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Article: Documenting the documenters: The conservation survey of the Akeley Hall of African Mammals

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## **DOCUMENTING THE DOCUMENTERS: THE CONSERVATION SURVEY OF THE AKELEY HALL OF AFRICAN MAMMALS**

Judith Levinson and Sari Uricheck

### **Abstract**

In 2002-3 the American Museum of Natural History undertook a conservation survey project to ascertain the condition of the 28 large dioramas and a group of eight mounted elephants in the Akeley Hall of African Mammals. The hall is the physical and iconic centerpiece of the American Museum. It is characterized by innovations in the production of museum exhibits, taxidermy and education that were largely made by Carl Akeley, after whom the hall is named. Results of the survey indicated that all specimens, wall paintings and foreground materials were very desiccated, largely the result of uncontrolled environmental conditions, especially high heat and UV illumination from the lighting. Other condition issues of the diorama specimens were caused by prior restoration. The mounted elephants were found to be in the worst condition due to being exhibited in the open. Recommendations for future renovation of the hall included environmental modification: replacing old light fixtures with more modern lighting technology and adding humidification to the HVAC system, in addition to treatment of the elephants.

### **1. Introduction**

The Akeley Hall of African Mammals is the centerpiece of the American Museum of Natural History, both literally and as an icon. It is located just beyond the grand entrance of the museum at the Roosevelt Rotunda and is comprised of two floors of exhibition space, which consists of 28 large dioramas and a central open platform with 8 mounted elephants (Fig. 1).



Figure 1. View of  
Akeley Hall of African  
Mammals.

Over 60 species of mammals and 15 species of birds are presented in numerous African habitats, including wetlands, deserts, mountains and rain forests from specific sites ranging from the volcano of Mt. Karisimbi to the Kalihari Desert. Although one of the oldest displays in the museum, it is still considered among its most important in terms of exhibition technique, museum education, artistic production and audience popularity. The purpose of the conservation survey was to investigate the hall's current condition with regard to the need for renovation to assure preservation for the future.

## 2. History of the Akeley Hall

The Akeley Hall is named in honor of its creator, Carl Akeley, inveterate naturalist, artist, taxidermist and inventor. Carl Akeley was a man ahead of his time. From humble beginnings as a lab preparator for Ward's Natural Science, Carl Akeley became the driving force behind one of the museum world's most ambitious and impressive exhibit halls. In describing his life-long dream, Akeley wrote:

The African Hall which I proposed to the AMNH is meant to record fast disappearing phenomena and put in permanent and artistic form a complete hall of exhibits of animals in the best manner known to museum technique...(it would) preserve a unique record of Africa but also it would establish a unique and new record in taxidermy and the associated arts. (Akeley, C.E. 1920, 194)

Akeley led several expeditions to Africa between the years 1905-26. As with other scientific expeditions of the day, he brought painters with him to record the landscapes and included teams of artists and scientists to collect samples and data on flora and fauna (Fig. 2).



Figure 2. Photograph taken by Carl Akeley of painters documenting landscape for Klipspringer Diorama. Courtesy of AMNH Library.



Figure 3. Completed Klipspringer Diorama in Akeley Hall.

Akeley invented new camera equipment, for which he holds numerous patents, to accurately record the natural phenomena he witnessed and which he was convinced were rapidly disappearing. With a comprehensive vision of the final product, Akeley seemed to plan every detail of hall construction from structural dimensions, electrical layouts, exact measurements of canvas backgrounds and environmental specifications for exhibit preservation – all with the audience's experience in mind (Fig. 3).

The museum's board of directors approved Akeley's African Hall proposal in 1912 and work began in 1914. In a publication from 1936, the author states that

"In no other museum have whole halls been planned and carried out as a unit. Even while carpenters, iron workers, and masons are constructing the cases, an artist is at work painting a background. Every available preparator is at work on some part of a group. (Clark 1936; 80)

Production continued slowly through the Depression, and the death of Akeley himself in 1926. The first stage of the Hall opened in 1936. By 1942 the entire hall was open, with few compromises to Akeley's original plan, as specified in his earliest descriptions and letters in the museum archives. An army of artists and craftsmen, including the highly regarded naturalist artists William R. Leigh, James Clark and James Perry Wilson, had contributed their efforts toward realizing Akeley's vision (Fig. 4).



Figure 4. Work in process: construction in Akeley Hall. Courtesy of AMNH Library.

### 3. Construction and technical aspects of the dioramas

The diorama enclosure designed by Akeley was a concave enclosure constructed from vertical angle iron beams and heavy wire mesh as support, built up with layers of plaster and then canvas with lead white primer to the surface. The front face of the diorama consists of a large glass panel that is tilted slightly so the viewer sees no reflection. A light box with fixtures for interior illumination is located above the concave enclosure. Access to the light attic is achieved via catwalks into them on the first floor of the hall and by removing decorative bronze panels above the glass fronts on the second floor, which has a lower ceiling height (Fig. 5).

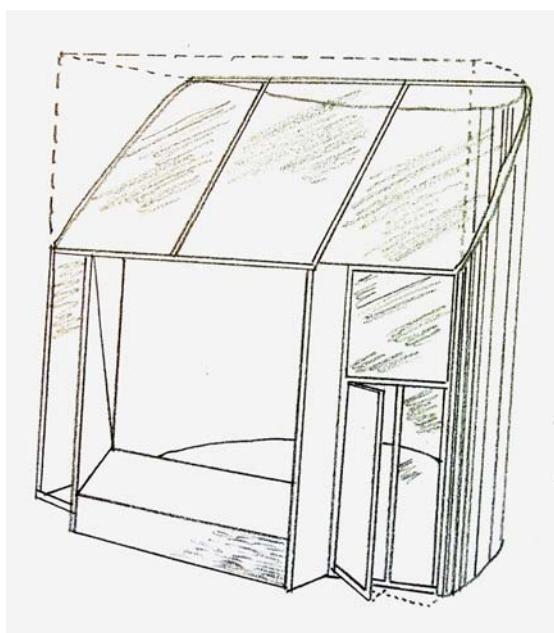


Figure 5. Illustration of Akeley diorama design. Drawing by J. Levinson, after Jacques 1931: 10, Fig. C.

The diorama is a relatively well-sealed concave shell whose shape is the secret of its successful illusion. It is an enveloping panorama with no seams or corners; the three dimensional elements blend smoothly into the 2-dimensional scene (Fig. 6).



Figure 6. An example of blending foreground elements into the painted background, from Upper Nile Region Diorama.

The painted backgrounds were meticulously distorted by arithmetic convention, so as to play with the viewer's perspective, drawing the observer into the scene. Using field notes, sketches and models, artists including Robert Perry Wilson and James Clark, made innovations to the process of diorama background painting of the day that lend these exhibits their realistic, atmospheric genius (Fig. 7).



Figure 7. Photograph of James Clark with model for Lion Diorama. Courtesy of AMNH Library.

#### 4. Taxidermy and foreground techniques

While the painted backgrounds were innovative, the taxidermy of the specimens was the most revolutionary aspect of the Akeley diorama ensemble. Building on his early experience, Carl Akeley developed a new taxidermy process, changing it from a crude process to a precise sculptural technique. The goal of his method was to record and recreate the animal form with the greatest and most dramatic accuracy.

As a young man, Akeley gained experience at Ward's Natural Science Establishment where, among other projects, he helped prepare the Barnum Circus' original 'Jumbo' exhibit. This experience led him to question the accepted mounting procedures of the nineteenth century. Instead of the standard taxidermy method, which to him created lifeless forms by "filling a raw skin with greasy bones of the legs and skull and stuffing the body out with straw, excelsior, old rags, and the like" (Akeley, C.E. 1920, 188), Akeley created an accurately modeled animal body and tightly fit the tanned skins over it. The over-riding significance of Akeley's innovations to the taxidermy process is that he developed an art form objective and accurate enough to be used in scientific presentations. (Quinn 2005)

For mounting specimens with fur using the Akeley method, an exact replica of the animal, based on measurements and casts made in the field, is modeled in clay (Fig. 8). A plaster mold is then made from the clay model and a thin paper mache replica is formed inside the mold. The paper mache figure is supported on its interior with burlap, wire mesh and wood ribs and then the tanned skin is applied to the outside of the paper mache replica (Fig. 9). This hollow, light-weight mount attains a life-like appearance that results from the high degree of accuracy transmitted throughout the entire process.

The process Akeley developed for elephants, as well as for rhinoceros and hippopotamus, was slightly different and could only be used on hairless animals. The tanned, thinned elephant skin was modeled and shaped onto the accurate, sculpted clay model whose dimensions, again, were based on measurements and casts made in the field.

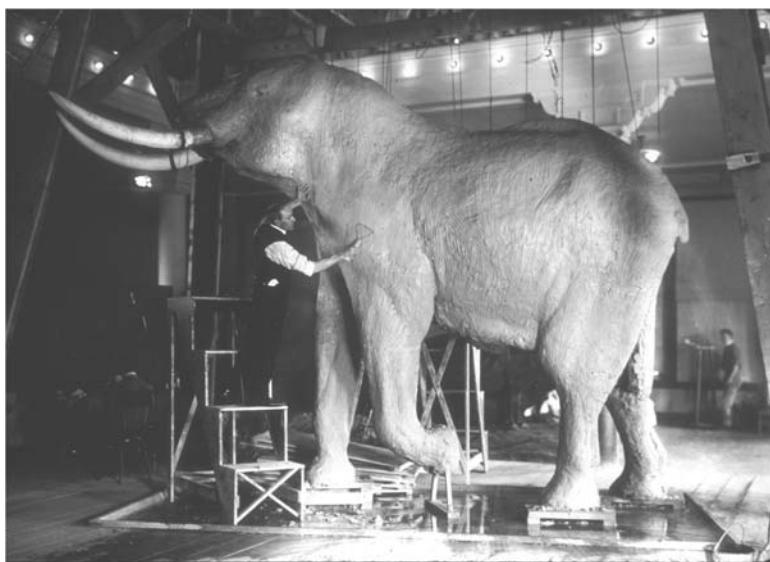


Figure 8. Photograph of Carl Akeley sculpting elephant model in clay. Courtesy of AMNH Library.



Figure 9. Image of pulling elephant skin over sculpted model, taken from film of mounting Asian elephant. Courtesy of AMNH Library.

A plaster jacket was applied directly onto the elephant's skin (this process can only be used on hairless specimens). After the plaster mold had dried, it was split in half laterally and the clay was removed from the inside. The skin was reinforced on the interior with layers of wire mesh, hardware cloth, mache mixture and wood. The outer jacket was then scraped off with wire brushes and the resulting thin but strong halves of the elephant's body, as well as the head (which had been prepared in the same manner), were joined together from the inside around a new wood and steel armature (Quinn 2005).

While known for the "Akeley method" of taxidermy, Carl Akeley's vision was to bring the same high level of innovation to the environmental aspects of the diorama. To accomplish this, artists accompanied the field expeditions to collect floral and faunal specimens. They made corresponding sketches and models of the landscapes they encountered. Small-scale dioramas made on site are recorded in photographs of expeditions. Their three-dimensional elements are made from wood, wire and plaster, the same core components as were ultimately used in the Akeley Hall dioramas. The most ground-breaking aspect of this approach was the combination of natural and fabricated elements and the high degree of realism achieved (Fig. 10).

The technology of creating imitation plants was just being mastered during the production of the Akeley Hall. Natural collected elements from the field, such as grasses and moss preserved by soaking in glycerine, soil, and tree branches, were combined with fabricated specimens using combinations of painted cast wax, paper, plaster, paper mache and metal sheeting. Molds of leaves, flowers, rocks, bark and tree trunks taken on site were utilized to create the fabricated foreground materials. In situ drawings and paintings helped to insure color accuracy (Fig. 11).



Figure 10. Image of deck construction of foreground in Upper Nile Region Diorama.



Figure 11. Photograph of a step in leaf fabrication process. Courtesy of AMNH Library.

## 5. The survey process

The broad nature of the materials in the dioramas and the complex environments within the hall demanded various types of expertise to evaluate them. Given the magnitude of this conservation survey project in terms of its goals – to be as comprehensive and holistic as possible – and the large number of participants, an efficient methodology and clear organization were required. Procedurally, standard art conservation survey protocols were applied to assess exhibits previously viewed as expendable educational or exhibit materials. The numerous dioramas and specimens and the complex nature of this particular exhibit hall makes exhaustive reporting of all the elements of the survey beyond the scope of this paper. It should be read as an outline of what were considered the most important elements that ought to be included in a survey of this type.

The goal of the survey was to examine the condition of all the specimens, background paintings and foreground materials to gain as full an understanding of the environment within the dioramas and the hall as possible, given time and financial limitations. The dioramas had never been systematically assessed, but there were at least two previous cleaning and restoration campaigns. These took place in the 1960's and the first half of the 1980's. Documentation of prior condition and the work undertaken was not carried out for either effort.

The most recent conservation survey, funded by the Getty Grant Office, took place over the course of 18 months in 2002-3. An initial period was dedicated to preliminary research and planning, which was followed by three phases for active surveying. A fourth phase of several months, consisting of performing additional scientific analyses, gathering of cost assessments and planning for future implementation, was added to the project at the end.

The research and planning phase involved searching through the museum's archives for background information about materials, methods, personnel and landmark dates. Photographs, films, personal correspondence of Akeley and other museum personnel regarding trips, finances, aesthetic goals, etc. were gleaned from these sources, and lastly, resources were focused on planning and executing the survey.

Before embarking on the enormous task of surveying every specimen and piece of foreground material, a system for labeling and recording was developed, which included devising detailed condition forms and making diagrams of cases with specimen identification systems. A system for labeling and recording was developed for each diorama and this specimen identification system was integrated into a central database (Fig. 12).

A FileMaker Pro/Access convertible database was designed to collect all the data regarding the foreground materials. Tick mark condition forms simplified data collection and allowed for additional non-conservation staff to contribute/aid in the survey (Fig. 13). The relational aspect of the database allowed for the background and archival information to be merged with the generated condition notes. The outside consultants came with their own forms for collecting information, although ideally, their data would have been merged into the central database file.

The survey process had to be accomplished in stages in order to schedule around a number of special events for which the hall had been long committed. Barriers were built in front of runs of contiguous dioramas to provide a secure work environment and behind which survey materials could be stored. The staggered scheduling ensured that no more than 1/4 of the hall was closed to the public at any one time.

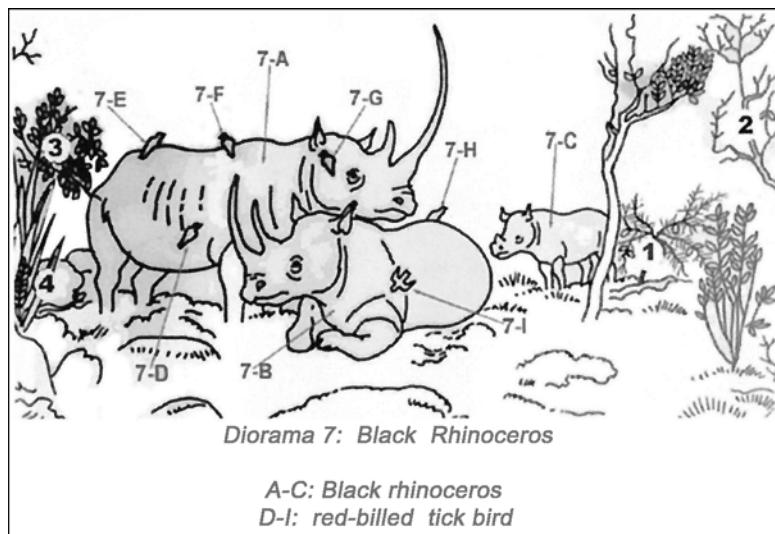


Figure 12. Annotated drawing with species and plant identification system from Black Rhinoceros Diorama.

diorama leopard/bush pigs			
foreground elements			
<input type="checkbox"/> ground	<input type="checkbox"/> tree	<input type="checkbox"/> fruit	<input type="checkbox"/> sticks
<input type="checkbox"/> rock	<input type="checkbox"/> shrub	<input type="checkbox"/> water	<input type="checkbox"/> vines
<input type="checkbox"/> dirt	<input type="checkbox"/> grass	<input type="checkbox"/> termite hill	<input type="checkbox"/> moss
<input type="checkbox"/> real plant matter	<input type="checkbox"/> painted surface	<input type="checkbox"/> wax	<input type="checkbox"/> bark
<input type="checkbox"/> real dirt	<input type="checkbox"/> plaster	<input type="checkbox"/> paper	<input type="checkbox"/> flower
<input type="checkbox"/> wire <input type="checkbox"/> wire			
<input type="checkbox"/> cotton/ fiber <input type="checkbox"/> cellulose acetate <input type="checkbox"/> misc. props			
<input type="checkbox"/> cast resin <input type="checkbox"/> Other...			
(natural)			
DRIED LEAVES			
(natural)			
FLAKING TAGS on edges			
#	common name	description/manufacture	condition
1	Lion's ear (Orange flower plant)	NATURAL BRANCHES -STEMS? FABRICATED? LEAVES? CENTER - PAPER?	GOOD ✓ 1 - LEAF HAS SOME PAINT (Orange - brown, red) 1 - LEAF - THE LEAF IS WEAK, THIN, FOLLY (Orange - red) 1 - LEAF - WHITE, NATURAL, FOLLY (Orange - red)
2	gladiola	PAINTED PAPER FLOWERS STEM - PAINTED WAX/PLASTIC? LEAVES - PAINTED PAPER?	GOOD - MINOR PAINT PEELING → MINOR PAINT PEELING
3	torch flower (red-hot poker)	PAINTED WAX w/ PAPER LEAVES AT - BASE OF LEAVES - WOOD? STEMS - PAINTED WAX/PLASTIC	GOOD CONDITION NETT # 1 - MIN. PAINT HAS HIDDEN TOP, INCL. LEAVES NETT # 1 - MIN. PAINT HAS HIDDEN TOP, INCL. LEAVES NETT # 1 - MIN. PAINT HAS HIDDEN TOP, INCL. LEAVES
4	myrtle	PAINTED NATURAL BRANCHES THIN STEM (PAINTED)	GOOD ✓ SOME SMALL LEAVES SEEM TO BE DRY NATURAL (Brown) OTHER (GUM) COULD BE PAINTED ON MODEL (PAPER) ON CONDITION - GOOD COND. ✓ SOME AREA'S - SOME
5	PAINTED PAPER (WAX?) LEAVES vine on tree	PAINTED NATURAL DRIED NATURAL PAINTED VINES WAX? LEAVES w/ WAX & WATER PAPER	VERY WAXY, DISSECTED → GOOD ✓ * - 1 SMALL VINE ON 1ST STEM - DISSECTED FROM STEM - 1 SMALL VINE ON 1ST STEM - DISSECTED FROM
6	fem. orange flower - natural double known branch/stock bed	WAX BRANCHES PAINTED WAX / PAPER LEAVES	GOOD ✓ - SOME LEAVES BENDING OUT OF POSITION WHILE LEAVES ARE DROOPY - SOME ARE GLOSSY
7	mushrooms (on left)	CAST WAX & PAINTED ON SURFACE	GOOD - ATTACHMENT TO BANK IS DISCOLORED AND GLOSSY (glue)
8	log (in foreground)	PLASTER/MACHE? WAX MESH W/ NATURAL BARK/WOOD PAINTED NATURAL MESH COVERED	GOOD COND. ✓ BANK SEEMS STABLE + PAINTED WAX? PAPER LEAVES - GOOD ✓
9	plant w/green and orange leaves 4 groups	COTTON WAX/PLASTIC LEAVES PAINTED NATURAL BRANCHES & STEMS	1 - BACKED STEM/LEAVES - NEEDS ATTACHMENT LEAVES STICKED ON BACK STems w/ WAX
10	grass	DRY, NATURAL, SOME PAINTED	VERY DRY BUT PRETTY GOOD SPLATTERED PAINT ON SURFACE TO INTEGRATE? **CRACKS IN THE BANK (in back)

Figure 13. Survey condition form for foreground materials, in process.

To carry out the survey, close examination of specimens was essential. Among the greatest challenges of this project was the difficulty of reaching the materials in the diorama interiors without causing damage to them. Walkways had to be custom built to provide adequate access to examine specimens and wall-paintings, while avoiding grasses, bushes and other fragile groundcover and over-hanging vegetation (Fig. 14). This was accomplished with the careful work of the Exhibition Department preparators, who utilized lightweight “Bronco” sawhorses [1] with padded feet, as support for plywood walkways.



Figure 14. Walkway for access to specimens in Water Hole Diorama.

## 6. Environmental testing

Dioramas, because of the individual lighting and the specimens contained within, are unique environments; however, like the collection of galleries in any individual museum, they share numerous characteristics, both chemically and thermally. To understand the dynamics of these factors, selective testing was carried out to detail air and particulate quality within the dioramas, particularly to determine the level of protection needed for those working in them.

Air sampling for volatile organic compounds was conducted before opening the cases in order to ascertain whether, in the relatively tightly sealed enclosures, there had been a build-up of substances related to prior insect eradication techniques or preparation methods. After removing the diorama fronts, wipe samples were taken of the dust build-up on specimens and foreground materials, again to detect residues of insect control materials such as arsenic or mercuric chloride, and of asbestos, which was commonly utilized in the fabrication of certain foreground materials [2], which were also directly sampled for analysis.

Although the level of VOC's detected from air sampling was far below OSHA standards, numerous substances such as xylenes, trimethyl benzene, toluene and acetone were detected from the air sampling, presumably the residues of preparation and prior cleaning techniques. Arsenic had almost certainly been used on the skins in the field and during preparation and, indeed, low levels of arsenic as well as lead were detected. Asbestos was routinely utilized in the museum, for example in maché mixtures for the fabrication of diorama floors and sculpted elements such as rocks. Although expected to be present, asbestos was not detected in the circulating air, settled dust or maché samples.

Gaining an understanding of the interplay between the diorama lighting, ambient temperature and relative humidity was a critical part of the investigation. Their relationships proved to be interesting, given the relatively tightly sealed environments. Prior to the survey, data loggers had been placed in the diorama interiors and light boxes to record temperature and relative humidity. This information provided critical background for our specialists in all areas. It became clear that the key to preserving these exhibits would likely involve major modification of the equipment that controls these fundamental components.

One indication of Akeley's prescient forethought in planning the hall relates to his specifications about the environment in order to promote preservation. Letters in the archives document his desire to keep the hall at 60 degF. After his death, over great objections by Akeley's wife, heaters were added to protect the exterior walls behind the dioramas from 'sweating' and deteriorating (Faunce 1931, July 17). She wrote that Akeley expected there to be a ventilation system within the light boxes to dissipate the heat, thereby preventing condensation within the walls (Akeley, M. 1931, July 22). This ingenious ventilation system was not provided and, as a result, the lighting contributes greatly to the heat buildup found within the dioramas.

As might be expected, internal temperature in the dioramas was quite high year-round. It frequently exceeded 80 degF, particularly in those dioramas whose scenes depict locales in full daylight. Seasonal fluctuation in relative humidity mirrored that seen in other non-climate controlled parts of the museum and ranged from below 20% to about 65%. There were additional daily fluctuations in both temperature and relative humidity from turning off the diorama lighting at night. It was obvious from the data logger results that the lighting was the cause of both the high heat loads and environmental cycling.

Consideration of the diorama lighting became one of the more interesting and challenging aspects of the project because changes to enhance preservation would require innovation. The lighting scheme for these dioramas was, from the beginning, considered integral to the interpretation of the habitat, supporting the overall atmosphere of the original location, including time of day, season and weather variations. During the original planning Akeley specified that incandescent spotlights and floodlights be utilized to simulate natural light. Frances Jacques, one of the museum's background painters, stated that 'modern electric light is yellow and insufficient in comparison with daylight' (Jacques 1931, 9). Letters in the archives indicate that there was considerable confusion and lack of decision about the type of lights to illuminate both the dioramas and the hall itself. Ultimately, incandescent spots and floods with specially made reflectors were utilized.

These fixtures, however, were recognized soon after installation to be problematic. They produced too much heat, leading to cracking of glass in the light boxes and to fading of specimens. Combining the incandescent fixtures with newly invented fluorescent lighting was done soon after the hall opened, probably in 1945. The fluorescent lights were thought to simulate the reflected blue of the sky. The wavelengths provided by the incandescent fixtures were thought to simulate the warm tones provided by sunlight. The same lighting scheme exists today, as a combination of linear fluorescent fixtures to wash the center of the diorama, augmented by incandescent R lamps and tungsten halogen PAR lamps, all sources of either high heat, infrared and/or ultraviolet illumination. Filtering to remove ultraviolet emissions from the lighting sources was not provided.

Because lighting is fundamental to the visual perception of each group, the project participants considered it important to document the current layout of the lights, as well as the amount of illumination and the direction of illumination of each fixture (Fig. 15). These diagrams would serve as models for any new lighting scheme. Light level readings on each specimen were also documented and, in spite of the high heat load, current actual light levels were surprisingly low, seldom exceeding 20 foot candles and, frequently as low as 3 or 4 foot candles of illumination.

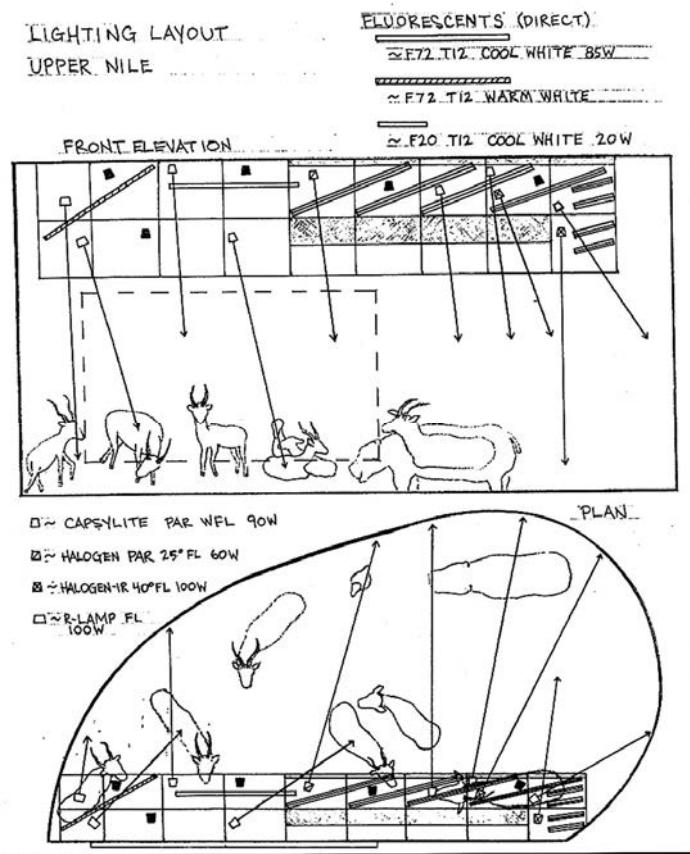


Figure 15. Diagram of current lighting scheme in Upper Nile Region Diorama, indicating type of fixture and direction of illumination.

## 7. Survey results: Specimens, wall paintings and foreground materials

Several generalizations can be made about the condition of the specimens, wall paintings and foreground materials within the dioramas. All are in relatively good condition, though uniformly quite desiccated. Damage from the environment has been far less catastrophic than expected. A thin layer of dust covers original surfaces, but this has an almost negligible effect on the viewer's experience.

Damage to animal specimens was found to be minor, except in the case of the elephants. Early treatments to eradicate pests in the preparation of the skins appear to have been effective in protecting most of them for the last 75 years. Little insect damage was observed and no active infestations have occurred in at least 20 years. Only a limited number of specimens, such as the hippo in the Upper Nile diorama, exhibited extreme damage, such as massive cracking through the skin (Fig. 16). These cracks were exacerbated by subsequent attempts at repair and restoration, which was frequently found to be the main source of current condition issues.



Figure 16. Cracked skin of hippopotamus in Upper Nile Region Diorama.

Ultraviolet illumination was used to help sort out and distinguish original materials from those used during undocumented restorations. Both original materials and materials used during prior restoration (which included waxes and oils, paints, natural and synthetic resins), seemed to have fared poorly and become unstable as they aged. For instance, fills to damages in skins or fills around noses, horns and other features applied during either original taxidermy or as later restoration were found to be dry, chipping and shrunken (Fig. 17). During restoration many of these fills, as well as furs in some cases, were over-painted, and the various applications can frequently be distinguished. Some specimens have a layer of now-insoluble resin applied to make them appear more glossy or wet, such as on rocks and the noses of animals.



Figure 17. Cracks and loss of fill around horn in White Rhinoceros Diorama.

Slight fading of furs was documented in numerous specimens, but more often than not the fading is uniform. This level of damage is generally perceived to be an acceptable result of aging. One exception to this generalization is seen on the zebra skins in the Waterhole Diorama, where more obvious pattern fading has occurred due to the overly bright, unfiltered light. Comparison of the tone of the now-brown zebras with the wall painting behind them, as well as comparison of the upper surfaces of the skins with the shadowed undersides, fairly indicates the degree of fading.

The background paintings were similarly desiccated and on the surface of paintings with high stipple, such as that painted by Robert W. Kane in the Wild Hunting Dogs case, a very fine crystalline layer could be seen as a glistening in raking light. These crystals were sampled and analyzed and are hypothesized to be deterioration products of oil paint [3]. Their presence is thought to be the result of the overly wet cleaning that took place during the 1980's treatment, as described by a preparator who was present (Quinn 2005; Schwartzman 1985). The components of deterioration were probably solubilized and then drawn to the surface as efflorescence as the diorama environment dried out.

A minimum of structural instability, such as cracking in the substrate or unstable paint layers, was seen in the paintings. There has been little previous restoration, but where it appears to have occurred, it creates visual confusion.

Similar to the other elements within the dioramas, the foreground materials were desiccated. As was to be expected, natural grasses and moss were highly brittle, easily breaking upon contact. Their colors were faded, often over painted during prior restoration and their appearance is now dulled by dust accumulation. Fabricated leaves exhibited minor distortion from aging. Some of the wax/cotton leaves were drooping and plastic leaves were curling (as do cellulose acetate leaves formed using early fabrication methods; Fig. 18). Given the deleterious environment, however, these materials seemed to have fared remarkably well.



Figure 18. Curling leaves in Mandrill case.

Unfortunately, the condition of the elephants was found to be poor compared with those specimens buffered from the effects of the environment within the diorama enclosures. The effect of uncontrolled ambient environment is clear. Some of the tusks are cracked, the skin has advanced red rot and large areas of skin on the ears are very unstable (Figs. 19-21). Additionally, enormous dust-bunnies generated by fibers shed from visitors' clothing necessitate twice-yearly vacuuming, which can contribute to mechanical wear and damage.



Figure 19. Red rot on elephant's leg in mounted elephant group.



Figure 20: Deteriorated skin on elephant ear mounted by Akeley.



Figure 21. Loss along edge of baby elephant's ear in mounted elephant group.

The mounted elephants provided the only clear example of structural damage observed during the survey, providing an interesting study within the study. Cracking is present at the join of the tops of ears to skulls in four of the elephants, those that were mounted by William Rockwell, a follower of Akeley's. In order to investigate the cracking, in-situ digital radiography of the ears mounted by both Akeley and Rockwell was performed, comparing them for differences in technique and, hence, in condition [4]. A handheld x-ray tube and an x-ray receptive plate were rigged on a variety of lifts to achieve access to the tops of skull and ears (Figs. 22, 23).

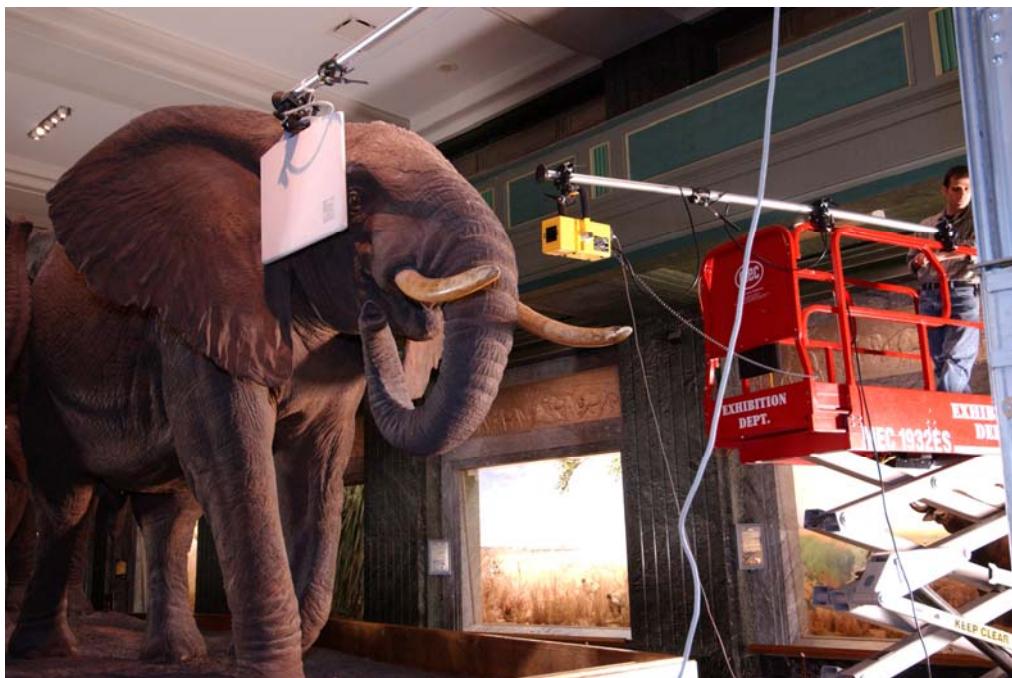


Figure 22. Digital X-radiography in progress.



Figure 23. Digital X-radiography in process – x-ray image of internal mounting of ear seen on computer screen.

It was found that the Rockwell ears were mounted using a heavy wire mesh screen on the back surface of the ears, while Akeley utilized a finer mesh that was inserted between split layers of the skin. Also differing from Akeley's well-integrated mounting scheme, Rockwell utilized a heavy iron rod for help with shaping and the rod was not tied into the internal armature within the skull. The cracking of the skin seen on the surface of the Rockwell heads was clearly the result of the skin separating due to gravity pulling down the weighty, cantilevered ears.

## 8. Recommendations

The final process of the conservation survey was to develop a plan for long-term preservation of the hall. Since the majority of specimens, wall paintings and foregrounds were not severely damaged, plans for treating these specific elements were relegated to the final phase of a future renovation. Most of the deterioration was caused by environmental conditions; hence, the most critical measures to bring about improvement consist of modifications to the HVAC and lighting systems. The challenge in implementing these changes is to create a balance between long-term preservation and preservation of the original intent of the dioramas (which included dramatic lighting effects), given the commercially available lighting options and feasible physical and financial modifications to the HVAC infrastructure.

Concerning the HVAC, the provision of humidification was an easy recommendation, as the current system, installed in 1995, provided only air-conditioning for human comfort.

During the survey, air infiltration tests were performed [5] in order to investigate the extent of supplementary duct-work that might be required to bring conditioned air behind and above the dioramas. It was determined that with the provision of doors at all four entrances to the hall, little additional ductwork would be required and passive circulation of the fully conditioned air would flow behind, above and into the dioramas. Fans and vents supplied at each end of a run of dioramas would remove heat generated by the lighting.

For the lighting, the goal was to identify a combination of fixtures that would reduce the amount of heat generated, while maintaining flexibility in terms of spread, color temperature and level of illumination. Also important was the desire to identify longer lasting bulbs for economy and in response to the difficulty of accessing the light attics. As mentioned above, ventilation of the light boxes to further reduce heat build-up, as well as the provision of ultraviolet filters were also considered mandatory improvements.

The particular lighting scheme that proved to be successful was a combination of linear and compact fluorescent bulbs with high intensity discharge lamps. The fluorescent fixtures provided overall illumination within the diorama without changing the color temperature, and therefore the interpretation, of the painted scenes. The high intensity discharge lamps were used for spot illumination. The color temperature of the HIDs or metal halide fixtures approximates that of natural daylight and is much more efficient than incandescent or halogen light sources. Both of the light sources used have virtually no infrared component and are very economical in terms of output and power consumption, making them appropriate choices for long-term lighting of fragile museum specimens. Filtering of the relatively high levels of ultraviolet radiation emitted from these fixtures, as mentioned above, is necessary.

To ascertain the efficacy of this new lighting fixture combination, prototypes were made by re-lamping both a large, bright corner diorama and a smaller, shady diorama. Curators, exhibition designers and others were invited to view the prototypes. All agreed that the quality of lighting was actually better than in the present lighting scenario, as it brought out certain features of the specimens, such as the iridescent qualities in feathers, and it seemed to enhance the almost surreal sense of 'being there'. Furthermore, the heat load generated by the prototype lighting was reduced by more than 50%. The decision was made to upgrade the lighting in the dioramas following these models when renovation of the hall is undertaken.

## 8. Conclusion

The Akeley Hall project can be seen as a model for carrying out this type of large-scale documentation survey. Conservation proposals have been detailed and will be executed pending funding. Environmental modifications are to be undertaken first, as they will benefit long term preservation of all the exhibits, followed by treatment of the elephants. Treatment of the dioramas is not presently deemed as critical as that of the elephants because the minor dirt and damages barely result in aesthetic disruption.

The aesthetic and scientific wonders presented in this multi-faceted exhibit are a testament to Carl Akeley's far-reaching vision and technical ingenuity. The most appropriate way to honor his achievements is to implement the survey's recommendations to ensure the future preservation of the Akeley Hall of African Mammals (Fig. 24).



Figure 24. Overall view of Akeley Hall

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Project consultants included: Catharine Hawks, natural history conservator; Harriet Irgang, paintings conservator (Rustin Levenson Art Conservation Associates); Steven Weintraub, environmental conservator (Art Preservation Services); and Ernest Conrad (Landmark Facilities),

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### Endnotes

1. “Bronco” sawhorses are manufactured by Reechcraft, P.O. Box 2426, Fargo, N.D. 58102, 888-600-6160.
2. Sampling carried out by GCI Environmental Advisory, Inc.
3. Analysis performed by James Martin, Orion Analytical.
4. X-radiography performed by Eklin Medical, with support of Canon USA.
5. Air infiltration testing performed by Ambient Group.

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