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From: Paul C. Murphey <pmurphey@paleosolutions.com>
Sent: Tuesday, March 13, 2018 2:17 PM
To: CEQA Guidelines@CNRA
Subject: CEQA Updates - Paleontological Resources
Attachments: 20 Murphey et al FINAL 2014_resized.pdf; TA Demere Letter to CNRA 03-09-2018.docx; PC Murphey Letter to CNRA 03132018.pdf

Dear Mr. Calfee:

Please find my comments and supporting documents attached.

Kind Regards, Paul

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ARTICLE

A FOUNDATION FOR BEST PRACTICES IN MITIGATION PALEONTOLOGY

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ABSTRACT—Mitigation paleontology focuses on the recovery and preservation of paleontological resources (fossils) that are threatened by ground disturbance associated with land and energy development projects. Mitigation includes the assessment of potential impacts and the development of measures to reduce or eliminate adverse impacts to scientifically important fossils, as well as the implementation of those measures. Despite several decades of steady progress with the development of standard procedures and regulatory guidelines for the assessment and mitigation of impacts, neither mitigation paleontologists nor the regulatory agencies that oversee their activities have been successful in developing industry-wide standard operating procedures. Best practices are methods and techniques that have consistently shown results superior to those achieved by other means, and are used as a benchmark for judging the adequacy of mitigation. They are a standard way of doing things that multiple organizations can adhere to, although they evolve and improve over time. In this paper we propose comprehensive and detailed best practices for the mitigation paleontology industry that fall into ten categories: 1) qualifications and permitting, 2) analyses of existing data, 3) research models and scientific context, 4) field data collection, 5) field surveys, 6) construction monitoring, 7) fossil salvage, 8) data management and reporting, 9) curation facilities, and 10) business ethics and scientific rigor. Our purpose, with input from the mitigation community, is to establish procedures that are successful in maintaining a rigorous scientific standard while promoting integrity in the industry in order to accomplish the common goal of paleontological resource preservation via impact mitigation.

INTRODUCTION

Since the 1970s, regulatory protections for scientifically important fossils in the western United States have resulted in the recovery of vast numbers of these non-renewable resources – many of which have been literally plucked from the path of bulldozers. From city and county regulations designed to protect paleontological resources from earth moving operations at residential and commercial construction sites in southern California, to state and federal policies developed largely in response to the increasing use of public lands by large-scale energy development projects for oil, gas, wind and solar energy; the trend is clearly towards resource management policies that are in favor of impact mitigation. The efforts of those who have been involved with policy development and implementation are laudable. After all, the recognition that paleontological resources are worthy of preservation and protection is an acknowledgement of their scientific value as finite and irreplaceable evidence of the history of life. The many benefits to science are illustrated by the vast amount of research that has been based on fossils collected as the result of impact mitigation projects.

Not surprisingly, paleontological resource regulatory requirements in combination with private development projects have created a new niche for paleontologists. The growing demand for mitigation paleontologists has to date resulted in at least two generations of paleontologists who, in addition to their academic and field training in paleontology, have expertise in working with fossils and associated rock strata exposed under the incredibly challenging field conditions that exist on construction sites, some of which are vast and in remote locations.

The last twenty years has seen an increase in employment opportunities for mitigation paleontologists – this at a time when funding to higher education and public funding for natural history museums has been sharply declining. In light of this, it is useful to consider the value, purpose and goals of the emerging profession of mitigation paleontology. As applied scientists, mitigation paleontologists are typically hired by private companies or less frequently, by government agencies. Under contract to such a client, a specific service, or set of services (scope of work), is provided. These services are often required in order to achieve regulatory compliance for the client's project. A common work product is a final project report, which is often necessary for the project proponent to obtain an environmental clearance for their project in the form of a license or permit, and/or to prepare other supporting environmental documents. A paleontological technical report may include recommendations for additional work that is needed in order to adequately mitigate potential impacts to fossils that would be exposed, damaged, or displaced as the result of project construction. An additional common work product is a collection of fossils typically made either prior to or during construction, or both. The prepared and identified fossils, along with associated data, are ultimately transferred to an approved curation facility. Such facilities are typically museums that are approved by the government agency that issues the paleontological resource use permit and/or grading permit.

Mitigation paleontologists, as applied scientists, have the contractual responsibility to achieve their client's objectives in a manner that complies with agency regulations and meets accepted scientific standards as well as the expectations of the institutions with which they hold curation agreements. It is the added, although regrettably more nebulous responsibility of mitigation paleontologists, to ensure that all paleontological work is done to an acceptable standard of scientific rigor so that detailed, reliable data accompanies every fossil. Unless specifically requested by a client, it is typically not the purview of the mitigation paleontologist to conduct research on the fossils they salvage under contract, but rather to ensure that the fossils and associated data are in a condition that is suitable for research upon arrival at the curation facility.

Despite legislative achievements such as the Paleontological Resources Preservation Act (PRPA) of 2009, and the many benefits to science resulting from paleontological resource impact mitigation, significant challenges related to scientific integrity and ethical business practices exist and must be addressed. Some examples of ethical issues include instructing paleontological monitors at a landfill project to sit in their vehicles so they do not find any fossils in order to avoid incurring additional costs, reporting that adequate field surveys have been completed via so-called 'windshield surveys' or 'drive-by surveys,' staffing projects with 'cross trained' archeological monitors who do not possess sufficient paleontological knowledge to properly document and collect fossils, or failing to curate fossils collected from mitigation projects in appropriate curation facilities—there are far more examples than can be listed here.

If left unchecked, these and many other unfortunate practices will continue to undermine regulatory intent and do a disservice to the resources that regulations were designed to protect. What's more, such practices are not consistent with preserving paleontological resources using scientific principles and expertise, which should be the goal of all paleontologists and involved agencies regardless of the jurisdictional applicability of the PRPA. The root of the problem is a compounding of three primary factors: 1) market forces that reward the lowest bidder with the most consulting contracts because of a lack of incentive to pay for quality; 2) an unwillingness or inability on the part of managing agencies due to lack of resources, knowledge, or authority to provide consistent and meaningful oversight and ensure compliance with regulations, leading to an environment where permittees are not held accountable for the quality and quantity of their work; and 3) a lack of proper training and/or ethical standards.

With recent industry growth and more paleontologists (and non-paleontologists) striving to work in the field of impact mitigation, it is our belief that a critical juncture has been reached. Paleontologists working in this field need to develop industry-wide standard operating procedures based on rigorous and scientifically defensible principles. The purpose and goal of this paper is therefore, with a degree of urgency, to articulate the problems and challenges that currently exist in the field of mitigation paleontology and to offer an effective path toward a solution. We present a preliminary set of detailed, comprehensive best practices in mitigation paleontology that are intended to be complimentary to other existing standards and procedural guidelines such as those of the Society of Vertebrate Paleontology (SVP) and those federal, state and local agencies that have already developed such standards and guidelines. This paper does not represent agency policy, which is a topic worthy of separate papers. Nor is it our purpose to convey paleontological and geological knowledge or field skills, which is also a required prerequisite for practicing mitigation paleontology. Rather, with a combined perspective gained from working on well over a thousand mitigation projects over a period of decades, our focus is on the day-to-day tasks of background research, field surveys, construction monitoring, fossil salvage, data management and reporting, business practices, scientific rigor, fossil preparation, and 'museum' curation. It is our hope that this paper will demonstrate that there is more to mitigation paleontology than simply finding fossils at construction sites.

METHODS

Much of the information in this paper was gathered and synthesized by the authors based on their own experiences in mitigation paleontology. Additional information and input was obtained from colleagues working as consultants, in museums, and for government agencies. Fact-checking with regard to the standard archeological procedures discussed in this paper was done in collaboration with cultural resource management professionals. Agency paleontologists were consulted for the purpose of fact-checking paleontological resource laws, regulations, and policies. Unpublished paleontological data obtained from the Department of PaleoServices at the San Diego Natural History Museum from projects completed in San Diego County, California; and from SWCA Environmental Consultants from projects completed in Uintah and Duchesne Counties, Utah, and Garfield County, Colorado, were analyzed for the purpose of providing real-world examples to illustrate mitigation concepts in this paper.

The best practices described in this paper are summarized in Appendix A, and for quick reference the text of the paper includes reference numbers that correspond to numbered best practices in the appendix.

Following publication of this initial document, the authors will solicit feedback from the mitigation paleontology community including those involved with mitigation work in museums and government agencies. Based on this feedback, the best practices will be modified as needed to best meet the goal of the project as defined herein. Although it is expected that the best practices will evolve to improve over time, this initial document will serve as a road map for elevating the practice of mitigation paleontology, thus increasing the potential of achieving scientific rigor with professional integrity for the preservation of paleontological resources.

HISTORY AND SCIENTIFIC CONTRIBUTIONS

Given the stereotypical image of paleontologists collecting fossils in remote, picturesque badlands, many people are surprised to learn just how many fossils have been discovered in mining and construction excavations, and how many of these discoveries have been made in areas with little or no opportunities for fossils to be found on in natural outcrops due to lack of exposed sedimentary bedrock. Classic examples of such discoveries include remains of the first formally named non-avian dinosaur, *Megalosaurus bucklandii* (recovered from the Stonesfield limestone quarry near Oxford, England), the first recognized fossil remains of the ornithopod dinosaur, *Iguanodon* (recovered from the Whitemans Green quarry, near Cuckfield, England), famous fossils of *Archaeopteryx lithographica* (recovered from the lithographic limestone quarries near Solnhofen, Germany), the spectacularly preserved Messel plant and vertebrate fossils (recovered from the Messel Pit bituminous shale quarry in Messel, Germany), and the renowned Rancho La Brea Pleistocene mammalian fossil assemblages (initially recovered from commercial asphalt quarry excavations in Los Angeles, California, USA), to name just a few. Today, excavations for natural gas and oil well pads, pipelines, electrical transmission lines, renewable energy generation facilities, coal mines, gravel pits, highway new and existing highways, railway alignments, above- and below-ground public transportation systems, housing developments, commercial developments, urban developments, and underground parking structures, all provide excellent and unique opportunities for paleontologists to access fossils and the strata in which they are preserved in settings which may not have been made available via natural processes of weathering and erosion. Most major natural history museums in the western United States house substantial collections of fossils recovered as a result of fossil salvage projects at construction sites.

Following the first formal gathering of mitigation paleontologists at an annual meeting of the SVP in 2013, a sub-set of the authors of this paper (Knauss, Fisk, and Murphey) posted an online survey, the purpose of which was to prepare a report on the demographics of mitigation paleontology (Knauss et al., 2014). In conjunction with the survey, an effort was launched to compile a comprehensive database of peer reviewed scientific publications, theses and dissertations that involve fossils collected as the result of mitigation paleontology. This database, while still under development, is complete enough to estimate that the total number of such publications is in the hundreds. Furthermore, based on the preliminary data from the published literature, combined with data obtained from museums and other curation facilities, we estimate the total number of curated fossil specimens from mitigation projects to be in the millions.

BRIEF HISTORY OF MITIGATION PALEONTOLOGY IN THE UNITED STATES

For more than a century, the importance of preserving the United States' cultural and natural heritage has been recognized and addressed by legislation, including the Antiquities Act of 1906, the National Environmental Policy Act (NEPA) of 1969, the Federal Land Policy and Management Act (FLPMA) of 1976, and the California Environmental Quality Act (CEQA) of 1970. A primary goal of these legislative actions was to require agencies to address concerns about development and other land uses that might impact significant and nonrenewable natural resources, including paleontological resources. CEQA specifically requires California state and local agencies "to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible." Local agencies such as county and city planning departments are tasked with maintaining compliance with CEQA and NEPA, thereby reducing impacts on resources to a level less than significant.

Following the passage of CEQA in 1970, Orange County was the first county in California to require mitigation of impacts to paleontological resources. The urban development of Orange County accelerated rapidly in the early 1970s and concerned citizens and scientists, including John Cooper, Carol Stadum, Larry Barnes, Mark Roeder, and Rod Raschke, lobbied for regulations to protect paleontological resources in the county as development increased and more land was disturbed (Babilonia and others, 2013). In response to these lobbying efforts, in 1972 the Mission Viejo Company hired one of the first paleontological monitors, Paul Kirkland. In 1976, as part of the conditions of approval for development, the County of Orange passed the first paleontological mitigation guidelines; Resolution No. 1977-866, requiring monitoring and salvage of fossils as part of the development process. This was followed a decade later by passage of Resolution No. 1987-516, requiring donation of paleontological finds from sites in unincorporated parts of Orange County to a central county facility "for the purpose of promoting scientific study and for display for the education and enjoyment of the people of Orange County."

These municipal resolutions required pre-construction surveys, impact assessments, and construction mitigation measures to prevent the destruction of fossils. However, although thousands of fossils were salvaged and housed at an Orange County facility, there were no provisions for these fossils to be accompanied by adequate field data or to be prepared, stabilized, and professionally housed for perpetuity in a repository where they could be retrieved for study. Even today, Orange County does not require that developers provide funds for preparation and curation of salvaged specimens. Fortunately, in 2009 Orange County Parks and California State University, Fullerton entered into an agreement to provide funding for a staff to manage a curation facility that meets the modern standards of professional collection care. CSU Fullerton's John D. Cooper Archaeological and Paleontological Center ('Cooper Center') in Santa Ana now serves as Orange County's authorized curatorial facility, with a large and growing collection of paleobotanical, invertebrate, and vertebrate fossils that document the unique paleontological record preserved in the sedimentary rocks of Orange County. Although still largely unstudied, this collection is beginning to attract the attention of numerous research paleontologists, students, and interested members of the public.

When adjacent California counties - Los Angeles, Riverside, San Bernardino, and San Diego - began to rely on mitigation paleontologists from Orange County to mitigate impacts, established museums in those four counties began to feel the burden of receiving large volumes of unprepared specimens without compensation for preparation and cabinet/storage space. Starting in the late 1970s, Robert (Bob) Reynolds, Earth Science curator at the San Bernardino County Museum and member of the San Bernardino County Environmental Review Committee, arranged meetings with museum curators and fossil salvage contractors to discuss differing standards, methods of salvage, and the unsustainable practice of 'dumping' salvaged specimens at museums or in warehouses. Participants in these discussions sought to create standard guidelines that would make assessment and salvage programs, methods of recovery, preparation and stabilization, and funded curation of specimens and associated field data 'conformable.'

Discussions focused on the necessity for advanced scoping of potential impacts using sensitivity maps; the need for adequate preconstruction assessment (including record and literature searches and field surveys); the importance of adequate full-time monitoring and criteria for reducing monitoring effort to half-time or spot-checking; the scientific value of salvaging not only skulls, but also post-cranial remains, small and microscopic vertebrate fossils, and associated environmental and habitat indicators; the necessity of preparation of specimens to a point of identification (thereby concurrently reducing storage volume and costs); and the need for funding for the curation of specimens, field data, and reports into an established repository.

In 1980, the City of Chula Vista in San Diego County began requiring residential developers to implement paleontological resource mitigation programs during mass grading operations. Soon other cities in the county (i.e., San Diego, Vista, Carlsbad, Oceanside, National City, and La Mesa) followed suit. The result was that a wealth of fossils ranging from Cretaceous ammonites, mosasaurs, and dinosaurs to Pliocene scallops, walruses, and baleen whales began to be salvaged from the upper Cretaceous through Pleistocene stratigraphic sequences along the coastal plain of San Diego County. By the early 1990s, even the California Department of Transportation (Caltrans) began to realize the significance and benefits of paleontological mitigation in the District 11 region (San Diego and Imperial counties) and issued the first on-call paleontological resource mitigation contract in state history. Fossils salvaged from District 11 roadway projects, together with fossils from the rampant growth of residential and commercial development in San Diego County during the 1980s and 1990s were deposited at the San Diego Natural History Museum (SDNHM). From the very beginning, the staff of this regional education, research, and curation facility realized the importance of avoiding the problems faced by Orange County in terms of the impact on institutions of receiving large amounts of unprepared and uncurated fossils. Fortunately, city and state environmental planners based in San Diego County also realized these potential problems and required paleontological mitigation contracts in the region to include provisions for preparation, curation, and long-term storage of salvaged fossils.

However, other regions of southern California were not faring so well during this period and seeing what was happening, Michael Woodburne, then President of SVP and a member of its Government Liaison Committee, appointed Bob Reynolds to chair the SVP Committee for Conformable Impact Mitigation in 1990. The existing southern California guidelines, already field tested in the states of California, Nevada, and Arizona on utility projects crossing federally (Bureau of Land Management [BLM]) administered lands as well as lands managed by counties and municipalities, were used as a template for guidelines that could be applied to agency managed lands elsewhere in the western states. A draft of the SVP "Standard Measures" was distributed for review in 1991 (SVP, 1991). The revised SVP "Standard Guidelines" were published in 1995 (SVP, 1995) and to strengthen the position of museums receiving salvage collections, in 1996 the SVP "Impact Committee" issued Conditions of Receivership (SVP, 1996). During 2009 and 2010, the SVP "Standard Guidelines" were reviewed, revised, and expanded by a committee co-chaired by Lanny Fisk and Bob Reynolds. The revised "Standard Procedures" are available online (SVP, 2010).

In 2009, the Paleontological Resources Preservation Act (PRPA) was signed into law by President Barack Obama as part of the Omnibus Public Land Management Act. PRPA requires that coordinated policies and standards be developed that apply to fossils on federal public lands. Section 6302 of the PRPA mandates that federal agencies "manage and protect paleontological resources on Federal land using scientific principles and expertise." Thus, federal agencies began looking to the professional paleontological community to implement these PRPA-mandated policies and regulations. It was partially in anticipation of new regulations that in 2009 the SVP re-activated the Conformable Impact Mitigation Committee as the Impact Mitigation Guidelines Revision Committee and invited input from federal and state land management agencies.

With the presentation of impact mitigation measures/guidelines/procedures by the SVP in 1991, 1995, 1996, and 2010 respectively, western states, federal agencies, counties, and other municipalities were able to adopt guidelines that would support the preservation of paleontological resources and associated data. In California, southern counties and several in the Bay Area (thanks largely to the efforts of Bruce Hanson) adopted guidelines. Examples were developed for San Bernardino County (1985), the BLM's California Desert Conservation Area (1985), Riverside County (1990; updated 2003 and 2008), San Diego County (2007; updated 2009), and San Bernardino National Forest (1995). Updated versions of these mitigation guidelines were prepared for the Needles (2005) and Barstow BLM (2008) field offices. With agency-specific modifications, Caltrans (2012) adopted similar guidelines.

As use of public lands increased from the late 1980s into the 2000s, largely tied to a surge in energy development projects (especially oil and gas), there was an increase in demand for mitigation paleontologists in the intermountain west, particularly in parts of Colorado, Wyoming, and Utah. Initially, the demand was met by paleontologists who were employees or associates of museums including the Utah Field House of Natural History Museum, the University of Colorado Museum, the Museum of Western Colorado, the Idaho Museum of Natural History, and the University of Wyoming Geological Museum. Small firms and independent consultants were soon established, agency positions were added (including highway department paleontologists in Colorado and Nebraska and BLM and United States Forest Service [USFS] paleontologists in multiple states), other museums became involved, and at least two larger environmental firms established paleontological resource programs. The BLM developed procedural guidance for paleontological resource management (1998), which included assessment and mitigation procedures, permitting and reporting requirements, and a resource management classification system (Conditions 1-3). The USFS revised its Fossil Yield Potential Classification (FYPC) system (2005), and the BLM adopted its own version of the FYPC, the Potential Fossil Yield Classification System (PFYC) in 2007. In 2008, the BLM released revised procedural guidelines for the assessment and mitigation of potential impacts to paleontological resources. Regulations under the PRPA are presently undergoing development and revision at the Departments of the Interior and Agriculture. In recognition of the ongoing demand for trained mitigation paleontologists, the South Dakota School of Mines and Technology continues to develop a curriculum with a track that prepares students for positions in paleontological resource management and impact mitigation, the first institution of higher education to do so.

1. QUALIFICATIONS AND PERMITTING

As with field-based paleontological research projects, paleontological resource use permits are required for mitigation work on public lands in order to ensure that those who perform the work are qualified to do so, that regulations are complied with, and that the results of work are adequately reported to the land managing agency. In this section, we describe the complex state of permitting, while avoiding discussion of specific agency stipulations for obtaining paleontological resource use permits. While we do point out some serious problems, our intent is not to judge the adequacy of current permitting requirements (where they exist), but rather to establish a baseline set of minimal qualifications for principal investigators, field supervisors, and field paleontologists (technicians/surveyors/monitors) that can serve as industry best practices (1.1).

Several federal and state agencies require persons proposing to conduct paleontological mitigation work on public lands to apply for paleontological resource use permits (1.2). Agency review of these applications is designed to ensure that only qualified paleontologists are issued such permits, which in turn helps to ensure that paleontological resources are properly protected. In the absence of such a permit process, some city and county jurisdictions in southern California have a vetting process by which resumes are reviewed and approved individuals are placed on lists of 'qualified' or 'certified' paleontologists. However, there are agencies and jurisdictions in California, where despite regulations including the California Environmental Quality Act (CEQA) (see Scott and Springer, 2003), there is no mechanism for permitting or vetting potential mitigation paleontologists. For this reason, it is fair to view California as the state with the strongest paleontological regulations on one hand, and the least oversight on the other. The result of this odd combination is ironic for the many California paleontologists who have been active in mitigation paleontology for decades, since the participation of non-paleontologists in mitigation paleontology has led to the preventable destruction and permanent loss of scientifically important fossils and associated data. Any agency with regulatory oversight for the protection for paleontological resources that has not developed minimal qualifications and a vetting process for prospective mitigation paleontologists will undoubtedly experience a similar result. This problem is most widespread in certain jurisdictions and agencies in California. But the problem is not unique to California. Over the last several decades many non-qualified paleontologists have obtained paleontological resource use permits (or worked without them) and then botched mitigation projects. This has contributed to the strict minimal qualifications for obtaining paleontological resource use permits that are now required by many federal and state agencies across the western U.S.A.

Most paleontological mitigation projects outside of California have taken place on federal, and to a much lesser extent, state lands in a handful of states, and are required by federal and state laws and regulations. In contrast, many mitigation projects located in California take place on privately owned lands and fall under the environmental requirements of state and local laws and regulations. Recently, mitigation requirements for privately owned lands in other western states have been adopted by state agencies for high profile projects with significant stakeholder concerns about paleontological resources, and even by the BLM if the project is a federal action. However, the bulk of mitigation work in states other than California takes place on BLM, and to a lesser extent, USFS administered lands. Both of these federal agencies have established processes and procedures that include a review of consultant qualifications to obtain or work under a paleontological resource use permit. BLM procedural guidelines (BLM, 1998, 2008), including minimal qualifications for permitting, are often consulted by other federal and even some tribal and state agencies that lack their own guidelines. We encourage this practice of standardizing permitting qualifications to the maximum extent possible.

Any consideration of minimal qualifications to work in mitigation paleontology must include justifications for why such qualifications are necessary, as well as consideration of the problems resulting from non-qualified paleontologists engaging in impact mitigation work. The obvious answer to why qualifications are necessary is to ensure that work is completed according to established professional standards (see SVP, 1991, 1995, 1996, 2010) including the best practices described herein, and in compliance with procedural guidelines, if any, of the overseeing lead agency (e.g. see BLM, 2008). To any paleontologist, the problems with non-qualified paleontologists doing paleontology are patently obvious. Would you hire a plumber to prescribe new glasses? Would you see a proctologist to clean your teeth? With no disrespect intended for the vast majority of highly knowledgeable and ethical archeologists, the fact is that many archeologists, and to a lesser extent geologists without paleontological training, have taken on mitigation paleontology projects presuming that their education and field experience renders them competent in mitigation paleontology.

Unfortunately, the seed for the confusion between paleontological and archeological resources was unknowingly planted by land managers and municipal planners who, several decades ago, programatically included paleontological resource management within cultural resources (and archeology). This confusion still permeates many agencies, municipal planning departments, and private firms in the environmental consulting industry. However, the confusion is not just the fault of land managers. The two disciplines are inextricably linked in our popular culture, much to the frustration of archeologists who often get questioned about dinosaurs, and paleontologists who often get questioned about projectile points. The fact is that in the Western Hemisphere, there is a clear distinction with relatively little temporal overlap between archeological and paleontological sciences. This distinction is fuzzier in the Old World due to the significantly more ancient record of pre-Holocene humans and associated cultural remains. Mitigation paleontologists need to do a better job of educating agency personnel and municipal planners with no background in paleontology about the differences between paleontology and archeology. The simplest way to convey the differences between paleontology and archeology is to emphasize the very few similarities between them: both disciplines work on old objects that sometimes needs to be excavated, even though the objects being excavated are different, and from distinct time periods. Virtually all of the research questions, field methods, and analytical techniques traditionally employed in each discipline are unique. Archeological testing methods are essentially useless for paleontology for reasons that will be discussed in Section 5.

Another manifestation of the confusion between paleontology and archeology is the notion that practitioners of either discipline are capable of doing the other, or can become capable with minimal training. 'Cross trained' is a term that applies to individuals who purportedly have sufficient expertise to work in both their own discipline and another, or even two or three others. The practice comes at the expense of the very resources that the laws and regulations are intended to preserve and demonstrates a lack of understanding of the complexity of paleontology, and the complexity of other resource disciplines. In the many years the authors have been involved with mitigation paleontology while working in universities, museums, and as consultants, we have known few individuals who are legitimately trained and sufficiently experienced to work as a 'cross trained' archeologist and paleontologist. The fact is that it is rare to come across an individual who is legitimately qualified to work as a cross trained scientist in any combination of disciplines. It is also a fact that there are few paleontologists (by training) who claim to have the expertise (or desire) to work as an archeologist, whereas many archeologists continue to profess expertise in both disciplines.

An example of a well-intentioned but largely ineffective effort to ensure that only qualified paleontologists work in mitigation paleontology is the currently unenforced attempt by the State of California's Board of Professional Engineers, Land Surveyors, and Geologists to equate paleontological mitigation work with professional geological work and in turn to imply that paleontological mitigation work should be supervised by either a California Professional Geologist (including California Certified Engineering Geologist, California Certified Hydrogeologist, or California Professional Geophysicist). However, the qualifications for being a Professional Geologist or other licensed geoscientist do not include an extensive knowledge of paleontology and paleontological methods and procedures and thus do not translate into qualifications for conducting paleontological mitigation work. While there are California paleontologists who are also licensed geoscientists, most are not, and a large percentage of those that are not licensed do not have the breadth of geological and engineering training that is required to pass the professional geologist exam, which largely focuses on engineering geology, hydrogeology, and geophysics and not on sedimentary geology, stratigraphy, paleontology, and taphonomy. A potential solution to this current confusion surrounding the issue of who is qualified to work as a mitigation paleontologist in California would be for the Board to develop a separate professional mitigation paleontologist licensing category and examination.

Paleontological mitigation work is generally conducted by three categories of personnel with different levels of expertise and responsibility (see Appendix A, 1.1 for a detailed list): 1) paleontological principal investigator, 2) paleontological field supervisor, and 3) field paleontologist. A paleontological principal investigator is someone with graduate level academic training (M.S. or Ph.D.) in paleontology and sedimentary geology or equivalent professional experience, in combination with demonstrated professional experience and competency with paleontological resource mitigation procedures and techniques. The principal investigator should also have a working knowledge of how paleontological resources and their associated data are used in conducting and publishing professional paleontological research (such as is demonstrated by having a peer-reviewed publication record). The principal investigator is responsible for obtaining all necessary federal and state agency permits, for submitting any and all required progress and final mitigation reports, and for ensuring compliance with all scientific and operational requirements of the project. Therefore, it is critical that the principal investigator have knowledge of federal, state, and local laws and procedures that apply to all aspects of mitigation paleontology.

A paleontological field supervisor is someone with academic training (B.S. or M.S.) in paleontology and sedimentary geology or equivalent professional experience, in combination with field experience in impact mitigation procedures (including fossil salvage/collection), stratigraphic competency, knowledge of fossil curation procedures, authorship experience with final mitigation reports, knowledge of resource management strategies and concerns, an understanding of the regulatory environment including knowledge of federal, state, and local laws and procedures that apply to mitigation paleontology, project management experience, and an understanding of the business of mitigation paleontology. The paleontological field supervisor typically manages the field paleontologists (on field survey and/or mitigation projects), supervises fossil salvage operations, communicates with construction foremen and superintendents, and assists with preparation of progress and final project reports.

The field paleontologist (paleontological technicians, surveyors, and monitors) is someone with academic training (B.S., B.A., or M.S.) in paleontology and sedimentary geology or equivalent professional experience, in combination with field experience in conducting field surveys, fossil salvages, and construction monitoring. The field paleontologist should be able to safely find, salvage, collect, identify to a basic level (taxon and element), and evaluate the scientific importance of fossils in undisturbed settings as well as in active cuts at construction sites, and accurately record data including site stratigraphy. Other recommended requirements include the ability to record field interpretations of the taphonomy of fossil assemblages and recognize and describe unusual depositional or preservational conditions and associations; the ability to interpret depositional environments based on site geology and paleontology; sufficient knowledge of geology to communicate with a registered professional geologist when necessary; the ability to properly complete field forms, operate a GPS, photograph fossils and localities, and plot localities on grading plans when applicable; and an understanding of safety requirements.

We recognize that few paleontologists have degrees in paleontology because few institutions offer degrees in it. Typically, paleontologists earn degrees in geology or biology with an emphasis in paleontology. Academic training and field experience in sedimentary geology is an important prerequisite to work in mitigation paleontology. The aforementioned three categories of paleontological mitigation personnel are not intended to correspond to paleontological mitigation personnel categories developed by agencies, but rather, to clearly represent the roles and responsibilities that have proven to achieve the best results across the spectrum of mitigation paleontological projects over several decades. Henceforth, we refer to paleontological principal investigators and field supervisors as 'professional mitigation paleontologists.' The field paleontologist is a technician level position that could lead to achieving the level of professional mitigation paleontologist.

The bottom line is that although there are archeologists and biologists who have sufficient expertise to work in more than one discipline, and registered professional geologists who have sufficient expertise in paleontology, it should never be assumed that any archeologist, biologist, or professional geologist is qualified to do so. Likewise it should not be assumed that all paleontologists have sufficient training and expertise to be considered professional mitigation paleontologists since there are paleontologists who specialize in morphology, taxonomy, or phylogeny of specific taxonomic groups, who may not have the knowledge needed in stratigraphy, taphonomy, or with other taxonomic groups. Thoroughly vetting all individuals in order to ensure their professional competency to work as mitigation paleontologists is a critical best practice. The proof is that this practice, when it has been well implemented, has been directly responsible for the successful recovery of countless scientifically significant fossils and associated data from construction sites in the last 30+ years, resulting in the preservation of large numbers of important fossil collections and the production of a vast body of published scientific research. Ultimately, a universally effective solution to the problem of ensuring professional competency may be a professional registration process that mirrors that of the 'Registered Professional Archeologist,' a process that was developed, ironically enough, to ensure that only properly trained archeologists conduct archeological work.

2. ANALYSES OF EXISTING DATA

The purpose of an existing data analysis is to evaluate the potential of a geologic unit in a geographic area to produce fossils of scientific importance. This potential is commonly referred to as paleontological sensitivity and is determined from an analysis of existing paleontological and geological data. There are six elements of an analysis of existing paleontological data: 1) geologic map review, 2) literature search, 3) institutional/agency records search, 4) land ownership analysis, 5) aerial photo review, and 6) consultation with local paleontological experts. The analysis of existing data is typically a prerequisite to any mitigation action such as a field survey or construction monitoring, and may also provide the background information for a paleontological resource evaluation. Like all aspects of mitigation paleontology covered in this paper, analyses of existing paleontological and geologic data should be completed under the oversight of a professional mitigation paleontologist in possession of a valid paleontological resource use permit or certification/qualification when applicable (See Section 1).

For the purpose of conducting geologic map reviews and quantifying the size of a project and its disturbance area, the area of analysis is conceptually three-dimensional – it is a two-dimensional geographic area with a third dimension consisting of a stratigraphic interval that underlies or is laterally equivalent to the area of proposed ground disturbance. The geographic area or areal extent of disturbance is most commonly expressed in acres or linear miles. The stratigraphic interval or thickness/depth of the proposed disturbance is most commonly expressed as the volume of rock or sediment in cubic yards or cubic meters. The geographic and stratigraphic limits of the disturbance area are important considerations in evaluating paleontological sensitivity and the potential impacts on paleontological resources associated with ground disturbing projects. However, information regarding disturbance depth is often not available to the mitigation paleontologist at the time of preliminary data analysis, at least not with any meaningful level of precision.

Geologic Map Review

Geologic map reviews should utilize published, and if necessary, unpublished but reputable sources. The highest precision maps available should be used. Because electronic geologic map data are often not available at the same scale as hard copy maps, it may be necessary to scan, georeference, and digitize portions of hard copy maps in order to utilize them in Geographic Information Systems (GIS). A geologic map review is especially important for stratigraphically and/or structurally complex project areas containing multiple geologic units. The purpose of the geologic map review is to determine which geologic units occur within a project area (especially fossiliferous units), and to determine their areal distribution. Soils maps may also assist in a determination of areas of potential fossiliferous bedrock or surficial deposits. However, it is the authors' experience that soils data are often inaccurate and should be used with caution, and only in combination with field verification.

While discussing geologic map reviews, it is useful to consider paleontological sensitivity classification systems because the most widely used systems, namely SVP's 'rock unit potential' classification system, the BLM's Potential Fossil Yield Classification System (PFYC), and the USFS's Fossil Yield Potential Classification System (FYPC), are all geospatially defined on the basis of geologic map units. It is important to distinguish between a project specific analysis of existing data done by a professional mitigation paleontologist and the assignment of PFY (FYP) class values. The latter is not the purview of the mitigation paleontologist, but is a resource management process undertaken by the agency to assess the general paleontological potential of a geologic unit (usually an entire formation) and inform agency personnel about recommended management approaches. The former, which is typically performed by a mitigation paleontologist on behalf of a client, is based on a more detailed dataset that is synthesized to inform the client and the lead agency about the need, or lack thereof, for the development of paleontological impact mitigation measures. Depending upon the scale of the available maps, the geologic units shown on a given map may consist of groups, formations, members, submembers, or combinations thereof; and may consist of bedrock units and/or surficial deposits. While a critique of the aforementioned predictive classification systems is beyond the scope of this paper, it should be pointed out that paleontological sensitivity class rankings are often assigned based on 1:500,000 scale (state scale) geologic mapping, and in such cases the highest class ranking is assigned to combined map units. This is both a practical function of the available geologic maps, since more precise geologic mapping generally is not available for entire states, but also because the PFYC and FYPC systems were designed to function as a resource management step completed by the agency that triggers further analysis by a professional mitigation paleontologist. Higher precision geologic mapping is available in many states, and should be used to refine the analysis to the greatest extent feasible. Additionally, the scale of the map used to assign the PFY/FYP classes may not account for rare or isolated occurrences of significant fossils that may necessitate further consideration.

As mentioned above, PFYC (or FYPC) assignments should be completed by the applicable lead agency prior to the start of a specific project. Exceptions occur if, for example, an agency has not yet completed the classification of the geologic unit(s) in question. In such cases, the mitigation paleontologist, using the results of the analysis of existing data, may assign preliminary values pending agency concurrence. Ideally, the predetermined paleontological sensitivity values of geologic units are provided by agencies prior to the mitigation paleontologist beginning work on a given project, and have been used by the lead agency in determining paleontological resource requirements for the project (2.1).

Literature Search

The literature search is the second component of the analysis of existing paleontological data. There is no standard literature search area size – in many cases, the most appropriate search area might be the geologic unit's entire distribution, the depositional basin in which the unit is located, or the entire distribution of the geologic unit within the state in which the project is located for more widely distributed geologic units. In other cases, it might be most appropriate to limit the search to a member or facies of a geologic unit that is known to be distinct from the other portions of the unit in terms of its fossil content.

The purpose of the literature search is to obtain published paleontological locality information and relevant geological and stratigraphic information, as well as qualitative information regarding the scientific importance of paleontological resources in a project area and in the same geologic units elsewhere in the region. The surveyed literature can include published scientific papers and unpublished gray literature such as technical reports written by government agencies and mitigation paleontologists. Detailed fossil locality data are typically not provided in recently published scientific papers. However, other information relevant to the analysis can consist of general information regarding fossil localities including the types and abundance of fossils collected, physical characteristics of the fossil-producing strata, the depositional environments in which fossils were preserved, and the scientific importance of the fossils. In many cases, project specific geotechnical reports are also very useful and provide critical information about the thickness of surficial deposits and the depths at which potentially fossil-bearing rock units are likely to occur. Popular websites including Wikipedia entries are not a reliable source of scientific knowledge and should not be a substitute for literature searches - even for the preparation of typically more abbreviated paleontological resource sections of National Environmental Policy (NEPA) documents (see Section 8) (2.2).

Paleontological Records Search

The third component of the analysis of existing data is a paleontological records search, the purpose of which is to obtain fossil locality data from within a project area in order to determine the extent of previous paleontological work and fossil discoveries, in particular geologic units and the types, modes of preservation, and relative abundance of known fossil assemblages from these units. Record searches for areas outside the project area can also be useful for establishing paleontological sensitivity for the same formation based on findings from another, adjacent geographic area. These data in turn provide a means for establishing the potential of a given rock unit to produce fossils within the project area. Record searches also provide information that can ensure that recorded localities in the project area are re-evaluated and avoided by the project if needed. Quantitative and qualitative information about fossil localities is used to determine the need for a field survey or construction monitoring of a project area.

The size of the area for paleontological records searches is more confined and precise than that for literature searches. Depending on the lead agency, the search area may either be specified or left to the discretion of the mitigation paleontologist. The format that the data are in at the source institutional/agency may also play into the determination of the search area. For small, block area projects, it is common to search for fossil localities within the same formation within one-mile of the project area. For larger block area projects or linear projects such as interstate pipelines, transmission lines, and highways, a good minimum search area is a one-mile buffer of the project area (one mile from the external boundaries of a project, or one mile on either side of the centerline of a linear project), although it may be more expedient to search the same township or county, depending upon the format of the data.

Paleontological locality data on public lands are confidential and are maintained by both government agencies and institutions including museums and universities. In many jurisdictions, fossil locality data are only provided to paleontologists in the possession of a valid paleontological resource use permit. Institutions are not under any obligation to provide locality data, and many charge for this service. Regardless of whether a locality search request is answered, it is critical to document that the request was made in whatever type of paleontological report is required for the project. Paleontological localities known to the authors have been destroyed simply because they were not identified due to either inadequate analyses of existing data or because institutions holding such data were unwilling to provide them. Importantly, the PRPA prohibits public disclosure of paleontological locality data from Department of Interior and USFS managed lands without permission. Once received, paleontological locality data must be kept confidential by the recipient of those data.

Paleontological locality data, including both institutional/agency records and locality records obtained from literature searches (and/or local experts), are vital to the development of paleontological resource impact mitigation plans, and they play a critical role in the decision making process for field survey and construction monitoring requirements. It is extremely useful to digitize fossil locality data originally contained on hard copy maps and documents upon receipt. These data are utilized for the data analysis, continued use in future projects, and to supplement the dataset with the results of subsequent searches conducted as they are completed. The results of record searches are also an important component of paleontological reports (see Section 8), although detailed locality data should only be included in copies of the report provided to the applicable agencies. The inclusion of record search requests (i.e. date, person contacted, response if any, etc.) and results obtained document that the analysis of existing data was conducted as required by the regulatory agency, and it provides the justification for the mitigation recommendations included in the report (or mitigation plan) both for the agency and the project proponent. It is important to bear in mind that an absence of fossil locality records is more likely to reflect the lack of prior paleontological field work in a particular area than the actual absence of fossils in that area. However, this may not be the case for areas that have been the subject of intensive and long term paleontological field work (2.3).

Land Ownership Analysis

The fourth component of the analysis of existing data is a determination of land ownership, an important issue in the increasingly complex web of regulatory requirements that in certain situations result in impact mitigation procedures that vary by land ownership type. Knowledge of land ownership in a project area as well as the regulatory environment that applies to land ownership is essential before undertaking any subsequent analyses or mitigation actions. All five other components of the analysis of existing data should be applied equally regardless of land ownership type unless otherwise specified by the lead agency. The major land ownership distinctions are federal, state, tribal, county, city, and private. Differences between certain types of federal, state, and tribal land may also affect the scope of mitigation paleontological work. For example, mitigation requirements may vary between different classifications of state land in some states, and also commonly vary between federally managed lands, even at the level of field and district offices. Land ownership data are available in a number of formats including hard copy maps and GIS data coverages. Because land ownership changes frequently, it is important to obtain the most recent and most accurate data available. This is often available from and provided by the project proponent and should be requested at the initiation of any project (2.4).

Aerial Photograph Review

The fifth component of the existing data analysis, aerial photograph review, is extremely easy to accomplish using widely available technology such as Google Earth. The purpose of this step is to virtually examine the terrain within the project area from above (or using ‘street view’) in order to estimate the amount and locations of exposed potentially paleontologically sensitive bedrock or surficial deposits. The result of the aerial photograph review provides information that is useful for the evaluation of paleontological resource potential as well as the logistical planning for field work (2.5).

Consultation with Local Technical Experts

The sixth and final component of an analysis of existing data is consultation with local technical experts. Such experts are researchers who are currently active in the area of interest, have worked there previously, or otherwise possess specialized knowledge of its paleontology and geology. These experts may include agency personnel and avocational paleontologists who are knowledgeable of the area. The types of contributions a technical expert can make to the analysis are important, and include information on undocumented or unpublished fossil localities, particularly productive (or unproductive) stratigraphic or geographic locations, detailed stratigraphic information, and information about any paleontological concerns including specialized data recordation procedures in support of ongoing research. If recent fossil collection activities are not taken into consideration, it could cause the paleontological potential of an area to appear lower than it actually is and skew recommendations based on the results of analyses of existing data or field surveys. In addition to supplementing the data obtained from literature and record searches, the information provided by technical experts can provide invaluable information for field surveys or other future mitigation actions. Contacting a technical expert is the responsibility of the mitigation paleontologist, although there is no obligation on the part of the expert to provide support for the project (2.6).

All six components of the analysis of existing data can be efficiently examined and analyzed together using GIS technology (Figure 1). The output of the analysis of existing data can be presented in a variety of formats, but should always include a discussion of the methods used, as well as the results obtained. If the analysis is a preliminary step to additional work, it may only involve synthesis of the data into a format that is useable in a later project report (i.e. field survey report), or it may form the subject of a report unto itself. A report based on an analysis of existing data is appropriate for many types of projects, and we recommend that it be called a paleontological resource impact evaluation report in order to avoid confusion with other types of reports (see Section 8). The purpose of these types of reports is typically to synthesize information necessary to evaluate the paleontological sensitivity of a project area. This information, in turn, can be used by a project proponent and the lead agency to make a determination of the need for paleontological impact mitigation measures such as field surveys, construction monitoring, or more project specific mitigation recommendations. It is also common for the product of an analysis of existing data to provide the basis for paleontological resource analyses for NEPA studies such as Environmental Assessments (EAs) and Environmental Impact Statements

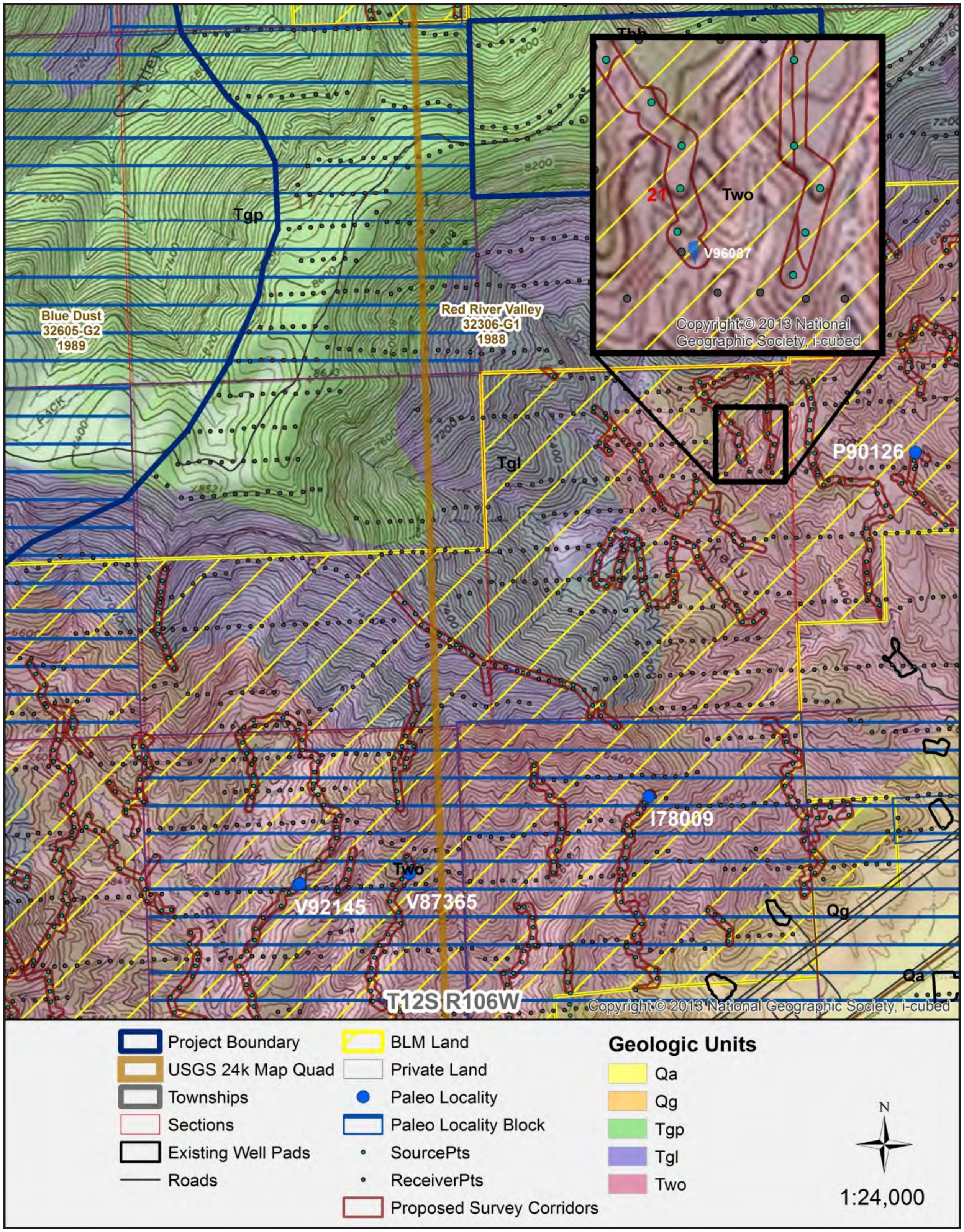

FIGURE 1. Fictional portrayal of information obtained from an analysis of existing data. Previously recorded fossil localities, topography, geology, project infrastructure locations, and land ownership are displayed.

(EISs). If a report based on the analysis of existing data is not required, then consultation with the lead agency (if applicable) should take place in order to determine the need for impact mitigation measures, and the consultation may include the development of project specific mitigation recommendations (2.7).

3. RESEARCH MODELS AND SCIENTIFIC CONTEXT

When properly implemented for a project with significant paleontological resources, the impact mitigation process can result in the discovery, recovery, and curation of well documented fossil collections permanently housed in curation facilities, where the fossils are then accessible for research and educational purposes. While the mitigation process does not include conducting hypothesis driven research per se, every impact mitigation program should be designed around a research model that places it in a scientific context, and which will allow the results of the program (i.e., fossil collections and associated data) to be employed in later research activities.

Essentially, a research model should serve as road map that guides the implementation of the mitigation work including the development of the threshold criteria for scientific importance, which fossils are collected, how they are collected, and the types of data that are collected (3.1). For smaller projects, a research model may be focused on a single fossil locality. For larger projects, multiple research models may be needed. Research model development should be built into project scopes of work and budgets, and the actual research models should be presented in paleontological resource impact evaluation mitigation evaluation reports and paleontological resource monitoring and mitigation plans (see Section 8). This approach will help ensure that these types of reports make detailed recommendations for field surveys, construction monitoring, and impact mitigation (3.2).

The research model concept is analogous to a research design in cultural resource management (CRM), which is a more or less standard requirement for excavation permits beyond simple testing, and may also be required for construction monitoring treatment plans. Like a CRM research design, a paleontological resource research model should include a statement of research objectives and specific research problems, hypotheses to be tested, methods to be employed to address the research problems, and a discussion of the expected results. Final survey and monitoring reports should, in their results sections, reference the research model and include a discussion of how the mitigation results preliminarily support or otherwise modify the research model (3.3).

The development of a research model is not currently implemented for the majority of paleontological resource impact mitigation projects, but is considered to be a best practice because it adds scientific value and integrity to the mitigation process and resulting fossil collections (3.2).

4. FIELD DATA COLLECTION

The collection of accurate field data is vitally important, and is one of the most complex aspects of mitigation paleontology. The main issue is to design and implement a data recordation protocol that promotes accuracy and is efficient, adaptable, and intuitive. The protocol also should be easy for field crew members to learn, readily comparable between field crew members, and designed for use on all sizes and types of projects. Ideally, the protocol should be designed so that it can be quality checked by the principal investigator, field supervisor, and/or project manager so that data corrections and methodological changes can be introduced if necessary. Field data often need to be collected quickly, especially on certain types of mitigation projects. Typically, there is only one opportunity and a brief window of time in which to record data. For example, when monitoring a mass grading project, the topography is modified rapidly and often drastically, and entire fossil localities (and enclosing strata) are graded away almost immediately after fossils have been salvaged.

In many cases, agency guidelines (if they exist) are vague about what data are required to be collected for mitigation paleontology projects. This decision is typically left up to the discretion of the principal investigator or field supervisor based on his or her training and field experience. Even agencies with robust procedural guidelines such as the BLM require little more than standard fossil locality data for project and permit reporting purposes. In fact, in order to properly implement a mitigation project with any degree of complexity, a lot of data must be recorded. A well designed research model can go a long way towards establishing, up front, the data recordation protocol to be followed in the field. It is often not just important to know what data to collect and how to collect it, but perhaps equally as important to know what data not to collect. It is well beyond the scope of this paper to recommend and describe detailed data capture procedures or provide a comprehensive list of data that should be collected. Most paleontologists prefer to do things in their own way, and projects may require variations in data collection and management. Rather, in this section we provide recommended minimal data capture guidelines that constitute best practices for typical paleontological mitigation paleontology projects. Additional data should be collected on specific projects depending upon scientific or reporting aspects of projects as determined by the principal investigator, field supervisor, project manager, or agency personnel.

Field data are traditionally recorded in field notebooks and on hard copy topographic maps, aerial photographs, and/or hard copies of grading plans or plan and profile sheets. Customized hard copy field forms (e.g. locality forms, photographic logs, etc.) are far more effective than field notebooks in most cases, especially when a crew of more than one person is involved (4.1). However, other readily available and relatively inexpensive data recordation devices include global positioning system (GPS) receivers, tablet computers, and digital cameras. For GPS receivers, sub-meter level precision may be needed in certain field applications. However, a position error of 20 to 30 feet is probably sufficient for most applications (4.2). Increasingly, digital data and integrated data recording systems are being utilized in the environmental consulting industry, and undoubtedly will replace hard copy field notes and field forms in the near future. Data entered directly into relational database management systems on tablets or advanced GPS units save significant amounts of data entry time. On the other hand, these data continue to require careful quality checking in the office because of the inherent difficulty of capturing information accurately in the field, which requires extra attention to detail and can be a drain on precious field time (a constant challenge in itself).

Prior to the commencement of any mitigation project, it is important to provide information about the project to crew members typically in the form of an orientation and training session (see Section 5). An important component of such a pre-field orientation session is a review of the types, preservation, and data needs of anticipated paleontological resources, as well as a review of field data collection procedures and associated data management responsibilities. This includes a review of field data forms and/or digital custom form applications, recording procedures and protocols, and nightly data management procedures. In particular, it is critical to discuss thresholds for paleontological significance for the purpose of providing guidance about what constitutes a paleontological locality, because this may vary by project as discussed below (4.3).

All data recording protocols should include capture of 'negative data' because such data can be important for resource management. There are two aspects to negative data in mitigation paleontology projects. The first is documentation of all areas that were surveyed or monitored regardless of whether fossils were found or not. This serves the dual purpose of providing data on where fossils were not present during surveys or monitoring, and also, as a best practice, providing a record that the field work was completed according to the scope of work and agency requirements. If possible, a GPS track log file and/or polygons depicting locations of field crew activities along with GIS locality data should accompany the agency copy of the mitigation report. The second aspect of negative data involves non-scientifically important fossil localities. Although these localities are often omitted from final reports, all fossil locality data are useful for resource management and should be reported. The primary distinction between scientifically important and non-important localities is that important fossil localities (those with fossils of scientific value, and as defined using agency provided significance criteria when applicable) are subject to mitigation whereas non-important fossil localities are not. Most land managers want negative data including non-important fossil localities because it provides information on the overall abundance and quality of preservation of fossils and the distribution of fossil-bearing strata in a project area (4.4). In addition, these data are critical during the analysis phase of subsequent projects. Finally, paleontological localities deemed non-significant may be reevaluated for significance at a later time.

The significance threshold for fossil localities varies by geologic unit, geographic area, agency criteria, and ongoing research related to the fossils within a project area. For example, in the middle Eocene Uinta Formation in northeastern Utah, fossil turtles consisting of both complete carapaces and fragments thereof are prolific. A survey of 17,000 acres yielded 3,910 localities with turtles, for a density of one locality per 4.35 acres. Of these, approximately 110 localities were recorded as scientifically important because they yielded relatively complete carapaces, some of which were associated with crania and post-crania. The other 3,800 localities were recorded as non-important because they produced exploded scatters of turtle carapace fragments with no associated cranial or post-cranial remains that either represented common taxa or were poorly preserved and unidentifiable (Imhof et al., 2008). Indeed, fossil turtles are so abundant in certain Uinta Formation strata that it is impractical to report isolated carapace fragments even as non-important fossil localities. Consequently, in this case a minimum non-significance threshold needs to be established and adhered to during field work. In stark contrast, in the stratigraphically overlying upper middle Eocene Duchesne River Formation, fossil reptiles, including turtles, are exceedingly rare. Even an isolated turtle carapace fragment found in this unit should be recorded as a significant fossil locality because of the rarity of turtles and the associated potential scientific contribution from the discovery of additional specimens (4.4).

Before discussing field data specifically, a final consideration involves data confidentiality, which is another aspect of data collection and management that varies between projects. It is a best practice to err on the side of discretion whenever working on a mitigation project, and this should be strongly emphasized to field crews. For example, it is important that field crew members refrain from posting any information about a project, including fossils that were found, on their websites or social media sites. This includes not posting images that may identify geological context or are geographically referenced. It is also important that field crew members refrain from discussing any aspect of projects, especially paleontological data, with non-project personnel. Such discretion is expected by clients who are paying for this work. Under PRPA it is unlawful for federal fossil locality data to be disclosed to the public (see Section 8) (4.5). However, disclosure to appropriate agency and curation personal is necessary.

There are two general categories of field data: paleontological data and project data. Paleontological data document the locations and types of fossils and their geologic context. These data provide the contextual information necessary to make the associated salvaged fossils scientifically valuable. Without adequate information concerning stratigraphic provenance and taphonomic fabric, most fossils become just pretty objects that immediately lose their scientific value. Project data, on the other hand, include details of the work performed on a daily basis and other project-related information and are discussed in greater detail below. Some clients also require project-specific daily logs that typically serve the purpose of reporting what work was done, where it was done, how many hours were spent at the field site, and localities found (if any). It is a best practice to fully and properly complete all client or company required project paper work. This may include vehicle inspection forms, job hazard analyses or other safety related forms, and project daily logs. These requirements are supplemental to scientific and project data recorded by field crews, and will not be discussed further (4.6).

Five general types of field forms suffice for most mitigation paleontology projects, and all contain both paleontological and project data fields (Table 1). Much of the information listed on fossil locality forms, such as geographic coordinates, stratigraphic and lithologic data, and fossil identifications, is standard for paleontological field work. The primary difference for mitigation projects is that the locality is associated with a project name and tied to a survey or monitoring area. A survey or monitoring area, in turn, is a subdivision of a project area depending on the project type, whether it be an alignment segment between highway mileposts, pipeline station numbers, or geophysical source points; or a transmission tower, wind turbine, well pad, or quarter-quarter section. Another important component is whether the locality is scientifically important or not, whether fossils were collected (non-important fossil localities typically are not), and preliminary mitigation recommendations depending upon the nature of the fossil locality and the type of anticipated impact. As discussed in Section 8, there is no single formula that can be used for designing mitigation recommendations. Best practices related to impact mitigation are those that accomplish the objectives of the project while preserving the value of paleontological resources. Finally, it should be noted that the information on field locality forms is not identical to fossil locality forms that are produced for mitigation reports – the former have some different data fields and they report preliminary information (4.7).

Monitoring and survey area logs accomplish the same thing for monitoring and survey projects, respectively, and can be utilized in place of or in addition to standard field notes. Such logs document what work was done in which part of a project area, whether the project has a linear (e.g., pipeline, transmission line, or roadway alignments) or a non-linear (e.g., solar energy generation facilities, residential developments, or landfills) footprint. The purpose of these log forms is to capture information about sub-areas within a project area to provide details about what was done and when, and observations about each area, regardless of whether fossils were found. It is not possible to accurately characterize any but the smallest of project areas unless the project area is subdivided into more meaningful sub-areas. Finally, both monitoring and survey area logs should also include a listing of other associated data such as scientifically important and non-important paleontological localities, stratigraphic logs and photographic points recorded within them, and bulk matrix or other samples collected (4.7).

Lithologic information is applicable to fossil locality logs, monitoring logs, and survey logs (see gray shaded fields under stratigraphic log in Table 1). The fossil-bearing stratum is typically recorded on the fossil locality log, while the complete exposed stratigraphic profile within a survey or monitoring area along with positioned fossil localities is recorded on monitoring and survey area logs. The purpose of a stratigraphic log is to record thicker sequences, and can either be used to record a traditional stratigraphic section or a trench log (log of strata exposed in a linear exposure such as a pipeline trench). Photographic logs simply provide a way to track digital photographs taken of localities, fossils, and other visual project aspects so that they can be used in mitigation reports and locality forms (4.7).

5. FIELD SURVEYS

The purpose of a field survey is to locate and document exposed fossils and potentially fossil-bearing surface strata within a project area, to re-locate previously recorded fossil localities, and to document areas that have high potential to produce subsurface fossils. It is assumed that basic required skills, such as finding and identifying fossils and documenting their geologic and stratigraphic context, have been mastered by professional mitigation paleontologists during the course of their academic training and/or pre-mitigation professional experience. In other words, the scientific skills required to prepare for and successfully complete a field survey are prerequisites to undertaking a mitigation project. As such, these subjects are not covered in this paper.

It is important to prepare for all field work in advance, and such preparations are generally similar whether the proposed work involves a field survey, construction monitoring, or other types of mitigation field activity. Pre-field preparation should also be included in scopes of work and budgets, and is focused on assembling information and providing training to those who will be doing the work. Field crew members should be provided with the results of the existing data analysis completed for the project (or similar information if a formal analysis was not completed), key publications and technical reports relating to the geology and paleontology of the general geographic area and geologic units involved, and maps and/or construction design or grading plans of the project area. A discussion of the necessary field equipment, data recordation and management procedures (see Section 4), and safety concerns should also be provided. Importantly, pre-field training should include a discussion of scientifically important versus non-important fossil localities, and fossil evaluation criteria and collection procedures. Ideally, for larger field surveys an orientation to the project area should be

Fossil Locality Log	Monitoring Area Log	Survey Area Log	Stratigraphic Log	Photographic log
Locality #	Monitor Name	Surveyor Name	Recorder Name	Photographer
Date	Date	Date	Project #	Date
Project #	Project #	Project #	Project Name	Project Name
Project Name	Project Name	Project Name	Infrastructure Name	Photograph Number
PLSS Location	Arrival and Departure Times	Survey Area Name	Unit	Location Reference
UTM or Lat/Long (NAD 83 datum)	Infrastructure Name	Survey Area Type	Thickness	Direction/Bearing
Found By	Infrastructure Type	Infrastructure Name	Rock Type	Photograph Description
Survey Area Name	Land Owner	Infrastructure Type	Color Fresh	
Survey Area Type	PLSS Location	Land Owner	Color Weathered	
Land Owner	County	PLSS Location	Texture	
Location Description	State	County	Grain Size	
Topography	Weather Conditions	State	Sorting	
Formation	Safety Concerns	Survey Type (pedestrian, visual, aerial)	Rounding	
Member	Equipment	Survey Start and Stop	Carbonate	
Age	Excavation Activities	Topography	Cementation	
Stratigraphic Position	Project Start and Stop	Amount and Approximate Locations of Bedrock Exposures	Bottom Contact	
Lithology	Continuous or Spot-Check	Formation	Sedimentary Structures	
Fossil Type(s)	Formation	Member	Fossils	
Field Taxonomic ID	Member	Age	Points Recorded	
Field Element ID	Age	Stratigraphic Observations	Start and Stop Points	
In Situ or Float	Stratigraphic Observations	Lithologies	Dip/Strike	
Preservation Quality	Lithologies	Site Sketch		
Taphonomic Observations	Site Sketch	Associated Fossil Localities		
Depositional Environment	Associated Fossil Localities	Associated Photographic Points		
Locality Dimensions	Associated Photographic Points	Associated Stratigraphic Points		
Collected?	Associated Stratigraphic Points	Matrix Collected		
Significant?	Matrix Collected	Field Recommendations		
Field Recommendations				
Photograph Numbers				

TABLE 1. Recommended types of field forms and minimal data fields. Gray shaded fields represent repeated subparts of a form for recording successive stratigraphic units and photographs.

provided by a technical expert (e.g., a researcher who does field work in the area) should take place, and such an expert, if available, should be kept informed of the results of the project as it proceeds (5.1).

If required, paleontological resource use permits must be obtained prior to field work. Furthermore, when working on projects on federal land or with federally mandated requirements, it is necessary to coordinate with agency personnel, typically in field or district offices, before initiating field work. For example, for BLM paleontological resource use permits it is mandatory to check in with the local paleontology coordinator. Additionally, it may be necessary to coordinate with the paleontology coordinator or regional paleontologist with regard to extensive fossil discoveries as defined below. Field work on tribal lands typically requires an access permit and daily check-ins. It is highly recommended that an email or other written authorization that contains details about the survey methodology be obtained from the applicable agency prior to beginning any field work on a project (5.2). Copies of this written authorization should be carried by each member of the field crew when in the field.

Land ownership is an important consideration when planning for field work. It is a complex topic, and the primary issues for both field surveys and construction monitoring concern whether a permit(s) is required to conduct field work and collect fossils, and whether or not fossils can be collected if discovered. It is essential to obtain written right-of-entry from the land owner prior to entering any private property, even if crossing over private land to work on federal or state land. Be sure to understand the trespass laws of the state you are working in. Fossils should never be collected from private land without written permission from the land owner (see Section 7).

Archeological field surveys are typically not conducted without 75% or greater ground visibility. This percentage is variable and is usually at the discretion of the principal investigator or local agency office. Some local agency offices extend a similar requirement to paleontological field surveys with regard to snow cover. However, the differences between these resources make this restriction inappropriate for paleontology. The small size of many scientifically important fossil specimens, and the presence of small bone fragments on the ground surface that could indicate more extensive subsurface fossil remains, makes it impossible to determine whether fossils are present in areas where the ground surface is not fully visible. For these reasons, the ground should be completely free of snow before a paleontological field survey commences (5.3).

Scopes of work and budgets for paleontological field surveys should be based on a pedestrian examination of outcrops of potentially fossil-bearing rocks or surficial deposits including the time necessary to perform reconnaissance for outcrops. All survey activities should be confined to the project area. In rocks and surficial deposits with high and very high sensitivity, all exposures should be surveyed. However, in rocks with moderate or unknown sensitivity, spot-checking of exposures of rocks and surficial deposits is typically an acceptable level of effort. Because exposures of sedimentary rocks are not continuous over the landscape in most areas, often being restricted to ridges, canyon walls, stream cuts, badland knobs, and so forth, surveys should be focused in such areas (Figure 2). Where walking evenly spaced transects is a standard procedure for archeological surveys, it is not a best practice in paleontology; rather, a survey field crew should spread out to cover as much ground in as little time as possible, as opposed to hiking closely together. Field surveyors should be cautioned to avoid the traditional research-oriented approach of making a beeline to the best-looking outcrops. For mitigation projects, all outcrops need to be thoroughly prospected – many important fossil discoveries have occurred in unlikely settings, including small exposures that are often ignored by researchers. For example, certain highly fossiliferous rock units are known to yield scientifically significant fossils even in areas with weathered and entirely vegetated exposures including flat prairie, so this should be taken into account during the scoping and planning process. For archeological surveys, a slope exclusion is sometimes imposed in order to eliminate steeper areas with a low likelihood of containing archeological sites. Slope exclusions should not be imposed on paleontological field surveys because of the high likelihood of finding fossils in steeper and more rugged terrain where bedrock is more likely to be exposed. However, field crews should be advised to exclude areas that are too steep to survey safely (5.4). Because fossils are never identifiable from a vehicle, windshield surveys are never appropriate for fossil prospecting and are only useful for determining the physical locations of rock outcrops from a road. For these reasons, field survey reports should differentiate between areas that were subject to pedestrian versus windshield survey (or any form of non-pedestrian visual inspection) (5.5).

There are two general types of field surveys with various permutations and exceptions. Block surveys are often employed at the programmatic level and provide a resource clearance for a larger project with unknown infrastructure locations by surveying the entire project area. Infrastructure-specific surveys are targeted to planned locations of specific project elements with anticipated ground disturbance within a larger project area (e.g. well pads, or seismic source points), and may include a survey buffer. The word ‘survey’ may or may not include fossil collection, whereas a paleontological resource inventory connotes resource documentation with no collection (see Section 7). The activities of the field survey generate the data used in reporting and result in mitigation recommendations. Impact mitigation in the form of fossil collection may occur at the time of initial fossil discovery during a field survey, or be deferred until input from the principal investigator, agency, client, and/or land owner has been obtained. Although resource avoidance has traditionally been the agency-preferred approach to impact mitigation, the fact is that most surface fossils have a very limited lifespan due to environmental factors such as weathering and erosion, not to mention poaching (theft) by humans. Therefore, fossil collection and museum curation is the best practice for paleontological resource preservation. This is another practice that deviates significantly from CRM, where most resources are recorded, but not collected. Clients are frequently concerned that collecting surface fossils identified during a field survey and repositing them in a curation facility will be more costly than avoiding the resources and believe that it is less costly to re-engineer the project in order to relocate it away from fossil localities. In the case of block surveys, if a project has not yet been designed, it may be possible to avoid scientifically important fossil localities. However, for projects that have been designed, it is often less costly to collect, prepare, identify, report, and curate isolated surface fossils than to reroute or move project infrastructure, and as a best practice, this should be explained to clients. Excep-

FIGURE 2. Field paleontologists Lauren Seckel and Hugh Wagner surface prospecting for fossils in the Ohio Creek Formation, Piceance Creek Basin, Colorado. SWCA Environmental Consultants photograph.

tions certainly exist, such as bone beds or large fossils (see extensive fossil discoveries below), and fossiliferous ant hills that may be time consuming to prospect, collect, and pick, since they may contain hundreds of small fossils. Of course the client always retains the option to pay for mitigation if it is not feasible to move the project to avoid a fossil locality. A client is under no obligation to mitigate impacts to paleontological resources that will not be affected by the project, because there will not be any project-related impacts. Fossil collection is not permitted on some tribal lands, and in these cases, for scientifically important fossils documented during field surveys, resource avoidance is the only mitigation alternative, necessitating project relocation. However, in the case of fossil discoveries of very high scientific importance, it is worth contacting the appropriate tribal authorities to make a case for fossil collection and curation (5.6).

It is advisable to exclude the mitigation of 'extensive' fossil discoveries from initial scopes of work unless of course that is the sole purpose of the project. During routine field surveys and monitoring in paleontologically sensitive rock units and surficial deposits, one expects to find fossils, and typical fossil discoveries can be anticipated and budgeted for. However, extensive fossil discoveries are those that are not anticipated, and are outside of the scope of work of normal mitigation. Typically, these include bone beds or other exceptionally rich accumulations of vertebrate fossils, or large fossils such as complete or nearly complete skeletons of large mammals or reptiles. In the case of such discoveries, the client and agency (when applicable) should be notified immediately, and the locality should be avoided until a decision on a mitigation approach has been reached. Generally, the locality will be avoided by the project, and the mitigation paleontologist or agency should contact an institution or researcher(s) who may have an interest in it. However, the client may choose to have the site excavated, and in such cases, the preparation of a locality specific mitigation plan may be required. There are cases in which it has been necessary for a client to provide security for fossil discoveries, even non-extensive localities (5.7). 'Unanticipated discovery' is another CRM term that is sometimes misapplied to mitigation paleontology. In CRM, an unanticipated discovery is a discovery that is very important and requires additional intensive mitigation work. Examples include a human burial or a buffalo kill site. Therefore, the terms unanticipated discovery and extensive paleontological discovery are functionally equivalent. However, it is a best practice to avoid the use of CRM terminology in mitigation paleontology, thereby minimizing continued confusion between the two disciplines (5.8).

Some additional important and often confusing terminological issues are worth discussing. In particular, these include the terms: disturbance area, project area, buffer, survey area, right-of-way, and area-of-potential-effect. Every project for which a mitigation paleontologist is contracted has a disturbance area that is never larger than the project area boundary. The disturbance area may include a buffer, and the disturbance area plus the buffer constitute the survey area. Linear survey areas are often referred to as survey corridors. The size and magnitude of planned disturbance varies greatly from minor for such activities as laying seismic cables across the landscape, to major for such activities as mass grading and open pit mining. The size of the buffer is also variable, and is determined by the agency or the client, depending on regulations and project objectives. The buffer provides flexibility for the project so that if resource surveys identify environmental concerns within the buffer such as fossil localities, archeological sites, or threatened species, the disturbance area can be shifted within the area surveyed to avoid them without having to perform additional resource surveys. However, the buffer also serves the practical purpose of reducing the possibility that project personnel or equipment that stray from the disturbance area will adversely impact the sensitive resources. There is no one appropriate buffer size since project needs and requirements are so variable. In our experience, survey areas, whether linear or not, can have buffers that vary from 10 feet from the disturbance area boundary, to 200 feet from the disturbance area boundary (= 400 feet total in addition to disturbance area width for linear projects). For mitigation paleontology, a buffer of 50 to 100 feet wide is adequate in most circumstances. Right-of-way, abbreviated ROW, is a term that refers to a linear easement for which a legal right has been granted to pass through property owned by another. For most projects the ROW represents an area within which all project activities must occur. The size of an area-of-potential-effect, abbreviated APE, is resource dependent and may be larger than the project area. The term APE is usually used in connection with NEPA related studies, and because the meaning and size are variable between local agency offices and resources, we recommend avoiding the use of APE in mitigation paleontology.

Various forms of exploratory 'shovel testing' are employed by archeologists in order to determine the presence of cultural resources in areas where the ground surface is obscured by vegetation, or where there is a known feature of unknown extent and eligibility. A key assumption in shovel testing is that human habitation is tied to certain features of the landscape, such as areas with low topographic relief and close proximity to water; and it is also assumed that despite climatically induced environmental change, the overall geomorphology of the area has not changed significantly between the time of earlier human occupation and the present day. With the arguable exception of the late Pleistocene, fossil occurrences are tied to depositional environments on the basis of lithofacies and taphofacies rather than the topographic features of the modern landscape. Therefore, the use of archeological testing techniques such as exploratory shovel testing to infer the presence or absence of paleontological resources is meaningless. This practice is typically imposed by uninformed agency personnel who lack paleontological training, and should be advised against by mitigation paleontologists. It is possible that future techniques or technologies will be developed that will be useful tests for the presence of subsurface paleontological resources. However, at the current time no such tests exist (5.10).

Field paleontologists know that fossils, especially small specimens, can be quickly eroded and exposed at the surface, and just as quickly be transported away from the locations of their initial exposure as the result of natural forces such as wind and rain. Therefore, the idea of an expiration date for an agency-required paleontological survey is nonsensical because erosion and exposure rates vary regionally, by rock unit (lithology), and are also related to the areal extent of rock exposures in an area. A time limit for CRM surveys exists but is highly variable depending on a number of factors. A five-year expiration date for paleontological field surveys is a common agency recommendation – meaning that the survey has to be repeated if the project has not been built within five years. Using local paleontological knowledge and experience, mitigation paleontologists should provide recommendations regarding the frequency of repeated field surveys and provide justification to land managers in field survey reports and end of year permit reports (5.11).

6. CONSTRUCTION MONITORING

Unlike field surveys, there is no academic training available for the basic skills of paleontological resource construction monitoring. On-the-job training is the only option. The purpose of monitoring is to reduce damage or destruction (i.e., minimize adverse impacts) to scientifically important fossils that are unearthed during construction. The job of a paleontological monitor is largely visual, but it is also mentally and physically demanding. Monitoring entails conducting inspections of excavation sidewalls, graded surfaces, trenches, and spoils piles for evidence of fossils exposed by excavations, often on surfaces that are obscured by debris and clouds of dust (or snow). The inspections must be conducted at a safe distance from the excavation equipment in the controlled chaos of a construction site (Figure 3). Time is of the essence because if equipment is running, the freshly exposed fossil can be

FIGURE 3. Field paleontologist Pat Sena monitoring mass grading activities in upper Pliocene strata of the San Diego Formation as exposed during construction of residential housing in coastal San Diego County. San Diego Natural History Museum, Department of PaleoServices photograph.

destroyed with the next scoop of a track-hoe bucket or the next pass of a scraper or bulldozer. For this reason, the equipment operator must be alerted before the fossil is irreparably damaged.

Monitoring stands apart from other aspects of mitigation paleontology in that it requires not only a specialized skill set, but also a particular temperament. For example, most mitigation paleontologists would agree that being skilled at finding surface fossils in traditional paleontological field surveys does not necessarily translate into the ability to find fossils in an active construction site. Also, it is necessary to stay alert at all times both for safety reasons, and because depending upon the density of subsurface fossil occurrences, weeks can go by without a fossil discovery and then a fossil is exposed with no warning. In this sense, paleontological monitoring is like fishing—long periods of inactivity punctuated by intervals of increased activity. However, if you do not have a line in the water or are not actively monitoring, you will not have any hope of catching a fish or finding a fossil. For this reason, a monitor does not have the luxury of letting his or her guard down for a moment. Many paleontologists find monitoring to be excruciatingly tedious, so it is not for everyone.

> “Monitoring a construction site is like looking for fossils during flight deck operations onboard the USS Nimitz.”
>
> —Patrick J. Sena, a long-time monitor (and ex-marine) for the Department of PaleoServices at the San Diego Natural History Museum

Before discussing specific monitoring procedures, and for the purpose of avoiding confusion, it is worth pointing out that some agencies do not consider paleontological monitoring to be mitigation. The distinction made by some agencies is that monitoring refers to the process of discovering fossils during ground disturbance, whereas mitigation is the process of reducing impacts by removing fossils from the path of construction. This is a distinction that these agencies have made for monitoring other types of natural resources. However, as a practical matter, monitoring and mitigation go hand in hand during excavation activities and for the field paleontologist, fossil salvage is a logical extension of the monitoring process.

Pre-field preparation procedures for monitoring are similar to those recommended for field surveys (see Section 8). Monitoring should be a mitigation requirement when avoidance is not an option and construction will disturb bedrock units or surficial deposits with a high potential to contain fossils of scientific importance (6.1). Continuous monitoring refers to a full-time level of effort, and is typically required for project areas (or portions thereof) with high and very high sensitivity. Spot-checking refers to a part-time level of effort, and is typically required for project areas with moderate or unknown sensitivity (also applied to low sensitivity when using SVP guidelines in California). Operationally, spot-checking can be a challenge in cases in which the project area is a great distance away from the nearest other project, and there are no other mitigation activities available for the monitor. As the name indicates, spot-checking means performing limited inspections at monitor-selected locations within a project area, and there is the possibility that fossils may be missed by the monitor in such situations since he or she is not always present. Regardless of the stipulated monitoring level of effort, the principal investigator should have the authority to increase (or decrease) the monitoring effort should the monitoring results indicate that a change is warranted.

In some instances, monitors have the opportunity to do a brief, final surface inspection prior to ground disturbance to ensure that no scientifically important fossils were missed during or exposed after the preceding field survey (6.2). However, in most cases monitors typically only watch active construction excavations, which can vary from relatively small disturbance areas such as access roads, oil and gas well pads, drilling for footings, and trenching for pipelines; to relatively large disturbance areas such as mass grading for residential or commercial development, new roadway construction projects, solar energy generation facilities, and open pit mining operations. In most sedimentary rock units and surficial deposits drilling with an auger with a tool diameter of two feet or less typically pulverizes the sedimentary matrix including any contained fossils. Therefore, monitoring of drilling activities when a small auger is used is typically not recommended. However, if a monitor is already on site inspecting project-related excavation activities, the drilling spoils should be periodically checked for the presence of fossils and the breakage characteristics of the matrix should be checked to see if the drilling is yielding rock fragments large enough to contain identifiable fossils (6.3). Some types of ditching equipment are known to turn rock to a fine powder, obliterating any evidence of fossils in the spoils piles. If such equipment is in use, the only option for monitoring is to inspect the trench sidewalls for exposed fossils (Figure 4). This procedure has been shown to be highly effective in identifying fossils in cross section depending on the lithology of the rock unit and types and sizes of fossils the rock unit is known to contain. Track hoe excavations have been found to be more conducive to the discovery and recovery of unearthed fossil remains than ditching machines, because they produce larger blocks of rock which can contain more complete fossils. Finally, when equipment is not running due to lunch breaks, end of shift periods, and/or equipment breakdown, there is an extra opportunity to safely examine the cut, document the stratigraphy, and dig through spoils piles. For all these reasons, and especially for large footprint projects, monitors do a lot of walking (6.4).

Monitoring inspections should be performed as close to the active cut or other type of excavation as is safe in order to see fossils as they are unearthed, whether in spoils piles or exposed in excavation sidewalls or horizontal graded surfaces. Monitoring cannot succeed if monitors are not within visual range of the excavation, ideally 5 to 20 feet but no greater than 30 feet, and even at that distance fossils may not be visible (6.4). There are specific Occupational Safety and Health Administration (OSHA) safety requirements for the types and depths of excavations that can be entered by project personnel, and it is critical that these safety requirements be strictly adhered to. For example, monitors should not enter trenches that are greater than five feet deep; and should not approach the edge of a trench that is more than six feet deep without a guard rail. Also, monitors should never walk underneath any construction equipment, and should stand at a distance greater than the length of the extended arm of equipment that can rotate, such as track hoes. Be sure to consult with project safety personnel prior to entering the construction area for site-specific safety requirements. However, as a rule of thumb, monitors should never do anything that feels unsafe. It is important for their safety that monitors understand the movement patterns of construction equipment around the project area (e.g. haul road), and use standard hand signals to communicate with equipment operators. If the monitor cannot see the operator, chances are that the reverse is also true and the operator cannot see the monitor. Verbal communication with all project personnel, including the foreman, environmental inspector(s), grade checker, other environmental monitors, and project geologist, is also very important. Although there is a safety benefit to communication, it is also very helpful for the success of monitoring to develop a good working relationship with all project personnel. Developing an attitude that the field paleontologist is just another member of the project team has been proven to help minimize the perception that paleontologists are ‘elitist academics out to shut down construction.’ Overall, this team approach will greatly increase the likelihood that in the event fossils

FIGURE 4. Georgia Knauss operates a Trimble GPS receiver while Dale Hanson examines rocks of the Sentinel Butte Formation (Fort Union Group) exposed in a natural gas pipeline trench in North Dakota. SWCA Environmental Consultants photograph.

are unearthed and unseen by the monitor, the operator will alert the monitor to their presence (6.5).

Monitors should be paying constant attention to, and documenting on a field form or in a field notebook, the stratigraphy of the project area as it is sequentially revealed in exposed strata. A minimum of one stratigraphic section should be measured as the project progresses, even if no fossils are found, and the monitor should consult with the project geologist if practical for geologic information about the project site and surrounding area. In the case of larger projects, it may be necessary to measure multiple stratigraphic sections in order to document facies changes and refine the stratigraphic position of local channel features and surfaces of erosion. Measuring stratigraphic sections on an active construction site is challenging because of discontinuous exposures, here-today-gone-tomorrow parts of the section, compaction which tends to obscure the stratigraphic profile, and ubiquitous dust and/or snow. However, the stratigraphic work need not take away from the monitoring effort. This is because the stratigraphy can be documented in the current monitoring area and added to and revised as the excavation moves and progresses up or down section. Having a working stratigraphic framework of the emerging section makes it possible to more unequivocally plot the stratigraphic position of discovered fossils. On projects with more than one monitor, all monitors should work cooperatively to ensure that the stratigraphic framework for the entire project area is documented consistently. For linear projects that follow the approximate contours of the landscape, such as a pipeline trench, and unless the bedding planes are dipping noticeably (in which case standard stratigraphic sections are preferable), a trench log may be the best option for documenting the lithologic changes along the project alignment and their relationships to discovered fossil localities. All stratigraphic and structural geologic observations should be for the purpose of interpreting the context of the fossil assemblages within the project area, and should never be construed as providing data for project geotechnical or engineering design purposes. For projects involving drilling operations, vertical stratigraphic position (i.e., depth below ground surface) can roughly be estimated by measuring the distance from the ground surface to the level of the bit on the auger. All fossil localities must be tied to the stratigraphic sections measured for the project, and all geologic documentation should be included in the final monitoring report. A stratigraphically well documented project should make it possible to interpret facies relations and depositional environments, as well as the relative age relationships of the recovered fossil assemblages (see

Section 8, figures 2 and 3) (6.6).

An unfortunate monitoring practice, but one which some project managers and equipment operators actually prefer, is for monitors to make themselves scarce on the job, and spend the majority of their time sitting (or sleeping) in their vehicles. The rationale is that by not actively monitoring, fossils will not be found and this will decrease project costs. Requiring monitors to stand too far from the equipment to visually observe the excavation under the guise of safety concerns is another way of preventing monitors from making fossil discoveries and thereby reducing perceived financial risks. Monitors and the firms and organizations they represent should educate clients and construction personnel about monitoring best practices, particularly with regard to safety, but also with regard to the need to be within view of the active excavation in order to keep the project in compliance with agency-approved environmental requirements. It may also be worth pointing out to clients that unless the land is owned by the project proponent, without adequate monitoring there is the potential for financial risk to projects, particularly if fossils with scientific importance (may translate to economic value on privately owned lands) are destroyed by construction equipment. Additionally, impeding the monitoring effort could be in violation of project conditions of approval or construction permits (6.7).

The discovery of a fossil(s) during monitoring initiates the recovery process with fossil evaluation and salvage (see Section 7). After a brief evaluation to determine whether the fossil discovery has the potential to be scientifically important, the monitor should immediately alert the equipment operator and make any other necessary project-specific notifications depending upon the nature of the fossil(s) and the requirements of any approved project monitoring and mitigation plan. The fossil discovery (plus a 20-foot buffer depending upon locality dimensions) should be cordoned off with high visibility flagging, and additional personnel immediately mobilized, as-needed, to provide monitoring or fossil salvage support while the discovery is explored and evaluated. Construction activity should not be discontinued, but should be directed away from the discovery locality in consultation with the construction foreman. Equipment should operate no less than 20 feet from the fossil discovery locality, although this buffer should be increased if the monitor believes that the extent of the fossil locality may be larger than what is currently exposed. All monitors should have expertise in fossil evaluation and salvage techniques (6.8).

7. FOSSIL SALVAGE: FROM COLLECTION TO PRE-CURATION

Broadly speaking, fossil salvage activities for mitigation paleontology projects can be separated into two categories: fossils that are collected during field surveys and fossils that are collected during construction monitoring projects. For the purpose of this paper, fossil salvage also includes laboratory fossil preparation, fossil identification and pre-curation. Although both salvage categories have many similarities in field procedures, they also have some important differences primarily having to do with impact mitigation. One of the most critical differences between the two is the amount of time available to complete salvage operations. For example, decisions regarding fossils discovered during monitoring have to be made quickly because the paleontological resource has already been impacted, whereas typically there are more options for fossils discovered during field surveys, and time is less of a factor. The fossil salvage process generally has five phases, as discussed below and summarized in Table 2.

Phase 1 of the salvage process involves a preliminary evaluation of the fossil(s) exposed by construction equipment or found on the surface. The decision should follow pre-determined threshold criteria for scientific importance (or agency specific criteria), and should determine whether or not the fossil(s) discovered warrant salvaging. If the decision is not to salvage, the locality should be recorded (see Section 4) as non-important and no further action taken. Note that locality avoidance is typically not an option for localities discovered while monitoring because the locality has likely already been impacted (7.1).

If the discovered locality contains one or more fossils that clearly have scientific importance, or that have the potential to have scientific importance based on what is exposed (i.e., visible), then Phase 2 of the salvage process, locality exploration, should begin. Mitigation evaluation continues during this phase because sometimes the full scientific importance of fossils cannot be determined until they have been more completely exposed. Locality exploration involves surface prospecting to determine the boundaries (lateral extent and depth) of the locality and the distribution and concentration of fossils. Digging is typically done using hand tools (e.g., small shovels, trowels, hammers, chisels, etc.). Because time is of the essence on active construction projects, heavy equipment can be useful to expedite the locality exploration process and can also facilitate access to the locality (e.g., by digging an access ramp), as long as the equipment does not come into direct contact with the fossil(s). If during the exploration phase, the locality is determined to lack scientific importance, it should be recorded as non-important, and no further action is needed. However, if during exploration the locality is determined to have scientific importance, the fossils can be collected; fossil collection can be deferred until the principal investigator, agency and/or client have evaluated the scientific importance and/or mitigation options; or the entire locality can be avoided (Phase 3). Avoidance is an option if the proposed activity is easily moved (e.g. a seismic project source point), or if the locality is extensive and would be prohibitively costly to mitigate. In such cases it is important to survey an alternative project infrastructure location or corridor that avoids other scientifically important fossil localities. Unlike field surveys, mitigation by fossil collection is typically the only option for scientifically important fossils

Phase	Field Survey	Construction Monitoring
1. Preliminary Mitigation Evaluation - Is the locality worth exploring?	Initial examination indicates that fossil(s) are either possibly identifiable and meet pre-determined threshold criteria for scientific importance, or unidentifiable in which case locality should be recorded as non-significant and no further action is required (skip to Phase 4). Time is not usually a critical factor for all phases.	Initial examination indicates that fossil(s) are either possibly identifiable and meet pre-determined threshold criteria for scientific importance, or unidentifiable in which case locality should be recorded as non-significant and no further action is required (skip to Phase 4). Locality avoidance is not typically an option, even in the case of extensive fossil discoveries as defined in Section 5. Time is usually a critical factor for all phases.
2. Locality Exploration - Is/Are the fossil(s) worth collecting?	Determine areal extent of locality by surface prospecting and probing surface sediments with hand tools. Western harvester ant (*Pogonomyrmex occidentalis)* hills should also be explored. Unless necessary avoid the use of adhesives or consolidants, and focus on exploration rather than stabilization or excavation. In cases in which partially exposed fossil(s) are determined to be non-significant following exploration, or can be avoided or collected later, skip to Phase 4. Locality avoidance is typically an option for scientifically important fossil localities, and is likely preferable for extensive fossil localities as defined in Section 5, depending upon client priorities.	Determine lateral and vertical extent of locality using hand tools, and if possible in the case of larger localities, with heavy equipment. Unless necessary, avoid the use of adhesives or consolidants and focus on exploration rather than excavation. If the fully explored fossil(s) are then determined to be non-significant, skip to Phase 4, and no further action is needed.
3. Locality Excavation and Collection (Phases 3 and 4 are partially concurrent.)	Collect fossil(s) from ground surface by hand quarrying or if necessary by larger, but permit-conformable, sized quarry. Use adhesives and consolidants as necessary. Collect fossiliferous anthills if scoped for. Collect bulk matrix samples if small fossils are present. If the budget and schedule permit, collect and wash test samples to determine whether the density of small fossils warrants bulk sampling.	Collect unearthed fossil(s) by hand quarrying and/or with the assistance of heavy equipment if needed and appropriate, and if applicable, from the ground surface or spoils piles. Use adhesives and consolidants as necessary. Collect bulk matrix if scientifically important small fossils are present. Heavy equipment can be used to stockpile matrix away from construction activity. If the budget and schedule permit, collect and wash test samples to determine whether the density of small fossils warrants bulk sampling.
4. Locality Documentation (See Section 4 for greater detail.)	Record locality as non-significant if fossils discovered were found to lack scientific importance. For scientifically important fossil(s), complete locality data recordation during surface collection and/or excavation phases, but prior to jacketing or packing and removal of fossil(s) from locality. Additional mitigation recommendations could include collection if avoidance is not feasible, or deferred collection pending client and/or agency approval. If client-preferred mitigation is avoidance, survey and record an alternative corridor or project infrastructure location which avoids scientifically important fossil localities.	Record locality as non-significant if fossils discovered were found to lack scientific importance. For scientifically important fossil(s), complete locality data recordation during surface collection and/or excavation phases, but prior to jacketing or packing and removal of fossil(s) from locality. Additional mitigation recommendations are usually not relevant to localities discovered during monitoring because such localities are typically graded away.
5. Laboratory Work	Transport fossil(s) to paleontological laboratory for preparation identification, and pre-curation work.	Same as Field Surveys.

TABLE 2. Phases of the fossil salvage process (collection to pre-curation) during field surveys versus construction monitoring.

discovered during construction monitoring. However, it is never necessary to shut down the project due to the discovery of a fossil. Furthermore, the stipulation sometimes applied to CRM projects that construction work be suspended project wide pending agency review and approval of a site specific mitigation plan should not be applied to paleontological discoveries (7.2).

Fossil collection (Phase 4) and documentation (Phase 5) are considered to constitute impact mitigation because they remove fossil(s) (and/or collected fossiliferous ant hills and matrix samples), along with associated information, from the construction disturbance area. Locality excavation and fossil collection for mitigation paleontology projects is a complex topic due to the many considerations involved. Standard types of fossil salvage techniques for construction monitoring projects include pre-construction surface collection, 'pluck n' run' (for isolated and quickly collected fossils), small quarries, large excavations, and bulk matrix collection. Standard types of fossil salvage recommended for deferred collection (i.e., collected later pending client or agency consultation techniques for field surveys) include surface collection (including high-grading of western red harvester ant hills), small quarries, large excavations, and bulk matrix collection (including ant hills). Excavations to collect fossil(s) discovered during field surveys or prior to construction may require a special permit. On BLM managed land, an excavation permit is required for any ground disturbance that exceeds 1 square meter in size and an environmental assessment of the excavation site must be performed as part of the permitting process (although is some cases the NEPA evaluation done for the larger project may streamline this process or make a subsequent analysis unnecessary). Fossiliferous concretions can be surface collected or excavated during monitoring, and should be documented and then removed from the project area whole for later preparation in a laboratory setting.

Salvage techniques appropriate to the size and preservation of the discovered fossils should always be used. All monitors should be knowledgeable of fossil salvage and sampling techniques and be properly equipped with field tools and supplies, including archival quality reversible adhesives and consolidants. Speed and efficiency are crucial for salvaging fossil localities found during construction monitoring. Medium- to large-sized fossils or groups of fossils should be excavated as blocks, still encased in matrix to provide additional stability and to expedite excavations and minimize construction delays (Figures 5 and 6). Removing enclosing matrix to fully expose a fossil adds substantial time and increases the possibility of breakage during transport. As during the exploration phase, construction equipment can be used during Phase 3 to expedite fossil excavation so long as the equipment does not come into direct contact with the fossil(s). Construction equipment is also useful during Phase 4 and can lift heavy plaster jackets into vehicles for transport off-site. Equipment operators are usually willing to provide assistance to expedite the salvage process and reduce construction delays. Prior to moving or jacketing any fossil specimens, ensure that all data are recorded including the original orientation and concentration of the fossils. If applicable, a scaled quarry map should be produced to accurately record critical taphonomic data. Properly label all bags, containers, and plaster jackets with field locality numbers. If needed and within scope, rock or sediment samples for future analysis (e.g., radiometric or biochronological dating) should be collected at the time fossils are salvaged (7.3).

Screenwashing for small fossils (vertebrate, invertebrate and plant) is a critical procedure that has been demonstrated to yield results unobtainable via any other means, and has greatly increased the taxonomic diversity and number of specimens available for study in formations wherein it has been employed (Table 3, Figure 7). For fossil accumulations including bone beds (whether considered to be 'extensive' fossil localities as defined in Section 5 or not), it may be necessary to collect bulk matrix samples, or excavate and jacket blocks of more indurated fossil-bearing sedimentary rock, depending on fossil size, durability, quality of preservation, and other factors evaluated by the field supervisor or principal investigator. SVP (2010, p. 7) provides guidance for bulk matrix sampling, recommending the collection of 600 pound test samples and if warranted, screenwashing of 6,000 pounds or more of matrix from each "site, horizon, or paleosol," depending on the "uniqueness" of the fossil content. However, because of variation in fossil density within and between geologic units, smaller samples may be sufficient based on the results of rarefaction analysis, or in cases in which the locality contains exceptionally high concentrations of fossils or has less matrix available for sampling. During Phase 3 and 4 work, construction equipment can be used to collect bulk matrix and/or stockpile matrix away from the disturbance area for later processing by paleontologists.

If a locality contains at least one scientifically important fossil, then it should be considered scientifically im-

FIGURE 5 (next page top). Field paleontologists from the San Diego Natural History Museum's Department of PaleoServices plaster jacketing the skeleton of mysticete whale discovered in upper Pliocene strata of the San Diego Formation during construction of a water facility at the San Diego Zoo. San Diego Natural History Museum, Department of PaleoServices photograph.

FIGURE 6 (next page bottom). Field paleontologists from SWCA Environmental Consultants salvaging a fossil leatherback turtle from steeply dipping strata of the Miocene Monterey Formation in San Clemente, California. SWCA Environmental Consultants photograph.

FIGURE 7. Paleontologists Mark Roeder and Patrick Sena screenwash sedimentary matrix samples from the middle Eocene Duchesne River Formation at the Utah Field House Museum of Natural History in Vernal, Utah.

portant and recorded as such (see Section 4). However, other than generalized significance criteria, there is little agency guidance provided about what to actually collect at a locality. Using the significance criteria alone, the implication is that only 'scientifically significant' fossils should be collected. However, partial collection of fossil localities is generally not considered good scientific practice in vertebrate paleontology. For example, leaving some unidentifiable bone fragments at an outcrop after collecting the bulk of a given specimen could prevent a broken skeletal element from being reunited. The best approach is to incorporate guidance from technical experts and/or regional museums during the development of threshold criteria for paleontological importance so that field paleontologists are as well informed as possible about the criteria for scientific importance and fossil collection. Based on knowledge of the research context and paleontology of the area (see Section 3), collect all identifiable specimens that have scientific value using BLM or other federal 'significance' criteria, if applicable. If non-important but identifiable specimens representing other taxa are present, it is a best practice to make a census collection that reflects the taxonomic diversity of the locality for paleoecological analysis. Assuming locality avoidance is not the chosen mitigation option, it is the responsibility of the mitigation paleontologist to fully collect all scientifically important fossils from within a project area. In such cases the project scope of work and budget should be designed to accommodate this level of collection and subsequent curation needs (7.4).

Field paleontologists (technicians/surveyors/monitors) should refrain from collecting any non-paleontological natural resource objects from a project area, regardless of land ownership, and regardless of the legal status. These include modern bones and antlers, cultural artifacts (projectile and spear points, etc.), plants, rocks, and non-important (poorly preserved and unidentifiable) fossils. Nothing should be collected for personal use. Collecting for personal use on a mitigation project is unprofessional and may invite unanticipated problems for a project (7.5).

Land ownership is an important consideration pertaining to fossil collection. As emphasized in Section 2, it is critical that land ownership be known prior to undertaking any field work, and that pertinent regulations be fully understood. Regardless of their scientific value, fossils should never be collected without written permission from the land owner or without an approved paleontological resource use permit. In some southern California counties, all scientifically important fossils recovered from privately owned lands during construction monitoring projects are required to be curated at a designated regional paleontological curation facility. However, in other states, land

TABLE 3. Examples of screenwashing results from representative impact mitigation projects completed by the Department of PaleoServices, San Diego Natural History Museum (Both projects in middle Eocene Santiago Formation, Oceanside, California).

	Localities	Total Specimens	Type Specimens	lbs Washed	Specimens from screenwashing	lbs/Specimen
Ocean Ranch	30	2,409 (217 invert., 2,183 vert)	53 (22 vert., 30 invert)	26,250	1,681	*0.7 - 263
Jeff's Discovery	6	4,828 (88 invert., 4,736 vert)	28 (23 vert., 5 invert)	16,650	3,148	5.9

*Range provided for this project because lbs/specimen were highly variable by unit sampled.

owners own all fossils on their lands, are not required to reposit them in a curation facility, and only occasionally donate them to a curation facility. Assuming right-of-entry is granted, the standard practice for field surveys on large (interstate) projects with hundreds of land owners involved is to evaluate and document all fossils, and notify land owners in writing of any that have scientific importance. Land owners are then provided with the option to have the fossil(s) collected for land owner use, left in place in the path of construction (waiving the project proponent of any liability in the event of damage), or to have them collected, prepared, and donated to a curation facility. The donation may be tax-deductible. A similar procedure is followed for construction monitoring projects, the primary difference being that the fossil likely has already been impacted at the time it was discovered, so the decision to salvage has to be made by the monitor usually without the possibility of immediate land owner input. This removes the option of having the fossil left in the path of construction, and all fossils with scientific importance should be collected by default.

Fossil collection policies for mitigation projects on Native American tribal lands are variable and can be challenging. Of foremost importance is to respect all tribal policies and work within them to reduce impacts. Some Tribes do not permit fossil collection even by professional paleontologists, and yet they still have the resource management objective of reducing impacts to paleontological resources associated with energy development. The mitigation strategy in this scenario is avoidance, which works well for fossils discovered during field surveys but can be problematic for fossils discovered during construction monitoring because it is too late to avoid them once their presence is known. Unless it is for the purpose of permanent preservation in a curation facility, a fossil should never be physically moved from its original locality, thereby removing it from its stratigraphic context. While it may be worthwhile to recommend fossil collection to the on-site tribal monitor or other tribal representative if a scientifically important fossil is discovered during monitoring, there may be no option provided by the Tribe other than to document the fossil and leave it in place. In-situ molding of scientifically important fossils found on tribal lands during field surveys has been shown to be an effective means of collecting scientifically useful information in cases where fossil collection is not permitted (Imhof et al., 2008), and this approach could also be employed for scientifically important fossils found while monitoring (7.7).

In all cases, fossil localities should be differentiated stratigraphically, even if they are geographically proximate. Using GPS receivers, fossil localities should be geographically documented appropriately for their size. Single, isolated fossils should be recorded as locality points. Taking into account GPS position error (typically 20-30 feet for most recreational quality GPS receivers), larger localities should be documented as lines for localities exposed along beds, and polygons for non-linear localities. If the GPS receiver lacks the capability to record lines and polygons, a series of points should be recorded (again taking into account GPS position error) (7.8). Additional information on locality documentation can be found in Section 4.

The final phase of fossil salvage includes laboratory work (Phase 5). This phase includes fossil preparation, identification, completion of any necessary associated analyses, and pre-curation. Preparation includes removal of surplus and concealing sedimentary matrix, repair and conservation using archival adhesives and consolidants, and limited infilling (with archival products) of voids that compromise the structural integrity of the fossils. In consultation with the curation facility, fossils should be prepared to the point of curation - operationally the point at which the bulk of enclosing matrix has been removed and the curation facility does not need to do additional preparation work prior to curation (see Section 9). Bulk matrix samples should be screeenwashed (see SVP, 2010, p. 7), floated with heavy liquids if appropriate, and picked/sorted for small fossils. All fossils should be identified to the level of genus or lowest taxonomic level possible by a paleontologist with technical expertise with that taxonomic group. As a practical matter, salvaged fossil specimens are not typically identified to the level of species because the level of detailed study needed to determine species crosses into the realm of research. It is assumed that the curation facility will verify the fossil identifications if there is a staff member with the necessary technical expertise. If included in the scope of work, additional analyses relating to the paleontological resources mitigated should be completed for inclusion in the monitoring or field survey report (e.g. palynological, radioisotopic, magnetostratigraphic, petrographic, etc.). Pre-curation entails entry of field (e.g., geographic, topographic, and stratigraphic position) and laboratory (e.g., taxonomic, taphonomic, and preparation details) data into a computerized database, as well as proper labeling (e.g., temporary inventory or permanent catalogue numbers) and packaging fossils (e.g., placement in vials and/or specimen trays and construction of fiberglass-reinforced 'hydrocal' support cradles) for transport to the curation facility according to the terms of the curation agreement. Laboratory fossil preparation procedures for individual specimens should be recorded on a fossil preparation log form which should be provided to the curation facility along with the fossil collection (7.9). Data management is discussed in greater detail in Section 8.

8. DATA MANAGEMENT AND REPORTING

In this section we propose best practices in data management and reporting. Purely business data-related functions such as accounts payable/receivable, contracts, and human resources are not discussed because these have minimal overlap with best practices in mitigation paleontology. As with field data collection, data management and reporting requires the establishment of a system that works for the individual mitigation paleontologist or larger mitigation program – currently there is no universally correct system.

Data management strategies should emphasize efficient data entry, accuracy, regular backup, and efficient retrieval of information. Networked databases permit data entry, storage, and manipulation by multiple users working remotely. In mitigation paleontology, various types of data are generated prior to and during field work (see Section 4) and subsequent analyses such as fossil preparation, specimen inventory, and specimen identification. There are numerous interrelated datasets that must be computerized, analyzed, and synthesized for inclusion in project reports, annual permit reports, and associated data that accompanies fossil collections reposited at curation facilities (Table 4). Effective management of these data represents a logistical challenge, especially for large projects such as those that include multiple agencies, multiple states, multiple land ownership types, multiple curation facilities, complex geology, or large numbers of fossils. Often, the data consist of a combination of purely electronic information such as coordinate based geographic coordinates and digital images, and non-electronic information in the form of hard copy field forms, scientific papers, and paleontological resource use permits. Increasingly, information in hard copy format is being scanned or entered into databases for more efficient organization and rapid retrieval. As discussed below, the product ('deliverable') in mitigation paleontology is the final project report that documents the work performed. Therefore, all data types are related to the completion of the project and the content and format of final project reports (8.1).

Final project report requirements vary by agency, and should be prepared to meet or exceed agency standards even if no agency is involved (8.2). Although there are permutations of each, and differences may exist within them depending upon regulatory requirements, fossils discovered, mitigation recommendations, land ownership, and other factors, there are five general types of reports in mitigation paleontology (Table 5). However, not all of them necessarily report on actual impact mitigation. For example, a paleontological impact evaluation report is a preliminary assessment of the potential for impacts on paleontological resources within a project area based on an analysis of existing data with no field survey. The term 'assessment' is also often applied to such reports and is confusing because it may or may not include a field survey. For example, SVP (2010) proposes the term paleontological resource impact assessment report for a level of effort equivalent to an analysis of existing data with a field survey. We prefer the terms paleontological impact evaluation report and paleontological field survey report to clearly differentiate between reports that do not and do contain field survey results, respectively.

This distinction would also avoid confusion with environmental assessments (EAs) under NEPA, which may or may not include field surveys. A report based only on an analysis of existing data with no field work is sometimes referred to by clients and agencies as a 'desktop' review or analysis. However, this term is problematic because it is vague. A field survey report may or may not have been preceded by a stand-alone impact evaluation report. If not, a survey report should contain the results of the analysis of existing data as well as the results of the field survey. Likewise, a monitoring report may or may not have been preceded by a stand-alone impact evaluation report and a field survey report. If not, a monitoring report should contain the results of the analysis of existing data and field survey if one was completed. A field survey is not always a prerequisite to monitoring based on agency requirements and/or surface sensitivity (8.3).

Monitoring and mitigation plans are most commonly an agency requirement for large projects. Agencies use the results of an analysis of existing data and/or field survey to make detailed recommendations on monitoring locations and procedures, and impact mitigation (fossil salvage) procedures. For smaller projects, this information, in a less detailed format, may be included in either the paleontological evaluation report or the field survey report (8.4).

In reference to mitigation paleontology, NEPA documents are based on paleontological resource analyses completed under the National Environmental Policy Act (1969), and include sections of Environmental Impact Statements (EISs), Environmental Assessments (EAs), and Categorical Exclusions (CXs). CEQA documents are parallel in their overall scope and approach to NEPA documents, but are triggered by the California Environmental Quality Act (1970), and consist of Environmental Impact Reports (EIRs). It is common for CEQA EIRs and NEPA

Data Type	Typical Data Source Format	Uses and Considerations
Fossil Locality (newly recorded)	GIS data, hard and electronic copies of field data forms	Agency confidential appendix in project report; non-georeferenced summarized data for client final project report; end of year permit report
Fossil Locality (previously recorded)	GIS data, hard and electronic copies of field data forms	Analyses of existing data; non-georeferenced summarized data for client final project reports
Survey areas	GIS data, hard and electronic copies of field data forms	Final project reports, end of year permit reports. Surveyed areas need to be compared to changes in infrastructure locations throughout pre-construction phase of project
Monitoring areas	GIS data, hard and electronic copies of field data forms	Final project report, end of year permit reports
Field Photographs	Images and photographic logs	Locality forms in agency confidential appendix in final project report; project reports
Aerial Photographs	Digital Orthophotograph Quads (USDA - National Aerial Imagery Project, Google Earth, etc.)	Cost proposals; analyses of existing data (pre-field work review)
Geologic Maps	Digital or hard copy USGS and state geological survey maps, published scientific literature	Analysis of existing data; final project reports
Topographic Maps	Digital or hard copy USGS Topographic Quadrangle Maps	Analysis of existing data; final project reports
Digital Elevation Models	GIS data	Analysis of existing data; final project reports
Literature	Digital or hard copy scientific publications and gray literature	Analyses of existing data; final project reports
Site Geology and Stratigraphy	Digital or hard copy scientific publications and gray literature; hard and electronic copies of field data forms	Final project reports, information for curation facility
Land Ownership	Client or agency provided data usually as GIS or AutoCAD files	Agency confidential appendix in project report; non-georeferenced summarized data for client final project report; end of year permit report
Fossil Identifications	Principal investigator and technical expert(s): hard or electronic copy	Agency confidential appendix in project reports; project reports for client; identifications to lowest possible taxonomic level above species, and detailed descriptions of elements
Literature	Digital or hard copies of scientific publications and gray literature	Analyses of existing data; project reports (a copy of each cited reference is required for NEPA document administrative records)
Project Reports	GIS data, hard and/or electronic copy	End of year permit reports
Fossil Preparation	Hard and/or electronic copies of lab preparation forms	Project files, curation facilities
Paleontological Resource Use Permits and Authorizations	Hard and/or electronic copy	Project reports, paleontological resource use permit files
Annual Permit Reports	GIS data, hard and/or electronic copy	Paleontological resource use permit files
Curation agreements	Hard and/or electronic copy	Paleontological resource use permit files
Project and Staff Schedules	Hard and/or electronic copy	Project implementation
Client, Agency and Curation Facility Communications	Hard and/or electronic copy	Permit files, project files (including administrative record if applicable)

TABLE 4. Typical data types, formats and uses in mitigation paleontology ('Final Project Report' refers to any report type listed in Table 5).

CXs to include field surveys, whereas they may or may not be required during NEPA EISs and EAs (however, there may be a mitigation measure that is required in subsequent field surveys). It is beyond the scope of this paper to discuss the NEPA/CEQA process in detail, but paleontological resource sections completed for NEPA/CEQA studies generally consist of three sections (analysis of existing data, impacts analysis, and mitigation measures; Table 5). An analysis of existing data generally provides the information needed to prepare the existing conditions (also known as affected environment) section. The impacts analysis (also known as environmental consequences)

Paleontological Resource Impact Evaluation Report	**Paleontological Field Survey Report**	**Paleontological Monitoring Report**	**Paleontological Resource Monitoring and Impact Mitigation Plan**	**NEPA/CEQA documents**
Summary and/ or Introduction	Summary and/ or Introduction	Summary and/ or Introduction	Introduction	Existing Conditions/ Affected Environment
Methods	Methods	Methods	Laws, Ordinances, Regulations, and Standards	Environmental Consequences/ Impact Analysis
Laws, Ordinances, Regulations, and Standards	Laws, Ordinances, Regulations, and Standards	Laws, Ordinances, Regulations, and Standards	Project requirements (including agency-provided sensitivity classification if applicable)	Mitigation Measures
Project requirements (including agency-provided sensitivity classification if applicable)	Project requirements (including agency-provided sensitivity classification if applicable)	Project requirements (including agency-provided sensitivity classification if applicable)	*Institution/agency Search Results (without locality coordinates)	References
Institution/agency Search Results (without locality coordinates)	*Institution/agency Records Search Results (without locality coordinates)	*Institution/agency Records Search Results (without locality coordinates)	Monitoring Methods and Procedures	Administrative Record
Geologic Map Review and Literature Search Results	*Geologic Map Review and Literature Search Results	*Geologic Map Review and Literature Search Results	Mitigation Methods and Procedures	
Research Model	Field Survey Results	*Field Survey Results	Research Model	
Recommendations	Recommendations	Monitoring and Mitigation Results (stratigraphy and fossils recovered, if any)	Recommended Monitoring Locations and level of effort	
References	References	Recommendations	Additional Pre-construction tasks	
	Appendix: Documentation of Areas Surveyed	References	References	
	Confidential Appendix: Fossil Locality Data	Appendix: Documentation of Areas Monitored	Appendix: Fossil Localities Discovered During Pre-construction field surveys	
	Appendix: Receipt of Fossil(s) from Curation Facility	Confidential Appendix: Fossil Locality Data		
	Appendix: Permit(s)	Appendix: Receipt of Fossil(s) from Curation Facility		
		Appendix: Permit(s)		

TABLE 5. General types and typical minimum content of mitigation paleontology reports (*if not already completed for an earlier report for the same project or project area. Cite earlier reports).

analyzes the anticipated impacts of the project or project alternatives on paleontological resources. Mitigation measures (as needed) are developed based on the results of the impacts analysis. The administrative record is an important part of the NEPA process because it contains all references and other sources used in the analysis. All paleontological reports, including NEPA/CEQA sections, should be written by or at a minimum, reviewed by, a professional mitigation paleontologist (8.5).

The BLM has requirements for the content of project and annual permit reports for work conducted under paleontological resource use permits (BLM, 1998, 2008). These requirements are also generally useful for preparing reports for other federal agencies that lack their own resource management and reporting procedures. BLM end-of-year project reporting requirements fall entirely within the recommended content of field survey and monitoring reports listed in Table 5. BLM end of year permit reporting requirements are different than those for project reports (see BLM 1998). Annual permit reports are due on December 31st of each year. Some states (e.g. Colorado and Utah) also have annual permit reporting requirements, but these vary by state.

There are various other issues related to paleontological reports, and paleontological locality confidentiality is one of the most important. It is unlawful to disclose to the public the locations of fossil localities on federal land and state lands in some states, either previously recorded or newly recorded during field surveys or monitoring. Some paleontologists find the policy of fossil locality confidentiality objectionable for reasons that are outside of the scope of this paper, and the issue continues to be the subject of debate despite the passage of the PRPA (2009). However, mitigation paleontologists should always treat paleontological locality data as confidential. This can be a difficult task when working with clients and sharing GIS data. All final project reports should omit legal locations, coordinates, and photographs of fossil localities in client copies and include this information as a confidential appendix of locality data for agency copies (8.7). However, all fossil localities, both scientifically important and non-important, should be recorded and reported (8.8). Because avoidance is a legitimate mitigation approach (although not the preferred approach for paleontological resource preservation), it is necessary to disclose the avoidance areas to clients so they can avoid known paleontological localities. This is typically dealt with by providing a map and/or GPS data with the avoidance area as a polygon that encompasses the fossil locality without displaying the actual locality. Similar polygons can be used to identify areas that are recommended for monitoring based on field survey results without disclosing locality coordinates. All field survey and monitoring reports should include documentation of areas that were surveyed or monitored, regardless of whether fossils were found (see Section 4). All reports should include stratigraphic documentation of the project area with stratigraphically positioned fossil localities as appropriate to the project. Examples of graphically portrayed stratigraphic data are provided in Figures 8 and 9 (8.9). As discussed and described in Section 3, paleontological resource impact evaluation reports and monitoring and mitigation plans should contain research models, and final survey and monitoring reports should reference the research models and include a discussion of how the mitigation results preliminarily support or otherwise modify them.

It is appropriate for all types of paleontological resource reports to include recommendations (including mitigation measures as needed) relevant to the proposed project. Standard post-field survey mitigation recommendations for individual fossil localities include (in no particular order):

- Clearance: No further action recommended
- Salvage: Collect fossil locality(s) if collection was deferred during survey
- Avoidance: Avoid fossil locality by moving project elements
- Sample: Collect bulk sedimentary matrix sample and screenwash for small fossils
- Monitor: Monitor locality or larger sensitive area during construction

In this paper we provide only general guidance with respect to the development of mitigation measures because this is a highly complex aspect of mitigation paleontology. There is no one-size-fits-all solution for designing mitigation measures. The broad post-field survey mitigation approaches listed above appear simple at face value, but become far more complex when extended to large project areas and taking into account such factors as amount of ground disturbance, specific agency and regulatory requirements, client objectives, potential for impacting scientifically important fossils, land ownership, and ongoing research projects in the area. Project complexity may necessitate the development of novel mitigation strategies. The best approach is to work closely with the agency (if any) and client while taking into account the paleontological resource potential of the project area (see Section 3) and the standards of the designated curation facility. Effective mitigation measures in mitigation paleontology accomplish client objectives while meeting regulatory requirements and preserving (reducing adverse impacts on) paleontological resources (8.10).

9. CURATION FACILITIES

In the mitigation and resource management world, museums are often referred to as repositories, or curation facilities, and mitigation paleontology would not be possible without them. However, not all curation facilities have the educational and outreach missions of museums – some are primarily designed for collections storage with access for research purposes. Curation facilities are the essential endpoint in the impact mitigation process as they are the final destination for mitigation generated fossil collections (Figure 10). At these facilities, institutional fossil locality numbers are assigned, individual specimens or specimen 'lots' are catalogued with unique specimen numbers, field data are entered into computerized databases, and fossil specimens are housed in museum cabinets. Like fossil collections made during research projects, mitigation fossil collections should, as a best practice and in many cases an agency requirement, be curated in a facility where they are available for research and educational purposes. The Department of the Interior requires that a repository meet curation standards outlined in departmental manual 411 and also be approved by the permitting agency for a given project (9.1). Additional information about the role of curation facilities in mitigation paleontology can be found in SVP (1996).

In addition to their essential role in the long term preservation of paleontological collections, curation facilities serve a critical function on the front end of the mitigation process. All federal and some state issued paleontological resource use permits require that the project proponent or applicant possess a curation agreement (also referred to as a repository agreement) (9.2). Some institutions charge a fee for issuing curation agreements. To the best of our knowledge, all federally approved curation facilities require that every recipient of a curation agreement be a

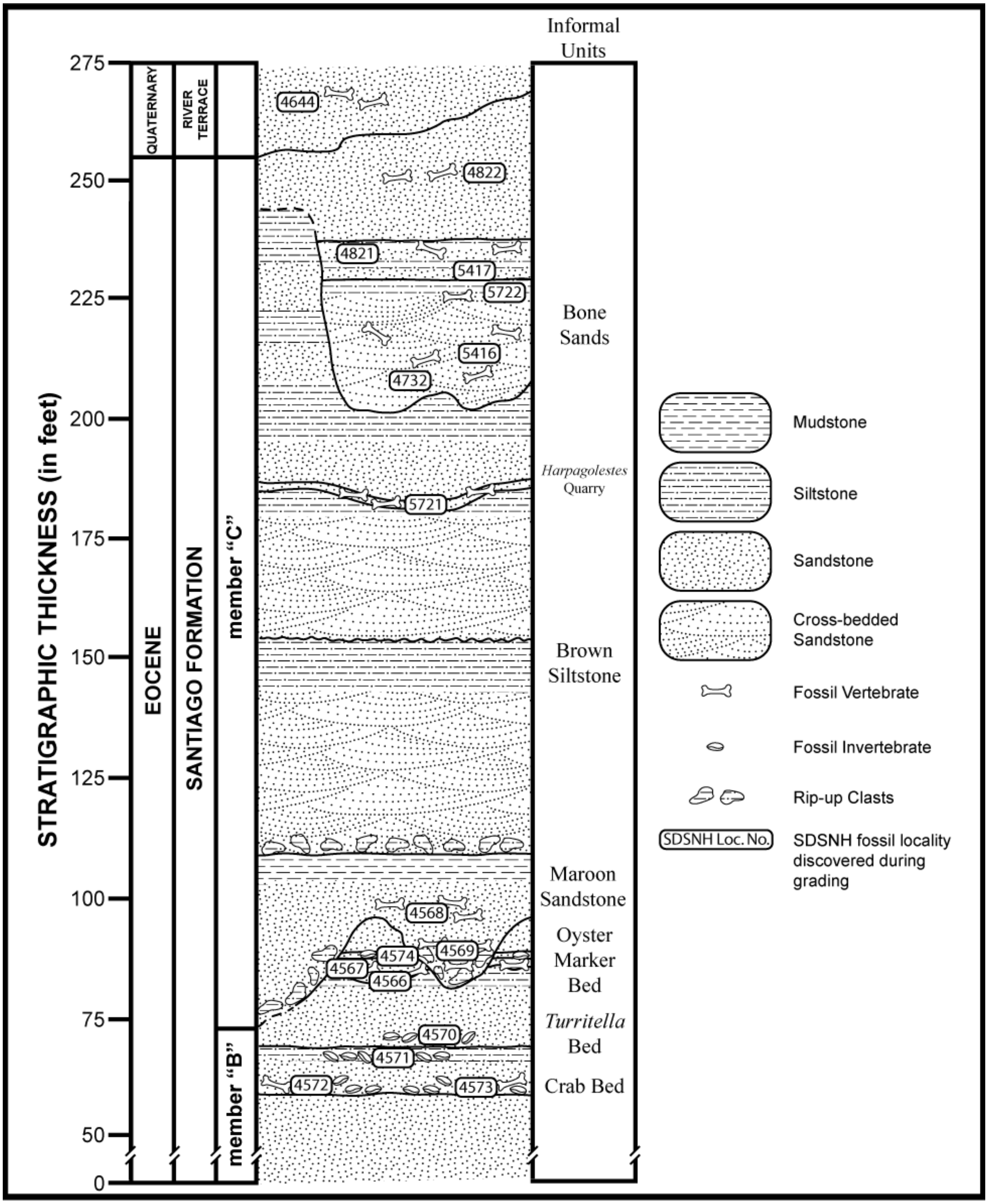

FIGURE 8. Composite stratigraphic column for the Ocean Ranch Project, City of Oceanside, California. Diagram depicts the lithologies, stratigraphic contacts, and stratigraphic positions of some of the fossil localities discovered within exposures of the Santiago Formation and Quaternary stream terrace deposits. Diagram courtesy of the Department of PaleoServices, San Diego Natural History Museum.

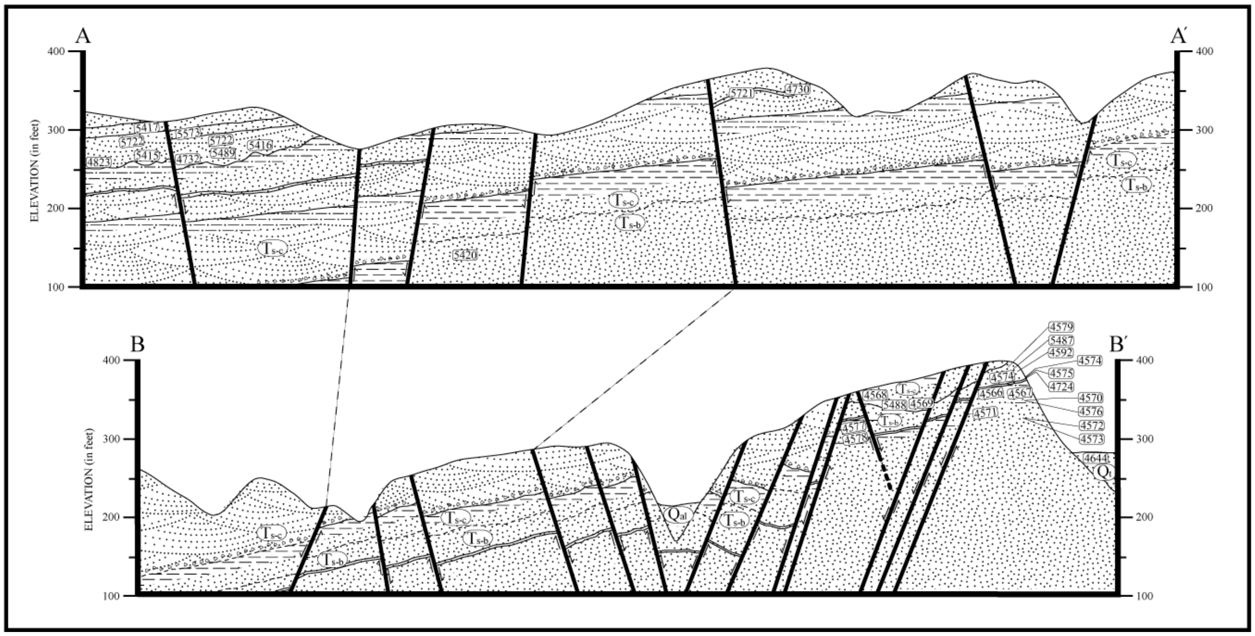

FIGURE 9. Diagrammatic cross sections through the Ocean Ranch project site, City of Oceanside, California. Diagram depicts lithologies, stratigraphic contacts, faults, and positions of fossil localities discovered within exposures of members ‘B’ and ‘C’ of the Santiago Formation (Ts-b, Ts-c) and a Pleistocene stream channel deposit (Qt). The base of the maroon sandstone is the boundary between Santiago Formation members ‘B’ and ‘C’. See Figure 2 for rock symbol legend. Diagram courtesy of the Department of PaleoServices, San Diego Natural History Museum.

professional mitigation paleontologist (see Section 1). The role played by curation facilities therefore represents an important additional check to the permitting process in ensuring that, in circumstances wherein curation agreements are required to obtain paleontological permits, only qualified paleontologists receive them. However, it is important to understand that regardless of one’s qualifications, there is no obligation on the part of curation facilities to provide curation agreements or to accession fossils collected as the result of paleontological mitigation. The incentive to regional repositories to grant curation agreements is primarily to fulfill their mission, grow their regional scientific collections, and enhance the use for research and educational purposes. It is also necessary for curation facilities to charge one time fees for collections curation and storage because of the additional costs related to processing the incoming collections, purchasing cabinets and curation supplies, and providing and maintaining the physical space for long-term preservation. While many institutions charge a one-time fee for curation and storage, the rates vary greatly between institutions (9.3).

Collections space is an ongoing concern for curation facilities, and many institutions have little or no collections expansion space. Naturally, this limitation affects decisions about which fossil collections can be accessioned. Overall though, it has become increasingly apparent to curatorial personnel that it is in the best long term interest of paleontological resource management and preservation to ensure that mitigation fossil collections have a high degree of scientific value that justifies the space they occupy. In other words, the fossil collections need to be well documented (see Section 4) and consist of specimens with educational value and scientific importance (research potential), and not just ‘bone scrap’ or ‘plant hash’. The issue of scientific value has, at least in part, driven agencies to develop criteria for establishing the ‘scientific significance’ of fossils so that the decision to collect or not collect can be made in the field. This issue also underscores the importance of close communication between mitigation paleontologists, agency paleontologists, and the curation facilities with which they work, especially with regard to an understanding of the museum’s research focus and the types of fossils that the curators consider worthy of accessioning and that are pertinent to the research focus of the institution. If a curation facility is not willing or able to accession fossils that meet agency defined scientific significance criteria, it is the job of the mitigation paleontologist to find an institution that will (9.4). Currently, agency guidance for the disposal of fossils collected on federal lands by museums is lacking. This adds to the importance of ensuring that fossils collected during impact mitigation have scientific value and are worthy of curation.

Consider that most archeological repositories were completely filled with artifacts years ago, and many no longer accept collections - those that do are highly selective. This fundamentally and permanently changed

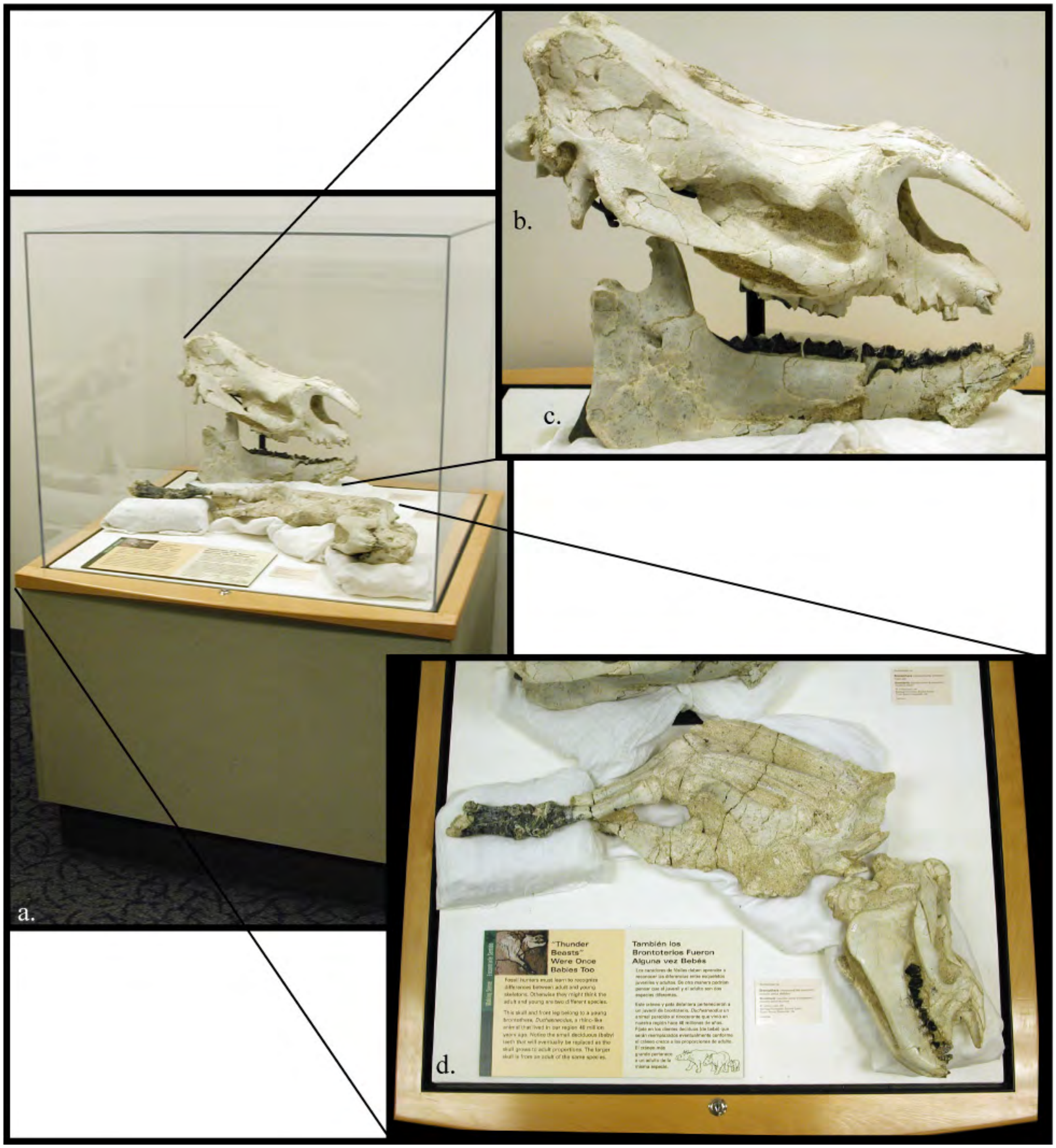

FIGURE 10. Adult and juvenile specimens of the brontothere *Parvicornis occidentalis* on display at the San Diego Natural History Museum. The specimens were salvaged from the middle Eocene Santiago Formation in Oceanside, California. San Diego Natural History Museum, Department of PaleoServices photograph.

cultural resource management so that now, archeological artifacts are only rarely collected. There is a lesson to be learned here with respect to mitigation paleontology that has not been lost on curators and resource managers. The preservation of mitigation fossil collections depends on the ability of curation facilities to store these collections. Consequently, storage space must remain a central focus of resource managers and curation facilities alike. However, curatorial personnel have to make the long term storage commitment, and should assess one-time curation fees based on the institution's costs for providing long term storage and preservation. It is in the best interest of institutions to set high scientific standards for mitigation paleontologists to adhere to for obtaining curation agreements and curating fossil collections.

Obviously, problems can and do arise when there is no pre-construction permitting process and no requirement for obtaining a curation agreement prior to working on a mitigation paleontology project. In the absence of agency guidelines for determining scientific significance and guidance from curation facilities, there have been numerous cases of poorly documented and/or unidentifiable mitigation fossil collections being delivered to curation facilities across the western United States. While this continues to be a problem in some parts of California, the situation has greatly improved during the last decade with respect to fossils from federal lands (e.g. from BLM and USFS managed lands). Furthermore, in the absence of agency oversight, it is easy for mitigation paleontologists to end up with 'orphan collections' – these are fossil collections that are never delivered to a curation facility.

Curation facilities also function as storehouses of associated paleontological data. Locality data, in particular, are vital to the work of mitigation paleontologists (see Section 2) because without access to recorded locality data, it is difficult to know the extent of previous paleontological work and discoveries in a given geographic area or geologic unit. In addition, access to these data provides a means for protecting previously recorded fossil localities from destruction by proposed construction project. Locality data, in the form of precise geographic coordinates (or as precise as possible), should be shared with professional mitigation paleontologists upon request. The types of locality data that are useful to mitigation paleontologists requesting a records search include stratigraphic data (e.g., formation, member, and/or horizon), sedimentological data (e.g., lithology, sedimentary structures, and facies), taphonomic data (e.g., bioclast orientation, packing, and sorting), and information about the conditions of discovery (e.g., natural outcrop or construction site) and depth below original ground surface (if applicable). A reasonable fee for providing this paleontological record service is frequently assessed because it is necessary to support the data management infrastructure of the curation facility (9.3). It is important to emphasize that curation facilities that accept mitigation fossil collections and the fees that come with those collections, have a responsibility to make paleontological data available to professional mitigation paleontologists and to do so in a reasonable and timely fashion. Thus, requests for paleontological collections data should be treated as a high priority by these facilities.

Ideally, the following information for a given recorded fossil locality should be provided by the curation facility: a map plot of the locality and geographic coordinates (this information will be kept confidential); the stratigraphic context of recorded localities (i.e., a description of strata exposed at a locality, the nature of contacts, lithologic descriptions, stratigraphic thicknesses, geometry of deposit, etc.); the nature of the exposure (i.e., natural outcrop, temporary artificial exposure, road cut, etc.) ; the conditions of discovery (i.e., general prospecting, construction monitoring, etc.); the types of recovered fossils (including a listing of catalogued fossils); a description of the taphonomy of the locality (i.e., how the fossils were preserved in the original stratum including mode of preservation, taxonomic composition, specimen orientation, specimen packing, degree of fragmentation, etc.); and method of recovery (i.e., recovered as float, excavated as single element, bulk matrix sampling followed by screenwashing, quarry excavation, etc.) (9.5).

In addition to providing an important service by reviewing the qualifications of individuals who are seeking curation agreements and requesting paleontological data (9.6), curation facilities have other quality assurance roles. As discussed above, these include requiring that mitigation collections consist of fossils of scientific value that are properly documented and pertinent to the research focus of the institution. Curation facilities also have the leverage and scientific credibility needed to ensure that fossils are properly identified, and should require that fossils are prepared and conserved using proper adhesives and consolidants prior to their arrival at the institution. The degree to which fossils are prepared and identified should be included within the language of the curation agreement or otherwise communicated to the mitigation paleontologist prior to fossil delivery. Some curation facilities require that specimen numbers be affixed to specimens prior to delivery, and that they arrive in archival trays of specific sizes or, in the cases of some small fossils (e.g. isolated teeth), mounted on pins. All curation facilities require associated data recorded during a mitigation project (e.g., field notes, measured stratigraphic sections, field maps with plotted collecting localities and locations of measured stratigraphic sections, and field photographs documenting collecting sites and taphonomic conditions). In addition, most curation facilities also require a copy of the final mitigation (survey or monitoring) report (9.7). Unless absolutely necessary, fossil collections from the same project, and especially the same locality, should not be divided between different curation facilities (9.8). Mitigation paleontologists must have a clear understanding of the expectations and standards of each of the curation facilities they work with as these standards vary greatly.

10. BUSINESS ETHICS AND SCIENTIFIC RIGOR

Ethical standards in mitigation paleontology involve individual professional mitigation paleontologists placing the purpose of impact mitigation - to preserve and minimize adverse impacts (per NEPA/CEQA) to scientifically important paleontological resources - at the forefront of their business decisions (10.1). Adhering to rigorous scientific standards and following best practices is the best way to ensure that such decisions are ethical. The best practices described in this section are intended to provide general guidance only since the issues involved are evolving. Issues surrounding business ethics and scientific rigor in mitigation paleontology can generally be broken into three overlapping categories: 1) project scoping and implementation, 2) project personnel, and 3) external pressure.

Project Scoping and Implementation

Project scoping typically happens during the preparation of cost proposals or in preliminary discussions with clients about the amount and type of work that needs to be done. Because cost proposals are usually competitive bids, there is an obvious incentive on the part of consultants to scope the project in a way that lowers project costs as much as possible in order to capture as much business as possible. This is free enterprise and there is nothing wrong with trying to maximize efficiency, reduce costs, and make one's clients as happy as possible in a competitive marketplace. However, ethical concerns exist when proposals to undertake projects are scoped in a manner that is insufficient to properly accomplish the work in a manner that is consistent with agency policies, mitigation best practices (outlined in this paper), and accepted professional standards (SVP, 1991, 1995, 1996, 2010) in paleontology. We refer to this as 'underscoping,' and it is likely more prevalent and less detectable in mitigation paleontology than in other, larger resource disciplines because there is usually very little, if any, specific and direct agency guidance provided during the scoping process. In some areas the amount of agency guidance provided during project implementation is increasing. Underscoping is involved if a consultant knowingly underestimates the tasks and associated costs needed to properly complete a project. Greater agency participation during the scoping process would be helpful. Additionally, there are many cases in which clients do not permit agency interactions during the scoping process. Nevertheless, if allowed, it is advisable to consult with agency paleontologists, paleontology coordinators, or project managers during the scoping process, especially for large projects. A professional mitigation paleontologist should be provided with the opportunity to provide input on scopes of work that are developed by project managers or other personnel that lack paleontological expertise (10.2).

A scope of work contains the details of the work that is to be done typically including some combination of an existing data analysis, field survey, construction monitoring, fossil salvage, preparation, identification, analysis, curation, and reporting. The proposal budget is an estimate of the amount of money needed to complete the scope of work. Often, underscoping in a cost estimate manifests itself as an insufficient level of effort to complete the tasks listed in the scope of work. An example of underscoping would be to lower proposal costs by planning to do pedestrian surveys in less time than it should take to properly survey an area, such as scoping for a 'windshield' survey rather than a pedestrian survey (as discussed in Section 5, there is very little that can actually be accomplished via a windshield survey other than locating rock outcrops along a road). However, low bids are not always problematic or unethical, since a consultant with greater local knowledge of a project area may submit a better-informed bid that is lower. Regardless of whether any aspect of a project is intentionally or accidentally underscoped, it may be necessary to negotiate a contract modification with the client in order to, as a best practice, complete the project according to agency requirements and accepted professional standards (10.3).

An important and challenging aspect of mitigation cost proposals is estimating the number, types, and costs associated with fossils discovered during a project, including the added costs of reporting and if fossils are salvaged, the costs of lab work and curation. There are various ways to produce an informed estimate of fossil discoveries including the number and types of fossils that have been previously found in a given project area. The results of previous mitigation projects completed in the same geologic units in the same general area provide a means of estimating the density of fossil localities which can in turn, for example, be used to predict the number of scientifically important fossil localities per area of disturbance, per mile of survey corridor, or per well pad location.

The decision about whether to include the costs of fossil discoveries in a proposal or include an assumption that no fossils will be found significantly affects the project budget, and an assumption of negative findings will obviously result in a lower estimated cost. However, a client might not be pleased if fossils are then indeed found and additional unanticipated costs are incurred. While it does not necessarily imply an ethical concern and there is no single correct answer, a best practice is, to accurately and in good faith, reflect the likelihood of fossil finds and the resulting costs in proposals. If there is a low likelihood of fossils, then it is appropriate to include an assumption of negative findings. However, if there is a high likelihood of fossils being discovered, then an assumption of negative findings represents underscoping, is not a best practice, and risks alienating one's client (10.4). Keep in mind that some clients understand the risk and do not want fossil-related costs included in cost proposals, whereas others actually prefer an overestimate. These differences in client expectation and preferences underscore the importance of understanding a client's needs.

Overscoping is far less common then underscoping since it typically makes a project cost more and the firm less likely to be selected by a client. However, doing more work than is needed to accomplish the goals of the project is also an ethical conflict and is not consistent with best practices. The reality is that clients rarely want to fund a research project, and often shy away from proposals that seem to include what they view as extraneous tasks that sound like scientific research. However, this is not to say that fossil collections made during mitigation projects should not be collected in a way that supports future research. A properly scoped mitigation project should be designed to accomplish the objective of reducing adverse impacts on scientifically important fossils in a manner that anticipates future paleontological research objectives (see Sections 4, 8, and 9). Another aspect of overscoping involves proposing to do work that has no paleontological resource potential (i.e. there is little to no chance that paleontological resources will be impacted by a proposed action). An example would be a proposal for monitoring an area in which the substrate is composed of granite (or other geologic unit/rock type with extremely low paleontological potential). In cases of very low paleontological sensitivity, recommend to the agency and/or client that impact mitigation is unnecessary (10.5). While the response in such cases may well be that the requirement is still in effect, it is ethical for a mitigation paleontologist to make a good faith effort to inform the parties about very low paleontological resource potential when applicable. In summary, there are numerous potential ethical pitfalls that can befall a project during scoping and implementation, but they can all be addressed by closely adhering to a scientifically sound scope of work. In this way, scientific rigor and ethical standards are upheld.

Project Personnel

Making scientifically appropriate personnel decisions when staffing mitigation projects is the second category of ethical practices. As discussed in Section 1, the most critical aspect involved is to use professional mitigation paleontologists to staff all project tasks for which paleontological knowledge is necessary. While this may not necessarily include project management, it most certainly includes project scoping, existing data analyses, field surveys, monitoring, fossil preparation, fossil identification, faunal/floral analysis, report preparation, and curation. All field monitors should be vetted in order to ensure that they are properly qualified. Hiring underqualified employees or overstating a worker's qualifications in order to put less-than-qualified people in the field, usually to avoid paying a professional's salary, is a persistent issue for federal permitting officers. Additionally, professional mitigation paleontologists should be utilized to write paleontological resource reports including NEPA/CEQA documents, or at the very minimum, should supervise their preparation, review, and sign off on them (see Section 8) (10.6).

Clients do need to know where avoidance areas are in order to be able to avoid them, but this information can be less precise than locality coordinates (see sections 5 and 8). No paleontologist is an expert in all paleontological subdisciplines and taxonomic groups. Recognizing the specialized nature of paleontology, subject matter experts, whether on staff or subcontracted, should be used to identify fossils collected during mitigation projects to the lowest taxonomic level and for any other specialized analyses, but also for obtaining information about a project area and its paleontological content (10.7). With regard to permitting, the majority of agencies grant paleontological resource use permits to individual principal investigators, rather than to firms. It is important that project personnel be aware of this, since the responsibility to complete the work in compliance with regulations and according to accepted professional standards is the responsibility of the principal investigator. Finally, professional mitigation paleontologists who prepare mitigation reports should, according to universally accepted scientific practice, properly cite all sources including gray literature, agency policy, other technical reports, NEPA/CEQA documents, and museum record searches. Obviously, plagiarism and falsification are clear violations of ethical standards (10.8).

External Pressure

External pressure that is brought to bear on a consultant by an agency or client is the third category of ethical concern. However, with regard to best practices, the concern is how the mitigation paleontologist responds to such pressure rather than the pressure itself. In recent years, the ongoing confusion between paleontology and archeology, has, in certain jurisdictions in California for example, resulted in agency required (and even consultant recommended) mitigation measures that stipulate archeological shovel testing procedures for ascertaining the presence of paleontological resources (see Section 5). Because there is no scientific basis for the use of such methods to inform the presence, content, or abundance of paleontological resources, the use of archeological testing techniques for paleontological resources is not recommended (10.9). Another frequently observed example of unethical pressure concerns agency personnel or clients asking mitigation paleontologists to change their mitigation recommendations. A professional mitigation paleontologist should develop mitigation recommendations that are consistent with the objectives of resource preservation, and stand by them. If an overseeing agency or client wishes to modify the recommendations, it is appropriate for the consultant to listen, negotiate in good faith, and modify the mitigation measures based on new information, if appropriate. Any modifications along with associated justifications should be documented in the final project report. However, downgrading (or upgrading) mitigation measures as the result of pressure from either clients or agencies is not a best practice because it will increase the likelihood of adverse impacts to the resource. Mitigation recommendations from a consultant are just that – if an agency or client wishes to ignore them, that is their prerogative. However, if possible, the overseeing agency should be informed if client modifications to mitigation recommendations are contrary to best practices (10.10).

CONCLUSIONS

It is the experience of the authors that actually adopting and consistently following the details of the best practices we propose is a constant challenge, from the point of project scoping and budgeting, through project initiation and implementation, to project completion. In other words, as with everything, it is always harder to do things well. However, the long term payoff will be a sustainable and professional field of applied paleontology that stands on its own apart from other fields of paleontology, and that is clearly distinct from archeology and CRM. This will result in a much more consistent, more professional, and higher quality job of mitigating impacts and preserving non-renewable paleontological resources. Another benefit to adopting best practices will be the development of a more cohesive community that works together with agency and museum partners to succeed in common goals to preserve paleontological resources and manage fossils using scientific principles and expertise, while also successfully achieving the project objectives of proponents. Ultimately, the industry-wide adoption of and adherence to scientifically rigorous and ethical best practices will require the combined efforts of mitigation paleontologists, policy makers, resource managers, and museums. The development of best practices is the necessary first step, and is a process that other more established resource disciplines have undergone during the course of their evolution.

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The motivating force behind this project was the need, as expressed among many mitigation paleontologists in the course of countless conversations over years, for a comprehensive set of best practices to help create and ensure a universal high scientific standard for the purpose of preserving paleontological resources via impact mitigation. Thus, foremost, we are thankful to all professional mitigation paleontologists and the amazing work they have done throughout North America over the last several decades. Their legacy laid the ground work and provided the inspiration for this paper. We are also indebted to the efforts of the many museum paleontologists across the continent who have made critically important contributions by directing numerous salvage projects, and whose institutions are the repositories of the specimens, data, and ultimately, the scientific knowledge generated by mitigation fossil collections in the form of research publications. Finally, we thank the tireless efforts of the paleontologists who serve in government agencies, and acknowledge their essential role in the stewardship of non-renewable paleontological resources.

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APPENDIX A

QUALIFICATIONS AND PERMITTING

1.1 The following are suggested as minimal requirements for paleontological principal investigators, paleontological field supervisors, and field paleontologists. Paleontological principal investigators and paleontological field supervisors are considered to be qualified professional mitigation paleontologists. The field paleontologist is an introductory level position for training to be a professional mitigation paleontologist.

Paleontological Principal Investigator

- Graduate level academic training (M.S. or Ph.D.) in paleontology and sedimentary geology or equivalent professional experience.
- Demonstrated professional experience and competency with paleontological resource mitigation procedures and techniques.
- A working knowledge of how paleontological resources and their associated data are used in conducting and publishing professional paleontological research.
- Knowledge of federal, state, and local laws and procedures that apply to all aspects of mitigation paleontology.

Paleontological Field Supervisor

- Academic training (B.S. or M.S.) in paleontology and sedimentary geology or equivalent professional experience.
- Field experience in impact mitigation procedures (including fossil salvage/collection).
- Stratigraphic competency.
- Knowledge of fossil curation procedures.
- Authorship experience with mitigation reports.
- Knowledge of resource management strategies and concerns.
- An understanding of the regulatory environment, including knowledge of federal, state, and local laws and procedures that apply to mitigation paleontology.
- Project management experience.
- An understanding of the consulting business.

Field Paleontologist (technician/surveyor/monitor)

- Academic training (B.S., B.A., or M.S.) in paleontology and sedimentary geology or equivalent professional experience.
- Ability to find fossils in both undisturbed and disturbed (construction) settings.
- Knowledge of fossil collection and salvage techniques: hand quarrying, pluck n' run, systematic excavation, bulk matrix collection, etc.
- Ability to identify fossils to a basic level (taxon and element) and evaluate their scientific importance.
- Ability to identify and describe sedimentary rocks and surficial deposits.
- Ability to measure and describe stratigraphic sections and tie fossil localities to them.
- Ability to record a field interpretation of the taphonomy of fossil assemblages, and recognize and describe unusual depositional or preservational conditions and associations.
- Ability to interpret depositional environments based on site geology and paleontology.
- Sufficient knowledge of geology to communicate with a registered professional geologist when necessary.
- Ability to properly complete field forms, operate a GPS, photograph fossils and localities, and plot localities on grading plans when applicable.
- Understanding of safety requirements.
- For professional mitigation paleontologists and field paleontologists, experience in similar rock units with similar fossils is far more important to the successful outcome of a mitigation project than experience in the same state.

1.2 Be sure that no work is undertaken without the proper permit or other written authorization.

ANALYSES OF EXISTING PALEONTOLOGICAL DATA

2.1. By reviewing geologic maps at the most precise scale available, determine the geologic units within a project area and their areal distribution.
2.2. Complete a thorough literature review using an appropriately sized search area.
2.3. Complete a paleontological record search using an appropriately sized search area.
2.4. Determine the land ownership and the pertinent regulatory requirements.
2.5. Conduct an aerial photograph review to determine locations of potentially paleontologically sensitive bedrock exposures.
2.6. Consult with local technical experts for information on the paleontology and geology of the area.
2.7. Synthesize the results of the analysis for use in determining the need for impact mitigation measures.

RESEARCH MODELS AND SCIENTIFIC CONTEXT

3.1. Every impact mitigation program should be designed around a research model that places it in a scientific context, and which facilitates later research activities. It should serve as road map that guides the implementation of the mitigation work including the development of the threshold criteria for scientific importance, which fossils are collected, how they are collected, and the types of data that are collected.
3.2. Research model development should be built into project scopes of work and budgets, and the actual research models should be presented in paleontological resource impact mitigation evaluation reports and paleontological resource monitoring and mitigation plans.
3.3. A research model should include a statement of research objectives and specific research problems, hypotheses to be tested, methods to be employed to address the research problems, and a discussion of the expected re-

sults. Final survey and monitoring reports should, in their results sections, reference the research model and include a discussion of how the mitigation results preliminarily support or otherwise modify the research model.

FIELD DATA COLLECTION

4.1. If working with a crew, design and use forms (hard copy or digital) for data capture during field work rather than using traditional field notebooks.

4.2. Always use a GPS receiver to record geographic coordinates. While sub-meter level precision may be needed in certain field applications, a position error of 20 to 30 feet is recommended for most situations.

4.3. Provide pre-field training and project orientation on data recordation and project-specific fossil locality significance and non-significance thresholds to field crew members.

4.4. Using field data, photographs, and/or GPS track logs or polygons, document all areas that were physically surveyed regardless of whether fossils were found, as well as those areas cleared visually or through desktop review. In addition to scientifically important fossil localities, document non-scientifically important localities as defined based on the paleontological resource abundance and preservation of the geographic area and/or geologic unit.

4.5. Avoid unnecessarily or improperly disclosing any project information including survey and monitoring data. Sensitive fossil locality data should only be shared with appropriate agencies and curation facilities (and not clients, although it is acceptable to disclose less precise areas recommended for resource avoidance).

4.6. Fully complete all client and company required paper work including vehicle inspection forms, job hazard analyses or other safety related forms, and project daily logs.

4.7. Ensure that field data capture the minimum recommended information in order to meet the needs of clients, the requirements of agencies, and the scientific standards of curation facilities. This includes paleontological locality documentation consistent with accepted professional and scientific standards, and documentation that the scope of work was fully and properly completed.

FIELD SURVEYS

5.1. Thoroughly prepare all field personnel for field work: existing data and key publications, maps and design plans, field equipment needs, safety concerns, data procedures, parameters for significant versus non-significant localities, fossil collection, and criteria for field mitigation recommendations.

5.2. Obtain all required paleontological resource use permits, access permits, and right on entry in writing prior to field work initiation. Coordinate with agency personnel as needed. Obtain written authorization from the applicable agency prior to beginning any field work on a project. Understand all land ownership issues and trespass laws prior to field work.

5.3. Ensure that the ground surface is free of snow prior to initiating any field surveys.

5.4. Field surveys should be scoped for a pedestrian examination of fossiliferous outcrops of bedrock and surficial deposits. All survey activities should be confined to the project area. In rocks and surficial deposits with high and very high sensitivity, all exposures should be surveyed. However, in rocks with moderate or unknown sensitivity, spot-checking of exposures of rocks and surficial deposits is typically an acceptable level of effort. Field surveyors should not walk transects, but should spread out to cover as much ground as possible and focus their inspections on exposures of fresh and weathered bedrock and surficial deposits. All exposures should be thoroughly examined and documentation provided in the survey report.

5.5. Avoid windshield surveys since they are not useful for finding fossils. If they are used to provide visual clearance for a portion of a project area, be sure to differentiate between areas that were subject to pedestrian versus visual survey in the field survey report.

5.6. When possible and cost effective, recommend fossil collection rather than resource avoidance for the greater goal of resource preservation. Block surveys provide the client with the greatest flexibility for avoiding scientifically important fossils if that is their preference. However, a client is under no obligation to mitigate impacts to paleontological resources that will not be affected by the project, because there won’t be any project-related impacts. Be cognizant of the resource management policies and objectives of all land owners with regard to fossil collection. Never collect fossils on private land without written permission from the land owner.

5.7. Exclude extensive fossil discoveries from scopes of work, but be sure to communicate the rationale and possibility of their occurrence to clients. If discovered, clients typically choose to avoid them with their project. If they elect to mitigate impacts to the locality (usually in the form of an excavation to salvage the fossil[s]), preparation of a locality specific mitigation plan may be required. If avoided, the mitigation paleontologist or agency should report the locality to an institution or researcher with an interest in it.

5.8. Avoid the use of cultural resource management terminology in mitigation paleontology so as to minimize confusion between the two disciplines.

5.9. Understand the dimensions of the disturbance area, project area, buffer (if any), and area-of-potential-effect, prior to commencing field work.

5.10. If requested to perform exploratory shovel testing for paleontological resources or similar inappropriate technique, educate the requestor about the futility of such an exercise.

5.11. Using local paleontological knowledge and experience, mitigation paleontologists should provide recommendations regarding the frequency of repeated field surveys and provide justification to land managers in field survey reports and end of year permit reports.

CONSTRUCTION MONITORING

6.1. Monitoring should be a mitigation requirement when construction will disturb bedrock units or surficial deposits with a high potential to contain fossils of scientific importance. Continuous monitoring is generally stipulated for geologic units with high and very high sensitivity, whereas spot-checking is generally stipulated for geologic units with moderate and unknown sensitivity. The principal investigator should have the authority to increase or decrease the monitoring level of effort if warranted.

6.2. In some cases, monitors have a brief opportunity to do a final surface check immediately prior to ground disturbance to ensure that no scientifically important fossils were missed during the preceding field survey.

6.3. Active construction excavations should be monitored by inspecting freshly exposed surfaces and spoils piles from a safe distance. Be aware of the effects of certain types of construction equipment on bedrock and contained fossils. When equipment is not running, use the opportunity to examine the excavation, document the stratigraphy, and check through spoils piles. In most sedimentary rock units and surficial deposits, drilling with an auger with a tool diameter of two feet or less, typically pulverizes the sedimentary matrix, including any contained fossils. Therefore, monitoring of drilling activities when a small auger is used is typically not conducted or recommended.

6.4. Monitoring cannot succeed if monitors are not within visual range of the excavation, ideally 5 to 20 feet, but no greater than 30 feet, and even at that distance fossils may not be visible.

6.5. Monitors should strictly adhere to all project and OSHA safety requirements, particularly with regard to working around heavy equipment and entering project excavations. As a rule, monitors should never do anything that feels unsafe. Monitors should understand the movement patterns of construction equipment, and use hand signals to communicate with operators. Establishing a good relationship and open communication with all project personnel is beneficial to the success of the monitoring effort.

6.6. Regardless of whether fossils are found, monitors should document the stratigraphy of the project area for the purpose of interpreting its paleontological record, as well as facies relationships and depositional environments. All fossil localities should be tied to the stratigraphic section for use in the monitoring report.

6.7. Monitors should be on site at all times during project excavations in paleontologically sensitive bedrock and/or surficial deposits. Monitors and the firms they represent should educate clients and construction personnel about monitoring practices, particularly with regard to safety, but also with regard to the need to be within view of the active cut.

6.8. When a potentially scientifically important fossil is discovered, fossil salvage activities begin (see Section 7). The monitor should immediately alert the equipment operator and after an initial evaluation, make any other project-specific notifications. The fossil locality should be cordoned off, if applicable, and additional personnel mobilized as needed to support monitoring and locality exploration and evaluation. Construction should be directed away from the locality with a minimum buffer of 20 feet, although the buffer size should be increased if the monitor determines that the locality is larger. Monitors should have expertise in fossil evaluation and salvage techniques.

FOSSIL SALVAGE: FROM COLLECTION TO PRE-CURATION

7.1. Following fossil discovery, a preliminary mitigation evaluation should be performed based on pre-determined threshold criteria for scientific importance (or scientific significance criteria for BLM lands), the purpose of which is to determine whether or not the fossil(s) observed warrant salvaging.

7.2. If the preliminary mitigation evaluation determines that the fossil(s) at the locality have scientific importance or appear to have scientific importance based on what is visible, locality exploration should be initiated. Locality exploration could result in a determination that the fossil(s) lack scientific importance, in which case the fossil(s) should be recorded as non-important and no further action is required. If one or more of the fossils at the locality are scientifically important, then the locality should be recorded as significant. For localities discovered during field surveys, there are typically three standard mitigation options: collection, deferred collection, and avoidance. If avoidance is the preferred option, then an alternate route or project location that avoids other scientifically important fossil localities should be surveyed. Unlike field surveys, mitigation by fossil collection is typically the only option for scientifically important fossils discovered during construction monitoring.

7.3. For all important fossil localities, salvage techniques appropriate to the size and preservation of the fossil remains should always be used. All monitors should be knowledgeable of fossil salvage and sampling techniques and properly equipped. Medium- to large sized specimens or groups of specimens should be excavated encased in matrix to provide stability, expedite the excavation and minimize construction delays. Construction equipment can be used to expedite fossil excavation so long as the equipment does not come into direct contact with the fossil(s), and can also lift heavy jackets onto vehicles for transport off-site. All containers and jackets should be properly labeled prior to removal from the locality.

7.4. It is the responsibility of a professional mitigation paleontologist to collect all scientifically important fossils from within a project area, and the project scope of work and budget should be designed to accommodate this.

7.5. Field paleontologists should refrain from collecting any non-paleontological objects from a project area, regardless of land ownership, and regardless of the legal status.

7.6. Fossils should not be collected from privately owned land without written permission, and professional mitigation paleontologists should understand pertinent regulations. For fossils discovered during field surveys, land owners should be provided with the choice to keep the fossils, donate them, or leave them in place waiving the project proponent of any liability in the event of damage. For fossils discovered during construction monitoring, unless the land owner can be reached immediately, all fossils with scientific importance should be salvaged by default.

7.7. When working on Native American tribal lands, respect all tribal policies and work within them to reduce impacts. Document all fossil localities, and if locality avoidance is the only mitigation option, consider implementing a field specimen molding protocol for specimens with high scientific value.

7.8. Fossil localities should be differentiated stratigraphically, and should be recorded as points, lines, or polygons taking into account the position error of the specific GPS receiver being used.

7.9. Once transferred from the field to the laboratory, fossils should be properly prepared to the point of curation. Matrix samples should be washed, floated if appropriate, and picked, and all fossils should be identified to the level of genus or lowest taxonomic level possible by a paleontologist with technical expertise with that taxonomic group. Any additional analyses within the scope of work should be completed, and pre-curation work including preparation of a fossil catalogue, entry of field and laboratory data into a computerized database, and properly labeling and packaging fossils in preparation for transport to the curation facility, should be completed.

DATA MANAGEMENT AND REPORTING

8.1. Data management strategies should emphasize efficient data entry, accuracy, regular backup, and efficient retrieval of information.

8.2. Project reporting requirements vary by agency, and final project reports should be prepared to meet or exceed agency standards even if no agency is involved.

8.3. Paleontological survey and monitoring reports should include the results of the existing data analysis if it was not included in a prior standalone project report.

8.4. Monitoring and mitigation plans should be based on an existing data analysis and/or field survey, and should make detailed recommendations on monitoring locations and procedures, and impact mitigation (fossil salvage) procedures.

8.5. All paleontological reports, including NEPA/CEQA sections, should be written by or at a minimum, reviewed by, a professional mitigation paleontologist.

8.6. BLM or other agency reporting requirements must be followed when working on agency-managed lands and/or projects.

8.7. Mitigation paleontologists should always treat all fossil locality data as confidential. Locations (i.e. legals, coordinates, photographs) of fossil localities in client copies should be prepared in a confidential appendix of locality data for agency and repository copies.

8.8. All fossil localities, both scientifically important and non-important, should be recorded and reported.

8.9. All field survey and monitoring reports should include documentation of areas that were surveyed or monitored, regardless of whether fossils were found.

8.10. It is appropriate for all types of reports to contain recommendations (including mitigation measures if appropriate) relevant to the proposed project. Recommendations, including mitigation measures, should be developed by working closely with the agency (if any) and client while taking into account the paleontological research potential of the Project area (see Section 3) and the standards of the curation facility. Effective mitigation measures accomplish client objectives while meeting regulatory requirements and preserving (reducing adverse impacts on) paleontological resources.

CURATION FACILITIES

9.1. Mitigation paleontologists should ensure that all scientifically significant fossils collected during mitigation projects are curated at an approved curation facility.

9.2. Mitigation paleontologists should obtain curation agreements in advance of project scoping and obtaining paleontological resource use permits.

9.3. When necessary to support data management costs and sustain the ability to accession and house mitigation fossil collections, curation facilities should charge mitigation paleontologists for data searches and for the curation and storage of fossil collections.

9.4. Mitigation paleontologists should only collect and reposit paleontological resources that have scientific value (fossils that meet significance criteria).

9.5. Unless the locality has been graded away, curation facilities should provide locality data in the form of legal locations (PLSS) and precise geographic coordinates.

9.6. Curation facilities should ensure that recipients of curation agreements and sensitive paleontological data are professional mitigation paleontologists.

9.7. Mitigation paleontologists should ensure that all fossils are properly identified, prepared and documented according to the terms of the curation agreement and the standards of the institution.

9.8. Unless absolutely necessary, fossil collections from the same project, and especially the same locality, should not be divided between curation facilities.

BUSINESS ETHICS AND SCIENTIFIC RIGOR

10.1. Recognizing that mitigation paleontology is a business, all decisions, including scoping of projects and formulation of budgets, should be made in a manner that promotes the intrinsic scientific value, research potential, and long term preservation of non-renewable paleontological resources.

10.2. It is advisable to consult with agency paleontologists, paleontology coordinators, or project managers during the scoping process, especially for large projects. Also, a professional mitigation paleontologist should provide input on all scopes of work and budgets developed by personnel who lack paleontological expertise.

10.3. Obtain contract modifications/change orders as needed in order to ensure that all mitigation work is properly completed, and that all scientifically important paleontological resources are properly collected, prepared, identified, and curated.

10.4. If there is a high likelihood that fossils will be found during a project, incorporate this into the scope of work and budget rather than building a no findings assumption into the proposal. If there is little to no paleontological potential, a negative findings assumption is appropriate.

10.5. In cases of very low or no paleontological sensitivity, recommend to the agency and/or client that impact mitigation is unnecessary.

10.6. Employ only properly trained and experienced paleontologists to do mitigation work, and avoid the use of so-called cross trained personnel unless they are legitimately qualified and have the demonstrated expertise to perform the work. Only professional mitigation paleontologists as defined herein should be used to conduct record searches, prepare paleontological technical reports including mitigation plans, and write paleontological resource sections for NEPQ/CEQA documents.

10.7. Recognizing the paleobiodiversity of the fossil record, utilize professional mitigation paleontologists and/or subject matter experts to ensure that fossils recovered during mitigation are accurately and properly identified to the lowest possible taxonomic level, for conducting faunal and floral analyses, and for obtaining local paleontologic or geologic expertise for a project area.

10.8. Cite (but never plagiarize) paleontological resource and other types of reports and never falsify reports.

10.9. Insist on employing paleontological field techniques to do paleontological work. Succumbing to pressure from an uninformed overseeing agency to employ archeological or other scientifically unproven techniques is not consistent with best practices.

10.10. Avoid letting clients or agencies alter impact mitigation measures in a manner that conflicts with the objective of paleontological resource preservation. Report occurrences of client mandated alterations to agencies. If possible, the overseeing agency should be informed if client modifications to mitigation recommendations are contrary to best practices.

Editor's Note: This paper was modified slightly after the files were sent to the printer for the hardcopy version.

March 9, 2018

Mr. Christopher Calfee
Deputy Secretary and General Counsel
California Natural Resources Agency
1416 Ninth Street, Suite 1311
Sacramento, CA 95814

Dear Mr. Calfee:

I am writing your office to comment on the proposed updates to the CEQA review process. My primary concern is on how the proposed changes affect the treatment and protection of California's Paleontological Resources under CEQA, and I would like to recommend that they be treated separately as a standalone issue in the CEQA checklist of Appendix G.

Until recently Paleontological Resources, which consist of the remains and behavioral traces of ancient organisms (fossils), were addressed in Appendix G as part of the Cultural Resources issue. This lumping of Paleontological Resources with Cultural Resources (prehistoric and historic) has often caused confusion to agency personnel and citizens alike, and this confusion is in part what ultimately lead to the removal of Paleontological Resources from Cultural Resources with the passage of AB-52. While this change will most likely have a positive effect on the treatment of Cultural Resources, the decision to shoehorn consideration of Paleontological Resources into the Geology and Soils issue will not significantly improve the treatment of Paleontological Resources and may make matters worse.

Although Paleontological Resources are preserved and found in geological rock units, they are not related in any way to the environmental concerns traditionally addressed under the Geology and Soils issue; namely earthquake rupture, seismic ground shaking, unstable land surfaces and geologic units, expansive soils, and soil erosion. The treatment of paleontological resources, including the types of data gathered during the assessment phase of resource evaluation, the content and structure of the environmental documents produced, and the types of mitigation strategies employed, differs greatly from that of Geology and Soils. In fact, Paleontological Resources are really better thought of as ancient Biological Resources. This does not mean that Paleontological Resources should be addressed under the Biological Resources issue, but rather emphasizes the unique aspect of Paleontological Resources and the need for them to be treated as a new and separate issue during the CEQA review process.

I realize that one of the goals of the proposed updates to CEQA is to streamline the review process. However, it seems that another goal of the updates is to clarify the environmental issues under consideration and to recognize the changes in our understanding of these issues since the original passage of CEQA in 1970. This need for clarification and recognition of changes in understanding is apparently the reason that four new environmental issues have been added to the Appendix G checklist in the proposed updates, including Energy, Greenhouse Gas Emissions, Tribal Cultural Resources, and Wildfire. It is in this spirit of clarification and recognition that I recommend that Paleontological Resources be added to the Appendix G checklist as another new, standalone environmental issue. In making this request, I propose the following language:

Would the project:
Directly or indirectly cause a substantial adverse effect on a paleontological resource or site?

It is noteworthy that this suggested new question differs from that currently proposed for Paleontological Resources under Geology and Soils, which reads, "*Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?*" There are several problems with the current question. First, as written the question combines two separate, unrelated, and distinctly different resources -- paleontological resources and geologic features. It is critical that these unrelated issues should be decoupled, with geologic features remaining as a consideration under Geology and Soils, and Paleontological Resources being moved into its own issue. The second problem with the current question is the difference in impact criteria required for action relative to other resources. For Biological and Cultural resources, the criteria are "*have a substantial adverse effect on*" Biological Resources or "*cause a substantial adverse change*" to Cultural Resources. In contrast, for Paleontological Resources the impact criteria are currently "*destroy a unique paleontological resource*". Thus, to be considered a potentially significant impact, Paleontological Resources must not be just adversely affected or adversely changed, they must be destroyed before the impact is considered significant. And finally, as currently written the implication is that the only impacts to be considered for Paleontological Resources are impacts to "*unique paleontological resources*" [undefined in CEQA], rather than to Paleontological Resources in general. This leaves the potential significance of an impact up to interpretation of what is meant by “unique.” For all these reasons and for the enhanced protection of California’s rich paleontological record, I strongly urge you to consider the above recommendations.

Thank you for the opportunity to comment on the proposed updates to the CEQA review process.

Sincerely,

Thomas A. Deméré, Ph.D.
Curator, Department of Paleontology
Director, Department of PaleoServices
San Diego Natural History Museum

March 13, 2018

Mr. Christopher Calfee
Deputy Secretary and General Counsel
California Natural Resources Agency
1416 Ninth Street, Suite 1311
Sacramento, CA 95814

Dear Mr. Calfee:

I am writing to provide input on proposed updates and changes to the CEQA review process. The CEQA process with regard to paleontological resources is a topic I have been tracking and discussing with colleagues for many years.

I realize you have lots of comments to sift through, so rather than writing you a lengthy letter, I am attaching a letter that has already been submitted to you by Dr. Thomas A. Deméré, Curator of Paleontology at the San Diego Natural History Museum. I have discussed the topic of paleontological resources under CEQA with my colleague Dr. Deméré on many occasions, and I am in 100% agreement with his letter dated March 9, 2018, which is attached hereto.

I am also attaching a PDF of the first edition of a publication outlining best practices in mitigation paleontology that my coauthors and I have recently revised with input in the form of over 3,000 individual comments from paleontologists representing government agencies, museums and environmental consulting firms. The expanded and improved second edition will be published this spring as a volume of the Proceedings of the San Diego Natural History Museum. My purpose in showing you this publication, entitled A Foundation for Best Practices in Mitigation Paleontology, is to demonstrate that paleontological resources are unique, non-renewable environmental resources distinct from cultural, geological, or biological resources. This publication clearly demonstrates that the evaluation and impact mitigation process for paleontological resources is unlike that for other resources, so combining them with and under another resource category is not sound science. In fact, the existing CEQA checklist language has contributed to numerous documented cases of paleontological resources being damaged, destroyed or completely disregarded during the environmental review and impact mitigation process in California.

To summarize my comments generally, and as outlined above and in Dr. Deméré's letter:

1. Paleontological Resources should be included as a standalone resource category in the CEQA checklist of Appendix G.

2. The existing language in the CEQA checklist for paleontological resources should be separated from "geologic features" and the word "unique" should be removed. The language should be revised as follows: "Would the project directly or indirectly cause a substantial adverse effect on a paleontological resource or site?"

Please do not hesitate to contact me for further comment.

Yours Sincerely,

Paul C. Murphey, Ph.D.
Vice President, Paleo Solutions
Research Associate, San Diego Natural History Museum