

**A Synthesis of the
Literature about Visitor
Outcomes at Habitat Dioramas**

Fall 2013

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Table of Contents

- Introduction..... 3**
- Methods..... 3**
- Overview of the Visitor Experience at Habitat Dioramas..... 5**
- Diorama Outcomes..... 8**
 - Outcomes with Substantial Evidence 9
 - Outcomes with Some Evidence..... 25
- Conclusions..... 37**
- References..... 41**
- Appendix..... 44**

Introduction

The Oakland Museum of California (OMCA), with funding from the National Science Foundation, is renovating their Natural Sciences Gallery. The existing Gallery uses dioramas and mounted animal specimens displayed in freestanding small vitrines with sections of recreated habitats. The renovated Natural Sciences Gallery, *Hotspot California*, will showcase five real places in California that show the state's high biological diversity and how they are threatened by complex environmental issues. It is envisioned as a renovation that realizes the potential of wildlife dioramas to engage the public in environmental issues. In addition to the transformation of the Natural Sciences Gallery, Garibay Group will be conducting research about dioramas focused some aspect of the overall project goals such as connection to place and/or environmental issues.

In order to help ground the team in the literature about what outcomes have been documented at habitat diorama experiences and as a first step in determining a potential research focus about habitat dioramas for the project, Garibay Group conducted a literature review focused on the following question: *What do we know about visitor outcomes at habitat dioramas and how are those outcomes are achieved?*

Scope and Definitions

A major goal of the review was to provide the team with a working document that could help inform their thinking in developing the new Natural Sciences Hall. Thus, this report is an analysis and synthesis of the findings from our review. Its goal is provide an summary of outcomes identified along with examples from the literature that illustrate those outcomes.

We adopt Wonders' (2003) definition of dioramas: "Habitat dioramas are museum exhibits of stuffed animals set in an imitation of their natural environment" (p. 89). "Outcomes" are the specific changes in participants' behavior, knowledge, skills, status, and level of functioning (W.K. Kellogg Foundation, 2004). For the purposes of this report, "exhibit outcomes" are considered the changes in visitors' behavior, knowledge, skills, attitudes, or feelings based on the experiences these visitors have at exhibitions. Thus, while there is significant literature about other aspects of dioramas such as historical examinations, we only considered literature that would help us document outcomes.

Methods

This review incorporated a number of literatures, including evaluations and research studies conducted in habitat diorama halls or in exhibitions that included at least some dioramas. The synthesis also included studies about learning and other outcomes of diorama experiences, some conducted in museums, intended to help put diorama-related literature in context. Considering all sources, this review involved consulting more than 185 studies (see Table 1).

Table 1. Literature Type Reviewed (with number of articles indicated)

Research about or within dioramas and diorama halls	21
Evaluations of dioramas and diorama halls	48
Scholarship about dioramas and diorama halls (did not involve visitor research)	14
Research/evaluation in other (non-diorama) exhibits but pertinent to this focus of the literature review	56
Research, evaluation, and scholarship in non-exhibit settings	32
Research/scholarship on learning related to museums (to help define the outcomes)	14
Total	185

Garibay Group researchers developed outcome worksheets to organize and analyze the information from the literatures. Outcome categories were created using emergent coding (Altheide, Coyle, DeVriese, and Schneider, 2008). In emergent coding, categories are established after an examination of the data (in this case, the literature). Based on the data from the literature, we created categories to account for outcomes documented. A conscious effort was made to adopt terms used in the diorama literature.

Data were then analyzed using an *inductive constant comparison* approach (Lincoln & Guba, 1985) to analyze the data. This method takes each unit of data and systematically compares it to all previous units of data. This allows researchers to identify, develop, and refine ideas and categories of data and patterns as they emerge. This comparison took place at three junctures. The first level of analysis began during the initial review and note-taking for each paper, book, or report. The second occurred as each worksheet was developed. The third interval of comparison took place during the final synthesis of data. To strengthen reliability, two researchers independently analyzed the data, which had been organized via outcomes worksheets to assess evidence of outcomes from the studies reviewed.

Limitations

Given that a significant portion studies about diorama are in the form of grey literature (e.g., unpublished evaluation reports), it was not possible for us to obtain every unpublished study. While researchers, made every effort to obtain as much of the unpublished literature as possible, some of these evaluations were not accessible to us for this review.

Overview of the Visitor Experience in Habitat Dioramas

Findings from the literature review indicate that many visitors pay attention to dioramas, even though they do not spend as much time at dioramas as museum staff might hope—and rarely look at all the dioramas available. For instance, Korenic (1996) conducted 40 hours of tracking 15 visitor groups in the Milwaukee Public Museum. Of the 832 exhibits considered in this study, the average visitor stopped at 58 (7%). Visitors stopped more frequently at dioramas than non-dioramas; they stopped, on average, at 12% of the dioramas (28 of the 225 on average) versus 5% of non-diorama exhibits (30 of the 607).

Giusti (1994) suggested that traditional dioramas still have attracting power. She found that the four dioramas in the American Museum's *Hall of Human Biology and Evolution* attracted between 67% to 80% of visitors. In contrast, the interactive video programs attracted 27% to 30% of visitors and the computer programs 27% to 31%. In addition, four of the five most frequently read labels were those describing dioramas. Based on these results, Giusti (1994) concluded,

If one defines effectiveness in terms of the number of visitors an exhibit reaches, dioramas and traditional object displays would have to be most effective. Interactive microcomputer programs are designed to be controlled by only one person at a time, while dioramas and object displays can reach numerous visitors simultaneously (p. 25).

While dioramas attract more visitors than other exhibits, their size may obscure their true impact on the visitor experience. Looking across more than 100 studies, Serrell (1998) found that although dioramas tended to be larger than other exhibits, visitors did not spend more time looking at them. Serrell's measure of "sweep rate" (how quickly visitors move through an exhibition relative to the area it occupies) for dioramas was twice that of other exhibitions. In other words, "visitors tend to spend less time per unit area in diorama exhibitions than in non-dioramas" (Serrell, 1998, p. 28).

Studies also indicate that dioramas inspire visitors to talk within groups of family, friends, or classmates. This talk often follows a predictable pattern, with visitors proceeding from locating and identifying specimens in the diorama, to describing them with others in their group, to making interpretations and inferences about what they see (Korenic, 1996). When visitors reach the last stage of interpretation and inference, their conversations can be both personally important and deeply meaningful.

Most visitors start with the first two stages in this process, but some become frustrated if the exhibit lacks the interpretive materials they need to complete their exploration. Therefore, fewer visitors reach the last stage of interpretation and inference. A study of the Oakland Museum of California's Natural Science Gallery (Garibay Group, 2008a) found this lack of information particularly problematic for people who rarely, if ever, visit museums ("non-visitors"). For example, one respondent said:

I was confused and sometimes angry. I couldn't understand what was going on in the exhibits....I realize that it's realistic, [but it was] really hard for me to see things....The labeling made me angry. [It was] inconsistent. Some had labels, some didn't, all different types of information (Garibay Group, 2008a, p. 4).

But [it] needed a lot of work with the labeling. I wasn't sure what was going on. How was I supposed to know what the bird was if I didn't know? What I liked more was the exhibits that had the specimens, names, and more information. If someone was doing a report, it would be very hard to know information if it wasn't there. Also, some of the words were hard for younger kids, like 10 year-olds, to understand (Garibay Group, 2008a, p. 4).

Dioramas seem to inspire many visitors to feel awe and wonder; some feel immersed in the experience and some feel connected to the places portrayed. For example,

It gives you a better idea of...you know, reminiscing?...you can visualize—these were actual real animals in a real place, doing things for 10, 20, 30 years, raising their little babies and stuff like that (Institutional Studies Office, 1999, p. 40).

It puts you in the middle of a place where you could not otherwise be...This is what it would feel like...a sense of immediacy of a place where you're not likely to go (Perry, Garibay, & Edington, 1995, p. 7)

When polled about their preferences for displaying mounted specimens, many, but not all, visitors preferred the realistic settings of dioramas as opposed to other types of displays (i.e., similar animals grouped together or explanatory displays) (Institutional Studies Office, 1999, p. 29). Some visitors have positive experiences with dioramas, while others feel upset that dead animals are on display. Still others—often novice visitors to museums—just do not respond to the diorama experience.

The visitor experience in renovated diorama halls

Many natural history museums have undertaken renovations of their old diorama halls over the past few decades. While some of these renovations involved removing dioramas in favor of different and newer exhibit techniques, other institutions have refurbished old dioramas and surrounded them with exhibit elements such as new labels, hands-on and interactive components, and multimedia elements that complement and supplement the original dioramas. Examples of diorama hall renovations preserving many or most of the original habitat dioramas (and sometimes creating new ones) include the Boston Museum of Science's *New England Life Zone Hall* habitat dioramas, the Denver Museum of Nature and Science's (formerly the Denver Museum of Natural History) *Explore Colorado* and *Edge of the Wild*, The

Field Museum's *Nature Walk* and *Messages from the Wilderness*, and the Milwaukee Public Museum's *Rain Forest* and *The Exploration Station* (Davidson, 1991; Davidson, Heald, & Hein, 1991; Dyer, 1992; Harvey, Girjulin, & Loomis, 1993; Harvey, Marino, & Loomis, 1997; Serrell, 1992a; Serrell, 1993, 1994; Young, 1989; Korenic & Young, 1990, 1991; Korenic, 1995).

Based on evaluations of these exhibitions, we know that visitors usually spend more time in renovated exhibitions than in old ones, looking at more components (including more dioramas), engaging with the interactive and sensory elements in new ways, and learning more, including higher-level concepts (Serrell, 1998; Harvey *et al.*, 1997; Harvey *et al.*, 1993; Davidson *et al.* 1991). For example, prior to renovation of the Boettcher Hall dioramas (renamed *Edge of the Wild*), visitors spent, on average, only two minutes in this large exhibition, resulting in a sweep rate of 3,600 square feet per minute—the highest sweep rate of any exhibition included in Serrell's study. After renovation, visitors spent an average of 11 minutes in the renovated exhibition, a sweep rate of 655 square feet per minute (Serrell, 1998, p. 45).

In a study of Denver's Mead Hall (which later became *Explore Colorado*), Harvey *et al.* (1993) found that visitors to the renovated exhibition spent significantly more time, explored more of the hall, and read more of the text panels mounted beside the dioramas than did pre-renovation visitors.

In a before-and-after study at Boston's Museum of Science, most post-renovation visitors interacted with either recorded or written labels and nearly half could cite something they had learned while exploring the gallery (45%, compared with 7% of visitors to the un-renovated exhibition). Finally, post-renovation interview respondents were far more likely to understand the underlying New England life zone themes of the exhibition and showed much better understanding of how New England animals adapted to their environments. (Davidson *et al.*, 1991)

Data suggest that additions to dioramas, such as new labels, hands-on and interactive components, and multimedia elements, can make the dioramas and the ideas they embody more accessible to a wide range of visitors, including children, those with disabilities, and visitors with less experience at museums. Depending on the themes emphasized by the new components, some visitors can be nudged toward thinking more about the places and habitats portrayed, advocating for the conservation of these habitats, or practicing ways that scientists study the natural world. However, former diorama halls can be successfully renovated even if dioramas are left out. For example, visitors can have a fun, engaging, and even immersive experiences with mounted mammal specimens with additions such as label texts, hands-on displays, videos, push-buttons, and flip panels, as in the case at the *Kenneth E. Behring Family Hall of Mammals* at the National Museum of Natural History (NMNH), Smithsonian Institution (Office of Policy and Analysis, 2005).

Diorama Outcomes

This section includes summaries describing and synthesizing the findings for each outcome of the diorama experience. We organized the outcomes by the relative strength of the evidence—either “substantial” or “some” evidence—documented in the literature. Figure 1. lists the 18 outcomes we identified and lists strength of outcomes for traditional and renovated diorama halls.

Figure 1. Relative Strength of Evidence for Each Outcome

Outcome	Outcome Type	Strength of Outcome	
		Traditional Diorama Halls	Renovated Diorama Halls
Gain knowledge, facts, identification	Cognitive	●	●
Retain complex memories	Cognitive	●	●
Understand concepts, explanations	Cognitive	●	●
Develop inquiry and science process skills	Skills	●	●
Feel disgusted, repulsed, fearful, sad	Affective	●	●
Feel immersed, feel psychological flow	Affective	●	●
Feel restored, refreshed, relaxed	Affective	●	●
Reflect on or develop new perspectives	Affective/Cognitive	●	●
Develop a sense of place	Affective/Cognitive	●	●
Develop a sense for a particular time	Affective/Cognitive	●	●
Feel excitement, awe, wonder	Affective	●	●
Develop appreciation, values	Attitudinal	●	●
Develop interest, curiosity, motivation	Attitudinal	●	●
Develop positive conservation attitudes	Attitudinal	●	●
Internalize a mental model	Cognitive	●	●
Declare an intention to act or actually change behavior	Behavior	●	<i>Not studied</i>
Learn about/cement bonds with family/social group	Other	<i>Not studied</i>	●

Substantial evidence = ● Some evidence = ●

Outcomes with Substantial Evidence

Gain knowledge, facts, identification

Simple facts, basic knowledge, and identifications of specimens rank low on the hierarchy of cognition, but research shows that they form the basis for visitors' understanding of higher level concepts embodied in diorama-based exhibits. In the traditional tripartite division of educational objectives, the cognitive domain includes knowledge and the development of intellectual skills. Butler (2002) subdivided this domain into a list of levels of competence: Remember, understand, apply, analyze, evaluate, and create.

Several studies converge on what seems to be a predictable pattern in visitors' interactions at dioramas. First, visitors locate specimens and other things in the dioramas. They then identify them as best they can, either on their own or using interpretive labels and exhibits. Visitors then describe what they see for others in their group, including form and behaviors, and finally some visitors are moved to interpret what they see, relating it to concepts, asking questions, and perhaps philosophizing a bit.

Poor labels frustrate this process, denying visitors the chance to identify and understand what they see. Well-designed labels help visitors move through each stage and take their learning further, helping them think about personally meaningful biological and ecological concepts.

In a study of dioramas at the Museum of Scotland (Edinburgh), Tunnicliffe (2005) described a pattern of interaction with dioramas that she had earlier noted at other museums. She described four levels of interpretation and use of the dioramas:

1. Locate. Visitors first locate items within the diorama based on their own observations and by using labels, if available.
2. Identify, by name, the located object. Identifications may come from the observer, companions, or labels if available.
3. Describe form, function, and behavior. Visitors frequently describe the items they have identified, noting attributes such as size, shape, and color, and perhaps discuss the function of a feature or the behavior implied by an animal's pose.
4. Interpret. Visitors may interpret what they've seen, using abstract terms to relate the exhibit to concepts, raising questions, or even philosophizing about what they've seen (Tunnicliffe, 2005).

As she noted, numerous evaluation and research studies have found that the first (and sometimes major) activity for visitors viewing dioramas is the location and identification of animals and plants. In a

qualitative study, Perry *et al.* (1995) provided some illustrative quotes from interviews with frequent visitors to the old Chicago Academy of Sciences dioramas:

We try to identify animals, point them out to the kids. We look at the line drawings, find an animal, identify it. Find a play. Identify it (p. 4).

We get to look at the animals, and point...[them out]...and see what animals we can find (p. 4).

In a quantitative study of an exhibition at the Royal British Columbia Museum that included both open and glassed-in dioramas as well as smaller didactic exhibits, Peart & Kool (1988) found that, on average, visitors gained *some* factual knowledge (though the difference in scores between visitors who had seen the exhibition and those who had not was only 12%). The authors noted that visitors looked at the exhibits for only a small fraction of the time it would have taken them to thoroughly view the entire exhibition. They also found that “concrete” three-dimensional exhibits, including objects attracted more visitors and held them for longer than did “abstract,” two-dimensional exhibits. No significant difference existed, however, in [researcher-defined] learning from these two categories of exhibits. It’s important to note that “knowledge,” as *pre-defined* by the researchers, may not include knowledge gained in ways other than from labels, such as by looking and comparing on one’s own or by talking with others in a group. Yet we know that visitors can gain knowledge in various ways.

Evaluators of the Smithsonian’s Hall of Mammals, for example, pointed out that visitors learned from the exhibition in several ways, acquiring different types of knowledge. In their study, visitors learned by:

- “Getting a close look,” which “leads naturally to certain types of knowledge....[including] a spontaneously acquired sense of the size and scale of particular animals. No text is needed. The measurement standard is either the visitor himself or other animals in the exhibits, and a typical response is ‘I didn’t realize it was that big (small)’” (Institutional Studies Office, 1999, p. 7).
- Making comparisons among the animals on display, which were often grouped in ways that suggested diversity within a theme. “This method of learning was very well received by these respondents, probably because it grows naturally out of the close-looking activity that is so central to the experience of the hall. It is also painless and unobtrusive” (Institutional Studies Office, 1999, p. 8).
- Reading exhibit texts. “This type of learning was least discussed by visitors, probably because the Mammals Hall is not rich in text. Several visitors pointed out how much they appreciated that....On the other hand, visitors were very pleased with the nuggets of information that struck them as interesting and different, or that touched on questions they’d long had” (Institutional Studies Office, 1999, p. 8).

In the evaluation of the renovated exhibition, interview respondents again mentioned gaining knowledge from looking at the mammal specimens, by reading labels, and by watching the film added to the exhibition. In addition, the evaluators of the renovated exhibition recognized that visitors gained knowledge by talking with other visitors. That said, the Hall of Mammals evaluators pointed out how difficult it was to sort out what visitors had learned about mammals from the exhibition from what they had learned from television programs or other sources (Office of Policy and Analysis, 2005).

Retain complex memories

This category includes the broad range of complex memories that people retain of past experiences, where images, sounds, smells, and feelings can come together. As Ansbacher (2002) puts it, these memories are added to visitors' *experience banks*, but are not necessarily processed into facts or concepts. Such experiences may lie dormant forever or may be recalled and processed at a later time when triggered by new experiences" (p. 4).

Strong evidence exists that people who have visited diorama halls several times during their lives retain lasting and vivid memories of their diorama experiences. Such memories can lead to *delayed learning* when visitors draw on their experience banks to make sense of things they encounter long after their museum visit.

During 1991, as part of the Museum Impact and Evaluation Study (MIES), the Chicago Academy of Sciences (CAS) conducted telephone interviews with adult museum members concerning their experiences in the museum's diorama hall, which included habitat dioramas constructed from 1905 to 1933 and then updated during the 1960s and early 1970s with natural scenes from around the Chicago area. Perhaps not surprisingly, because the respondents were museum members,

[Discussing] the dioramas elicited strong memories of previous visits to the museum and of the second floor [where the dioramas were located] in general. While some respondents discussed childhood memories, the majority of respondents mentioned visiting the museum as adults and simply had recollections of the dioramas themselves. Most often-cited recollections included a) animals and plants, b) specific diorama scenes, c) the realism and detail of the dioramas, and d) the second floor in general (Perry et al., 1995, p. 2-3).

Anderson, Piscitelli, Weier, Everett, & Tayler (2002) found that children more often remembered large-scale elements and elements that were part of a story. These authors described that the recall of natural history exhibits as "exemplified by rich description," which we consider to be a hallmark of this sort of memory (p. 228).

The Field Museum's *Life Over Time* exhibition included a large, walk-through Coal Age Forest diorama. When 18-and-over visitors to *Life Over Time* were shown a photo of the Coal Age Forest as they left the overall exhibition (some 9,000 square feet later), 99% said they remembered this area (Hayward & Hart, 1996). In contrast, when adult phone-interview respondents were asked to list what they remembered about *Life Over Time* several months after their visit, only 12% of the respondents mentioned the Coal Age Forest diorama. On the other hand, 48% mentioned something about dinosaurs, 46% mentioned one or more of the interactive exhibits included in *Life Over Time*, and 21% mentioned video newscasts “from the past” anchored by local TV personalities (Hayward & Hart, 1997). (One issue may have been the immense size of the exhibition. The evaluators listed more than 20 categories of answers from respondents, and most of these categories included several different exhibit elements.)

One of the interesting questions here is what forms visitors' memories take. Do visitors remember names and verbal descriptions of what they saw, which they can reproduce during a telephone interview? Do they retain internal images that they can match with photos of an exhibition? Do they store something even more complex?

Understand concepts, explanations

Evaluations and research studies suggest that visitors think about larger concepts in diorama halls, including life cycles, predator/prey relationships, interconnectedness in natural systems, and humans' impact on nature. Diorama renovations have usually increased this type of thinking. Families with children—and other visitors—tend to think and talk about these concepts in personally meaningful ways. There is, however, reason for concern that some dioramas present inaccurate, stereotypical, and overly dramatic views of nature, which may reinforce visitors' misconceptions about topics such as the roles that animals play in the lives of their offspring.

As described earlier, Tunnicliffe (2005) described four levels of interpretation and usage of the dioramas. The two highest levels seem most likely to generate understanding of concepts and ideas: *Describe form, function, and behavior* and *Interpret*. She noted that fewer visitors reached the upper levels of interpretation, although some did on their own, without support from labels.

Perry, Garibay, & Edington. (1995) found evidence that at the old Chicago Academy of Sciences, dioramas helped frequent visitors think about larger concepts including life cycles, predator/prey relationships, and larger ecological concepts. For instance, respondents said that:

[When we visit the dioramas] usually we talk about the conditions that the animals live in...the type of environment they live in (p. 5).

[We discuss] how the scene that's represented... shows what the area looks like and what they eat, and what different animals live there (p. 5).

In these cases, some parents played a teaching role in the diorama halls, sometimes returning many times as their children grew:

That's how they learn. The process of accumulated memories, and also understanding it... [We come back] so they can see, at different ages, the same things, and gain more memories and knowledge (p. 5).

Parents did express frustration that diorama labels did not help them get beyond pointing out and naming the animals and plants. (Perry *et al.* 1995)

Other studies have found that dioramas without effective labels may not communicate intended concepts, even when the dioramas are designed with those larger ideas in mind. For instance, in a study of Milwaukee Public Museum dioramas, Korenic (1995) concluded:

Most visitors see the diorama as a 3-D snapshot, or "a panoramic view in a window." Visitors did not state concepts, conceptual relationships, biological principles, or science processes relating or unifying themes or diorama groups. Visitors did see objects displayed in a concrete manner. They can interpret the concrete visuals by identifying geographic location and general relationship. Visitors did not extrapolate from the concrete to abstract concepts (p. xi).

In contrast, Korenic (1995) found that in *The Exploration Zone*, when interactive exhibits were present, more visitors talked about conceptual relationships at the diorama that served as the core of this exhibition. It seems that dioramas, when combined with other sorts of exhibits, can encourage visitors to think more conceptually about what they are seeing.

In another case, Serrell (1994) found that the Field Museum's renovated *Messages from the Wilderness* exhibition was more successful in communicating higher-level messages to visitors than was an adjacent un-renovated diorama hall. Visitors to *Messages* "talked about many of the new and more complex or abstract messages, e.g., the interconnectedness in natural systems, succession in natural vegetation, predator-prey relationships, and human impacts on nature" (Serrell, 1994, p. 54). She attributed this success to the focused nature of *Messages* "in terms of the number of themes (fewer) and the ways in which many interpretive modes (e.g., diorama, video, text, and graphics) support the same ideas" (Serrell, 1994, p. 56).

In a pre-renovation evaluation of the Smithsonian National Museum of Natural History's Hall of Mammals, evaluators tried to understand the process by which visitors deal with more complex ideas—the mental activity through which they make what they see their own. The evaluators contrasted this kind of thinking with the performance-oriented tasks associated with more formal learning.

The kind of thinking that sometimes seems to be taking place in the Mammals Hall is more like a careful, repeated tracing of existing mental patterns. It is like a meandering walk through the existing landscape of the mind. The familiar paths, worn by repeated wanderings, seem to be personally important to the visitor, even if, to an outsider, they do not seem to lead anywhere in particular (Institutional Studies Office, 1999, p. 9).

The evaluators compared this mental pattern-tracing with Doering & Pekarik's (1997) concept on the *entrance narrative*, which are the ideas and attitudes toward a subject that visitors bring with them into an exhibition. They point to a potential benefit to visitors of this kind of “mental pattern-tracing” which, although perhaps difficult to fit in one of our outcome categories, may still represent a reason people visit museums.

Many visitors use museums to reinforce their entrance narratives, confirming or strengthening beliefs or understandings that they already have. The kind of thinking that we see in some of these interviews probably represents the mental process that underlies the reinforcement effect (Institutional Studies Office, 1999, p. 9).

Finally, critics have pointed out that the abstractions that dioramas embody often portray distorted views of nature and science. For instance, as Moser (1999) points out:

Despite their success as didactic displays dioramas have many limitations. First, they tend to produce stereotypes that have been virtually impossible to erase from our consciousness. Second, they tend to present singular visions of the world that are formulaic and provide little room for alternatives. Third, despite the fact that these displays aim to be as scientifically accurate as possible, they still appear entirely imaginary or hypothetical (p. 110).

Some have also criticized the frequent use of ersatz “family” groupings in large-mammal dioramas created during the last century, with the males often given the most prominent positions in the group (e.g., Flannery, 1998; Haraway, 1989).

While we should be concerned that dioramas may communicate misleading ideas or provide inadequate views of the nature of knowledge to our audiences, we have found no visitor studies directly addressing these criticisms.

Develop inquiry and science processes skills

Several diorama renovation projects have focused on developing visitors' skills with *science tools* and *processes* and *scientific inquiry*. Research suggests that some skills, like observation and identification, are quite frequent. On the other hand higher-level processes are less frequently, although well designed labels can encourage their use. Many family groups use *dialogic inquiry*. The *biological themes* they discuss, such as life cycles, plants vs. animals, protections, and sexual dimorphism, seem school-approved, but the ways they talk about them may use *biological principles* that while personally meaningful are not strictly scientific. Several research and evaluation projects have investigated the extent to which visitors use inquiry and science process skills in diorama halls, both with and without the addition of interactives designed to support these behaviors.

Science Process Skills (and related formulations).

In their analysis of interviews with members of the Chicago Academy of Sciences, Perry *et al.* (1995) examined the transcripts in terms of what the Academy called "thinking skills." The Academy's list of skills includes both science process skills and intellectual skills within the cognitive domain: "Observing, communicating, identifying, comparing/contrasting, classifying, hypothesizing/predicting, experimenting, analyzing, synthesizing, conceptualizing, evaluating, and applying/transferring." Based on the phone interview transcripts, the authors wrote:

It became clear that the dioramas were successful at engaging respondents in the basic thinking skills of the model. Most respondents clearly used observation, communication, and identification skills when engaging with the dioramas. Some respondents also referred to comparing/contrasting, classifying, and possibly analyzing, but to a much lesser degree. (Perry et al., 1995, p. 10-11).

This analysis suggested that visitors frequently use basic process skills at dioramas, but the higher-level skills are used less frequently (or not at all), at least in a traditional diorama exhibition. Perry *et al.* (1995) also noted, however, that

A number of respondents indicated that they wanted to take their children beyond observation and identification, but they didn't know how. The problem with the dioramas was not that most visitors appeared to spend the most time observing and identifying, but that there was little to help them move to higher levels of intellectual processing, even when they wanted to....(Perry et al. 1995, p. 11)

Korenic (1995) completed front-end, formative, and summative evaluations of *The Exploration Zone*, a diorama-based exhibition designed to “help visitors build confidence in their ability to use the tools and processes of science using dioramas which represent the real world.” The summative study of the completed exhibition found that:

- Visitors used the science tools incorporated into the interactives. Although 95% of visitors stopped by at least one interactive, most interactives were used by relatively few visitors; only 1 of 33 interactive components was used by more than half of the visitors.
- Some three-quarters of visitors used basic science process skills to observe and identify the animals, plants, and science tools in the diorama. Half of visitors named an animal or plant, and about a quarter named a science tool, such as a thermometer.
- About a quarter of visitors used higher order process skills, such as describing relationships, making inferences and predictions, and drawing conclusions as they investigated the diorama and related exhibits (Korenic, 1995).

Korenic’s (1995) front-end study for *The Exploration Station* discussed some of the challenges of involving visitors with science process skills in a diorama-based exhibition. For instance, although most visitors were familiar with the names of tools used by scientists, some didn’t know how to use the tools or how to select the appropriate tool for the job. Visitors had the preconception that scientists *do tests*; the testing process seemed to be mysterious to most visitors. The formative evaluation of *The Exploration Station* discovered an additional challenge: Gender differences in middle-schoolers’ use of science tools. Boys were more apt to pick up a tool than were girls, who seemed to watch the action more often than participate (Korenic, 1995).

During formative evaluation of *The Exploration Station*, Korenic (1995) found that the following techniques promoted better understanding of the diorama and the science tools and processes:

- Using common names and vocabulary rather than scientific terms.
- Using familiar animals to demonstrate science concepts and the use of scientific tools.
- Making the science tools accessible to all visitors.

Inquiry and Science Process Skills.

Studying young visitors’ inquiry and science processes in a traditional diorama hall, Tunnicliffe (2009) observed, recorded conversations, and interviewed school-aged children in family and school groups at three African dioramas in the Natural History Museum, London. Although most of the conversations involved naming the animals on display or describing diorama scenes and animal behaviors, she also

garnered interpretive comments and other evidence of higher-order science processes, such as drawing inferences and making hypotheses. In many of the dialogues, children noticed the biological specimens and labeled them according to their existing knowledge. Next, children began to interpret the scenes, often in narrative terms that revealed their understanding of the situation. Finally, some children began asking questions and posing hypotheses as answers (Tunnicliffe, 2009). As with the studies cited above, the dioramas in this case stimulated young visitors to engage in mostly basic science process skills (observation and identification), even though some engaged in higher-order skills and inquiries. The lesson from these studies seems to be that visitors to dioramas engage quite naturally with basic process skills (observation, identification, communication), but that higher-level skills are used less frequently in both traditional diorama halls and newer diorama-based exhibitions.

Dialogic Inquiry.

Ash (2003) has studied the ways in which family groups engage in inquiry as they discuss museum, zoo, and aquarium exhibits with biological themes. Her research studies have included dioramas. Through in-depth analysis of families' conversations, Ash demonstrated the ways in which these conversations:

- Introduce biological themes, such as the *life cycle*, *plant vs. animal*, *protection*, and *sexual dimorphism* (Ash, 2003).
- Develop biological principles, such as *essence* (fundamental differences exist between living and non-living things), *personification* (projecting human motives and characteristics onto other living things), and *analogy* (understanding frogs by analogy to humans) (Ash, 2003).
- Are often mediated by parents' questions, by reading labels, or by third parties such as interpreters (Ash, 2003). Parent-developed questioning strategies seem particularly important in mediating inquiry (Ash, 2004).

Feel disgusted, repulsed, fearful, sad

Although dioramas can promote many positive affective outcomes, some visitors experience negative feelings in diorama-based exhibitions. Negative outcomes of a diorama experience may reflect previously held values and attitude, but they are also inspired by the museum experience, and that experience may confirm, reshape, or extend previously held values and attitudes in ways that imply that a kind of learning has taken place.

Negative reactions to mounted animals.

In exhibitions with mounted animals—whether in dioramas, display cases, or vitrines—some visitors may have problems getting past their discomfort with the remains of dead animals. During exit surveys for the Natural Sciences Gallery at Oakland Museum of California, for example, 11% of respondents reported they found the experience of viewing mounted animal specimens disconcerting. “Those who did not like the ‘dead animals’ as a feature, and said so, seemed to have questions about how the animals were acquired. Some wondered whether the animals were killed for the purpose of placing them in the exhibits” (Garibay Group, 2008b, p. 6).

In another study, at the Smithsonian’s National Museum of Natural History, evaluators stated,

At its deepest level, the Mammals Hall can arouse thoughts of life and death. But visitors were not very comfortable discussing them. Nearly all the visitors in this study made some comment that indicated that death was on their minds—one woman said, for example, that her first thought on entering the galleries was “ew, animal mummies.” But all of them quickly put that aside and either assumed the animals died peacefully or else justified it in terms of the higher principle of education (Institutional Studies Office, 1999, p. 19).

Some visitors cannot put such thoughts aside. In a follow-up survey at the National Museum of Natural History, evaluators asked visitors to select the feeling that best described how they felt about seeing animal specimens on display:

40% said they were excited by them;

41% said they were not bothered by them;

14% said they felt sad or uneasy but were not disturbed by them;

5% said they felt disturbed by them (Institutional Studies Office, 1999, p. 24).

The evaluators noted that younger visitors (ages 12–24), adults visiting with children, and women were more apt to say they felt disturbed by these displays. Renovating the exhibition did not solve this problem. The mounted specimens in the Smithsonian’s renovated Hall of Mammals inspired negative feelings in some visitors, because the animals were dead. “Many believed that the animals had been killed for the purpose of displaying them,” and some visitors had trouble getting past that (Office of Policy and Analysis, 2005, p. 9).

Prior to renovating the diorama-based African Hall at the California Academy of Sciences, Bjork (1999) analyzed the results of an activity where visitors sorted cards with proposed topics based on their interest in the topic. The topic “Whether these animals were killed for display” rated 12th of 16, and the topic

“Whether these animals are real or replicas” rated 11th.¹ The responses on these two topics were spread rather evenly, indicating a lack of consensus among visitors. Mackinney (1999) analyzed comments from this activity. Some visitors were interested in these topics, while others did not want to think about them. In response to the question about whether the animals were killed for display, some visitors said things like:

I don't care. I'm sure they didn't die of old age (p. 2).

Oh, God, I don't want to know. I don't like stuffed animals; I only come to this part because the kids like it (p. 2).

The “real versus replica” question elicited a similar range of opinions (Mackinney, 1999). What happened when one museum tried to answer visitors’ questions about the origins of taxidermied animals? In an evaluation at the Michigan State University Museum, *Wild Cats: Powerful Predators, Vulnerable Prey*, Morrissey & Carmichael (1996) explored visitors’ reactions to natural history specimens including mounted specimens, study skins, bones, and skulls (but not dioramas). The evaluators found that “visitors were overwhelmingly positive toward the mounted specimens and the unique opportunities for an ‘up close’ experience” (p. 63-64).

[However, visitors also] expressed concerns about displaying ‘dead stuffed animals’ and needed to know how the museum acquired them.... when they understood how we acquired the mounts (through donations), they appreciated the fact that they were at least used for educational purposes (p. 64).

The study skins, however, were a different matter. “Many reactions paralleled those of one visitor who commented ‘mounted animals are a whole thing, and the skins looked like somebody had killed it for the skin. I hate that.’ Others couldn’t articulate it, but were uncomfortable with the skins” (p. 64).

Evaluation of this exhibition revealed that exhibit interpretation in *Wild Cats* effectively answered visitors’ question about the origins of the specimens:

Aspects of interpretive approach that seemed most effective were those directly addressing visitor concerns and interest, facilitating social interaction, and redundant messages about the source of the specimens (Morrissey & Carmichael, 1996, p. 64).

¹ The top-rated topics were “What predators eat these animals?” and “What sounds you would hear in this environment?” The lowest-rated topic was “The explorer Livingston died 20 miles from this site,” and two topics tied for second-lowest: “Scientists from the Academy do research in Africa” and “Why there are swamps in Africa.”

The evaluators of the Smithsonian’s Hall of Mammals recommended that designers consider “adding something in the exhibition that tells visitors where the specimens came from and how they were made to look so lifelike, and that addresses the problem of ‘real’ vs. fake” (Office of Policy and Analysis, 2005, p. 15). Evidence from the Michigan State University Museum study suggests that informing visitors about the origins of mammal specimens can effectively answer their questions and allay some of their concerns (e.g., the Morrissey & Carmichael, 1996, study), but it’s not clear how visitors would feel if they knew that specimens had been killed especially for a diorama, as is the case in many major natural history museums.

Frightened by the simulated environment.

Walk-through dioramas can have negative effects on visitor groups with young children. In the Field Museum’s *Underground Adventure* evaluation, Schaefer, Perry, & Gyllenhaal (2002) found that children five and under were often frightened enough by the dark tunnels and hundred-times life-sized animals to disrupt the entire family’s experience. Similarly, an evaluation of the Smithsonian’s Hall of Mammals noted that a simulated thunderstorm frightened some children, though it drew others in. The experiences that many children crave may frighten younger and more sensitive children, and this makes visiting with a mix of pre-schoolers and older children a real challenge. (Office of Policy and Analysis, 2005).

Sadness.

One study (Fialkowski, Siska, Edington, & Roe, 1992) indicated that visitors sometimes expressed sadness about the disappearance of changes in habitats depicted in some dioramas.

I’m sad because I think that is disappearing, and that [dioramas] is the only opportunity my nephews and nieces will ever get to see those types of things. (p. 4)

I find it rather depressing that it’s not like that anymore around here (p. 6).

Of course, the extent to which experiences that provoke feelings such as sadness may not necessarily be negative, depending on the goals of an exhibition. For example, when exhibit goals include habitat conservation, evoking such feelings may foster reflection on such issues. Obviously, the larger question is whether these negative emotions might inspire visitors to act for the environment or simply create feelings of hopelessness. This issue was not addressed in the literature we reviewed.

Feel immersed, feel psychological flow

Several studies have described the feelings of immersion and psychological flow that visitors get from dioramas and other exhibits that reach out and surround them (such as walk-through caves and diorama halls, where the galleries are decorated and lit to grade into the dioramas). Ample evidence exists that

visitors remember what they hear and feel in diorama-based exhibitions, and that immersive exhibitions produce more sensory memories than do other types of exhibitions. Research suggests that other exhibit components, such as interactive and multisensory components and videos of moving animals and their native habitats, can also contribute to visitors' sense of immersion and flow.

Based on examples ranging from simulated walkthrough caves to historical recreations, Bitgood (1990) defined *simulated immersion* as “the degree to which an exhibit effectively involves, absorbs, engrosses, or creates for visitors the experience of a particular time and place.” Gilbert (2000), however, found that many museum professionals use “immersion” to describe two distinctive types of immersive exhibits:

- Immersive environments: Re-created realistic settings intended to make visitors feel as if they are visiting a particular time or place.
- Immersive experiences: The creation of a situation/experience distinct from merely a physical re-creation of the environment.

In a 1993 study at the (then) Denver Museum of Natural History (Harvey, et al., 1993), researchers noted that diorama-based exhibitions, like computer-generated Virtual Reality, can be three-dimensional, dynamic learning environments that visitors view from their own perspective and where visitors control their exploration of the experience. Later studies (Harvey *et al.*, 1997) stated that psychological flow is “characterized by focused concentration and a distorted sense of time where the awareness of self is temporarily lost” (p. 240). The authors postulated that psychological flow occurs “when the goal of the museum visit is the experience or behavior itself rather than a future reward or advantage” (p. 3), and that designing for immersive experiences may promote flow by pulling visitors' attention toward the environment and away from their internal states (Harvey *et al.*, 1997).

Bitgood (1990) claimed that “learning associated with immersion is more experience-driven than information-driven. Instead of emphasizing the acquisition of facts, concepts, etc., a more pervasive understanding of the subject is sought—one that includes the feelings of experiencing another time and/or place, curiosity, excitement, etc.” (p. 5). When an exhibit's context is immersive, children may retain memories that draw on a range of sensory aspects of the experience.

Based on studies in walkthrough dioramas and similar museum experiences, Bitgood (1990) found that when visitors were immersed in an exhibit, they reported experiencing one or more of the following things about the exhibit:

- It involves or absorbs you.
- It creates an exciting experience.
- It creates the feeling of being in a particular time and place.
- It is realistic and natural.
- It makes the subject matter come to life.
- It focuses your attention.
- It is memorable.

When visitors discuss their experiences with habitat dioramas, they often do so in terms that describe the concept of immersion, though they rarely use the term. When the hallways around the dioramas are lit and decorated in ways that make them part of the experience (as in the Chicago Academy of Sciences diorama hall), the sense of immersion can be deepened. This is how some frequent visitors to the hall described their experiences:

It was like I was in the big fat middle of it!...It seems like I'm walking 100 yards into the diorama...a forest path with footprints (Perry, 1995, p. 7).

I feel like I'm there, I'm in the scene (Fialkowski, et al., 1992, p. 2-27).

In their analysis of these interviews, Academy staff expressed concerns that the immersion experience did not seem to lead to the type of advanced scientific thinking that the Academy wanted to encourage among its visitors.

Although aesthetics, nostalgia, and immersion experiences are considered good beginnings of rational thought and enlightenment (Costa, 1985), it does not appear from this study that the CAS repeat visitor is coming to the Academy with knowledge, prior background, or expectations to make BIG CONNECTIONS² using higher level thinking skills (Fialkowski et al., 1992, p. 2-13).

While some visitors seem to have immersive experiences at traditional dioramas (or at the dioramas and the darkened spaces around them), renovated diorama halls that include additional components can also provide significant immersive experiences. At the Denver Museum of Natural History, Harvey *et al.* (1998) investigated visitor experiences in a newly renovated exhibit diorama hall and linked the experience of flow to immersive experiences in museums. Their analysis demonstrated that the factors most responsible for visitors' feelings of flow and immersion were the interactive components, multisensory stimulation, and "dynamic displays" (e.g., videos of the animals in action).

² According to Fialkowski *et al.* (1992), BIG CONNECTIONS include higher level thinking skills such as conceptualizing, evaluating, and applying knowledge.

The Smithsonian's National Museum of Natural History removed the dioramas from Hall of Mammals and built a new exhibition around mounted mammal specimens displayed with new labels, hands-on and interactive displays, and a variety of multimedia elements. According to the summative evaluation of this project (Office of Policy and Analysis, 2005), the combination of elements seemed to create a sense of immersion for some visitors. The evaluators wrote that

The realistic mounts, background videos, and combinations of animals led visitors to speak of the animals as being shown "in their own habitats," despite the lack of specific contextual representations such as those found in traditional dioramas...The combination of poses, groupings, videos, photographs, and suggestive patterns seems to have to have created a kind of "virtual diorama" (Office of Policy and Analysis, 2005, p. 3).

Immersion clearly can be an important aspect of the diorama experience for many visitors. It seems, though, that immersion comes at least in part from the visitor and that some visitors are more skilled at immersing themselves than others. (An outstanding question is what role immersion plays in stimulating visitors' sense of place and other conservation-related outcomes).

Feel restored, refreshed, relaxed

The relationships between the restorative benefits of ersatz "diorama" nature and "real" nature have been studied separately, but we found no research linking the two. Evaluation studies suggested that renovated diorama halls may have fewer restorative benefits if they include lots of interactives and attract large crowds. Also, research suggests that frequent museum visitors have more restorative experiences than do infrequent visitors.

According to Kaplan, Bardwell, & Slakter (1993a), the following are the four characteristics of the sorts of restorative environments where directed attention can be rested while awake:

- *Being Away* means the environment is separate and distinct from the usual, away from everyday concerns.
- *Extent* means the environment is large enough for one to enter it, explore it, and spend time—that it is coherent rather than fragmented.
- *Fascination* means the environment is interesting and engaging, stimulating attention of a different kind that requires no mental effort.
- *Compatibility* means the environment supports one's purposes (what one intends to do).

The authors stated that the presence of an *aesthetic* component influences the depth or intensity of restorative experiences. Intense restorative experiences often lead to *reflection*, which “constitutes a kind of ‘internal housekeeping’ that allows one to function with less demand on directed attention in the future. Thus a restorative experience that also promotes reflection is particularly beneficial to the psychological health of the individual” (Kaplan *et al.*, 1993a, p. 728).

Korenic (1996) noted that Kaplan, Bardwell, & Slakter (1993b) have “suggested that dioramas are attractive to visitors because they provide a reflective, ‘restorative,’ experience, an opportunity for people to use their imaginations and travel to the place represented in the diorama... [They] assert that the restorative role of museum exhibits may permit people to recover their cognitive and emotional effectiveness” (Korenic, 1996, p. 38).

Perry *et al.* (1995) provided some direct evidence of restorative effects of dioramas in their analysis of phone interviews with frequent visitors of the Chicago Academy of Sciences.

The dioramas also appeared to provide a restorative experience for respondents, giving them an opportunity for escape and relaxation. The dioramas seemed to have a calming effect and respondents talked of appreciating the chance to “get away” and take a break from other people and from reality (p. 8).

The quote below provides one example that illustrates such an experience:

*I feel very relaxed [in front of the dioramas]...It’s dark, and it can be very quiet, and there’s not a lot of people there. You can just sit back and relax a little bit. You get a sense of peace and security. (Perry *et al.*, 1995, p. 9).*

Although some studies have identified positive impacts of renovating older diorama halls, evaluations of the new exhibitions also found negative impacts of renovation on visitors who come to dioramas for quieter experiences. Davidson *et al.* (1991) noted, concerning the renovated diorama hall at Boston’s Museum of Science:

The gallery has changed from a rather quiet, secluded place favored by adults to a livelier hall populated by families and children. The noise level has increased, and the mood has altered. During the collection of baseline data, we observed many adult couples in the gallery who appeared to appreciate the relative seclusion and quiet of the gallery at least as much as the exhibits. The population does not appear as frequently after alteration. (p. 288).

The Boston study did not explicitly consider the restorative effects of diorama halls, so it is unclear if this explanation is complete.

Reflect on or develop new perspectives

Only a couple studies have specifically investigated reflection in diorama-based exhibitions. Korenic (1996) found that a reflective experience was the second most common visitor response to dioramas at the Milwaukee Public Museum. (Her definition of a reflective experience cuts across several of the outcome categories identified in this report, as it includes imagining and reminiscing, valuing and appreciating, and expressing a range of other feelings.) When she assessed *The Exploration Station*, a diorama that had been supplemented with many interactive exhibits, however, Korenic (1995) found that fewer visitors treated the diorama as a reflective experience. Only about 10% of visitors responded to *The Exploration Station* diorama by describing feelings, reminiscing, or using their imaginations to discuss what they were seeing, compared with 29% of visitors in a gallery of North American habitat dioramas.

Outcomes with Some Evidence

Develop a sense of place

Sense of place is a popular but complex concept addressed within many academic disciplines. Ardoin (2006, 2004) lists a number of disciplines that address this concept, including geography, cultural anthropology, architecture, leisure studies, forest science, and environmental education. Ardoin (2006) defines the term this way: “Sense of place describes the complex cognitive, affective, and evaluative relationships people develop with social and ecological communities” (p. 118),

In a study about immersive museum experiences (Bitgood, Ellingsen, & Patterson, 1990), exhibits that rated highly on “Feeling of being in the time and place” included a simulated walk-through cave and a diorama exhibit about the African Plains. The authors concluded that the realistic backgrounds in these exhibits helped the “feeling of time and place” (Bitgood *et al.*, 1990). This study is one of the few we found that linked dioramas, immersion, and feelings of place. This research, however, focused on immersion and not sense of place.

While we did not find other research or evaluation studies that specifically addressed the connections between habitat dioramas and visitors’ sense of place some data suggest that dioramas depicting familiar natural areas seemed to stimulate visitors’ pre-existing sense of place. When we examined visitor quotes from several studies, it was obvious that “place” was on many visitors’ minds. For instance, the Chicago Academy of Sciences dioramas represented real places in the Chicago region, and visitors with experience or interest in these places noticed and appreciated that.

I think always the draw for me to the Academy was the dioramas, because they were of Chicago area wildlife.

What I really value about the Academy is that it's focused on this bio-region...It's very much on the Great Lakes, prairie, that whole thing (Perry et al., 1995, p. 4).

In some cases, museum members discussed connections between the dioramas and the “real” outdoors, especially wild places—particularly those they remembered from childhood—that they had visited and seemed to feel attached to. For example, one said, “I grew up in Indiana, so I spent a lot of time at the Dunes” (Fialkowski et al., 1992, p. 2-26).³

At the Oakland Museum of California, visitors to the Natural Sciences Gallery were asked about places they had been or wanted to see in the future. Many visitors seemed to have developed, or were in the process of developing, relationships with the wild places depicted in the dioramas. Answers from two-thirds of respondents suggested they recognized that the Gallery was California-specific:

[It] shows the different ecological areas of California (Garibay Group, 2008b, p. 8).

[It] introduces visitors to California climates and different plants and animals living in different areas (Garibay Group, 2008b, p. 8).

When asked how the Gallery helped them reflect on nature in California, one-fifth of respondents recalled places they had visited:

Yosemite. I visited there before and really enjoyed it. This gallery certainly reminds me of there (Garibay Group, 2008b, p. 11).

It made me think of my childhood and traveling to the Redwoods and to the water. I felt nostalgic (Garibay Group, 2008b, p. 11).

The study also asked respondents about the extent to which they were able to personally connect to natural places portrayed in the Gallery. Most visitors noted feeling connected to these places, but repeat visitors to the Natural Sciences Gallery gave significantly higher ratings than did first-time visitors. Some

³ The dioramas included representations of dune habitats.

60% of visitors who felt a connection said it was because they had been to that specific place, seen an animal or plant portrayed in the diorama, or had an interest or memory relating to these places.

Additionally, researchers (Garibay Group, 2008a) found that visitors often shared memories about the places depicted in a diorama (or of places the diorama reminded them of) such as family vacations or favorite spots or just memorable events in their lives.

Visitors in these studies, therefore, linked habitat dioramas to places that had meaning to them, and “sense of place” may be the concept that most closely explains their experiences.

Nonetheless, there were other visitors in the OMCA study sample who thought of the Natural Sciences Gallery in much more general terms—as places where animals live, rather than as places that might be meaningful to *them*.

While participants clearly saw the Gallery as depicting nature and animal habitats, very few mentioned that these were California-specific places. Of course, on some level, visitors likely knew that these were supposed to be California habitats, but what is more important here is that this is not something they recalled about the Gallery. Instead, what was most memorable for them is that it depicts nature and wildlife rather than nature in California. In other words, the Gallery seems to portray nature—at least in respondents’ minds—in a somewhat generic manner and location. Clearly this major issue needs to be addressed in the redesign of the Gallery (Garibay Group, 2008a, p. 5).

While some evidence exists that dioramas can stimulate visitors’ pre-existing sense of place, it is not known how frequently dioramas help visitors build their sense of place, especially for places they have never been. Although this outcome seems like a useful lens through which to view the diorama experience, more research specific to dioramas is needed.

Develop a sense for a particular time

We use *sense of time* as a temporal analog to sense of place; it is the complex cognitive, affective, and evaluative relationship that people can develop for a long-ago time differs from today. It seems likely that popular exhibits, like dinosaur dioramas, Charles Knight paintings, and historical reconstructions, contribute to visitors’ sense of time for the long-agos represented in these exhibits. Often the literature seems to conflate time with place (Filene, 2010 & Bitgood *et al.*, 1990). Only history museum exhibitors and educators seem to use sense of time in a literal way (McRaney, 2010).

Some evidence exists that visitors see habitat dioramas as depicting times past, even when the habitats persist. In interviews with members of the Chicago Academy of Sciences, respondents sometimes talked about their habitat dioramas as representing the past:

This is the way it used to be, before we built cities.

I kind of look at it from a historical perspective. It's hard to think that this area once looked like that (Perry *et al.*, 1995, p. 6).

It confirms that these things [flora and fauna] used to live in the area (Fialkowski *et al.*, 1992, p. 2-6).

On the other hand, Garibay Group (2008a) found that some visitors were not sure what particular time the habitat dioramas portrayed. “Visitors were not sure if the dioramas were supposed to illustrate habitats many years ago or in the recent past or present” (p. 5).

We have no idea if it is nature now, or 200 years ago (p. 5).

These animals were vs. are. It would be great to get stats on these animals today. The bobcat, the ram, does it still exist? Is it extinct? This starts conversation, and how people can save them.

Sometimes one thinks museums show has-beens, not the present (p. 5).

Feel excitement, awe, wonder

Museum curators and educators have speculated about the roles that excitement, awe, and wonder may play as precursors to short-term and long-term interest and conservation-related outcomes. Quinn (2006) wrote of the American Museum of Natural History’s Hall of North American Mammals that, “In spite of a dissenting faction of scientists at the museum who felt that the dioramas were of limited educational value, the majority endorsed these exhibits as the best means to turn visitors on to the science by replication of the sense of awe, wonder, and discovery that nature engenders” (p. 19). Museum curators hoped that visitors’ awe was more than an end in itself and that it helped them “develop a concern for the preservation and stewardship of these national treasures” (Quinn, 2006, p. 110).

In a study at Australian museums, Anderson *et al.* (2002) found that elementary-aged children more often remembered large-scale elements and those elements that were part of a story, and that the recall of natural history exhibits was “exemplified by rich description” because children were “excited by many of the exhibitions that held either direct or indirect experiential relevance to them” (p. 228). As Chicago Academy of Sciences members talked about their diorama memories (Perry *et al.* 1995), it was clear that the awe frequent visitors felt towards the dioramas led, in turn, to questions about the creation of the dioramas.

Some visitor quotes illustrate this point:

How do they do this?... You stand there and think “wow!”... I just get a kick at seeing how they’re done.

I wonder who makes them. I wonder about the people who actually put this thing together
(Perry et al., 1995, p. 8).

While evaluations found that some visitors talk about dioramas in awe-struck tones, we found little research as to whether awe and wonder play a role in developing interest, awareness, caring attitudes, sense of place, and stewardship for nature or the environment.

Develop appreciation, values

According to Wonders (1993), as museum staff became aware that North America’s natural environment was disappearing, they set out to “impart to the museum public an appreciation of the natural national heritage that was being damaged, diminished, or lost altogether” (p. 10). This new focus on the environment represented a “radical transformation” from the previous century’s focus on taxonomy (Moser, 1999, p. 98). Traditional habitat dioramas, therefore, can be seen as value-laden exhibits from their inception a hundred years or more ago.

The visitor research and evaluation team at the Smithsonian introduced the concept of the *entrance* model to explain how *visitors’* values affect their visits to museums (Doering, 1999; Doering & Pekarik, 1997). In trying to explain why many of their evaluation studies revealed exhibitions to be both inefficient and ineffective at changing visitors’ attitudes, they came to realize that rather than affecting changes in visitors, exhibitions were being used by visitors to confirm, reinforce, and extend their existing beliefs.

The entrance narrative, or internal storyline that visitors enter with, has three distinct components: 1) a basic framework, i.e., the fundamental way that visitors construe and contemplate the world; 2) information about the given topic, organized according to that basic framework; and 3) personal experiences, emotions, and memories that verify and support this understanding. This model suggests that the most satisfying exhibitions for visitors will be those that resonate with their entrance narrative and confirm and enrich their existing view of the world (Doering, 1999, p. 8).

While studies have not focused on how visitors’ values may affect their experience at dioramas, there is some evidence from a number of qualitative evaluation studies that visitors to dioramas express their own values when they discuss, for example, the implications of dioramas for conservation. Examining quotes

from visitors from a couple diorama studies (Garibay Group, 2008b; Perry *et al.*, 1995) illuminates the type of values about nature expressed by visitors to dioramas halls.

What I really value about the Academy is that it's focused on this bio-region...It's very much on the Great Lakes, prairie, that whole thing (Perry et al., 1995, p. 4)

There's nothing really on how the ecology's affected by us...and how you can try to help and stabilize it (Perry et al., 1995, p. 6).

I love the coasts, the Redwoods, I used to be a backpacker so I recognize a lot of the places (Garibay Group, 2008b, p. 13)

It's so important to educate people about the problems in California. It is your responsibility as the museum to do this. (Garibay Group, 2008b, p. 10)

Develop interest, curiosity, motivation

Research exists on how people develop short-term or *situational interests*, including advice on how exhibit developers can increase visitors' situational interest in dioramas and other exhibits.

An important outcome of any museum experience may be *sparking an interest* in something the visitor previously had previously given little thought or attention (e.g., Perry, 2002; Falk, Scott, Dierking, Rennie, & Cohen-Jones, 2004). Ansbacher (2002) also wrote about *active curiosity* and interest as outcomes of museum experiences. By sparking interests, museums can share credit for learning what visitors undertake at places and times far from their initial museum experiences.

Researchers often distinguish between *situational interest* and *personal interest* (Chen, Darst, & Pangrazi, 2001). "Personal interest is defined as a person's preference for one activity over others. It is developed over time through a person's constant and consistent interaction with the activity.... Situational interest is defined as the appealing effect of an activity or learning task on an individual, rather than the individual's personal preference for the activity" (p. 384). A personal interest in a particular topic may inspire a visit to a museum; a situational interest may be inspired by a particularly appealing exhibit on a completely different topic once one is in the museum. Situational interest is important because "an interest-triggered learning activity leads to better learning results, especially with qualitative criteria such as a higher degree of conceptual or deep-level learning" (p. 11).

Scheersoi's (2009) research, completed in several natural history museums, investigated "what specific features in dioramas support the development of situational interest [in biology] by attracting visitors and encouraging focused observations and continued curiosity" (p. 11). She summarized her findings as follows:

The data indicate that the development of situational interest depends on the quality of subjective experiences and the immediate emotional feedback during the visit. Situational interest is engendered by recognizing either the familiar, seeing young or big animals, or by the unexpected (e.g., human traces in the wildlife scenes, such as a beer bottle in an elk diorama at Senckenberg Museum in Frankfurt). Visitors spontaneously name certain specimens and scenes, comment about that to which they relate personally, interpret—mainly anthropomorphic—and use narratives to share their knowledge. They show emotional reactions concerning the animals presented (affective), the diorama design and arrangement (aesthetic) and historical aspects or human traces presented in the diorama (cultural, experiential) (p. 12).

Scheersoi (2009) concluded that “dioramas stimulate situational interest if they evoke emotional responses and provide different anchor points which enable visitors with varying individual background to relate previous experiences to the scenes or artefacts presented” (p. 13). She suggested that educators can build on situational interests evoked by dioramas.

In a study of the Smithsonian’s Hall of Mammals, evaluators noted that visitors arrived at the exhibition with differing degrees of long-term personal interest in the topic, which affected their visit goals and outcomes and sometimes led to conflict within a group. Apparently situational interest can also lead to inter-group conflict; evaluators cited as an example of situational interest their observations of adults pulling happily engaged children away from the exhibits (Office of Policy and Analysis, 2005).

Develop positive conservation attitudes

Recent studies have investigated attitudes in concert with a range of conservation-related outcomes, including knowledge and understanding, expressions of affect beyond attitudes, and behavior changes (or, at least, intentions to act). Some of the strongest work on visitor attitudes about the environment has been done at aquaria and zoos, including the Bronx Zoo (Hayward & Rothenberg, 2004), National Aquarium in Baltimore (Adelman, Falk, & James, 2000), Monterey Bay Aquarium (Yalowitz, 2004), and Disney’s *Animal Kingdom* (Dierking, Adelman, Ogden, Lehnhardt, Miller, & Mellen, 2004). These studies, however, looked at attitudes in concert with a range of conservation-related outcomes, including knowledge and understanding, expressions of affect beyond attitudes, and behavior change.

In a nutshell, the important attitude-related finding from these studies is that although many visitors enter conservation-related exhibitions with positive attitudes toward the environment, some visitors may express shifts in attitudes following their visit. It can be challenging to gauge attitudes without inspiring “politically correct” statements that have little to do with what visitors actually experienced in the exhibition. In addition, attitude changes may vary considerably among various subgroups of visitors (see especially Hayward & Rothenberg, 2004).

We did not find any studies in natural history museums that looked at conservation attitudes in depth. A few diorama hall evaluations (Serrell, 1992; Fialkowski, 1992; Perry *et al.*, 1995), however, found evidence of visitors who care about natural settings and the creatures who live there. Summative evaluations of renovated diorama halls often contain survey or interview questions that focus on the idea of caring toward nature or the environment. Serrell (1992) described visitors' answers to a question about the main purpose of the Field Museum's Nature Walk displays, which used the prompt "To make people...":

About the same number of comments related to conservation and making observations. A typical response combining these ideas is "to look closely and care about conserving the environment." People made comments about preservation of habitat, the fragility of nature, responsible and irresponsible actions by humans and the need for conservation.... In many cases, people used modifiers such as "increase awareness," or "more aware," giving themselves credit for already having some awareness, knowledge and appreciation of the environment (p. 1-2, emphasis in original document).

In the summative study, Serrell (1992) also asked respondents if they were taking new ideas with them:

Responses to the prompt, "It reminded me that..." were primarily (47%) "green" comments, that is, ones that reflect caring for the environment, such as, "we all must recognize the importance of not paving over every inch of greenery..." or "we are all to blame. We're the ones driving cars, using fuel and voting Republican" and "we really need to take care of our planet" (p. 2).

In contrast, one study of an exhibition that included both open and glassed-in dioramas as well a smaller didactic exhibits, Peart & Kool (1988) found no difference in attitudes between visitors who had seen the exhibition and those who had not. Unfortunately, in the published version of did not include the questions asked of visitors, so were not certain what those attitudes were about.

Garibay Group study (2008a) the OMCA Natural Sciences Gallery researchers concluded that visitors did not generally think about larger environmental issues during their experiences at the habitat dioramas.

Overall, families stated that the Gallery reflected nature in general (particularly animals and their habitats). In general, however, the Gallery did not make visitors think about larger environmental issues or problems. Once interviewers brought up specific questions, most visitors could see ways in which the Gallery could connect to environmental issues, but it was clear that this was not respondents' main experience with (or take-away from) the Gallery (p. 9).

It's also interesting to note that in every diorama evaluation that included quotes from visitors, at least some respondents discussed conservation of wildlife and wild places, even if that these were not explicit in the exhibition. For example, some frequent visitors to the Chicago Academy of Sciences dioramas (Perry *et al.*, 1995) discussed human damage to the environment and their sense of loss viewing the dioramas of wild places.

I usually get very pessimistic and I think about how the environment has changed. [I] think a lot about how we've changed the environment, and how we are still in the process of changing the environment. (p. 6)

[I] regret that we have lost so much contact with so much stuff...there's a real poignancy...how did we lose contact with so much biological richness? (p. 6).

Some of these respondents expressed frustration because the Academy exhibition lacked a stronger environmental message.

There's nothing really on how the ecology's affected by us...and how you can try to help and stabilize it (p. 6).

For these visitors, their conservation-related feelings may reflect part of an “ecological identity.” Thomashow (1995) defined ecological identity as “how people perceive themselves in reference to nature, as living and breathing beings connected to the rhythms of the earth, the biogeochemical cycles, the grand and complex diversity of ecological systems” (p. 266). Although conservation or identity have not been explicitly studied in diorama halls, there seems to be some evidence that the diorama experience does provide some visitors an opportunity to think about and perhaps even enact their ecological identities. (In the section titled “Declare an intention to act or change behavior,” we further discuss the conservation focus there on behavior change as the outcome).

Internalize a mental model

The *mental models* approach seems like a useful way to think about how visitors synthesize diorama experiences with their understandings of the natural world. Researchers describe how our brains assemble mental models as needed, combining stored *images* and *propositions* (statements about the subject of the model) (Gilbert & Priest, 1997). Wildlife dioramas are a special kind of *physical model* because most of them incorporate something real from the very thing they model (such as skins of mammals). Nyhart (2004) describes natural history dioramas as unlike most other models in science. Although many models in physics and chemistry make things we cannot see visible, most habitat dioramas depict animals, plants, and landscapes that we recognize. Unlike abstract models in math and

economics, dioramas depict “slices of life” that appear, at first, non-theoretical. They also differ from hands-on anatomical teaching models because they are hands-off (for looking only). Many habitat dioramas are also life-size, scaled neither up nor down. And many bird and mammal dioramas are not completely artificial, including at least the skins, beaks, and teeth of the animals portrayed (Nyhart, 2004).

Yet dioramas, as well as mounted specimens and plant reproductions in isolation, are unquestionably teaching models developed through consensus by the curators, preparators, and artists who created them. The open questions seem to be: In what ways and to what extent do visitors incorporate these teaching models into their developing mental models of the organisms, places, and habitats portrayed? And (following Gilbert & Ireton’s [2003] suggestions), if dioramas are models, are they *good* models? How are they the same (and different) as what they represent? What are their strengths and weaknesses?

Some models have misrepresented nature from the moment they were built, such as the Field Museum’s 1949 Alaskan Brown Bears diorama (Metzler, 2007), which depicts a nuclear family with father, mother, and cubs—a situation that would never occur in the wild (Asma, 2001). Other dioramas’ inaccuracies became clear only in retrospect, as new discoveries and interpretations modified scientists’ understanding of how things used to be.

Museum researchers have described how visitors’ mental models of the animals and habitats help them make sense of dioramas in a “mental model matching process.” Tunnicliffe (2009) described children recognizing and naming the animals in an African habitat diorama by matching what they saw in the dioramas to their mental models of those animals. “Children allocated names according to the salient criteria features which they recognized in a mental model matching process” (p. 19). In another study (Mifsud, 2009), students were asked to draw a scene from one of the dioramas they had seen earlier that day. While 90% of the drawings reproduced some aspect of habitat, such as a beach or yard, many of the drawings included features *not* in the museum dioramas. Mifsud concluded that the students were “matching” what they had seen in the dioramas with their existing mental models of what a beach or yard looks like.

Declare an intention to act or actually change behavior

Conservation-related goals—including the hope that the public could be motivated to support protection of natural areas—played a role in the creation of the first dioramas. Hope of changing public conservation-related behaviors continues to motivate many museums, zoos, and aquaria, as well as the broader field of environmental education. Relative to this study, we define *intention to act* as visitor statements indicating that they plan to do something differently in the future based on their experiences at the museum. Friedman (2008) defines a behavior outcome as a “measurable demonstration of, change in, or exercise of behavior” (p. 21). Measurement can be based on self-reports of behavior, but it may also be

possible to track some changes by direct observation. Evaluation studies show that some attempts at behavioral change met with some success, but that motivating and measuring behavior change can be challenging in informal settings.

One of the few evaluations of a diorama-based exhibition to research intention or behavior change based on exhibit experiences was the evaluation of *The Exploration Zone* at the Milwaukee Public Museum (Korenic, 1995). As part of the summative evaluation, visitors were asked the question, “Will you do anything differently or look at anything differently as a result of seeing this exhibit?” Different sets of visitors were asked this question when 1) only the diorama was present and 2) when the diorama was surrounded by interactive exhibits that focused on science tools and science processes. In both cases, about a quarter of respondents answered yes, about two-thirds answered no, and the rest failed to respond. With just the diorama present, visitors most frequently answered that they would look at nature differently (35%) or take care of the Earth (30%). With the science-centered interactives present, 16% of visitors said they would be more aware of what scientists were doing and fewer noted that they would view nature differently or take care of the Earth (24% and 20%, respectively) (Korenic, 1995). This seems to indicate that dioramas alone can inspire some visitors to declare their intentions regarding nature and conservation, and that adding new interpretation can alter what visitors say about their intentions.

Learn about/cement bonds with family/social group

We define this outcome category to include both learning about other members of one’s family or social group and building and cementing bonds among members of that group. Falk *et al.* (2004) described a category of learning where visitors discover something about other members of their groups in ways that may or may not be directly related to the subject matter and themes of the exhibit; this they term *social learning*. In a report on the Smithsonian’s Hall of Mammals exhibition, the authors related both interest and identity to family visits to museums. “By ‘sharing’ interests, a family can use the museum visit to emphasize the bonds that define them as a unit, contained and separate from others” (Institution Studies Office, 1999, p. 6).

The research evidence for this outcome is scant, primarily because few studies have focused on this issue. We found evidence, however, that a few Chicago Academy of Sciences visitors were inspired by the dioramas to speak with their children about their own childhoods.

I talk about it with my kids, like, “When I was little, I saw a ‘possum run across the road, and I asked my mom, ‘Is that a mouse? Mom, there’s a big mouse’” (Fialkowski et al., 1992, p. 2-26).

Garibay Group (2008a) also documented conversations at OMCA's Natural Sciences Gallery where families shared stories with each other—some of experiences they had together and others where one member of the group shared their experiences with the group.

There were some indications that the Natural Sciences Gallery provided opportunities for visitors to share stories with each other as well. In some cases, exchanges revolved around group memories. In other cases, certain members in the group came up with memories and then shared them other family members. For example, one adult respondent talked about the yucca flower in one of the dioramas and how she used to eat yucca flowers in her native El Salvador. (p 8.)

We include this outcome because it may play a role in how visitors, particularly children, build their identities relative to nature and possibly conservation.

Conclusions

The goal of this review was to synthesize the findings of studies concerning the visitor outcomes at habitat dioramas. The goals of this review were to: a) help inform the development of the Hotspot California exhibition and; b) to identify gaps in the research and thus inform decisions about possible areas of investigation for the projects' planned research about dioramas.

This review documented a broad range of potential outcomes at habitat diorama experiences. Based on the literature available, we identified 18 specific visitor outcomes. The evidence for these outcomes, based on evaluation and research studies conducted with visitors in diorama halls, varied considerably. We summarize these outcomes below:

Gain knowledge, facts, identifications	Several studies suggest that the first things visitors focus on at dioramas are the locations, identifications, and descriptions of the organisms portrayed.
Retain complex memories	Several studies suggest that visitors retain memories of their diorama experiences for months or years.
Understand concepts, explanations	Several studies suggest families, in particular, discuss personally meaningful concepts about reproduction, feeding, and defense at traditional dioramas. Studies in renovated diorama halls suggest that visitors notice, discuss, and remember concepts included in the revised labels and at hands-on and multimedia displays.
Develop inquiry and science processes skills	Several studies suggest that visitors use science process skills in dioramas and that they use basic processes (observation, identification, communication) more often than advanced skills (analyzing, inferring).
Feel disgusted, repulsed, fearful, sad	Numerous studies have found that some visitors have trouble getting past their discomfort viewing the remains of dead animals. Young children, in particular, may be frightened by dramatic experiences in renovated diorama halls. Some data indicated that dioramas can evoke a sense of sadness about habitat loss.
Feel immersed, feel psychological flow	This outcome has been studied in both traditional and renovated diorama halls. Findings suggest that renovations such as extending the diorama into the surrounding hallways and adding multimedia can make the immersive experience available to more visitors.
Feel restored, refreshed, relaxed	Studies in traditional diorama halls suggest that frequent museum visitors are more apt to experience restorative feelings. There is some evidence that renovations can diminish the restorative experience by attracting larger, younger, and more active audiences.

Reflect on or develop new perspectives	A series of studies at one museum found reflective experiences (imagining, reminiscing) were fairly common at traditional dioramas but happened less often when a diorama was supplemented with interactive exhibits.
Develop a sense of place	Data from some studies suggest that diorama experiences can stimulate visitors' existing sense of place, but it is unclear whether visitors can also develop a sense of place based on diorama experiences.
Develop a sense for a particular time	Data from some studies suggest that some visitors use habitat dioramas as windows into the past, interpreting them as representations of what nature "used to look like."
Feel excitement, awe, wonder	Evidence for this outcome comes mostly from visitor responses to open-ended questions. Comment generally reflect awe and wonder about the actual process of constructing dioramas. We did not find studies that looked specifically at awe or wonder as an outcome.
Develop appreciation, value	Responses to open-ended questions from some studies suggest that some visitors <i>express</i> appreciation and values in diorama halls. We found no studies about whether, and/or how, visitors <i>develop</i> values in diorama halls.
Develop interest, curiosity, motivation	One study looked at the development of situational interest in diorama halls. Other evidence suggests that visitors often <i>express</i> their interests through their diorama experiences.
Develop positive conservation attitudes	Responses to open-ended questions from some evaluations suggest that some visitors <i>express</i> positive conservation attitudes in diorama halls. We found no studies about whether, and/or how, visitors <i>develop</i> such attitudes in diorama halls. Indirect evidence exists that some visitors express their ecological identities in response to open-ended questions.
Internalize a mental model	One study suggested that young visitors internalized a model of what they see in habitat dioramas, and that this is influenced by their existing models of the habitat portrayed. Another study found that young visitors used their existing mental models to interpret the animals they see in dioramas.
Declare an intention to act or actually change behavior	Although this outcome has not been studied specifically in diorama halls, there is evidence from some studies that some visitors to renovated halls stressing conservation concepts declared their intentions to engage in positive conservation behaviors.
Learn about/cement bonds with family/social group	Responses to open-ended questions in some studies at traditional diorama halls suggested that dioramas stimulated personal memories for visitors and that they shared these memories with each other. This outcome has not otherwise been studied in diorama halls.

Although this review focused on outcomes of the diorama experience, data also provide some evidence of both the strengths and weaknesses of traditional diorama halls.

Collectively, the studies reviewed suggest that dioramas can provide deep and lasting experiences for some museum visitors. Dioramas provide deep and lasting experiences for many visitors. Dioramas provide opportunities for visitors to look closely at the animals and plants in dioramas and can build some understanding about the natural places depicted and the animals and plants that live there. Dioramas can also unlock visitors' imaginations (often transporting them to far away) and can stimulate memories of natural places visitors have visited. While less prevalent, there is some data to suggest that dioramas can inspire visitors to express interest in and caring feelings for natural environments and the animals and plants that live there.

Among the weaknesses identified of traditional habitat dioramas is that they do little to supplement the experience of looking through the glass at static scenes and the quality and depth of the experience often depends on the existing knowledge visitors bring to the museum. Data also suggests that while dioramas can transport visitors to other times, they can also confound visitors as to what time/era they depict. Furthermore, traditional dioramas often depict animal groups in scenes that are inaccurate. Some visitors can also experience negative feelings at seeing dead, stuffed animals in dioramas. Renovated dioramas, however, have been able to address some of these issues (e.g., providing more interpretation, hands-on and interactive elements). When we examine some of the goals museums hope to achieve with habitat dioramas, we also see how they embody some paradoxes. For example, we might expect visitors to develop caring attitudes toward wildlife and wild places when, in fact, many of the specimens were killed specifically for display. We also want visitors to forge connections to natural places by showing them ersatz habitats, human-made depictions or these places.

It is also worth noting some of the specific ways in which renovated dioramas can strengthen the visitor experience in diorama halls. They encourage visitors to spend more time in diorama halls, visitors look at more components, and interpretation and enhancements help visitors more readily figure out what they are seeing in the diorama. They provide a more immersive and enjoyable experience when the diorama builds out and surrounds them (although the larger crowds and increased activity may disrupt the restorative and reflective experiences that drew some visitors to diorama halls in the past). Some evidence also indicates that renovated dioramas can encourage more visitors to think about and reflect on intended exhibition goals such as ecological concepts, doing science in the wild, and conservation-related issues.

Finally, based on this review, there are a number of findings that may be especially relevant in identifying a focus for the project's planned research about habitat dioramas. There is some evidence that visitors' pre-existing sense of place may be stimulated by diorama experiences. However, many visitors may arrive to *Hotspot California* without much sense of the five natural places depicted in the dioramas of the renovated gallery. Thus a potential research focus might be to investigate whether diorama experiences can help visitors develop a sense of place to places they have never visited.

There is also some evidence that visitors express care for natural places when thinking about their experiences at dioramas (at least in the context of responding to evaluation questions). While diorama experiences may stimulate visitors' pre-existing values about nature and conservation, we do not know whether habitat dioramas actually foster caring attitudes in those visitors who may not already come to the experience with these values. Furthermore, it's possible that some visitors who express conservation-related ideas as they reflect on their experiences at habitat dioramas do so because it is already part of their "ecological identity." Thus, two potential threads for the project's research component are: 1) to explore the role dioramas play—or could play—in building caring attitudes about the natural world and 2) to focus on identity and investigate whether diorama experiences can contribute to developing conservation-related aspects of visitors' identities.

It's important to note that as we reviewed the literature related to dioramas and conservation-related outcomes, it became apparent these threads are likely interwoven. That is, visitors' sense of place is very likely intertwined with their pre-existing values about nature, caring attitudes toward the natural world and their ecological identities. Thus, in developing a final focus for the research it may be helpful to further glean from the literature what is known about the interaction between them.

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This section includes only references cited in the body of the report. Additional references used in the analysis of this review are listed in Appendix A.

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- Serrell, B. (1994). Messages from "Messages". *Current Trends in Audience Research*, 8, 54-56.
- Serrell, B. (1998). *Paying attention: Visitors and museum exhibitions*. Washington, DC: American Association of Museums, Technical Information Service.
- Thomashow, M. (1995). *Ecological identity: Becoming a reflective environmentalist*. Cambridge, MA: The MIT Press.
- Tunncliffe, S. D. (2005). What do dioramas tell visitors? A Study of the history of wildlife diorama at the Museum of Scotland. *Current Trends in Audience Research and Evaluation*, 18, 23-31.
- Tunncliffe, S. D. (2009). Inquiry at natural history dioramas -- useful resource in science education. *International Council of Museums Natural History Committee Newsletter*, 29, 16-20.
- Wonders, K. (1993). *Habitat dioramas: Illusions of wilderness in museums of natural history*. Acta Universitatis Upsaliensis. Figura nova ser. 25. Stockholm, Sweden: Almqvist & Wiksell International.
- Wonders, K. (2003). Habitat dioramas and the issue of nativeness. *Landscape Research*, 28(1), 89-100.
- Yalowitz, S. S. (2004). Evaluating visitor conservation research at the Monterey Bay Aquarium. *Curator*, 47(3), 283-298.
- Young, A. M. (1989). The rain forest in Milwaukee. *Curator*, 32(3), 229-244.

Appendix A: Diorama Renovation Projects and Research Sites

This appendix includes diorama hall renovation projects that have been documented in the literature and diorama-based exhibitions that have served as research sites.

Evaluation Studies of Dioramas and Diorama Hall Renovation Projects

We have studies conducted before, during, and after the renovations (i.e., front-end, formative, and summative evaluations) for some diorama halls. Other halls have only one stage of evaluation; some projects apparently never got past the planning stage.

American Museum of Natural History, New York, New York

Summative evaluations of the Hall of Human Biology & Evolution, which includes new dioramas of ancient humans.

Giusti, E. (1994). Hall of Human Biology & Evolution: *Summative evaluation*. Unpublished manuscript, American Museum of Natural History, New York, NY.

Giusti, E. (1994). The comparative impact on visitors of hi-tech & traditional exhibits in a natural history museum. *Current Trends in Audience Research*, 8, 21-25.

These reports are proprietary and will not be listed in the final version of the report:

Giusti, E. (1994). *Labels in the Akeley Hall of African Mammals: The visitor's perspective*. Unpublished manuscript, American Museum of Natural History, New York, NY.

Giusti, E. (1995). *Visitor behavior in the North American Mammals Hall*. Unpublished manuscript, American Museum of Natural History, New York, NY.

California Academy of Sciences, San Francisco, California

Front-end studies:

Bjork, L. (1999). *Results of card sort question in Lechwe diorama interviews*. Unpublished memo, California Academy of Sciences, San Francisco, CA.

Mackinney, L. (1997). *Cape buffalo front-end interviews*. Unpublished manuscript, California Academy of Sciences, San Francisco, CA.

Mackinney, L. H. (1997). *Front-end interviews about the Bushbuck diorama in African Hall at the California Academy of Sciences: Tally of responses*. Unpublished manuscript, California Academy of Sciences, San Francisco, CA.

Mackinney, L. H. (1999). *Front-end interviews about the Black Lechwe diorama in African Hall at the California Academy of Sciences: Tally of responses*. Unpublished manuscript, California Academy of Sciences, San Francisco, CA.

Before-and-after renovation:

Mackinney, L. (1997). *Visitor behavior in African Hall at the California Academy of Sciences before and after addition of hands-on and multimedia modules*. Unpublished manuscript, California Academy of Sciences, San Francisco, CA.

Chicago Academy of Sciences, Chicago, Illinois

These front-end studies were completed prior to the CAS moving to a new building. The new building includes new walk-through dioramas, but we have no summative studies.

Fialkowski, C., Siska, J., Edington, G., & Roe, B. C. (1992). Chicago Academy of Sciences. In P. Anderson & B. C. Roe (Eds.), *MIES: The Museum Impact and Evaluation Study: Roles of affect in the museum visit and ways of assessing them* (Vol. 3) (pp. 2/1-2/33). Chicago, IL: Museum of Science and Industry.

Perry, D. L., Garibay, C., & Edington, G. (1995). *"It was like I was in the big fat middle of it!": The diorama experience*. Unpublished manuscript, Chicago Academy of Sciences, Chicago, IL.

Cincinnati Museum of Natural History, Cincinnati, Ohio

This study was completed after labels were added to a walk-through diorama of Ice Age life.

Larsen, J. (2002). To label or not - visitors win: New life for an immersion exhibit. *Visitor Studies Today!*, 5(2), 11,14-16.

Denver Museum of Nature and Science, Denver, Colorado

These papers and studies were completed after the diorama halls were renovated. The first paper describes the process.

Dyer, J. (1992). New life on an old hall: A prototype for restoring aging diorama halls. *Curator*, 35(4), 268-284.

Harvey, M., Girjulin, A., & Loomis, R. (1993). A virtual reality & human factors analysis of a renovated diorama hall. *Visitor studies: Theory, research and practice: Collected papers from the 1993 Visitor Studies Conference*, 6, 129-139.

Harvey, M. L., Loomis, R. J., Bell, P. A., & Marino, M. (1998). The influence of museum exhibit design on immersion and psychological flow. *Environment and Behavior*, 30, 601-628.

Harvey, M., Marino, M., & Loomis, R. (1997). Design features which encourage psychological flow in museum visitors. *Visitor studies: Theory, research and practice: Selected papers from the 1996 Visitor Studies Conference*, 9, 239-246.

The Field Museum, Chicago, Illinois

The first set of studies concerns the renovations of mammal and bird exhibitions.

Front-end studies:

- Serrell, B., & Becker, B. (1991). Stuffed birds on sticks: Plans to re-do the animal halls at Field Museum. *Visitor Studies: Theory, research and practice: Proceedings of the 1990 Visitor Studies Conference*, 3, 263-269.
- Serrell, B. (1992). *American Mammal Hall dioramas. Front end evaluation summary*. Unpublished manuscript, The Field Museum of Natural History, Chicago, IL.

Formative study:

- Serrell, B. (1991). Into the Wild. *Summary of Animal Kingdom prototype testing 1990-91*. Unpublished manuscript, The Field Museum of Natural History, Chicago, IL.

Summative studies of diorama halls:

- Serrell, B. (1992). Into the Wild. *Summative evaluation. 1. Nature Walk*. Unpublished manuscript, The Field Museum of Natural History, Chicago, IL.
- Serrell, B. (1993). *Summative evaluation of Messages from the Wilderness (Hall 16)*. Unpublished manuscript, The Field Museum of Natural History, Chicago, IL.

Summative studies of synoptic bird and mammal collections:

- Serrell, B. (1992). Into the Wild. *Summative evaluation. 2. The W. K. Kellogg Foundation World of Mammals*. Unpublished manuscript, The Field Museum of Natural History, Chicago, IL.
- Serrell, B. (1992). *From stuffed birds on sticks to vivid feathers, gleaming talons, and sparkling beaks: A summative evaluation of the Bird Halls at Field Museum of Natural History*. Unpublished manuscript, The Field Museum of Natural History, Chicago, IL.
- Serrell, B. (1994). Messages from "Messages." *Current Trends in Audience Research*, 8, 54-56.

Other Field Museum exhibitions with dioramas:

The following studies are summative evaluations of other Field Museum exhibitions with dioramas:

- Hayward, J. (1990). *Summative evaluation of Traveling the Pacific, Phase I, Field Museum of Natural History*. Unpublished manuscript, The Field Museum, Chicago, IL.
- Hayward, J. (1994). *Evaluation of the Africa exhibit: An enlightening interpretive experience for a wide range of visitors*. Unpublished manuscript, The Field Museum, Chicago, IL.
- Hayward, J., & Hart, J. (1996). *Summative evaluation of the Life Over Time exhibit at The Field Museum*. Unpublished manuscript, The Field Museum, Chicago, IL.
- Hayward, J., & Hart, J. (1997). *Visitors' recollections of Life Over Time several months later*. Unpublished manuscript, The Field Museum, Chicago, IL.
- Schaefer, J., Perry, D. L., & Gyllenhaal, E. D. (2002). *Underground Adventure: Summative/remedial evaluation*. Unpublished manuscript, The Field Museum, Chicago, IL.

Milwaukee Public Museum, Milwaukee, Wisconsin

Prior to renovation:

Korenic, M. S. (1996). Visitor use and understanding of selected dioramas at the Milwaukee Public Museum. *Current Trends in Audience Research*, 10, 34-39.

Before and after adding additional elements to a habitat diorama:

Korenic, M. S. (1995). *The visitor and the diorama at the Milwaukee Public Museum*. Milwaukee, WI: Milwaukee Public Museum.

Rainforest exhibition that includes dioramas:

Young, A. M. (1989). The rain forest in Milwaukee. *Curator*, 32(3), 229-244.

Korenic, M., & Young, A. (1990). "Rain Forest: Exploring Life on Earth" exhibit. *Current Trends in Audience Research*, 4, 21.

Korenic, M. S., & Young, A. M. (1991). The rain forest in Milwaukee: An evaluation. *Curator*, 34(2), 144-160.

Fossil and geology exhibition that includes dioramas:

Korn, R. (2002). *Exploring Life on Earth: Summative evaluation*. Milwaukee Public Museum. Retrieved January 13, 2010, from the World Wide Web: http://informalscience.org/evaluations/report_49.pdf

Museum of Science, Boston, Massachusetts

These studies were completed after renovations of a hall with dioramas of New England habitats.

Anonymous. (1997). *Betty Davidson: Making Exhibits Accessible*. Association of Science and Technology Centers. Retrieved January 9, 2010, from the World Wide Web:

<http://www.astc.org/resource/access/btscenes/betty.htm> (Interview with the lead developer of the renovations.)

Davidson, B. (1991). *New dimensions for traditional dioramas: Multisensory additions for access, interest and learning*. Boston: Museum of Science.

Davidson, B., Heald, C. L., & Hein, G. L. (1991). Increased exhibit accessibility through multisensory interaction. *Curator*, 34(4), 273-290.

Davidson, B., Heald, C. L., & Hein, G. L. (1994). Increased exhibit accessibility through multisensory interaction. In E. Hooper-Greenhill (Ed.), *The educational role of museums* (pp. 179-194). London: Routledge. [This is a reprint of the *Curator* article.]

Natural History Museum of Los Angeles County, Los Angeles, California

Testing prototype labels in a gallery with African dioramas.

Olds, J. P. (2000). Assessing new label prototypes in an African mammal hall. *Current Trends in Audience Research*, 13, 29-40.

Olds, J. P. (2000). Assessing new label prototypes in an African mammal hall. *Conference Abstracts: Visitor Studies Association 2000*, 24-25.

National Museum of Natural History (Smithsonian), Washington, DC

Kenneth E. Behring Family Hall of Mammals. (This renovation removed old habitat dioramas, replacing them with mammal mounts, interactives, multimedia, and revised labels.)

Studies of the old Hall of Mammals as planning for the new exhibition:

Institutional Studies Office. (1999). *Examining mammals: Three studies of visitor responses to the Hall of Mammals at the National Museum of Natural History*. Smithsonian Institution. Retrieved February 11, 2010, from the World Wide Web: <http://www.si.edu/opanda/Reports/Earlier/99-5-Mammals.pdf>

Summative evaluation of new exhibition:

Office of Policy and Analysis. (2005). *Visitor Responses and Behaviors in the Kenneth E. Behring Family Hall of Mammals*. Smithsonian Institution. Retrieved January 8, 2010, from the World Wide Web: <http://www.si.edu/opanda/Reports/Reports/MammalsReport.pdf>

Site visit and gallery review by National Park Service staff:

Guiney, D. (2004). *Mammal Hall Study Report*. Kenneth E. Behring Family Hall of Mammals. National Park Service, Harpers Ferry Center Interpretive Media Institute. Retrieved January 8, 2010, from the World Wide Web: <http://www.nps.gov/hfc/products/imi/imi-mammal-hall.htm#>

Oakland Museum of California, Oakland, California

All studies are front-end evaluations completed in preparation for renovating the Natural Sciences Gallery into *Hotspot California*.

Garibay Group (2008). *OMCA Front-end evaluation family interviews results brief*. Unpublished manuscript, Oakland Museum of California, Oakland, CA.

Garibay Group (2008). *Oakland Museum of California Natural Sciences Gallery exit survey analysis*. Unpublished manuscript, Oakland Museum of California, Oakland, CA.

Neitzel, D. (2003). *Mountain Lion case front end summary*. Unpublished manuscript, Oakland Museum of California, Oakland, CA.

Neitzel, D. (2003). *Borderline case front end summary*. Unpublished manuscript, Oakland Museum of California, Oakland, CA.

Diorama-based Exhibitions as Research Sites

Note that some of these studies also included renovations to the exhibitions or research in new dioramas.

Anniston Museum of Natural History, Anniston, Alabama

Bitgood, S. (1990). *The role of simulated immersion in exhibition* (Tech. Rep. No. 90-20). Jacksonville, AL: Center for Social Design. (Includes several published papers by Bitgood and collaborators, plus some otherwise unpublished material.)

California Academy of Sciences, San Francisco, California, Natural History Museum of Los Angeles County, Los Angeles, California, and other museums in California

Ash, D. (2002). Negotiations of thematic conversations about biology. In G. Leinhardt & K. Crowley & K. Knutson (Eds.), *Learning conversations in museums* (pp. 357-400). Mahwah, NJ: Lawrence Erlbaum Associates.

Ash, D. (2003). Dialogic inquiry and biological themes and principles: Implications for exhibit design. *Journal of Museum Education*, 28(1), 8-13.

Ash, D. (2003). Dialogic inquiry in life science conversations of family groups in museums. *Journal of Research in Science Teaching*, 40(2), 138-162.

Ash, D. (2004). Reflective scientific sense-making dialogue in two languages: The science in the dialogue and the dialogue in the science. *Science Education*, 88, 855-884.

Ash, D. (2004). How families use questions at dioramas: Ideas for exhibit design. *Curator*, 47(1), 84-100.

Denver Museum of Nature and Science, Denver, Colorado

This is a study of a program using live costumed interpreters in diorama halls.

Tinworth, K. (2009). Creating a unique visitor experience through enactors. *International Council of Museums Natural History Committee Newsletter*, 29, 21-25.

http://curis.ku.dk/ws/fbspretrieve/16305246/ICOM_newsletter.pdf

Milwaukee Public Museum, Milwaukee, Wisconsin

Litwak, J. M. (1996). Using questions as titles on museum exhibit labels to direct visitor attention and increase learning. University of Minnesota.

Litwak, J. M. (1996). Visitors learn more from labels that ask questions. *Current Trends in Audience Research and Evaluation*, 10, 40-50.

Litwak, J. M. (1996). Using questions as titles on museum exhibit labels to direct visitor attention and increase learning. *Visitor Behavior*, 11(2), 20.

Milwaukee Public Museum Rainforest exhibition:

Vance, C. L., & Schroeder, D. A. (1992). Matching visitor learning style with exhibit type: Implications for learning in informal settings. *Visitor studies: Theory, research and practice: Collected papers from the 1991 Visitor Studies Conference*, 4, 185-200.

Natural History Museum, London, United Kingdom

African dioramas in the Rowland Ward Pavilion (dismantled in 2004).

Tunncliffe, S. D. (2009). Inquiry at natural history dioramas—useful resource in science education.

International Council of Museums Natural History Committee Newsletter, 29, 16-20.

http://curis.ku.dk/ws/fbspretrieve/16305246/ICOM_newsletter.pdf

National Museum of Natural History, Malta

Borg, J. J. (2009). Dioramas—an untapped educational resource. *International Council of Museums*

Natural History Committee Newsletter, 29, 5-6.

http://curis.ku.dk/ws/fbspretrieve/16305246/ICOM_newsletter.pdf

National Museum of Scotland, Edinburgh

Tunncliffe, S. D. (2005). What do dioramas tell visitors? A Study of the history of wildlife diorama at the

Museum of Scotland. *Current Trends in Audience Research and Evaluation*, 18, 23-31.

Royal British Columbia Museum, Victoria, British Columbia, Canada

These studies included experimental manipulations of the *Living Land Living Sea* exhibition.

Peart, B. (1984). Impact of exhibit type on knowledge gain, attitudes, and behavior. *Curator*, 27(3), 220-237.

Peart, B., & Kool, R. (1988). Analysis of a natural history exhibit: Are dioramas the answer? *The*

International Journal of Museum Management and Curatorship, 7, 117-128.

Science Museum of Minnesota, St. Paul, Minnesota

Study in the anthropology hall, which included dioramas.

Cone, C. A., & Kendall, K. (1978). Space, time and family interactions: Visitor behavior at the Science

Museum of Minnesota. *Curator*, 21(3), 245-258.

Senckenberg Museum, Frankfurt, Germany & Vonderau Museum, Fulda, Germany

Scheersoi, A. (2009). Biological interest development at natural history dioramas. *International Council of*

Museums Natural History Committee Newsletter, 29, 10-13.

http://curis.ku.dk/ws/fbspretrieve/16305246/ICOM_newsletter.pdf

Swedish Museum of Natural History, Stockholm

Piqueras, J., Hamza, K., & Edvall, S. (2008). The practical epistemologies in the museum: A study of

students' learning in encounters with dioramas. *Journal of Museum Education*, 33(2), 153-164.