist recommendations will be the ultimate determinate of effectiveness. If industry and others are not complying, then significant paleontological resources would be at risk.

This option would be costly in terms of implementation and maintenance. In order to implement this option, extensive consultation would be required. Consultation could bog down the process of implementation, and could create delays. Once the details have been worked out, there would be continual operational costs in terms of staff needed by the ministry to review project proposals. This option has been designed to shift costs of conducting assessments, and dealing with significant paleontological discoveries to the proponent. This will save the government money, but may not be welcomed by some industry stakeholders.

This option would take a significant amount of time to implement in order to ensure stakeholder support. The need for sufficient paleontological expertise within BC may also create delays, as proponents would need access to this knowledge in order to comply with Option 1. Delays may be necessary to ensure that everything is in place for the smooth operation of this option.

## **Option 2: PIA Draft Guidelines (Less Stringent)**

Paleontological monitoring may be required as part of the application process for any project that disturbs bedrock. In order to conduct monitoring in British Columbia a permit granted by the Ministry of Forests, Lands, and Natural Resource Operations is required.

### *Permitting Qualifications*

In order to receive a permit an individual must possess formal education, training, or experience related to the monitoring task. Applications will be considered on a case-by-case basis and the applicant bears the onus of proving they are qualified. Archeologists may be used to conduct monitoring if other expertise is not available.

### *Assessment Process*

Any project that disturbs bedrock should include a preliminary paleontological assessment to determine the potential of the project area. Preliminary assessments involve an examination of geological maps to determine potential of the project area and the surrounding areas.

### *Proponent Requirements (Mitigation and Monitoring)*

If paleontological resources are encountered at any time during the development of a project, the proponent must retain a qualified paleontologist. This is in order to assess significance and potential impacts caused by the project. All vertebrate and trace fossils are considered significant. Other paleontological resources may be considered significant on a case-by-case basis.

Proponents may consider the mitigation and monitoring strategies recommended by the paleontological consultant. Proponents always bear the cost of paleontological salvaging, transportation, and site management. Proponents should also make arrangements for an acceptable institution to accept discoveries.

All project proponents must provide education about paleontological resources and training to workers informing them how to properly identify paleontological resources discovered in the course of construction or development. If new discoveries are made, work must stop until a qualified paleontologist can assess significance of the discovery. If the paleontological resource is significant an impact assessment and mitigation plan is recommended.

### *Advantages*

The main advantage of this option is that it is a simplified version of Option 1. Valuable, but non-essential components of Option 1 were removed to create Option 2. Option 2 was designed to require less resources, and to take into account the potential lack of paleontological expertise within British Columbia. Proponents are likely to support this option as it is less prescriptive.

### *Disadvantages*

The main disadvantage of this option is that it provides less protection for paleontological resources. Protection for significant paleontological resources depends on the ability of proponents to train their workers to identify paleontological resources. Furthermore, the protection of significant paleontological resources is very dependent on the proponents' willingness to implement the recommended strategies and to bear the costs of any

monitoring, mitigation, or salvaging. The paleontological community would likely not support this option as the level of protection is greatly reduced.

*Evaluation: Effectiveness, Feasibility, Speed of Implementation*

Although it is not the most effective of the two options, it does provide basic effectiveness for the protection of significant paleontological resources. Its effectiveness is reliant on the proponent's willingness to protect significant paleontological resources. Some proponents may be more willing than others to protect paleontological resources, and this will have an impact on the overall effectiveness of this option.

Like Option 1, this option will also require extensive consultation with stakeholders. This option is far cheaper to implement, and allows for greater flexibility in terms of qualifications which allow a system to be in place despite a potential lack of paleontological expertise.

Option 2 could be quickly implemented as the requirements set out in this option are less stringent. There would be less consultation with stakeholders. Industry would likely not oppose this option for costs or delay reasons. Further, this option could piggyback off the established infrastructure in place for archeological impact assessments.

Table 6 - Comparison of Options.

Evaluation Criteria	Option 1	Option 2
Effectiveness	More effective at protecting paleontological resources	Less effective at protecting paleontological resources
Feasibility	Equally feasible	
Speed of Implementation	Longer implementation time	Shorter implementation time

**Recommendation: Option 1 Draft Guidelines (Most Stringent)**

Option 1 is recommended as it provides the greatest level of protection to significant paleontological resources. This increase in protection is derived from the need to retain qualified expertise, conduct assessments, and implement mitigation and monitoring strategies. Option 2 does provide a reasonable amount of protection when considering costs and time. However, significant paleontological resources are more likely to be damaged or destroyed under this approach. Some industries may favour this approach, as it requires fewer delays, and a lower investment of resources. Option 1 would be more in line with international smart practices. Option 2 would be an anomaly internationally, and would most likely be criticized by paleontologists.

## 10. IMPLEMENTATION PLAN

Currently, there is no systematic process in place for conducting impact assessments to paleontological resources when projects are developed on Crown land. The development and implementation of a paleontological impact assessment process will help to further protect British Columbia's significant paleontological resources for their scientific and educational value.

This section outlines detailed implementation plan with estimated costs and implementation time frame for the implementation of a paleontological impact assessment process for British Columbia. This implementation plan is based on the recommended Option 1.

The following table provides a general overview of the implementation steps in terms of estimated time and costs.

Table 7 - Implementation Steps Summary.

<b>Policy Implementation Steps</b>	<b>Time</b>	<b>Costs</b>
Internal Consultation with Government Ministries	3-4 months.	No additional costs.
Consultation with BC Paleontological Community	6-12 months.	\$40,000
Consultation with Stakeholders	6-12 months.	\$80,000
Formalization of Paleontological Impact Assessment Process	3-4 months.	No additional costs.
Development of the Tools Needed for the Paleontological Impact Process	6 months.	\$100,000
Informational Campaign	3-4 months.	No additional costs.
Evaluation of Paleontological Impact Assessment Process	5 years.	No additional costs.
Capacity Development (Optional)	Continuous.	Costs vary.
Public Educational Campaign (Optional)	Continuous.	\$50,000
<b>Total</b>	87-102 months.	\$270,000 +

### **Step 1: Internal Consultation with Government Ministries**

Consultation would be needed with the Ministry of Environment to include PIAs as part of its environmental assessment process. A series of meetings between interested and/or essential ministry representatives could take place.

Meetings with regional staff of the Ministry of Forests, Lands, and Natural Resource Operations to discuss guidelines for PIAs as part of the land application process would be required as well.

Estimated Time Frame: 3-4 months.

Estimated Cost: No additional costs over and above standard operating costs.

## **Step 2: Consultation with BC Paleontological Community**

Consultation would be needed with the BC Paleontological community in regards to the finalization of qualification requirements. Input would be needed on the recommended contents of paleontological reports and in regards to the recommended trigger for PIAs (e.g., disturbance of bedrock). Consultation with the BC paleontological community is also important in that the government would need to establish baseline information about the paleontological expertise within British Columbia. This interest group could be essential to the regulation of the PIA process and may have ideas on how to grow expertise within BC if it is found to be lacking. They may also be an important source of oversight as they would be able to assess the contents of paleontological reports from the viewpoint of subject experts (i.e., blind-peer review). This interest group may also have suggestions on how monitoring and enforcement of the PIA process could be achieved, and may be able to aid in the monitoring process. Consultation with the BC paleontological community may garner the community's support for the PIA process, and would be a important endorsement.

Estimated Time Frame: 6-12 months.

Estimated Cost: \$40,000 (venue, A/V equipment, facilitation, and hospitality costs).

## **Step 3: Consultations with Stakeholders**

Industry feedback and support would be important in the development process as compliance is essential to the success of the PIA process. As mentioned earlier, APEGBC is the regulatory body of geoscientists, and paleontology may be considered a sub-field of geology. APEGBC support would be essential to expanding the qualifications to include other relevant disciplines in regards to paleontological consultants. The support of this body could be useful as it is already well established in a regulatory role, and may be able to assume responsibility for regulating a more comprehensive definition of paleontology. Other stakeholders such as industry should also be consulted. Given the numerous amount of activities that can impact paleontological resources some work will be needed to identify which industry stakeholders should be consulted. Some major stakeholders that should be consulted would include aggregate companies or associations, construction companies or associations, BC Hydro, oil and gas industries, mining industries, railway industries, and logging industries. This list is not meant to be exhaustive.

It would be important to reach a consensus with stakeholders about the enforcement and compliance of industry with the paleontological impact assessment process. It may be difficult to enforce the paleontological impact assessment process without this support given the logistic issues of enforcement (e.g., numerous activities, geographically diverse, limited manpower).

Estimated Time Frame: 6-12 months.

Estimated Cost: \$80,000 (venue, A/V equipment, facilitation, and hospitality costs).

## **Step 4: Formalization of Paleontological Impact Assessment Process**

It will be necessary to combine feedback from the various consultation processes with the findings of this report to develop paleontological impact assessment guidelines. This step will be less about research and more about the assembly of existing information. The

interests of the paleontological community will need to be balanced with those of industry. The goal would be to achieve a happy medium between these competing interests.

Estimated Time Frame: 3-4 months.

Estimated Cost: No additional costs over and above standard operating costs.

### **Step 5: Development of the Tools Needed for the Paleontological Impact Process**

This step would involve the establishment of a database that contained information about British Columbia's paleontological resources (e.g., sensitive locations, past discoveries). This step would entail a literature review of scientific paleontological resources, and an inventory of all discoveries from museum collections that have originated from British Columbia. This information could be compiled into a GIS program to make the information readily available to paleontological consultants. The database could also incorporate future paleontological impact assessment reports as this information becomes available. Research will also need to be conducted into where paleontological discoveries will be stored if they are salvaged.

Estimated Time Frame: 6 months to establish the process, and then continuous maintenance.

Estimated Cost: \$100,000 (development of the database, mapping, equipment, conducting a literature review, and museum inventory).

### **Step 6: Informational Campaign**

Proponents will need to be made aware of their responsibilities in regards to paleontological impact assessments. Informational documents will need to be developed with proponents in mind so that the process is laid out in a clear manner. This could be achieved through the addition of this information to the fossil management website of the Land Tenures Branch. A policy document could be developed for publication on the Land Tenures Branch policy website.

Estimated Time Frame: 3-4 months.

Estimated Cost: No additional costs over and above standard operating costs.

### **Step 7: Evaluation of Paleontological Impact Assessment Process**

Once the guidelines are in place they should be assessed annually for the first five years with a survey. After this period, an email address could be set up to receive further feedback from practitioners and industry. Sample questions for evaluating the Paleontological Impact Assessment process are outlined below.

#### **Paleontological Impact Assessment (PIA) Process Evaluation Survey**

1. Do you believe that the PIA process has been successful in protecting significant paleontological resources?
2. How do you think the PIA process could be improved?
3. Do you believe that the number of paleontological consultants available in the Province of BC is sufficient? Please provide specific examples of any issues you have faced.

4. Have you experienced unjustifiable project delays as a result of the assessment process?
5. Do you believe that PIAs are financially burdensome to proponents?
6. Do you believe there are other ways that paleontological resources could be identified and protected? If yes, please provide concrete examples.
7. Other comments?

This survey will allow for the PIA process to be evaluated in terms of availability of expertise, time, cost, and effectiveness in protecting paleontological resources.

Estimated Time Frame: Five years-continuous.

Estimated Cost: No additional costs over and above standard operating costs.

### **Step 8: Capacity Development (Optional)**

In order to ensure the sustainability of the paleontological impact assessment process it may be beneficial to look at partnerships with the Royal BC Museum (among others) to develop a certificate program for individuals interested in conducting paleontological impact assessments. The Denver Museum of Natural History may be able to help out in this regard as they have established a program of this nature, and it has been very successful in terms of producing qualified individuals, and also in terms of salvaging important paleontological resources. This step would help to increase the robustness of British Columbia's paleontological community, and would be necessary for the long-term viability of the paleontological impact assessment process.

Estimated Time Frame: Continuous process.

Estimate Cost: Costs would vary depending on if the Province started from scratch, or adopted the Denver curriculum.

### **Step 9: Public Educational Campaign (Optional)**

One way of ensuring that significant paleontological resources are protected is to inform the public of their educational and/or scientific value. Partnerships could be formed with the Royal BC Museum and other museums to establish educational sessions for youth. Through these educational sessions, youth can learn about paleontology and why fossils are important to our understanding of Earth's history. This appreciation for fossil preservation and study can produce support for a paleontological impact assessment process in the general community, as youth share their enthusiasm for the subject with their parents. These information sessions would involve guest speakers from the paleontological community visiting schools, and providing talks related to fossils.

Estimated Time Frame: Continuous.

Estimated Cost: \$50,000 (travel, printing of materials, radio/tv ads, website, honorariums)

## **Conclusion**

The above implementation plan outlines the necessary steps to implement the recommended option, Option 1. Steps 8 and 9 are optional, and are not essential to the implementation of Option 1, however, their inclusion could strengthen the effectiveness of Option 1. The implementation plan discussed above was designed to be comprehensive, and considers implementation from various perspectives.

## 11. CONCLUSION

The goal of this report was to investigate smart practices for conducting paleontological impact assessments (PIAs), and to develop a draft process and guidelines for British Columbia. A literature review was conducted to identify smart practices. The following jurisdictions were included in the jurisdictional scan: Abu Dhabi, Alberta, California, Mongolia, New Mexico, San Diego, South Africa, South Australia, and the United States (BLM & SVP). Two case studies were included to provide detail about the experiences of other jurisdictions. Further, a survey of paleontologists and paleontological resource managers was also conducted, and the findings were incorporated into the draft guidelines.

In terms of who is qualified to conduct PIAs, most jurisdictions require a graduate degree in paleontology, or a related field with specialization in paleontology in addition to training and field experience. The PIA process often involves preliminary studies followed up by more in depth research and fieldwork depending on the findings of the earlier studies. If paleontological resources are found, paleontological consultants develop mitigation and monitoring plans. High probability of having paleontological resources can be determined through the use of geological maps, as only certain geological features can contain fossils. However, just because a geological feature has the potential for paleontological resources, there is no guarantee that they will contain them. Determining potential is possible, however, determining fossil distribution is not. Therefore, fieldwork is ultimately required to ensure that no significant fossils are present. Mitigation and monitoring strategies can vary.

Finally, industries may voluntarily endorse paleontological resource management strategies if it will support their public image. Companies are becoming increasingly concerned with more than just financial success, and often incorporate social responsibility into their guiding values.

Two options were provided for consideration. Option 1 was based on international smart practices, and was designed with the greatest level of protection in mind. Option 2 was also based on these international smart practices, but was designed to be less stringent, and therefore less onerous. Rather than relying on PIAs to manage paleontological resources, Option 2 relies heavily on paleontological monitoring during project development. In this way, delays are avoided, but some protection is still afforded to paleontological resources. However, delays may be greater if paleontological resources are discovered during a project's development. Option 1 is more thorough leading up to a project's development, and in this way, costly delays can be avoided. More time and resources are required up front, however. Option 2 allows for fewer delays initially, but there is always the risk that paleontological resources will be discovered, that could delay the project, as the resources would need to be assessed for significance and addressed accordingly. It is for those reasons that Option 1 is recommended as it provides more protection, and would safeguard against delays later on in a project's development.

The following list represents the potential areas for future exploration. Although this list is not exhaustive, it provides a starting ground.

- Determine the level of paleontological expertise in British Columbia
- Find repositories to store any found paleontological resources
- Examine alternatives/incentives for gaining industry support and compliance
- Research how to formalize qualifications (legislation, or regulation by a professional association)
- Form partnerships with universities and other academic institutions to foster the growth of paleontological expertise within British Columbia
- Examine GIS technology to create a paleontological resource inventory
- Consider First Nations' involvement in PIA process

Fossils are a very rare resource, and fossil formation is a serendipitous process. It can take hundreds of millions of years for a fossil to be formed, and only then under extremely fortunate circumstances. Fossils offer a window into the past. They help us to uncover how life has evolved and interacted over time. Significant fossils need to be protected. Paleontological impact assessments are one way of ensuring that the educational and scientific value of this non-renewable resource is protected for all British Columbians for years to come.

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## APPENDICES

### Appendix A: Ethics Information: Recruitment Materials (Approved Version)

Dear [name of participant],

My name is Corey Lowndes, and I am a graduate student in the School of Public Administration at the University of Victoria. I am conducting comparative research on paleontological impact assessments, and mitigation strategies. I am seeking professional expertise and information with regards to this aspect of paleontological resource management. This research is being conducted as part of a client-oriented MPA project for the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) Land Tenures Branch.

MFLNRO is responsible for the management of paleontological resources in British Columbia, and the development of a fossil management framework. One of the elements of the framework is the assessment and management of fossil resources in concert with natural resource development. I am assisting the Land Tenures Branch by researching current and smart practices for paleontological impact assessment (PIA) and mitigation of impacts, and proposing a set of guidelines for further discussion.

As a recognized expert in this field you are invited to participate in a survey designed to gather your views and expertise on PIAs. [If applicable: You were identified by another participant in this study as someone who could have valuable contributions and information to share.]

I am the principal researcher for this study. The University of Victoria Human Research Ethics Board has approved this study. An implied consent form will be provided along with the 11-item survey. Information provided through the survey will be kept strictly confidential and results will be reported anonymously. Only I will have access to your original data and be able to utilize it

The survey will require no more than 15-30 minutes of your time. Your comments will be confidential and the reporting of your insights will be kept anonymous – only I will have access to the survey responses. Survey responses will be destroyed once the report is completed and approved.

If you are willing to participate in this survey, please contact me (email below) so that I may provide you with the survey.

Thank you again for your contribution to my research, and if you have any questions about my research, please do not hesitate to contact me.

Corey Lowndes

Email: [clowndes@uvic.ca](mailto:clowndes@uvic.ca)

## **Appendix B: Ethics Information: Letter Of Implied Consent (Approved Version)**

Developing Paleontological Impact Assessment and Mitigation Guidelines for British Columbia: Jurisdictional Review and Best Practices

You are invited to participate in a study titled Developing Paleontological Impact Assessment and Mitigation Guidelines for British Columbia - Jurisdictional Review and Best Practices that is being conducted by Corey Lowndes as part of a client-oriented MPA project for the Ministry of Forests, Lands and Natural Resource Operations.

Corey Lowndes is a Graduate Student in the department of Human and Social Development, School of Public Administration at the University of Victoria and you may contact him if you have further questions by email at clowndes@uvic.ca.

This research is required for the successful completion of a Masters degree in Public Administration. It is being conducted under the supervision of Dr. Evert Lindquist. He may be contacted by email at evert@uvic.ca.

### **Purpose and Objectives**

The purpose of this research project is to determine how paleontological impact assessments should be conducted, who would be qualified to conduct paleontological assessments, and how paleontological resources can be protected from impacts.

### **Importance of this Research**

Research of this type is important because paleontological resources are non-renewable, and have scientific and educational value.

### **Participants Selection**

You are being asked to participate in this study because you are a recognized expert (you may have been recommended by another participant) in the field of paleontology/paleontological resource management or a related discipline. Your knowledge is invaluable, and important as a non-expert is conducting the research.

### **What is Involved**

If you consent to participate in this research, your participation will include completing a 11-item survey that will take approximately 15-30 minutes to complete. Your participation is entirely voluntary, and you may withdraw at any time. Once you have completed the survey, the survey will be returned via email. **IT IS IMPORTANT TO NOTE, THAT IF YOU CHOOSE TO ANSWER "YES" TO QUESTION #11, YOU WILL BE CONTACTED TO PROVIDE EITHER CLARIFICATION ON YOUR SURVEY RESPONSES, OR OPEN-ENDED FEEDBACK ON THE DRAFT GUIDELINES.**

### **Inconvenience**

Participation in this study may cause some inconvenience to you, but only in terms of your time commitment.

### **Risks**

There are no known or anticipated risks to you by participating in this research.

### **Benefits**

The potential benefits of your participation in this research include knowing that you have

helped to contribute to the effective management of paleontological resources. Society will benefit from having these resources managed for their educational and scientific value. Finally, the state of knowledge will be enhanced, as knowledge about paleontological resource management is not readily available.

### **Voluntary Participation**

Your participation in this research AND SUBSEQUENT PARTS OF THIS RESEARCH (I.E., CLARIFYING RESPONSES AND PROVIDING FEEDBACK ON THE DRAFT GUIDELINES) must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study your data will not be collected as you will not be required to send the portion of the survey that had been completed.

### **Anonymity**

In terms of protecting your anonymity, names and affiliations will not be included in the final report. Only the field of expertise will be acknowledged. Only the researcher will have access to your original data and be able to utilize it. Only those that may have recommended you as a participant could also be aware of your participation.

### **Confidentiality**

Your confidentiality and the confidentiality of the data will be protected by electronic storage on a password-protected laptop in a password-protected UVic email account.

### **Dissemination of Results**

It is anticipated that the results of this study will be shared with others in the form of a public presentation (i.e., project defense) and through the final report.

### **Disposal of Data**

Original data from this study will be disposed of upon completion and approval of the final report. A list of people contacted and a separate spreadsheet of responses with identifying information removed will be provided to MFLNRO. All electronic emails will be securely deleted.

### **Contacts**

Individuals that may be contacted regarding this study include the researcher, Corey Lowndes at [clowndes@uvic.ca](mailto:clowndes@uvic.ca) and his supervisor, Dr. Evert Lindquist at [evert@uvic.ca](mailto:evert@uvic.ca).

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or [ethics@uvic.ca](mailto:ethics@uvic.ca)).

By completing and submitting the survey, **YOUR FREE AND INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

*Please retain a copy of this letter for your reference.*

## **Appendix C: Ethics Information: Script And Survey Questions (Approved Version)**

Dear [name of participant],

Thank you again for agreeing to participate in this survey, and for providing me with your expertise in the field of paleontology and paleontological resource management. As you read in the implied consent, by completing this survey you agree to the conditions of the research, and know that your responses will be anonymous and confidential. Further, your participation is voluntary, and you are free to withdraw from the study at any time.

This project is concerned with the protection of paleontological resources through paleontological impact assessments, and mitigation strategies. It is being conducted by Corey Lowndes as part of a client-oriented MPA project for the Ministry of Forests, Lands and Natural Resource Operations. The following 11 questions are concerned with elements of these assessments, and it is encouraged that you answer the questions as openly and honestly as possible.

Once you have completed the survey, please send it to myself, Corey Lowndes, at [clowndes@uvic.ca](mailto:clowndes@uvic.ca).

Thank you again for your participation.

Corey Lowndes

### Paleontological Resource Management Survey Questions

- 1) In the space below, please briefly provide background information with regards to the extent of your expertise, field of study, and firsthand knowledge of paleontological resource management.
- 2) Under what circumstances should a paleontological impact assessment be conducted? What are the current practices in your jurisdictions?
- 3) Many jurisdictions require paleontological impact assessments when bedrock is disturbed. Based on your experience, is this a sufficient condition, or are there other conditions? Please explain. What are the current practices in your jurisdictions?
- 4) Who would be qualified to conduct paleontological impact assessments? Many jurisdictions require a graduate degree in fields such as palaeontology, geology, biology, zoology, anthropology, and botany so long as there has been a specialization on palaeontology. In your professional opinion, do you believe this is sufficient? What are the current practices in your jurisdictions?
- 5) How much, and what kind of, experience do you think an individual would need in order to conduct a paleontological impact assessment properly? What are the current practices in your jurisdictions?
- 6) In your professional opinion, what do you think the content of a paleontological impact assessment report should contain? (e.g., maps, literature review of unpublished/published

documents, an overview of geological units and corresponding paleontological elements, identification of potential impacts, mitigation strategies, and/or monitoring recommendations). What are the current practices in your jurisdictions?

7) What activities are you personally aware of that can impact paleontological resources? (e.g., roads, pipelines, mining)

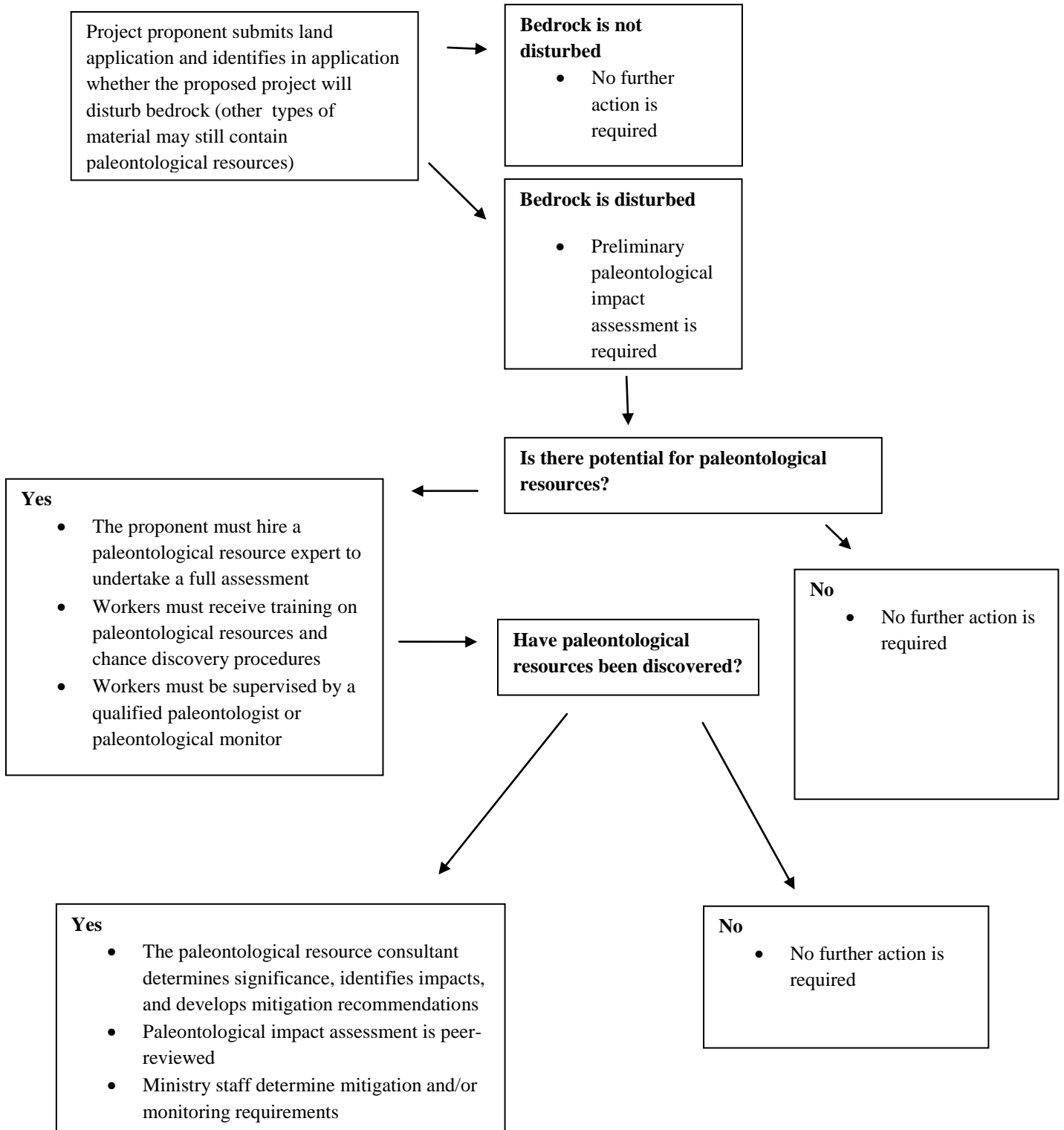
8) Based on your answer to #7, what mitigation strategies would you recommend for protecting paleontological resources in those situations? (e.g., avoidance, monitoring, recovery, sampling)

9) How should paleontological significance be assessed? (e.g., aesthetic value, educational value, scientific value, economical value, rarity, uniqueness, abundance, public interest, fossil type) What are the current practices in your jurisdictions?

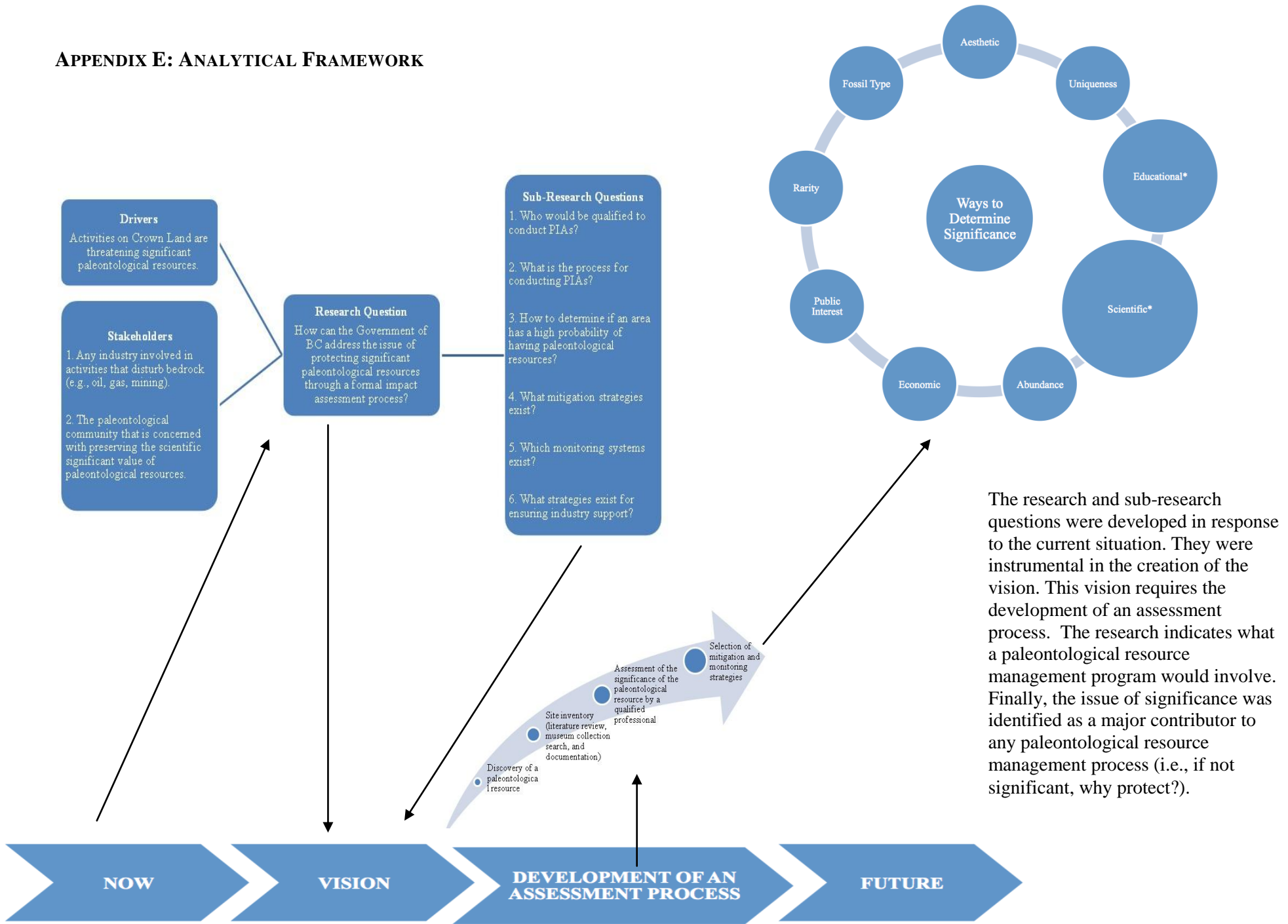
10) Please provide any information you may have on best practices for paleontological resource management? (e.g., recommended literature, other qualified professionals to contact)

11) Are you willing to be contacted by email for further clarification in regards to your responses? Would you be willing to review the draft guidelines and provide feedback?

## Appendix D: Recommended Option Process Map



**APPENDIX E: ANALYTICAL FRAMEWORK**



The research and sub-research questions were developed in response to the current situation. They were instrumental in the creation of the vision. This vision requires the development of an assessment process. The research indicates what a paleontological resource management program would involve. Finally, the issue of significance was identified as a major contributor to any paleontological resource management process (i.e., if not significant, why protect?).