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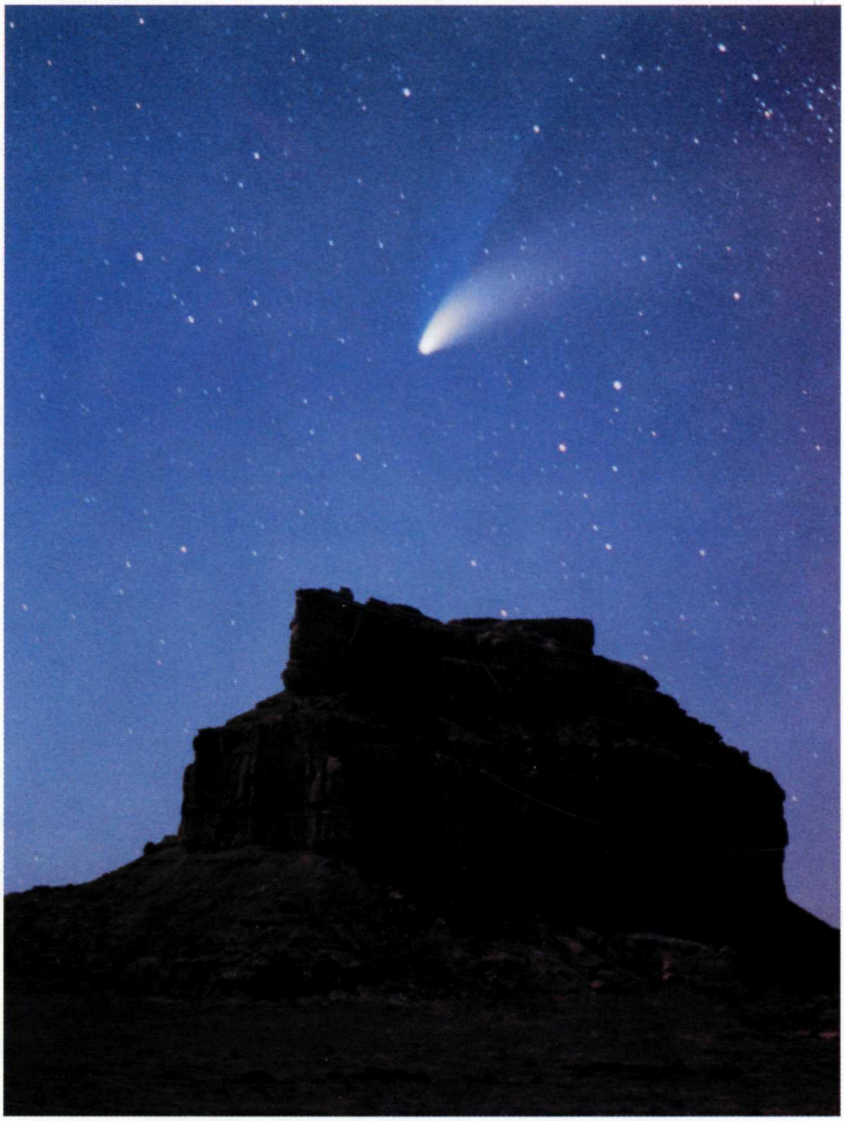

THE JOURNAL OF THE GEORGE WRIGHT SOCIETY

Dedicated to the Protection, Preservation and Management
of Cultural and Natural Parks and Reserves
Through Research and Education

The George Wright Society

Executive Office

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Volume 18 ❖ **2001** ❖ **Number 4**

On the Cover: Comet Hale-Bopp over Fajada Butte in Chaco Culture National Historical Park, by photographer Marko Kecman. The butte contains an ancient sun observatory. The "Chacoans" may have observed the solstices and equinoxes using the petroglyph known as "The Sun Dagger." Fajada Butte is closed to protect its fragile cultural sites from harmful impacts.

Society News, Notes & Mail

Missing Photo Credits from Last Issue

After publication of the last issue of THE GEORGE WRIGHT FORUM (Vol. 18, No. 3, on managing recreation use in parks), we received word that the photos in Myron F. Floyd's article, "Managing National Parks in a Multicultural Society: Searching for Common Ground," should have been credited to Nina S. Roberts, doctoral candidate at Colorado State University and research associate at Student Conservation Association. This includes the cover photo, showing a family of tourists at a mountain overlook. Our apologies to Ms. Roberts for failing to give her credit for these fine photographs.

2001 GWS Board Election Results

This fall's Board election proved to the closest in GWS history—so close, in fact, that the members of the Nominating Committee (who are in charge of tallying votes) felt compelled to do a recount to confirm the result. The final tally found the three candidates for the Board—Gillian Bowser, Abby Miller, and Rick Smith—separated by only a handful of votes, with Smith and Miller garnering the most. The result was so close that the Board unanimously decided to offer Bowser an appointed slot on the Board, which she has accepted. We are extremely pleased to be able to have all three of these well-qualified individuals on board to help guide the Society over the next triennium.

2001 GWS Conference Proceedings Published

By the time you read this, *Crossing Boundaries in Park Management: Proceedings of the 11th Conference on Research and Resource Management in Parks and on Public Lands,* will be hot off the press (and the CD burner, since it is also available as a series of PDF files on CD). This book is the record of the 2001 GWS biennial conference held last April in Denver. The volume has 71 papers from the conference covering a wide range of topics. Full-week and two-day registrants at the conference will receive a copy of the proceedings automatically. If you'd like to order a copy, here are your options:

- The paper edition (426 pp., softbound) is $20 postpaid to USA addresses; additional postage applies elsewhere.
- The CD edition is $10 postpaid to USA addresses; additional postage applies elsewhere. It will contain each chapter as an individual PDF file, as well as a PDF file of the entire book to facilitate keyword

searching using Adobe Acrobat Reader, the free software title required to view and print PDF files.

- As part of a new GWS publications policy, the entire book is available (chapter by chapter only) for free viewing or downloading as PDF files from the Society's Web site.

For complete ordering information, or to download or view files, go to http://www.georgewright.org and follow the appropriate links. You can order on-line using our secure payment form. You can also order by phone (1-906-487-9722) or fax (1-906-487-9405); be sure to include your credit card information (Visa, MasterCard, AMEX). All orders must be prepaid.

Revision of GWS Strategy Moving Ahead; Your Ideas Welcomed

A main topic of discussion at the GWS Board's recent meeting was the revision of the Society's strategic statement—a brief outline of where we want to go over the next five years. The document will replace a much longer one done in the early 1990s. We hope that the new strategic statement will provide succinct guidance to the Board and the executive office about what the GWS strengths are, where we need to improve, and what new activities we might take on. We would love to have input from as many GWS members as possible as we finalize the strategy. A draft of the strategic statement is on-line at

http://www.georgewright.org/strategy.html

We invite you to have a look and then send us your ideas. What should we be doing differently? How can we serve you, the membership, better? What new things should we take on? How can we interest more people in the mission of the GWS? We want to hear from you! Please send your comments to Dave Harmon, GWS executive director, at dharmon@georgewright.org, or by mail to the George Wright Society, P.O. Box 65, Hancock, MI 49930-0065 USA.

To Envelope or Not

Of 178 postcards received in response to enveloping the Forum, 102 claimed that the Forum was received in Better Shape, 71 said that the Forum was received in about the Same Shape, and 2 were received in Worse Shape. Some comments from the cards: "My copy is always in good shape. I'd prefer a more ragged copy without an envelope." "Please keep enveloping." "Except it's more paper to throw away/recycle. Guess it's better than plastic covers which could be another option." "However I would prefer just the magazine —NO wrap. Save paper." "Probably better, but would rather see you not waste the $ and paper!!" "We need a Stronger envelope." ...Well, we'll work on it!

Mark R. Peterson

Box 65: Commentary from the GWS office and our members

Using Numbers that Count: Information or Revelation?

You may recall the classic fable of the blind men and the elephant. Once, in a place inhabited by curious blind men and elephants, there was a group of blind men who knew nothing about these animals. The blind men went to a spot that elephants inhabit to learn first-hand what this large beast was like. As the men were directed to the place, they each came to the spot where an elephant stood, approaching from different directions. They explored the elephant with their hands and then began to discuss the nature of the beast.

One blind man said it was like a *tree*—cylindrical, widening as it met the ground, with a rough bark. The second man described it as being more like a *rope* than a tree. The third man said it reminded him of a *snake*—muscular and able to wrap itself around his arm. The fourth man thought he was with a bunch of fools, for he felt its great side from top to bottom, saying it was like a *wall*. The last man had listened carefully to the others, but described the elephant as a large *sheet of leather* because as he felt along its long, thin edge, it quivered.

The last man continued, "Each of you has experienced a beast that differs greatly from what I have found to be true. I propose that none of us has been mistaken in his observations, but rather that we have experienced different aspects of the same great beast. By combining our perceptions, we may be able to come to a better understanding of the essence of the elephant. I would propose that we share our research with each other so as to gain an understanding of the true nature of the elephant."

So, they each published an article on the elephant in respected journals of elephantology. They read each other's papers (with their digital audio readers), corresponded and shared their part of the elephant with each other. Eventually they came to understand that an elephant is like a tree (its feet), a rope (its tail), a snake (its trunk), a wall (its sides), a large sheet of leather (its ears), and many other things as well.

This fable has wisdom often forgotten. Pick a park or protected area. Do we describe it as being like a tree or a rope? Or do we strive to convey its collective, complex whole? Do we ever try to describe it holistically at all?

How we present numbers often has everything to do with our success (or failure) to achieve resource conservation goals. Too often we stop at the elephant's ear or foot. That research and shared information is important—critical to our understanding of the beast. But too often we stop there. It takes an entirely different process to connect the dots and portray the whole, and few (if any) people are given that task. Too often we don't convey the information comprehensively and tell it in a story that is meaningful to the public.

Telling the story is oftentimes the critical element coming out of research. For example, suppose I ask you, "What do I need to make orange juice?" You answer, " A quart of water and a can of frozen orange concentrate." Technically you're correct, but you haven't helped me to see the larger picture. A more informative answer to this question would be, "Two quarts of gasoline and a thousand quarts of water are required to produce one quart of Florida orange juice." This statistic is as correct as the first, but now you've got an opportunity to do some real education that is meaningful, connecting the parts of the systems responsible to produce your morning glass of juice.

Researchers and the number-crunchers among us would do well to find and dust off a copy of Freeman Tilden's classic book, *Interpreting Our Heritage,* published in 1957 but just as relevant today as ever. Contrary to popular thought, it is not just for interpreters and naturalists. It should be required reading for researchers as well. All of his six principles are relevant to researchers, but his second principle stresses the important distinction between information and interpretation. Interpretation uses information to generate revelation. It is my contention that there's far too much information and too little revelation within the realms in which we dwell.

Don't get me wrong. Oftentimes information — and information only — is needed. There is the need for technical information strictly for the purpose of informing resource managers. That's legitimate, and publishing in respected journals of elephantology is critical to the evolution of our understanding. But unfortunately, too many times it ends there, prematurely. It stops with that one audience when its implications are also pertinent to wider audiences, such as the public. And in doing so, we miss the opportunity to discuss the relevancy of the findings with the very publics whose support is critical to our stewardship efforts.

There have been notable accomplishments for packaging scattered information to reveal a story. The National Park Service's 1980 "State of the Parks" report to Congress is one example. It was the first Servicewide survey designed to identify and characterize threats that endanger park resources. Its discovery of 4,343 internal and external threats was extremely helpful in providing a context in which we came to learn considerably more about the perils facing parks. Unfortunately, further threat assessments such as this one have not been conducted.

Similarly, Parks Canada's efforts to assess "ecological integrity" in their national parks, based upon resource indicators, has received wide media coverage. Among other things, they discovered that only one of their 38 national parks was found to be in pristine condition, while 31 reported "significant to severe" ecological stresses; in 13 parks these stresses had increased in intensity since 1992. These findings were in part responsible for a government-appointed panel of ecological experts (the Panel on the Ecological Integrity of Canada's National Parks) to later conclude that, "ecological integrity in our national parks is in peril." It told a compelling story greater than any one resource or any one park that has key decision-makers sitting up and taking notice.

Other attempts at packaging data for a larger educational purpose are encouraging. Yellowstone published its "State of Yellowstone National Park" report in 1999, providing tremendous background in understanding the park. Similarly, the National Parks Conservation Association has begun a national effort to assess cultural and natural resource conditions in 40 or more park units. Assessments for Adams National Historical Park and Point Reyes National Seashore have been released, while those for Rocky Mountain National Park and Waterton-Glacier International Peace Park are due out soon. It is hoped, by pulling together existing information across the spectrum of park resources, a story emerges which can help the public and decision-makers better understand the critical needs of a park's resources. By then comparing much of the same information across parks, another important story emerges depicting the needs of the system.

Using numbers to convey a story is not confined to resource research. Even the National Park Service's accountants and budget offices have begun to repackage existing numbers in a way that communicates to the public a greater message than before. The Business Plan Initiative of the National Park Service, conducted in partnership with the National Parks Conservation Association and many of the nation's leading business schools, is working in individual parks to un-bundle numbers from their traditional esoteric constraints, and repackage that information to better convey a sense of how public monies are being spent, where the shortfalls exist, and how large they are. Forty parks now have developed business plans. Armed with that understanding and fresh perspective, the public and Congress may be motivated to address the critical shortfalls that exist.

These attempts may be seen as a blend of science and information with art. While the efforts are steeped in science and information, how the pieces of information are woven together to create a tapestry in which the patterns emerge—that is, the story that reveals important understandings for the park—is an art perhaps no less important than the pursuit of obtaining the resource information. For resource protection to advance, the marriage of information with revelation needs to be joined.

There are almost an infinite number of ways to create this marriage. One of the recent innovative strategies in the U.S. National Park System is the creation of Learning Centers, which are being advanced through the Natural Resource Challenge and operated as a public–private partnership. These centers will support research activities for all park resources, synthesize information, and transmit that understanding to the public with the help of an education specialist, working with park interpreters and partners. Five initial learning centers are now funded and, if funding goals are realized, the hope is to create a system of 32 learning centers by 2005.

Such an approach implicitly acknowledges what protected areas around the globe have learned: parks and preserves need to do a better job at communicating their relevance to the values of their publics. This is, no doubt, a considerable challenge in a world bombarded by advertising, mass communications, and a decline in civic participation. Yet, because of the public's relatively high interest in these special places, and the many forms in which that message can be packaged and transmitted, there are great expectations that it can be done.

Thus, the George Wright Society has the twin mission that is essential for resource stewardship: research *and* education. With information conveyed in a way that reveals the whole, rather than its parts, we can come to portray this elephant more accurately. In so doing, we'll advance public understanding and park resource protection.

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Reminder: this column is open to all GWS members. We welcome lively, provocative, informed opinion on anything in the world of parks and protected areas. The submission guidelines are the same as for other GEORGE WRIGHT FORUM *articles—please refer to the inside back cover of any issue. The views in "Box 65" are those of the author(s) and do not necessarily reflect the official position of The George Wright Society.*

Dale B. Engquist

A Dialogue on the Natural Resource Challenge

Early in 2000, Peter Brinkley, then calling himself simply "citizen" and now a member of the Board of the George Wright Society, proposed that it would be a good idea to take the National Park Service's (NPS's) Natural Resource Challenge on the road. The idea was to engage leaders outside NPS to build partnerships and a broader constituency for the Challenge. With some reassuring words from some NPS leaders about the concept, Paul Heltne, president emeritus of the Chicago Academy of Sciences, and I were enlisted to implement the first of what was hoped to be series of forums.

The Academy's new Peggy Notebaert Nature Museum in Chicago was selected as the venue for the event. Construction of the nature museum had previously first brought the three of us together in discussions of partnership efforts, efforts that continue between the Academy and Indiana Dunes National Lakeshore. Plans to hold the event later in 2000 soon proved overly optimistic, in part because of conflicts with Discovery 2000 conference, and it ultimately took place June 13 and 14, 2001.

The key word in the title for the event, "Dialogue," came rather easily to us as planners. We wanted to facilitate open and candid discussion, not have presentations by talking heads. "Dialogue" also sounded positive and, while we wanted candor, we didn't necessarily want debate as such. In fact, some of the people who were very involved with the Challenge were uneasy about having the event at all, apprehensive that the delicately balanced support mechanism that had succeeded in bringing about the first appropriations might be upset.

After lengthy discussions, a format for the Dialogue emerged. There was to be one brief presentation to summarize the history and strategy of the Challenge. This would be followed by two-hour sessions of dialogue on five key topics related to Challenge. The dialogue was to take place between a group of about eight of the top managers of NPS and up to 16 outside leaders that we called "respondents." The topics were place-based knowledge, long-term research in parks, institutional relationships, research and learning, and long-term needs of the Challenge. Each moderated and recorded session began with a brief introduction by an NPS participant followed by a response from one of the respondents followed by the dialogue between the key participants. The session ended with open Q&A by all the participants, including a larger audience of superintendents and managers, largely from the NPS Midwest Region.

Choosing and inviting the respondents was easily the most debated and most difficult task. The respondents were all to be not only knowledgeable but have standing and influence in their field. We also strove to balance both a national and regional perspective. Last minute conflicts forced some, including Peter Raven of the Missouri Botanical Garden, to have to cancel. The final, prestigious assembly comprised:

- G. Thomas Bancroft, vice president, the Wilderness Society
- Jennifer Blitz, manager, environmental services, Chicago Academy of Sciences
- David Blockstein, National Council for Science and the Environment
- Margaret Cavanaugh, Office of the Director, National Science Foundation
- Strachan Donnelley, senior fellow, The Hastings Center
- Ron Engel, research professor, Meadville-Lombard Theological School, University of Chicago
- Denny Fenn, chief biologist, U.S. Geological Survey Biological Resources Division
- Bruce Hannon, professor, Natural Resources and Environmental Science, University of Illinois
- George Rabb, director, Brookfield Zoo, Chicago
- Laurel Ross, The Nature Conservancy and Chicago Wilderness
- Paul Risser, president, Oregon State University
- Rick Wilke, distinguished service professor of environmental education, University of Wisconsin

The lists of NPS managers who accepted the invitation to the dialogue was also impressive, even though both Acting Director Deny Galvin and Regional Director Karen Wade were called away at the last minute to brief the new NPS Director, Fran Mainella, and deal with the Cerro Grande fire report, respectively. The final group included Bill Schenk and John Reynolds (regional directors), Mike Soukup (associate director for natural resources), Gary Vequist (Midwest associate regional director for natural resources), Doug Morris and Don Neubacher (superintendents and co-leaders of the NPS Challenge Council), and Gary Davis (marine biologist). In addition, Gary Machlis (social scientist and Cooperative Ecosystem Studies Unit coordinator) and Bob Chandler (NPS Advisory Board co-chair) also participated.

If anyone harbored doubts about whether the dialogue could be maintained for two days, those doubts quickly vanished. The real problems turned out to be that the recorders compiled such lengthy notes that it was hard, on Day 3, a day devoted to a discussion by NPS personnel only, to deal with the volume (30+ pages) of material at hand. A summary only of what we heard at the Dialogue is below.

It is clear that our respondents were impressed by the Challenge and the opportunities that the national parks present for research and education. They pointed out some of the obstacles that we faced, as well as those that researchers and others who might want to partner with us also face, but it was evident that the basis for partnerships to build on the foundation laid by the Challenge was there. We learned from the experience, but we are also left with many questions, some old and some new. Not only should we, but will we, assume an expanded leadership role at the regional, national, or international level? Will we provide a means for our resource professionals to realize their needs for advanced education, training, and work experiences? Will we successfully strengthen cooperation between researchers and educators? Perhaps these and other questions can be put to participants in a new forum.

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Summary, Challenge Dialogue,
June 13-14, 2001

I. The NPS and the Natural Resource Challenge (NRC) are vitally important. As was true at last year's Discovery 2000 Conference, we heard again and again that national parks can and should be central to global efforts in ecosystem management and the biodiversity struggle. We were challenged by our respondents not only to keep the NRC going, but to increase our efforts and capitalize on our unique position in new ways.

1. NPS has an inordinately important role in the future of the planet. Can we be a catalyst for the idea of living lightly on the planet in time to make a difference?
2. Whether we planned it or not, we are major players in the biodiversity struggle.
3. The parks and NPS are unequivocally important to America.
4. The NPS challenge is to educate our citizens and decision-makers about "good science" and the importance of its application in ecosystem management.
5. Parks are powerful ways of bringing different views together; we can use resources to help different groups understand each

other.

6. Untold millions are affected by their experiences in parks. "Appreciation is the father of understanding" (George Wright).

II. The NPS education mission. Education is the core of the just-released NPS Advisory Board Report 2001, *Rethinking the National Parks for the 21st Century.* Its first recommendation is "Building Pathways to Learning." The respondents at the Dialogue also challenged us to make education "a primary mission of the NPS … [and] to collaborate with organizations and scholars to … expand the Service's educational capacity" (quote from the Advisory Board report).

1. The NPS is uniquely positioned to communicate with the public.
2. There is much we do not know about how and why people come to have "feelings" about a place. We need to know much more about the personal assignment of meaning and value. Why are some people lovers of nature?
3. NPS, with other partners in "informal learning," should be exploring how people learn, change, and develop their values. The NPS could be involved in a multi-institutional research project to look into the issue of changing behaviors. Museum and zoos are in the forefront of the field now.
4. A challenge to the Challenge! What will NPS do to bring the public along on climate change in parks? How will we help to assure a different country 50 years from now?
5. We must educate ourselves. NPS has inadequate training for professionals and managers. We need a "conservation university."
6. We should be as concerned about increasing the quality of environmental education as we are about generating and applying good science; both are critically important.
7. Learning Centers are to be more that research field stations; they must educate.
8. How will Learning Centers be involved in environmental ethics and ecological citizenship?
9. The NRC should have at least two staff to work on coordination with education and educators, providing national leadership for the effort.

III. There are partners for the NPS and the NRC. There are many ways that NPS can and should partner with others to accomplish and enhance the goals of the NRC. The respondents, many of them existing or potential partners themselves, told us that the partners are not only there, they want to work with us. We were often reminded and sometimes chided for not "being at the table" with those we should be working with.

1. John Reynolds asked, "Who do we hang out with?" The respondents helped us develop a very long list of partners, both

new and old, including: natural history museums, nongovernmental organizations (NGOs), botanical gardens, think tanks, university professors, science organizations, Federal Interagency Committee on Education, restorationists, theologians and ethicists (www.earthcharter.org), zoos, arboretums, international organizations (IUCN, World Wildlife Fund, UNESCO's Man and the Biosphere Program), Cooperative Ecosystem Studies Units, North American Association For Environmental Education, International Association of Fish and Wildlife Agencies, Partners in Resource Education, Coastal America, National Science Teachers Association, aquariums, Illinois Environmental Education Advancement Consortium, informal learning associations, National Science Foundation, Coalition for Science in Land Management Agencies, and more.

2. We need to define who our partners are and we need to better communicate what it is that we want our partners to do for and with us. For example, The Nature Conservancy wants to partner with the NPS but is not always sure how to work with us.
3. Be selective with partners; have a strategy and resist the urge to partner with everyone. When you partner, you adopt the partner's priorities.
4. We need to define who we are as partners to others.
5. A lot of environmental NGOs want to help the NPS, but there can be limitations to working with advocacy NGOs.
6. If the NRC is the lever to help tip the organization toward change, partners can be the fulcrum.
7. Strategic partners can be helpful in finding "neutral turf" to confront controversial issues that they can embrace more easily than the NPS can. They can easily explore and develop programs on issues such as evolutionary biology ("How can we educate the citizenry unless we openly talk of Darwin and evolution?") and environmental and bio-ethics.

IV. Humans in nature. While it didn't dominate the dialogue, there was a recurring theme from respondents throughout that we must include humans and their influences when we deal with the natural landscape.

1. We must study nature with humans in it. It is an incredible challenge but we are learning how to do it. The NRC would be irresponsible without the element of humans within nature.
2. We need to know more about how humans have influenced and continue to influence the environment.
3. We must place humans in the natural landscape as a co-evolving part of the total biotic community; this is a part of the

turn to a more ecocentric perspective in environmental ethics and philosophy.

4. Place-based knowledge has to include the social and the cultural.

V. Science and research in the parks. The NRC is moving science to the forefront in NPS. That has not been the general rule in the past; in fact, NPS has even been perceived by some as anti-science or anti-scientist. The respondents offered many suggestions about how we might change our image to better foster science and research.

1. The NRC has to deliver on the concepts of science for parks and parks for science.
2. When we discuss research, we must define the current scientific issues and then place parks squarely in the middle of those issues; this will attract scientific interest.
3. The research design of the National Science Foundation is to integrate science and education; NPS should consider doing the same.
4. We need to pay attention to simplifying the research permit process and other procedures in order to do more to encourage researchers to utilize parks for their endeavors.
5. It is important to realize that universities do not have rewards in place to coordinate or take over the role of repository and disseminator; the parks ought to be the keepers of their own research information.
6. We need to know what "rewards" the researcher and then create that reward in the parks.
7. Researchers find value in their research. NPS has to show that it too values research.
8. The expertise of NPS needs to be in "place" rather than only in "taxonomy."
9. NPS hasn't done a good job in the past in the "care and feeding" of the scientific community. We need to demonstrate that things have changed. We need to share success stories and not dwell on bad examples of past research in our parks.
10. There is an incentive for scientists to do research that gets fast results—they get papers published more quickly. We need to create the incentives now lacking for long-term ecosystem studies.

VI. We need to stop being "egocentric" and become more "ecocentric." Respondents were candid in commenting that NPS has or can be perceived as having a fortress mentality. We need to broaden our perspective and think beyond park and national boundaries.

1. We need to accept an "evolutionary responsibility challenge": a responsibility for our evolutionary and ecological origins and our planetary future.
2. The environment is a complex, global system.
3. We need to display a park op-

eration that obviously values resources, is ecocentric rather than park-centric, works as park networks, and represents our role *in* the ecosystem, not *as* the ecosystem.
4. We need to understand the role of national parks in regional strategies for biodiversity.
5. We have not cast our net widely enough to encompass the health of communities that must interact with parks and other natural areas.
6. The country that gave birth to the national park idea and ideal needs to be more involved internationally; almost all other national park systems in the world are involved.
7. We need to understand the linkages between park management and dynamic ecosystems.
8. Parks can be the places where we develop and contemplate how basic ecological and evolutionary systems work.

VII. Communications. The success of the NRC will in large part depend on how well we communicate with the public, policy-makers, partners, and the scientific community. Lots of suggestions emerged from the respondents in every session on how we might best hone our communication skills.

1. Focus and be clear about what we are communicating about the NRC. Clarity needs to recognize differing constituencies; different language may be needed but the message must remain consistent.
2. Earlier generations had a much richer ethical vocabulary and we had much better civil discussions. We need to recover that richness of public debate.
3. We need to find ways to speak meaningfully to one another, distilling the information down so that scientists can talk to policy-makers and policy-makers can ask the right questions to get scientists to do applicable research.
4. The knowledge that the public needs to support the parks may not be the same knowledge that managers need to maintain the systems.
5. "Science recreationists" come to a park for completely different reasons than rafters or campers. They bring to the park unique opportunities to learn, to help, and to become advocates and volunteers.
6. The public is not familiar with the meaning of the word "biodiversity."
7. Tying environmental monitoring to indicators that the public in the park's region understands brings public acceptance, especially if they can be involved with the scientists in choosing the indicators.
8. Use the Web to get the full picture out to the public.

Joe Sovick

Toward an Appreciation of the Dark Night Sky

This is not a typical GEORGE WRIGHT FORUM—for never before has the FORUM dedicated an entire issue to topics relating to the preservation of the dark night sky.

Public interest in preserving the dark night sky has been growing by leaps and bounds during the past decade. Increasing public awareness of and appreciation for dark night skies has been reflected in frequent newspaper editorials, greater community activism, and a profusion of new local and state outdoor-lighting ordinances.

Astronomy is not the only perspective from which to view the preservation of the dark night sky. As shown by the wide variety of papers presented in this issue of the FORUM, the concept of preserving the night sky has broad-based support from numerous and diverse interest groups and individuals who share an appreciation of this very special resource.

Most of us have gained an appreciation of the night sky from personal experiences while viewing a dark sky filled with thousands of bright stars. My own experience began one clear, moonless summer night when I was 12, fishing on a remote lake in northern Wisconsin. The lake was surrounded by forest, and the horizon was formed by the black silhouettes of the tall Eastern white pines along the shoreline. Overhead, I viewed a magnificent night sky so full of stars that the cumulative starlight illuminated the night. The origin of the name "Milky Way" became suddenly obvious to me, as I viewed the wide cloudy white band running across the sky. There were so many stars in view it hardly seemed possible there could be room to fit any more. I found it so inspiring! And from that night on, the dark night sky would always be a source of great beauty and reflective thought for me.

A dark night sky can be so thought-provoking that it is no wonder that such a sky is associated with so many facets of history, philosophy, religion, societal development, poetry, song, mathematics, and science. It follows that, to fully achieve an understanding of the past, clear views of the night sky must be accessible to us. For example, without experiencing a view of the Big Dipper, it would be difficult to appreciate the underlying message in "Follow the Drinking Gourd," a song composed by slaves to help guide them north along the Underground Railroad.

I became involved in promoting the preservation of the dark night sky due to a series of repeated incidents at Chaco Culture National Historical Park. It was here that my heretofore passive appreciation turned to activism. During the summer of 1991, I was privileged to be detailed to Chaco as acting superintendent. Chaco has an eight-mile paved loop road that provides access to trailheads leading to the park's World Heritage archeological sites. After attending evening campfire talks, I would bicycle this loop road in the dark before returning to my residence. After my eyes became accustomed to the dark, I relied on starlight to enable me to follow the faint indication of the pavement of the road before me. On this loop road near the trailheads leading to Pueblo Bonito and Casa Rinconada, I would stop to peer at the Chaco's incredibly dark night sky. I suddenly realized that, because the sky was so pristine and devoid of diffuse artificial light or sky glow, I was experiencing the very same view of the sky that was seen by the Chacoans 1,000 years ago. And by experiencing such a profound connection to the past, I was experiencing Chaco's night sky as a prehistoric landscape.

Regrettably, the last leg of my evening bicycle rides was the approach to the park visitor center. The visitor center was closed at night, but its exterior was illuminated by unshielded mercury vapor lights that sent more light into the atmosphere than onto the parking lot. The lighting was supposedly needed for security; however, the security it provided turned out to be marginal at best, and the adverse impact it had on the resource was incontrovertible. I wondered, What kind of example could the National Park Service (NPS) be setting for visitors? For staff? For others? How could NPS persuade developers of future coal mines or gas wells in the San Juan Basin to install appropriate lighting when NPS did not do so for its own visitor centers?

I took this concern to John Cook, who was then the director of the NPS Southwest Region. Quickly understanding the Chaco situation within a larger vision, he first funded a project to retrofit Chaco's outdoor lights. A resourceful Chaco facility manager, Bobby Clark, designed and installed a system of motion sensors. These efforts were followed by development of a formal Night Sky Initiative for the Southwest Region, which you will find discussed in more detail in one of the papers in this issue of the FORUM.

National parks present special opportunities and offer great potential for the incubation of progressive ideas in resource conservation that can eventually be adopted by communities. Preservation of the dark night sky is an excellent example of a park resource- and facility-management activity that is well suited for universal adoption. *Sky glow does not have to be accepted as an unavoidable impact of growth and development.* Appropriate lighting measures are available, and these measures are more energy efficient and less costly to operate than inappropriate ones. With regard to private property rights, appropriate lighting affords greater protection from unwanted light for private landowners. Corresponding to the growing concern for dark skies within parks is a growing interest and activism in communities outside of parks. Statewide organizations, astronomy groups, and cultural resource preservationists dedicated to preserving the dark night sky are now active throughout the USA—and around the world.

Many people, representing numerous disciplines, research the stars, including those in astronomy, cosmology, archaeo-astronomy, and ethnography. Many programs and functions within NPS park staffs can be involved in preserving the dark sky, including resource management, visitor education, partnerships, sustainability design, energy conservation, and facility management. The wide variety of papers in this issue of THE GEORGE WRIGHT FORUM reflect the many disciplines involved within and outside of NPS units to preserve the dark night sky resource. Authors of these papers are distinguished as leaders in efforts to preserve the dark sky.

- Arguably, the most effective organization advocating the preservation of the dark night sky is the International Dark Sky Association, based in Tucson, Arizona. A book could be written on the leadership and accomplishments of this organization. We are fortunate to have a paper entitled "The Value of Dark Skies and of High-Quality Night Lighting — Building Public Awareness," co-authored by Elizabeth M. Alvarez del Castillo and David Crawford of the association.
- In "The Ultimate Cultural Resource," Jerry Rogers and I present the case for recognizing the dark night sky as a cultural resource, declaring it endangered, and using the "endangered" designation to support preservation.
- Adding to the cultural and astronomical values of a dark night sky, Dan Duriscoe, forest ecologist at Sequoia and Kings Canyon national parks, provides a convincing rationale for recognizing the dark night sky as a wilderness value in his paper "Preserving Pristine Night Skies in National Parks and the Wilderness Ethic."
- The Southwest features a great deal of undeveloped landscape, and offers a dry climate, high altitude, relatively unpolluted air, and a high incidence of clear nights. There are places in the Southwest in which the dark sky is virtually

pristine. Thus, high-quality sky viewing experiences are available—*but the resource is disappearing.* In "Let There Be Dark," Jerry Rogers and I address the work done in the Southwest using leadership, strategic thinking, and partnerships to promote interest in preserving the dark sky.

- You need to know where you are before you know how to get to where you are going. But how do we determine how much progress is being made in eliminating the degradation of dark skies we are experiencing in parks? While awareness of the dark sky issue has been building, before 2000 there were few tools available for the scientist and manager. The NPS Night Sky Team was formed that year to establish measurement standards and protocols. Led by Chad Moore and Dan Duriscoe, both of whom are authors in this issue, the team developed the needed tools for inventory and monitoring of this endangered resource. Ranging from simple to sophisticated, these methods have been employed in a successful pilot study. The team has also provided technical assistance ranging from interpretation and community outreach to facility lighting review. Moore, a physical scientist at Pinnacles National Monument, provides a paper entitled "Visual Estimations of Night Sky Brightness" on the quantitative measurement of the night sky. Duriscoe and astronomer Steve Albers of the National Oceanic and Atmospheric Administration collaborate on "Modeling Light Pollution from Population Data and Implications for National Park Service Lands."
- The evolution of star-watching as a popular activity at Cherry Valley State Park in north-central Pennsylvania provides insight into the growing public interest in preserving the dark night sky resource. Applying social science, demographics, and ecotourism and related economics, Thom Bemus, director of the National Public Observatory's Stars in the Parks Program, provides an explanation for growing public support for preservation efforts in "Stargazing as a Driving Force in Eco-Tourism at Cherry Springs State Park."
- Our park visitors are one of our most important resources. Management assistant Brad Shattuck and park interpreter G. B. Cornucopia of Chaco Culture National Historical Park share anecdotes from visitors' experiences of Chaco's dark night sky in the paper "Chaco's Night Lights." Parks such as Cherry Valley and Chaco also provide high-quality visitor experiences that will contribute to inspiring others to support preservation of the dark sky.
- Inappropriate outdoor lighting can also have indirect, unexpected adverse effects that do not have any-

thing to do with our views of the night sky. These effects can be ecological, and could lead to the degradation of cultural resources. In Washington, D.C., the bright white marble walls of the Lincoln Memorial are illuminated at night. Two species of midges, *Chironomus plumosus* and *Chironomus attenuatus*, are attracted to the building by the structure's lighting system. The lights dazzle and confuse the midges, causing the egg-laden females to literally dash themselves to death against the memorial's walls. Tiny spiders feed on the remains and deposit excrement. Along with the excrement, harmful deposition from the atmosphere (which is trapped by the spider webs) further stains the marble. This sequence of events degrading the building was initiated by inappropriate outdoor lighting. The adverse impacts of inappropriate artificial lighting can also extend to endangered species. The paper "Light Pollution and Marine Turtle Hatchlings: The Straw that Breaks the Camel's Back?", prepared by Mark Nicholas, resource management specialist at Gulf Islands National Seashore, provides a case study about the effects of outdoor lighting on marine turtles in the park.

- Most parks are vulnerable to light pollution from sources outside of park boundaries. Because of its size and location, Yellowstone National Park is one of the least affected—yet it has outdoor lighting issues attributed to its own facilities. The lighting issues in Yellowstone are symptomatic of the challenges faced by many other parks as they seek to install appropriate lighting. Lynn Chan and Eleanor Clark, landscape architects at the park, provide an introduction to the problem at a park level in "Yellowstone at Night."

Many thanks to the authors of the excellent papers published in this issue. For those of you who are interested in preserving the dark night sky for future generations, I hope these papers provide a stimulus to get actively involved in efforts to protect the environment from inappropriate lighting. And I hope that they help people recognize that light pollution can be minimized, and that national parks can be an environmental leader in contributing to changes that can benefit the quality of life beyond park boundaries.

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Elizabeth M. Alvarez del Castillo
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The Value of Dark Skies and of High-Quality Night Lighting—Building Public Awareness

Introduction

Our ancestors greatly enjoyed the solace and inspirational view of a blanket of stars above us ... to dream, to wonder, to be part of nature. Today, too many children only know hints of this splendor through planetarium shows. Our grandparents felt the richness of plant and animal life around them during the day and night. Today, it seems that we want to turn night into day, and let animals search for new habitats. Our parents thrived as society in tune with the richness of the Earth's resources. Tomorrow, what will be left for our children?

One small but too common aspect of modern society—low-quality outdoor lighting—has many detrimental effects. Fortunately, there are workable solutions. And so, as many are striving to regain a quality of life they find slipping away, the problems and solutions of light pollution are moving into view as one environmental problem that can be solved now.

Over the millennia, life on Earth developed with a day/night cycle. It is ingrained in our natures, and destroying it by turning night into day stresses our systems, including our immune system. This circadian rhythm, with its need for both light and dark, is required for the health of humans, animals, and plants.

Our natural environment can and does relax us, but poor nighttime lighting can be a definite psychosocial stressor, similar to noise. Our systems need a break, a better ambiance in life—indeed, better outdoor lighting. It is not hard to do; the technology exists.

Low-quality outdoor lighting creates glare that blinds us, hindering visibility, detracting from safety and security. Instead of guiding us, bad lighting creates clutter and confusion. Spill light pours in from our neighbor's yards or from the street. It wastes energy (and money) in a world that increasingly needs us to protect the environment. Poor lighting produces urban sky glow, a veil blocking our view of the once-pristine dark sky. We know that the steps necessary to preserve dark skies also improve the quality of our nighttime lighting.

How to Do It— The Keys to Good Lighting

- Determine if light is needed, and why. Use it only when actually needed.
- Use the right amount of light for the task; not too little nor too much.
- Direct the light only to the places where needed.
- Eliminate glare.
- Minimize "light trespass," or obtrusive lighting.
- Minimize direct up-going light, a major cause of urban sky glow.
- Use the light only when it is needed. Turn lights off when not needed.
- Use motion sensors when possible.
- Install dimmers or multi-level lighting; they can also be effective.
- Use energy-efficient sources.
- Minimize energy waste.

The Components of Poor-Quality Outdoor Lighting

Glare. Glare *never* helps visibility. The dictionaries call it "blinding light," yet it is common in most outdoor lighting. Glare is never good, and we should not tolerate it. It is not necessary. It can be avoided with good lighting design in any installation.

Obtrusive lighting, or light trespass. This is our neighbor's light bothering us; or that from the local automobile dealer, who has bad lighting; or from the local sports complex with its bad floodlighting. There is far too much light trespass; obtrusive lighting can even be considered offensive.

Clutter and confusion. This is light that is not adding anything to nighttime ambiance or to the convenience of life outdoors at night. Too much of our night lighting is actually ruining the nighttime environment, not adding to its value.

Wasted light. There is too much up-going, totally unused light. In addition, many still hold to the myth of "the more, the better." More light is not always better, no more than more noise is. Certainly there are many locations with inadequate light, but there are also many with far too much. The issues of transient adaptation and luminance overload are important ones.

Impact on the night sky. Up-going light brightens the night sky, wiping out our view of the stars and the universe around us. This is a key adverse environmental impact. Shall our city dwellers, our children, never see the stars again?

Energy waste. Lots of energy (and money) is wasted by this bad lighting and by inefficient lamps and fixtures. Billions of dollars are wasted lighting up the sky and blinding us with glare—literally an astronomical amount.

In these days of increasing attention to energy crises, one can easily note that all of the factors above waste energy, and energy costs money. The amount involved is significant because the operating cost of a light fixture throughout its lifetime is usually much greater than the initial cost of the lighting fixture or lamp. Even where energy is relatively cheap (and where is that these days?), wasted energy produces unnecessary environmental pollution due to the production of that wasted energy, regardless of its cost.

Good vs. Bad Lighting

Outdoor lighting allows us to see better at night and do more things than we can without such light. Unfortunately, there is too much bad nighttime lighting in most places. Good lighting has great value. It improves the quality of life, improves productivity and visibility, reduces energy waste, and promotes sustainability. We get rid of glare and most light trespass. We save a lot of energy by using the light effectively, not wasting it.

The reasons for better outdoor lighting are compelling, and people with diverse backgrounds and interests are demanding improvement. As the demand increases, so does the supply of high-quality light sources and fixtures, so does the demand for environmentally friendly lighting design. We must both get rid of the bad stuff and use only good lighting for all new installations. It is worth the difference in initial cost, if any. The life-cycle costs of high-quality lighting are always lower than those for bad lighting. The challenge is to build awareness and overcome apathy.

Sky glow is not the inevitable price of progress. Population growth combined with residential and commercial developments, along with the growth in lighting technology, has led to greatly increased use of outdoor lighting. The increased usage was particularly apparent in the age of relatively cheap electrical energy. The main design approach seemed to be "the more, the better." As energy costs rise, more ears open to the advantages of energy-saving luminaries and lighting design. Instead of quantity, we need to focus on the quality of lighting.

The Earth's atmosphere scatters light coming from sources in an urban area, creating the halo visible over cities even from a great distance. Light emitted directly into the sky and that reflected from the ground, buildings, or other objects is scattered by molecules and aerosols (solid or liquid particles) present in the air. Even a single bright source in a dark locale can be a source of light pollution.

High-quality lighting is the key to dealing with sky glow issues. For example, the city of Tucson has grown greatly from the time the first outdoor-lighting control ordinances went into effect in 1970. It is now a city of over 800,000 people. Yet the sky glow, as seen from observatories about 70 km from the city, have not increased much over that period of great population growth. The solutions do work.

Hundreds of communities are benefiting from the use of outdoor-lighting ordinances. They help a lot, and the process of educating a community and developing a consensus on outdoor lighting builds many educated allies and partners. Six states in the USA now have statewide ordinances to control light pollution: Arizona, Colorado, Connecticut, Maine, New Mexico, and Texas. Others are pending. Australia has adopted national lighting standards. Likewise, cities and communities worldwide have recognized the need to address the problems of bad lighting and enacted ordinances.

The National Park Service has also recognized the problems, and is taking steps to preserve both the daytime and nighttime experience for visitors. National parks frequently have dark sky programs for visitors, and some are beginning special initiatives to address light pollution in their surrounding communities. The U.S. Forest Service is looking for more information on how to maintain wilderness while managing multiple-use needs and border-community developments. In addition, several locales have created dark sky preserves to allow people to visit and enjoy the night experience. They have found that it has a strong positive impact on quality tourism. The night has value! These preserves include the Michigan Dark Sky Park at the Lake Hudson Recreation Area, McDonald Park in British Columbia, Torrance Barrens Conservation and Dark Sky Reserve in Ontario, Cherry Springs State Park in Pennsylvania, and the Manitoulin Island Dark Sky Preserve in Lake Huron, Ontario. Similar plans are well underway in other countries.

The International Dark-Sky Association (IDA)

Growing public awareness is the key. As the public becomes aware, they are demanding such changes, and governments are beginning to respond. It is clearly an area where all benefit. The problem is to accelerate the growth of awareness. A recent grant by the National Science Foundation to the International Dark-Sky Association (IDA) was aimed at building public awareness of the issues, and a similar grant from the Pauley Foundation had the same purpose. IDA is a non-profit, environmental, education and research organization. Incorporated in 1988, IDA seeks to preserve and protect the nighttime environment and our heritage of dark skies through high-quality nighttime outdoor lighting. This membership-based organization has well over 7,000 members from every state in the USA and from 70 other countries. Its diverse membership includes organizations, city officials, lighting professionals, architects, professional and amateur astronomers, environmentalists, and concerned members of the public.

Summary

Night is a vital part of our environment, and just as worthy of preservation as any other natural resource. It involves both the night around us and the view we have of the stars and the universe we live in. It is part of our culture, history, and nature. We lose something of ourselves when we can no longer look up and see our place in the universe. The worldwide problem of light pollution requires worldwide solutions. As we seek to educate everyone, everywhere, awareness is growing. While light pollution is still getting worse in most places, there are workable solutions. They improve the quality of our nighttime environment and our nighttime lighting, promoting safety and security and conserving energy. We all win!

Some Basic Web References

- International Dark-Sky Association (IDA). Pointers to useful resources such as a quarterly newsletter, over 170 information sheets, numerous papers and talks, images and slides, videos and CDs, links to manufacturers, and tips on how to identify good luminaires. IDA's *Outdoor Lighting Code Handbook* guides communities through the items to consider when enacting a lighting ordinance.
  http://www.darsky.org
- Illuminating Engineering Society of North America (IESNA) *Handbook 2000.* Various recommended practices, technical memoranda, design guides, and other documents.
  http://www.iesna.org.
- International Commission on Illumination (CIE). Various technical reports, guides, standards, and proceedings.
  http://www.cie.co.at/cie/.

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Jerry Rogers
Joe Sovick

The Ultimate Cultural Resource?

By the late 1990s, many Americans had noticed that nighttime stars were becoming less and less visible, and most had probably recognized the growing amount of human-generated light as the reason. Although people regretted the change, it probably seemed minor in comparison to more obviously life- and health-threatening degradation of the environment.

In the meantime, a growing cadre of environmentalists had been struggling for over a decade with the problem of light pollution (Hunter and Goff 1988). An international coalition of advanced thinkers had formed the International Dark-Sky Association, an advocacy body to raise public consciousness, certain parts of the news media had begun to call attention to the problem, and the National Park Service (NPS) Southwest Region had developed an initiative of multi-faceted actions to counteract light pollution in the parks (Cook 1991). These actions had limited effectiveness because the night sky of national park units was vulnerable to the impact from light sources well beyond park boundaries. Moreover, although excess nighttime light seemed clearly to be a diminution of the overall quality of human life, the atmosphere and the stars beyond it seemed to fall into the environmental category of natural resources. It took bold action by a fledgling statewide New Mexico citizen's group, with thoughtful support from NPS, to bring the night sky into focus as a cultural resource as well.

Although there had been somewhat desultory attempts earlier, New Mexico was one of the last few states to form a successful statewide citizen organization devoted to the preservation of history and cultural heritage (New Mexico Heritage Preservation Alliance 1995). Such organizations are encouraged and assisted by the National Trust for Historic Preservation. Several individuals involved in launching the New Mexico Heritage Preservation Alliance in 1995 had been players on the national historic preservation scene, particularly through the National Trust. They were eager not only to ensure the success of the new statewide alliance, but to have it demonstrate a precocious energy and bent for innovation. Consequently, in 1998, when the young alliance solicited nominations from which to designate its first list of "most endangered historic places" in the state, a practice long followed by other statewide organizations, it was in a frame of mind to be daring.

Statewide historic preservation organizations have no authority to remove threats to endangered places, and they generally have little money or staff time to devote to problems. However, they have found that press, public, government authorities, philanthropists, and potential volunteers tend to take great interest in the annual designations. Because the designations possess significant power to stimulate action, they actually have a very good track record for leading to the preservation of important places that had been on the brink of destruction.

In 1998, one of the members of the board of directors of the New Mexico Heritage Preservation Alliance was Jerry Rogers, the superintendent of the NPS support office in Santa Fe. Rogers, who had previously served as Keeper of the National Register and long-time representative of the Secretary of the Interior on the National Trust Board, was on the alliance's committee charged with developing the list of most endangered places. He shared information about the task with his staff, and Joe Sovick, chief of stewardship and partnerships in the support office, immediately suggested doing something concerning the night sky.

Encouraged by Rogers, Sovick put a few initial thoughts on paper (Sovick 1998). His draft revealed the difficulty of encompassing a clear, unpolluted night sky within the meanings suggested by terms such as "historic," "cultural," and "heritage preservation." They generally imply places and things that are created by human hands and meet criteria for the National Register. However, Rogers, as Keeper of the National Register, had observed and contributed over the past twenty years to some tentative beginnings, and then to accelerating progress, in defining the concept of "cultural landscapes." In general, landscape architects had led the cause in defining historic and cultural values in designed landscapes, such as gardens and some parks; geographers had focused upon landscapes that reflected less-formal human activity; and American Indian tribes and anthropologists had focused upon landscapes that were important because of values or beliefs projected upon the landscapes by human societies. In a few cases, large tracts of land, prominent topographical features, and even entire mountains (e.g., Bear Butte in South Dakota) had been listed in the National Register because of cultural values and traditional beliefs projected upon them. Sovick and Rogers were about to suggest that this concept could be applied to the nighttime visible universe.

The endangered historic places nomination, which combined Sovick's passion for the night sky with Rogers' long and varied experience in defining historic significance, read as follows:

From the Pleistocene to the present the night sky has been an important element in cultural heritage. The combination of what appeared to be eternal order in certain night sky patterns with such changeable things as lunar phases, planetary movements, seasonal angles of declination, and annual meteor showers was one of the early great stimuli to curiosity. The discovery of predictable order among the inconstants was important in the development of belief systems and their attendant cultural values—influencing even the idea of what it means to be human. It remains so today.

Mammoth hunters at Clovis and Folsom, ancestral Puebloans at Chaco and Pecos, Vasquez de Coronado in his explorations, Oñate and de Vargas in their conquests, cowboys on night herd duty, and office workers resting from their daily toils all have lived under, admired, and wondered about the same night sky—virtually unchanged in human history.

A pristine night sky almost universally stimulates thought. Some are humbled in their insignificance before the visible universe, and some are exhilarated by a sense of identification therewith. Some measure and test the movement of our earthly platform within the solar system, the solar system within the galaxy, and the galaxy within the universe until human understanding is exhausted and calculation at its limit. Some speculate about life elsewhere, and some contemplate that the flesh, blood, and bones of our very bodies—even the energy powering our thoughts—are of the light and substance we see coming down from the spangles above.

Without conscious action it will be much more difficult for future generations to have the same experiences, or even to imagine them. As urban areas expand and as change without consideration of the night sky continues, places where it can be experienced grow fewer and more difficult to reach. We risk losing a beauty that has been the backdrop to and motivator of human actions since time immemorial.

Surprisingly, it costs society more to pollute the sky with light than to keep it dark. Most upwardly directed light is wasted. We pay once in the electric bill for the light that goes where it is not needed, again in environmental degradation from emissions in generating the electricity, and again in the loss of the night sky that is masked by wasted light. The most common security lights are mercury vapor lights, which, although the cheapest to purchase are among the most expensive to operate. About 30% of their light goes into the sky at angles that perform no service but do contribute to light pollution.

There is no evil figure, no profiteering corporation, nor irresistible force behind the problem. Today's utility companies are environmentally conscious and interested in conserving, not wasting, energy resources. What is most lacking is public recognition of the problem, broad understanding that light pollution is not inevitable, and the will to do something about it. Fortunately costs are minimal in preventing light pollution, especially for new developments. Costs of incorporating outdoor lighting systems friendly to the night sky are not prohibitive. Sometimes they are not costs at all.

Several years ago, when the National Park Service realized that its own mercury vapor lights near the visitor center at Chaco Culture National Historical Park were a form of pollution and removed the lights, the park experienced a 30% reduction in the electric bill. At Chaco we learned that shielded floodlights directed downward, and properly directed motion sensors were effective in meeting visitor and security needs while serving as significant energy savers and pollution preventers.

It is not too late! New Mexico is fortunate that unimpaired remnants of the clear night sky remain. Some progressive New Mexico communities have or are developing ordinances to help preserve this exceptional visual, natural, and cultural resource. Some private developments are writing protective provisions into covenants on the deeds of the houses they build. The New Mexico Heritage Preservation Alliance can demonstrate its interest in everyone's heritage, show support for one of the most ancient and universal cultural values, and make a significant difference in citizen awareness and in public and private action by listing the night sky *among the most threatened heritage resources in 1998 (Rogers 1998).*

With the strong support of President Katherine Slick, herself a trustee of the National Trust and a recognized national preservation leader, the alliance readily included the New Mexico night sky among its 1999 list of New Mexico's "Most Endangered Historic Places" (New Mexico Heritage Preservation Alliance 1999). The novelty of the sky as a historic place quickly captured press attention, and positive articles and editorials generated public support for doing something about it.

Preservationists, tribes, certain developers, public-interest nonprofits such as the National Parks Conservation Association, professional and amateur astronomers, and others quickly coalesced to support a bill introduced into the state legislature to protect the night sky. With the alliance in the forefront, Sovick unobtrusively helped the coalition make its case and coordinate to maximum effect.

In almost every one of the various legislative committees that had to review the bill, a committee member would question the existence of a problem and of the need to pass legislation. However, committee members generally accepted the existence of a problem when public testimony emphasized that the New Mexico night sky had recently been designated as an endangered historic resource by the alliance.

On April 6, 1999, just three months after the alliance released its list of most endangered places, Governor Gary Johnson signed into law the New Mexico Night Sky Protection Act.. After previous unsuccessful attempts to enact legislation, the various interest groups in the supporting coalition were highly pleased. Meanwhile, the alliance continues to work in other ways toward preserving the dark sky of New Mexico. Through development of a brochure entitled "Seeing Stars," construction of a traveling exhibit, and other means, the alliance continues to work toward educating the public about protecting the night sky.

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Dan Duriscoe

Preserving Pristine Night Skies in National Parks and the Wilderness Ethic

In the American West throughout the latter part of the 19th century, the conquest of the frontier by American industrial culture led to a profound sense of loss among conservation-minded individuals. They mourned the passing of a way of life and of an unspoiled grand landscape that fostered individual freedoms, simple rewards for hard work, and an intimacy with the land that was required for mere survival. The last 20 or 30 years have seen a similar or analogous rapid disappearance of a resource that was once taken for granted: the unfettered view of the universe on a dark, clear, moonless night. Today, we are on the verge of losing the pristine night sky entirely in the 48 contiguous states. However, unlike losing a species to extinction, topsoil to erosion, or yet-to-be-explored virgin lands to development, the night sky is 100% recoverable.

The alarm signaling the potential irretrievable loss of wildlands was sounded in large part by the preservationists of the infant wilderness movement, such as Henry David Thoreau and John Muir. This alarm awakened the public and politicians, and the idea of wilderness preservation eventually became one of the hallmarks of American values. Professional and amateur astronomers were the first to cry out for preservation of night skies in the 1970s, and an effort to save what's left of visual astronomy from earth is now well underway. Loosely collected under the umbrella organization of the International Dark-Sky Association, those wishing to preserve night skies have become more eclectic, and now include lighting engineers, landscape architects, urban planners, federal land managers, and the general public. In the Far West, some of the darkest and clearest of night skies in the world are found in national parks such as Yellowstone, Glacier, Bryce Canyon, Canyonlands, and Death Valley. Many of these parks are now experiencing or are threatened by light pollution. I propose that the preservation of the right to view the universe from America's wilderness national parks is a duty assigned to the National Park Service under the Wilderness Act of 1964 and the Organic Act of 1916. Furthermore, the present-day effort to save night skies is not merely analogous to, but an integral part of the wilderness ethic.

The idea that wild and beautiful lands with all their appealing attributes should be preserved *for their own sake* has sometimes been described as "the esthetic of the sublime" (Rodman 1983). Since the Romantic movement, persons of European background have equated the feeling of awe such places bring about with sacredness, or a place that is beyond and far greater than humanity. Perhaps no landscape has promoted such feelings more than that which includes the night sky, which has been described as "that most glorious and compelling and inspiring of nature's faces" (Schaaf 1988, 205). While the environmental ethic has evolved to focus on a more holistic approach to ecosystem health rather than exclusively on the preservation of sacred, sublime places, the preservationist tradition is still very much a part of American culture. It is an idea that is particularly appropriate when applied to a place that is primarily beyond earth's boundaries, as no management practices humans have yet devised are affecting the health of extraterrestrial resources. The *ability to observe* that heavenly landscape is what is in danger.

Firsthand observations are exceedingly important to the development of values, philosophies, and matters of a spiritual nature. It may be argued that technological improvements in the observation of the universe beyond earth have rendered firsthand observations unnecessary or even inferior. The Hubble Space Telescope, placed above light pollution and atmospheric distortion of ground-based observatories, has provided views of space of unprecedented detail. One may merely log on to Web sites such as "Astronomy Picture of the Day" and enjoy an unparalleled view of the universe from the vantage point of a personal computer. While there is no reason to believe that such images have been artificially created or manufactured, such an experience is still essentially virtual reality. It is equivalent to watching a church service on television rather than attending in person, or watching a nature film on wild animal behavior rather than observing them firsthand. Part of the intent of the Wilderness Act of 1964 was to provide all Americans access to "primitive and unconfined" recreation and opportunities for the spiritual enlightenment and personal development such experiences provide. The view of a dark night sky can certainly be interpreted as an integral part of that experience, and remote wilderness parks are among the few places left where it can be seen.

It is illustrative to review events surrounding the creation of two of the most famous and cherished national parks, Yellowstone and Yosemite. Although Yellowstone is the nation's oldest national park, created in 1872, Yosemite Valley was actually set aside as a park or preserve first, by a federal grant of land to the state of California in 1864. Roderick Nash, in his classic work *Wilderness and the American Mind*, describes both these great milestones in America's cultural development. He attributes the creation and early maintenance of the Yosemite park largely to Fredrick Law Olmsted, the leading landscape architect of his time. Olmsted's words in an advisory report to the California Legislature in 1865, as quoted and commented on by Nash, make a strong case for the esthetic of the sublime:

> It [the report] opened with a commendation of the preservation idea which precluded 'natural scenes of an impressive character' from becoming 'private property.' Olmsted next launched a philoso phical defense of scenic beauty: it had a favorable influence on 'the health and vigor of men' and es pecially on their 'intellect'.... Capping his argument, Olmsted declared: 'the enjoyment of scenery employs the mind without fatigue and yet exercises it; tran quilizes it and yet enlivens it; and thus, through the influence of the mind over the body, gives the ef fect of refreshing rest and reinvigoration to the whole system' (Nash 1982, 106).

While Yosemite's unique and striking beauty was virtually indisputable and embraced by nearly all who visited the valley, the new state preserve was relatively small in area and was intended primarily to preserve the scenery in and around the valley only. Yellowstone National Park was initially thought of as a "museum of wonderful and natural curiosities," but it was realized later by members of Congress that this vast area of the Montana Territory was indeed a wilderness preserve. It was in this spirit that the language of the Wilderness Act of 1964 was crafted. The value of a wilderness area lies not only in the scenery and geologic oddities, but in its "primeval character," essentially "untrammeled by man." A challenge to the notion of the need for a large, wild preserve occurred in 1886 when a railroad was proposed to cross park land to support mining ventures in the area. Nash recounts the *Congressional Record* and comments on this major victory for the preservation ethic:

> Representative [Lewis E.] Payson [of Illinois] ... understood the park's function as the protection of curiosities. 'I can not understand the sentiment," he admitted, "which favors the retention of a few buffaloes to the development of mining interests amounting to millions of dollars.'
>
> But to Representative William McAdoo of New Jersey, Yellowstone performed a larger function. Answering Payson, he pointed out that the park also preserved wilderness which the railroad would destroy even if it did not harm the hot springs. He added that the park had been created for people who might care to seek 'in the great West the inspiring sights and mysteries of nature

that elevate mankind and bring it closer communion with omniscience' and that it 'should be preserved on this, if for no other ground.' McAdoo continued with a vindication of the principle of wilderness preservation: 'the glory of this territory is its sublime solitude. Civilization is so universal that man can only see nature in her majesty and primal glory, as it were, in these as yet virgin regions.'

A vote followed in which the railroad's application for a right-of-way was turned down 107 to 65. Never before had wilderness values withstood such a direct confront-ation with civilization (Nash 1982, 114-115).

These accounts demonstrate two important perspectives on wilderness preservation that appear to have a long history in our culture. In the Yosemite example, Olmsted's view that certain landscapes have such intrinsic beauty that they can never become "private property" can inarguably be applied to the view of the night sky. If an artificial light is erected and maintained that compromises or interferes with the view of the night sky from a wilderness preserve, that light is in violation of one of the basic premises of the wilderness ethic: namely, obvious evidence of human technology becomes visible on the landscape. Such a situation is known as "light trespass," and may be regarded as just as serious a violation of the wilderness character as the trespass of domestic livestock or off-highway vehicles onto wilderness lands. If Olmsted's philosophy is extended to night sky "scenery," skies visible from wilderness preserves should receive the same protection as the terrestrial landscape within the preserve itself. A similar concept was put forth in the Clean Air Act Amendments of 1977, whereby vistas that were considered integral to the meaning and purpose of federal Class I (wilderness) areas were given special protection from visibility impairment, even if the vista overlooked lands outside the preserve.

The Yellowstone example is remarkable in that it shows the firm conviction by members of Congress in the idea of wilderness preservation over 100 years ago, and in the realization that preservation of such areas requires a large buffer of protection from development. The proposed railroad would almost certainly have been routed to avoid the "natural curiosities" of the geysers, waterfalls, and canyons of Yellowstone, but Congress recognized that it would violate the character of "these as yet virgin regions" by voting to keep its path entirely outside of the park. Regions now possessing "virgin" night skies that also fall within designated wilderness can be seen to be experiencing a similar threat to that facing Yellowstone in the 1880s. To protect pristine sky quality, however, the buffer must extend beyond the park's boundaries because of the potential for the glow of lights from cities, towns, or industrial areas to pollute the skies within a hundred-mile or more radius of the source.

Exactly what is lost when the view of the night sky is less than pristine? Astronomers, professional and amateur, have addressed this question from a technical or scientific standpoint for at least three decades. An increase in sky brightness leads to a decrease in contrast between faint or diffuse astronomical objects and the sky background, in many cases rendering them invisible. Many of the more sublime features of the night sky are subtle or diffuse in nature, such as the zodiacal light and the Milky Way. A glow near the horizon from distant cities or towns, while not significantly affecting the sky quality near the zenith, may cause a "light dome" to become silhouetted against the horizon and foreground objects in the direction of the city, washing out stars and other astronomical objects. This leads to a significant degradation of the wild appearance of the landscape for the nighttime wilderness visitor. An unbroken carpet of stars extending nearly to the horizon in all directions with no evidence of artificial light is one of the more impressive features of a wilderness landscape, especially in the high-mountain or desert regions where the air is commonly very transparent.

The human eye–brain combination is well adapted to allow us to function in all but the densest of forests or deepest of canyons at night, even when the moon is not in the sky. According to Schaaf (1988, 167), "the faintest stars the human eye can glimpse without optical aid are about 100,000,000,000,000 (100 trillion) times dimmer than the brightest light it can perceive without suffering damage." A landscape illuminated by the full or nearly-full moon is relatively easy to negotiate for the properly dark-adapted human eye. In open country, even with nothing more than starlight at the most remote of wilderness locations, it is possible for humans to get around without the use of an artificial light. It became second nature to our ancestors to use what are now known as "astronomer's tricks" (such as averted vision) to enhance night vision. Wilderness travelers of today almost entirely restrict their wanderings to the daytime hours. Occasionally, however, there arises a need or desire to travel at night, planned or unplanned, and often without the aid of a flashlight. It is during these episodes that much is learned about the eye's true capabilities, and the natural light sources in the night sky are fully appreciated. There are those who actually *prefer* to travel at night, especially in hot desert regions or exposed subalpine or alpine environments, to avoid some of the harmful effects of full sunlight on the body. For them, the wilderness preservation ethic applies twenty-four hours a day.

It is no mere coincidence that amateur astronomers commonly pursue their hobby in national parks. What better environment to appreciate the beauty of the night sky than from protected and pristine earthly landscapes? The San Francisco Sidewalk Astronomers, led by John Dobson in the 1970s and 1980s, promoted the glories of the night sky with star parties at Glacier Point in Yosemite National Park and in Death Valley National Monument (now National Park), gatherings which continue to the present day. Most national parks have interpretive programs on the night sky for the public. It is a simple step to include the preservation of night sky visibility in programs concerned with wilderness values or air quality-related values.

The most important value of first-hand observations of the night sky wilderness may well be the possibility that such experiences will lead to an expansion of an individual's perception. Aldo Leopold, in his famous book *A Sand County Almanac* (1949, 204), put forth the idea of a land ethic, which "simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively the land." This concept is introduced only after Leopold relates many observations of animal behavior in wild places, so that it is obvious to the reader that such an ethic is an inevitable consequence of intimate knowledge with a place. The more one knows about a place, its features and inhabitants, the more one is likely to advocate preservation of those features, because they have led to one's personal and spiritual development. Rodman elaborates on this remarkable character of Leopold's work that has universal appeal:

> When perception is sufficiently changed, respectful types of con duct seem 'natural,' and one does not have to belabor them in the language of rights and duties. Here, finally, we reach the point of 'paradigm change.' What brings it about is not exhortation, threat, or logic, but a rebirth of the sense of wonder that in an cient times gave rise to philoso phers but is now more often found among field naturalists (Rodman 1983, 90).

Leopold writes of trying to put oneself in the position of various wild animals—the skunk, the mouse, the muskrat—and trying to imagine what their perception of their environment is. Those who would observe the universe under pristine skies from the platform of a wilderness preserve are ideally situated to place themselves *out there.* This type of perception expansion inevitably leads to the sense of wonder that fosters a better understanding of the place of humans, not only on this planet but in the universe as a whole. While the objects, events, and processes that go on outside earth may seem to some only to have practical value to theoretical physicists and fortune tellers, there can be little argument as to the cultural and spiritual significance of the face of the night sky. If it can be left "unimpaired for future generations," the opportunity for the development of such intimate knowledge of the universe may in fact lead to respectful types of conduct, one of which might just be the judicious and conservative use of artificial lighting.

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Let There Be Dark: The National Park Service and the New Mexico Night Sky Protection Act

The National Park Service (NPS) mission, supposed by some to be immutable, constantly changes and grows. This paper will review important episodes in the growth of this mission to include the ability to see, enjoy, and be influenced by moonlight, starlight, meteors, comets, and the vast darkness of interstellar space.

The beautiful and succinct initial statement of mission in the National Park Service Act of 1916 is often mistaken even today for the mission of the agency. It is instead a brilliant foundation for ever-maturing philosophical concepts and recognition of resources that could never have been dreamed of 85 years ago. Numerous laws have expanded the mission. Other changes have come in the interpretation of statutory language by the courts, by the many professional disciplines that are vital to the NPS mission, and by the people who are the National Park Service.

Although sometimes branded by opponents as arbitrary, these changes actually reflect normal growth in professional acuity and public consciousness. For example, the founders, in 1916, appear not to have been thinking of interdependence among great and small and popular and unpopular species, and NPS afterward participated in extirpation of unpopular species. We know now that unpopular species may need to be saved or even reintroduced in order for popular species to have the complete means for their own existence. That kind of awareness—rare in 1916—had to await broader understanding and acceptance of ecological concepts. Although it took many years, once this awareness had developed, NPS had no choice but to adopt a broader and more encompassing reading of its natural resource mission. Thus, mission requirements once presumed to be met by arresting poachers and fighting fires grew to include keeping water and air clean, removing exotic species, and other actions undreamed of when the intellectual and philosophical context of "natural resource management" was in its infancy (Sellars 1997).

Cultural resource concepts also had to outgrow a period of intellectual and philosophical infancy. At first, it was easy to acknowledge the importance of Cliff Palace, Casa Grande Ruins, and Chetro Ketl, because they were visually spectacular (just as moose, bison, and geysers were visually spectacular). However, it proved impossible to understand these structures without the archaeological information embedded in the soil around them. Giant steps then took us from a simple focus on the protection of ruins to the recognition that microscopic particles in stratified layers of earth are valuable cultural resources. Yet other giant steps, after scientific archaeology had been accepted, then expanded the intellectual and philosophical context to encompass the importance of values and belief systems of living contemporary cultures (NPS and Colorado Historical Society 1989). Now, with logic that allows a natural feature such as Plymouth Rock to be acknowledged as important to the cultural traditions (however apocryphal) of English-derived Americans, it is equally possible to acknowledge that sacredness attributed to a mountain may be important to the cultural traditions of an American Indian tribe (e.g., Bear Butte in South Dakota; Mount Shasta in California).

The relatively recent recognition of the night sky as a "resource" worthy of preservation within the NPS mission represents a giant, but logical, step in the growth of the intellectual and philosophical contexts of both natural and cultural resource management.

Before 1990, park managers and visitors watched in growing and helpless dismay as ambient artificial light, not yet called "light pollution," made its way from urban centers into less-populated areas of the American West (Advertising Age 1993; Denver Post Magazine 1993). A bright aura above a city might be visible from a park more than a hundred miles distant. Soon, however, similar glows were coming from small towns, and from mines, drilling rigs, refineries, and other industrial facilities that operated round the clock. Bryce Canyon National Park, in remote southern Utah, was affected by bright lights from a strip-mining operation beyond the park's boundaries. It became popular among rural dwellers to place mercury vapor lights on tall poles, ostensibly to discourage thieves. These streetlights without streets were more nearly statements of modernity than devices for security. They even penetrated Indian country. So many Navajo family dwellings had mercury vapor lights that from Mesa Verde's Far View Lodge, the vast and mostly empty reservation to the south sparkled at night like a thinner suburbia. Park managers of the era were like captains of ships, responsible only for their own individual parks and for looking inward within their own park boundaries. Little collaboration occurred among parks, and almost none occurred with non-NPS partners beyond park boundaries.

Professional astronomers took an

early lead. Ambient light from growing metropolitan Tucson was rapidly diminishing the ability of astronomers at Kitts Peak to make use of their advanced and expensive scientific facilities. MacDonald Observatory, near Fort Davis, Texas, feared the same result. They and others began to call attention to artificial light as a problem, and successfully obtained ordinances in nearby jurisdictions to limit "light pollution" (Santa Fe Reporter 1992; Santa Fe New Mexican 1994a, 1994b).

In August 1991, Joe Sovick, then chief of the Division of Environmental Coordination of the NPS Southwest Regional Office in Santa Fe, served as acting superintendent of Chaco Culture National Historical Park. Intended as a developmental assignment for Sovick during a temporary vacancy, it also became a moment of innovation for NPS. Chaco has a magnificently unspoiled night sky, and its prehistoric ruins make it clear that the builders had paid careful attention to the night sky of their own time. Archaeo-astronomy, therefore, became an important theme of the park. Did the NPS mission not, after all, require that present and future generations be allowed to view the same night sky that the Chacoans so carefully studied a thousand years ago? When park staff explained that the danger that light pollution from outside sources might soon make this impossible, Sovick became a champion of the night sky cause (Sovick 1992a).

Brief examination of the steps necessary to protect Chaco against external light brought into focus the park's own shortcomings. A mercury vapor light and other fixtures on and near the visitor center produced unnecessary light, and allowed much of it to escape upward as pollution. Chaco needed to "walk the talk" before it could protect itself against external pollution (NPS 1992a).

Sovick returned to his normal assignment in Santa Fe with a promise to get NPS regional help for Chaco, and also with the kernel of an idea for broader activity throughout the Southwest (Sovick 1991, 1992b). A modest sum was transferred to Chaco to support retrofitting with shielded, non-polluting lights. Soon, an inventory of other in-park light pollution problems had been conducted throughout the NPS Southwest Region, and a number of needs for retrofit had been identified. On December 27, 1991, Regional Director John Cook signed a memorandum to Southwest Region park superintendents and all employees of the regional office explaining a regionwide night sky initiative (Cook 1991). Inexpensive but effective retrofits were accomplished not only at Chaco but at Carlsbad Caverns, Canyon de Chelly (Smith 1993), and many other parks. As is the case outside parks, solving problems within parks often requires only a simple action. For example, the roadside sign indicating the turnout to Far View Lodge in Mesa Verde had long been visible as a disturbing glare from important points in the park. It had been tastefully designed in every way except that its lighting fixtures, carefully concealed at ground level, directed rays upward from below, upon the sign, with a resultant escape of much light as pollution. Simple reorientation of the lights eliminated the bright point, while leaving the sign sufficiently visible to approaching motorists. Cost—always a concern, and frequently cited by opponents to environmental improvement—is often not the genuine determining factor in a decision to retrofit: electricity bills at Chaco decreased by 30% as a result of the improvements (Sovick 1999).

Getting its own house in order enabled NPS to do more about light pollution elsewhere. The agency could now engage its tremendous power as an educator of the public through interpretive programs. Also, it could freely use the persuasive power of its considerable reputation as an environmental leader in counteracting specific threats and in moving the cause beyond the parks themselves. Proud of its momentum, the Southwest Region continued to behave as the Servicewide bellwether for night sky issues. When a developer undertook a major project at Chinle, Arizona, just outside of Canyon de Chelly National Monument, NPS staff found it easy to get the developer to install non-polluting light fixtures by urging him to meet the same standard that the agency was imposing upon itself (Cook 1992).

Nationally, 260 million visitors come to the parks each year. Most, presumably, learn something from their visits, and are open to learning more. This educational power had to be tapped if there were to be any hope of preventing the steady growth of light pollution. Interpreters took up the cause with characteristic gusto. G. B. Cornucopia at Chaco obtained grants for the construction of a small astronomical observatory to accommodate the donation of a 25-inch reflecting telescope from the Albuquerque Astronomy Society. The telescope is used to give visitors personal experiences in the value of an unpolluted night sky. Major new nighttime interpretation was also initiated at White Sands, El Malpais, El Morro, Pecos, Carlsbad, Salinas, and Fort Union. These interpretive activities take many forms. In some cases they involve tours, such as the popular "nightwalk" programs at Bandelier National Monument, which feature the nighttime magic of Frijoles Canyon. In other cases they involve the traditional NPS "campfire" programs, or storytelling under the stars, as at Tsankawi Mesa in Bandelier. Exhibits, brochures, and other media are also used. Southwest Region interpreters have developed and distributed basic materials for interpreting the night sky and the threats against it to the network of interpreters throughout NPS (NPS 1992b).

It is not possible to "save" America's national parks without also to some degree "saving" the United States as a whole. If it were somehow possible to save to perfection every acre of every national park unit, and the rest of the country were environmentally "lost," that preservation would have been for naught. NPS's obligation as a friendly and helpful environmental leader is therefore as great as its obligation to preserve the parks. It is not always necessary for this work to be accomplished amid controversy and conflict when reasonable cases can be presented to the broad public. Sovick and others have provided thoughtful and persuasive "op-ed" pieces to newspapers (e.g., Sovick 1997), and when newspapers ran the pieces or other stories about the night sky, they multiplied the public-awareness effect through follow-up letters to the editor.

Powerful and enthusiastic support came from the National Parks Conservation Association (NPCA). Spearheaded by Southwest Regional Director David J. Simon, NPCA conducted a nationwide survey of the effects of light pollution on the National Park System. Its report, "Vanishing Night Skies," was published in March 1999 and widely distributed to shapers of public opinion and makers of public policy. It estimated that only 10% of the U.S. population can see an unsullied night sky, and that light pollution is a resource problem in nearly two-thirds of National Park System units that offer overnight visitation. This report recommended that NPS lead by example; that it expand night sky interpretation programs; that gateway communities and others adopt outdoor lighting ordinances; that Congress bolster Environmental Protection Agency programs for energy-efficient lighting; that Congress strengthen the Clean Air Act; and that early special emphasis be given to preventing deterioration of the night sky in the Midwest, Pacific, and Intermountain regions before it becomes more widespread and serious (NPCA 1999a, 1999b). As usual, the NPCA study stimulated a large number of news stories and editorials in newspapers and magazines throughout the country.

As also related elsewhere in this issue, NPS assisted its new partner organization, the New Mexico Heritage Preservation Alliance, to take a bold step. In January 1999, the alliance declared the New Mexico night sky—almost 122,000 square miles where it touches the earth's surface, and extending outward into infinity—to be one of the state's "Most Endangered Historic Places." As intended, this extraordinary concept quickly captured the public's imagination, opposition was subdued, and a coalition of organizations and individuals who valued the night sky for many different reasons was able to generate powerful action (Albuquerque Journal 1999; High Country News 1999; Santa Fe New Mexican 1999).

State Representative Pauline Gubbells, a Republican from Albuquerque, timed her January 1999 introduction of H.B 39, "The Night Sky Protection Act," almost perfectly with the alliance's declaration. Sovick and the coalition had generated positive press attention throughout the state, creating a "head of steam" for the legislation (NMHPA 1999). They also worked with Representative Gubbells to identify and remove words and phrases likely to attract opposition. For example, the original title of the draft bill, "The Outdoor Lighting Control Act," was changed to emphasize the value to be protected rather than an intent to control (Sovick 1999; Blair 1999). Nonetheless, powerful forces affiliated with the state's outdoor advertising industry went into action to try to stop the bill or to amend it into ineffectiveness. The coalition redoubled efforts to support the bill. Dark sky advocates, including Robin and Meade Martin, Katherine Slick, Dave Simon, John Buting, and Stephen Gainey, applied passion to enlist support to overcome the small but powerful opposition.

Political forces that generally oppose any form of regulation, including the so-called land rights organizations, mounted their own campaign to persuade Governor Gary Johnson, a conservative Republican, to veto the bill. Johnson, however, valued the state's natural beauty himself, and he also recognized that the new law would do much good with only a minimum of cost and virtually no new regulatory burden. He signed the bill into law on April 6, 1999.

The New Mexico Night Sky Protection Act is by no means the comprehensive protection that is ultimately needed (Santa Fe New Mexican 1998). In order to win enactment, the bill was weakened by exempting farms, ranches, and—significantly—the outdoor advertising industry. However, cities and towns, whose streetlights are major pollution sources, were not exempted. Mercury vapor lights, the type cheapest to buy but most expensive to operate and among the worst sources of pollution, can no longer be sold legally in New Mexico. Thus, even the exempted groups will eventually be retrofitting with less polluting fixtures as present equipment wears out. The act requires that outdoor lighting be fitted with shielding that directs light downward, rather than upward or laterally. Downward-directed light is useful, whereas upward or laterally directed light is not only polluting but wasted, so greater efficiency will eventually reduce expenditures for electricity and focus attention on another reason for reducing pollution. The act allows present lighting to remain throughout its useful life, but requires the installation of conforming lights whenever replacement would normally occur, so that any economic burden is limited or avoided altogether. The law also allows local communities to enact more stringent local ordinances.

The New Mexico Night Sky Protection Act takes important steps to stop continued increase in light pollution while the bright stars are still among the things that make New Mexico the "Land of Enchantment." It makes provision for the present situation to be improved in the future, all without the costs, bureaucracies, and similar bugaboos that often thwart environmental protection legislation.

From the perspective of today, two years after enactment, certain flaws in the law have become more apparent. Lack of an enforcement mechanism or overseeing bureaucracy, for example, has caused the burden of making the law widely known to fall upon the press and night sky advocates. Some suppliers are still selling mercury vapor lights, presumably unaware that they are breaking the law.

Yet even such "flaws" may have positive sides. Advocates, upon enactment of a law, often relax their attention, move on to other issues, and disband their coalitions. It is a serious error to presume that any important "victory" is final, but environmental advocates often fall into that trap. Even when there is a dedicated bureaucracy, the continued existence of a cadre of vigilant citizen advocates is vital to invigorate the bureaucracy, to help it, and to keep the public policy agenda from stagnating. For future progress to be made or past progress sustained, new aspects of the subject must come to public attention from time to time. It may be well for a good but not perfect law to be enacted at first, so that the need for improvement can be brought to public attention in the future and momentum can be built or sustained. Indisputably, this is better than insisting upon a perfect law the first time or no law at all—a common tactic that commonly results in no law at all. The New Mexico Heritage Preservation Alliance, NPCA, the astronomers, and the other members of the coalition have an issue to nurture: they can praise lawmakers for their first step, later urge further steps, and all the while use the same efforts to educate the public (Simon 2000). A public that values the night sky and actively seeks ways by which individuals can voluntarily help to preserve it may prove to be the best and most important outcome of all.

For NPS, an important beginning has been made in recognizing, building public understanding of, and erecting actual protections for a resource that is of absolute importance to national park units, but that absolutely cannot be preserved by actions confined within park boundaries. A cadre of partners sharing a common interest has been developed that will help to preserve the night sky with the National Park Service and for the National Park Service, but also among themselves and for themselves. NPS has used its beyond-boundary authorities, such as the National Historic Preservation Act's mandate to provide education to the public and leadership to the preservation movement—authorities that hold great potential for better preservation of resources within national park units everywhere. NPS has learned that effective leadership must begin with leadership by example, and that the most effective action is often the action taken by a partner holding a common interest. And NPS, along with its partners, has learned how much greater creativity, resilience, and achievement ability lie in common action than in unilateral action.

What has been done in one state can and must be done—and improved upon—in other states.

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Chadwick A. Moore

Visual Estimations of Night Sky Brightness

*We can no longer avoid the issue of light pollution, because soon we will have nowhere left to go. The global problem of light pollution has never been so artfully expressed as in Woodruff T. Sullivan's famous 'Earth at Night' satellite images.**

Kosai and Isobe 1992

Introduction

Managers of parks, preserves, refuges, and wilderness areas are becoming increasingly concerned over the loss in visibility of the night sky. Like the apocalyptic threat of Rachel Carson's *Silent Spring*, those who cherish the night skies fear a night of no stars, with only the sallow glow of streetlights for inspiration. Encroaching city lights scatter light upward, bathing the otherwise dark sky and reducing the contrast to a point where stars are lost in urban glow. The effect of urban lighting, also known as light pollution, can reach surprisingly far. For example, from Death Valley National Park the lights of Las Vegas produce an obvious and obtrusive glow even though the city is 100 miles to the southeast. Los Angeles, 160 miles to the southwest, produces a dim but broad glow across the southern horizon (Moore and Duriscoe, in prep.).

Astronomers at observatories were perhaps first to notice this problem. As early as 1970, astronomers were scouring the USA for suitable observing sites away from city lights; remaining opportunities were few (Walker 1970; Garstang 1989). Today, astronomical observatories employ multi-million-dollar equipment to measure sky brightness, contrast, and atmospheric extinction. However, less costly tools are available to those interested in monitoring their dark sky resource. The simplest and least costly monitoring methods are visual estimations using the human eye.

Under a pristine dark sky, perhaps 14,000 stars in the celestial sphere would be discretely visible

*One of these images of the Earth at night is reproduced in color on the back outside cover. It depicts the widespread nature of the night sky issue. The degradation of the night sky by urban light sources extends far beyond what is detectable in this satellite image; large cities can scatter light well over a hundred miles in all directions.

(Figure 1). Outdoor lighting tends to scatter light upward, brightening the background of space. This increase in sky brightness reduces the contrast between the background and fainter stars until they become invisible to the eye. Also lost with the stars are the diffuse objects in the sky—

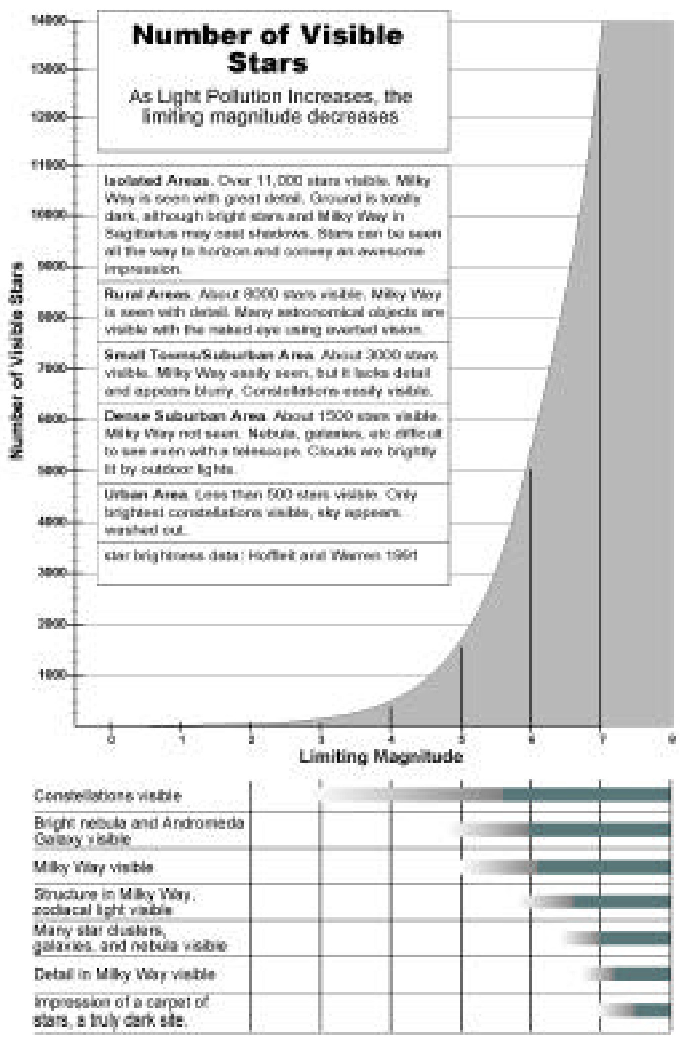

Figure 1. There is a sharp drop-off in number of visible stars as light pollution increases and the limiting magnitude decreases. Also lost is the impression of a primitive sky, and the attending astronomical objects that give it its splendor.

nebulae, galaxies, comets, and the river of stars in our galaxy called the Milky Way. The visible loss of these faint and diffuse astronomical objects is what troubles amateur astronomers so much. This group has been the most vocal in opposing light pollution and promoting the conservation of dark night skies.

Amateur astronomers and meteor observers have made visual estimations of limiting magnitude for years. Limiting magnitude is a measure of the brightness of the faintest star one can see. The astronomical magnitude scale increases with faintness. Magnitude zero represents bright stars such as Vega, Antares, or Rigel, while magnitude 7 stars would be near the faint limit of most dark skies. In exceptional cases, magnitude 8 stars have been observed with the naked eye (Russell 1917; Bowen 1947). The number of visible stars, and the diversity of astronomical objects visible, decrease rapidly as the limiting magnitude falls. It is not uncommon for a remote area surrounded by rapid urbanization to lose more than half the visible stars in a decade (Moore and Duriscoe, in prep.).

The human eye is a somewhat imprecise instrument. Few people have 20/20 vision without aid of lenses, and the eye changes in light-gathering capability and acuity with age (Carr et al. 1989b). There is also potential for bias in the eye's central processing unit— the brain. However, what the eye lacks in precision, it makes up for in sensitivity and ease of use. The scoptic (grayscale) vision we use at night is surprisingly sensitive, able to detect as few as 200 photons per second falling on the retina and transmitting a message to the brain (Russell 1917). The eye's rod cells are 1,000 times more sensitive than the color-detecting cone cells (Carr et al. 1989b). Scoptic vision is most sensitive in the greens and blues, and least sensitive to the reds; thus the use of red-filtered flashlights to preserve night vision. The star magnitudes used in this method are measured in the "Johnson V" spectrum, which closely matches the human eye's scoptic vision, and are therefore an appropriate analogue for brightness measurements.

Methodology

The visual estimation of limiting magnitude is based on star counts of 25 established sample areas (similar to methods utilized by meteor observers; Figure 2). Each area contains a field of mapped stars with known brightness values. The observer scans the field using averted vision, trying to detect sequentially fainter stars on the map. The faintest star observed becomes the sky's limiting magnitude (LM). By following the procedures for dark adaptation and counting, reasonable conformity can be attained between observers (Blackwell 1946).

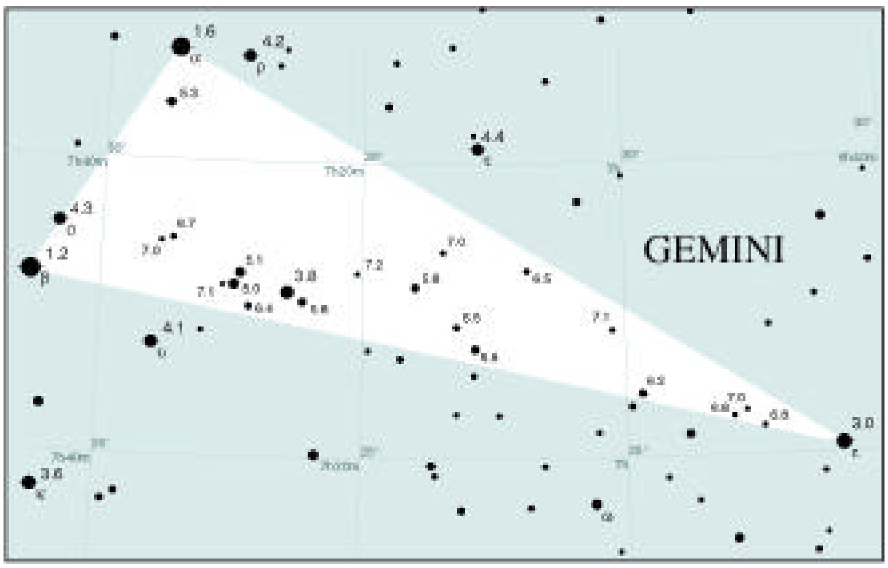

Figure 2. One of the 25 star count areas for determining limiting magnitude. This open triangle uses the familiar stars of Castor and Pollux (the Gemini Twin stars) for the short side. After proper dark adaptation, the observer takes 2-5 minutes to find the faintest visible stars, starting with the brighter ones and working fainter. The faintest visible star becomes the limiting magnitude.

Initially, this star count is conducted at the zenith (straight overhead). Counts can also be conducted in quadrants of the sky, and at various angular altitudes above the horizon. The process can take as little as 30 minutes to arrive at a zenith LM number. Observers have used this methodology to produce brightness maps of different parts of the night sky, or to take single measurements on multiple nights to capture the range of variation associated with weather, seasonal changes, or atmospheric scattering. Observations are conducted under cloudless, moonless nights. Even distant clouds or ground fog skew the results, amplifying some light sources while suppressing others. The effect of local weather upon sky brightness is an interesting study in itself, but such conditions should be avoided to produce a baseline inventory to track long-term changes.

Other Factors Affecting Limiting Magnitude

Light scattered upward is not the only factor affecting an LM measurement. Pollutants in the atmosphere can substantially increase the extinction of light as it is transmitted through the atmosphere. Airborne particulates, in the absence of light pollution, can substantially reduce the faintest stars visible, even thought the sky background may appear very dark (Garstang 1991). In this case, the visibility of stars and astronomical objects are lost to light scattering and absorption, not due to decreased contrast. Air pollution compounds the scattering of light pollution, furthering the degradation of night sky visibility. Finally, both factors are affected by humidity in the atmosphere (Carr et al. 1989b). The growth and size of aerosol particles in the atmosphere is related to moisture. Therefore, higher humidities are expected to exacerbate both the scattering of existing light pollution as well as the absorption of starlight (Garstang 1991). Conditions of greater scattering tend to brighten nearby light sources while dimming far-off light sources (Carr et al. 1989b). The corollary to this phenomenon is that dry, high-altitude dark-sky sites are more susceptible to far-off light sources.

The lower atmosphere is turbulent, producing the common effect of twinkling stars. Turbulence scatters light and reduces the LM. Those precious few photons will be deflected away from a single retinal cell, and the eye will fail to detect a star, even though the night is dark and pollution-free (Bortle 2001). Therefore, LM estimations will integrate a measure of atmospheric stability, when perhaps we are less interested in its effects than that of scattered light or air pollution. Observers often notice that the stars look sharpest and brightest in the late hours just before dawn. This trend is mostly due to atmospheric turbulence which settles and diminishes as the night progresses and the land cools. This trend may also be the result of reduced light pollution as people turn off their porch lights, park their cars, and outdoor athletic events come to a close.

Sources of Sky Glow

As with many natural resource measurements, much of the challenge can be separating the natural and human components. Natural sky brightness does exist; the human-made component of sky brightness is light pollution. Moonlight is the most obvious natural source, but can easily be avoided by sampling when the moon has set. Zodiacal light, the spike of illuminated dust particles circling the inner solar system, can be a significant natural light source. It is most obvious in spring and autumn, but will set a few hours after sunset and rise a few hours before dawn. Like the moon, zodiacal light is easily avoided and simply results in a shorter observing window at night (International Dark-Sky Association 2000).

Airglow is an important consideration at dark-sky locations. This results from the excitation of air molecules in the upper atmosphere that emit faint light. Airglow varies with solar activity, and tends to be highest during the solar maximum (which varies on an 11-year cycle; the most recent was in 2001). Lastly, galactic light and starlight can be a significant enough light source that they can affect both the eye's ability to see faint objects and the brightness of the sky itself. Star counts within the Milky Way are more difficult due to the glowing background of the galaxy (International Dark-Sky Association 2000). In extremely dark locations, the brightest portions of the Milky Way will create shadows and can spoil the eye's dark adaptation! However, for skies with LMs of 6.0 or lower, airglow, galactic light, and starlight are not a significant factor in total sky brightness.

The Bortle Dark-Sky Scale

Although LMs have long been used by serious amateur astronomers, John Bortle recently proposed a different, qualitative-based scale (Bortle 2001). Built on the idea of categorizing night skies (Schaaf 1994), this nine-step scale has proved immediately popular, and has a few advantages over the visual estimation of LM. Like the LM methods, only a beginning knowledge of the night sky is needed. The Bortle Dark-Sky Scale uses qualitative descriptors to differentiate one class of sky to another. For example, being able to see the Andromeda Galaxy with the naked eye is indicative of class 6 skies and better. His scale is based on 50 years of night sky observing, and unfortunately his best class 1 skies are so rare now that few have ever seen them.

The Bortle scale definitions are included and cross–referenced with LMs (Figure 3). The Bortle scale is suitable for a wide range of conditions, from the brightest urban areas (LM lower than 4) to the darkest sites (LM up to 8)—an advantage over the LM star count method. The LM star count is best suited to magnitude ranges between 5.5 and 6.5, and is unusable with LMs above 7.2 or below 4.5. The Bortle Dark-Sky Scale also integrates factors in a way similar to our own aesthetic appreciation of the night sky. However, this method tends to produce one measure for an entire sky, as opposed to the LM star count method, which can produce multiple measurements for different points in the sky, allowing sky brightness to be associated with directions or specific cities. It is also less able to capture finer variations in sky brightness. Bortle (2001) contends that the degree of human bias and error in LM star counts exceed the resolution of the method. However, basic tests using LMs found adherence to the methods produced an acceptable variation from observer to observer that is less than the 0.5-magnitude steps of the Bortle scale (Moore and Duriscoe, in prep.).

Conclusions

Dark night skies are an important resource. Dark night skies are an air quality-related value, and as such are

Bortle Dark-Sky Scale

	Milky Way	Astronomical Objects	Zodiacal Light/ Constellations	Airglow and Clouds	Night Time Scene	LM
Class 1	MW shows great detail, and Scorpio/Sagittarius region casts obvious shadow on ground	Pinwheel galaxy is an obvious object	Zodiacal light has obvious color, and can stretch across entire sky	Bluish airglow is visible near the horizon and clouds appear as dark blobs against stars	Jupiter and Venus annoy night vision, ground objects are barely lit, trees and hills are dark	7.6-8.0
Class 2	Summer MW shows great detail, and has a veined appearance	Pinwheel galaxy is an visible with direct vision, as are many globular clusters	Zodiacal light bright enough to cast weak shadows after dusk and has apparent color	Airglow may be weakly apparent, and clouds still appear as dark voids	Ground is mostly dark, but object projecting into the sky are discernible	7.1-7.5
Class 3	MW still appears complex, dark voids and bright patches and a meandering outline are visible	Brightest globular clusters are distinct, Pinwheel galaxy visible with averted vision	Zodiacal light is striking in Spring and Autumn, extending 60° above horizon	Airglow is not visible, and clouds are faintly illuminated except at zenith	Some light pollution evident along horizon, ground objects are vaguely apparent	6.6-7.0
Class 4	Only well above horizon does MW reveal any structure. Fine details are lost	Pinwheel galaxy is a difficult object, even with averted vision; Andromeda galaxy very visible	Zodiacal light is clearly evident, but extends less than 45° after dusk	Clouds are faintly illuminated except at zenith	Light pollution domes evident in several directions, sky is noticeable brighter than terrain	6.1-6.5
Class 5	MW appears washed out overhead, and is lost near the horizon.	The oval of Andromeda galaxy is detectable, as is the glow in the Orion nebula	Only hints of zodiacal light in Spring and Autumn	Clouds are noticeable brighter than sky, even at the zenith.	Light pollution domes are obvious to casual observers, ground objects are partly lit	5.6-6.0
Class 6	MW only apparent overhead, and appears broken as fainter parts are lost to sky glow	Andromeda galaxy detectable only as a faint smudge, Orion nebula is seldom glimpsed	Zodiacal light is not visible. Constellations are seen, and not lost against a starry sky	Clouds anywhere in the sky appear fairly bright as they reflect back light	Sky from horizon to 35° glows with grayish color, ground is well lit	5.1-5.5
Class 7	MW is totally invisible or nearly so	Andromeda galaxy and Beehive cluster are rarely glimpsed	Zodiacal light is not visible, and constellations are most easily seen	Clouds are brilliantly lit	Entire sky background appears washed out, with a grayish or yellowish color	4.6-5.0
Class 8	not visible	Pleiades are easily seen, but precious few other objects are visible	Zodiacal light not visible, and some dimmer constellations lack key stars	Clouds are brilliantly lit	Entire sky background has an orangish glow, and it is bright enough to read at night	4.0-4.5
Class 9	not visible	Only the Pleiades are visible to all but the most experienced observers	Only the brightest constellations are discernible	Clouds are brilliantly lit	Entire sky background has an bright glow, even at the zenith	<4.0

Figure 3. The Bortle Scale uses nine steps to rate the quality of the night sky. Using fairly common astronomical objects, and qualitative descriptors of the Milky Way, zodiacal light, and nighttime scene, a class can be established; some minor additions have been made by the author. Bortle's scale includes exceptionally dark skies that are increasingly rare today. His class 1 and 2 skies not only require the absence of light pollution, but also require atmospheric conditions low in air pollution, aerosols, and moisture. Because of this, the darkest skies are strongly weather-dependent. In the more humid eastern USA, such skies would be exceedingly rare today.

provided ancillary protection under the 1977 Clean Air Act Amendments. They are an important component of wilderness areas in "retaining primeval character and influence," as defined in the 1964 Wilderness Act. They are necessary to a growing list of wildlife species, and are increasingly sought after by park visitors as they lose the experience of a starry night at their homes in the city. Night skies also serve as a "vital sign": an indication of the degree of encroachment of development, and of the level of cooperation between a protected area and surrounding communities.

The Bortle scale gives glimpses of the potential quality of night sky that is currently lost at most locations in the USA. Land managers whose responsibilities include significant night skies, but who have no measure of their quality, are at least 30 years behind. The value of a baseline condition, even if substantial resources have already been lost, cannot be overestimated. Visual estimations of night sky brightness are simple and repeatable. Because of their simplicity, they can "readily become the most extensive body of data" available on night skies (Kosai and Isobe 1992). They also allow a direct comparison from one area to another, whether that area is a few miles away or atop a distant mountain.

Visual estimations of night sky brightness are an easy and rapid tool for land managers to inventory the quality of their dark sky resource. They are an effective first step in monitoring and ultimately protecting this threatened resource.

Epilogue

In early 2000, the National Park Service (NPS) funded a Night Sky Team. Using Natural Resource Preservation Program and Fee Demonstration funds, the team set out to standardize methods for measuring and monitoring night skies, and to employ these methods at several parks. Complete methods for visual estimations of LM are available from the Night Sky Team, and now include cross-references to the Bortle Dark-Sky Scale. Additional quantitative methods and computer models are being refined or developed, and will become the mainstay of the program's efforts. In addition to standardizing methods, the Night Sky Team provides technical assistance for community outreach and visitor interpretation. The Night Sky Team is based out of Pinnacles National Monument and Sequoia and Kings Canyon National Parks, with support from the NPS Air Quality Division.

Several studies provide examples of good science and leadership in night sky management. In a program between amateur astronomers, the National Astronomical Observatory, and the Japan Environmental Agency, a map of sky brightness was developed for the entire country of Japan (Kosai and Isobe 1992). Combining star counts, photographs, and photometric observations, the study documented the location of the darkest areas as well as the change in sky brightness over time.

Bryce Canyon National Park examined the potential impact from a planned coal mine, as well as the human perception of light pollution (Carr et al. 1989a, 1989b). These two studies were pioneering in their use of computer modeling of light pollution. Additionally, they cross-referenced particular brightness values in the sky to what is commonly perceived by park visitors. The human perception of sky glow is an important component of night sky protection, since aesthetics and the wilderness experience are often cited as core values.

In another study by NPS, Organ Pipe Cactus National Monument conducted complete sky surveys with a stellar photometer (NPS 1995). Light pollution contributions from near and distant cities were mapped and their exact brightness values determined. In 2001, these measurements were repeated, giving the park long-term monitoring data and the ability to detect small changes in night sky brightness over time (Casper 2001).

After only 18 months in operation, the Night Sky Team (composed of resource scientists with other full-time duties) is nearing standardization of methodologies and completion of a pilot study at four national parks. The task remaining is tremendous. At the time NPS was created, the night skies above our national treasures were unimpacted by light pollution. Today, only about 1% of parks are free from this problem. Many flagship parks in the National Park System have substantial degradation, but fewer than a dozen parks have any data whatsoever on the quality of their night skies.

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Steve Albers
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Modeling Light Pollution from Population Data and Implications for National Park Service Lands

Introduction

There are many factors that affect nighttime sky brightness, both natural and human-made. It is useful to think of what the main light sources are and how this light is scattered. The natural sources come from stars, the Milky Way, airglow, and moonlight. Human-made sources include streetlights and other outdoor lights, concentrated largely in towns and cities. Light is scattered by air molecules, natural and anthropogenic particulates, and haze (an enlargement of these particulates related to atmospheric moisture). The result of all these factors is what we see at night in terms of the sky brightness. To help clarify the further discussion, some simplifications will be helpful. We will assume no moonlight and relatively low levels of particulates and haze—in other words, that we are looking at the night sky under conditions that are among the best for a given location. We also neglect things such as surface albedo, which affects how much light is directed upward from city lights. The main remaining factor is city lights, whose effect is approximately related to population, and natural airglow (a continuous aurora-like glow) that actually varies during the course of the sunspot cycle. The darkest sites on earth have a brighter glow than those in outer space for two main reasons: the scattering of starlight by the atmosphere, and airglow.

Brief Review of Previous Modeling Efforts

A number of people have modeled light pollution in various ways. As an example, Garstang (1986) has done detailed calculations for a number of observatory sites, creating maps showing how the skyglow varies at different altitudes and azimuths from each site. Burton (2000) is analyzing satellite data from the Defense Meteorological Satellite Program (DMSP; run by the U.S. Air Force) to estimate skyglow in the close vicinity of urban areas. This has the advantage of considering actual satellite data at high resolution, both spatially and in terms of intensity. However, limited consideration is given to atmospheric scattering, especially over large distances.

DMSP data have been linked with

a robust scattering model in Europe by Cinzano et. al. (2000, 2001). When properly calibrated, this provides greater spatial information about the sources of light pollution than population data alone.

Description of the Model

Assumptions and data source. The present effort is unique in that it produces an areal map of zenithal sky brightness over the entire USA. It works both within and at large distances from urban centers. The model also employs assumptions about scattering embodied in Walker's Law, with additional consideration of the earth's curvature. The model is based on the location and population (1990 census) of significant U.S. cities and towns (over 50 population).

Mechanics of the model. The model creates a map of expected skyglow at the zenith. For each location in the map, the light pollution contribution from each city is assumed to be related linearly to the population and the inverse 2.5 power of the distance. This is similar to the relation used in Walker's law (Walker 1977), except that we are estimating light pollution at the zenith instead of 45 degrees high in the azimuth of the brightest city. The relation used here for each city *i* is in equation 1, where

$$I_i = 11{,}300{,}000pr^{-2.5} \quad (1)$$

I_i is sky glow in nanoLamberts, p is the city population, and r is the distance to the city in meters. This is corrected for earth's curvature at large distances (this necessity was pointed out by Garstang). The correction is done by calculating the fraction f of the air molecules and other scatterers over the observer that lie above the earth's shadow that is formed from light traveling in a straight line from the city. The overall scale height s for these scatterers (defined as the altitude increase required to see a drop-off by a factor of *e*) is currently set to 4,000 m. This is less than the "clear air" value of 8,000 m accounting for a typical amount of aerosols. The scattering from this mixture is more strongly concentrated at low altitudes than that from air molecules alone.

$$f = e^{-h/s} \quad (2)$$

The height h is the amount of the air column above the observing location that is not in a direct line of sight to the light-polluting city due to the curvature of the earth. Adding this correction term f into equation 1 yields a further modified form of Walker's law as shown in equation 3.

$$I_i = 11300000pr^{-2.5}f \quad (3)$$

Finally the light pollution from each city is summed to get the total artificial skyglow I at a given location on the light pollution map as in equation 4.

$$I = \text{summation } I_i \quad (4)$$

A number of other ideas and equations used come from publications by Garstang. The assumed radius of each city is a function of city population, ranging from 2.5 km to 24 km. Walker's law applies if we are outside the city radius. Inside the city radius, the sky glow increases linearly toward the center by another factor of 2.5.

A value for the natural skyglow is added onto the light pollution contribution. The natural skyglow is assumed to be equal to 60 nanoLamberts (V = 21.9 mag / sq sec) at solar minimum. The last step in arriving at a pixel value is scaling the brightness with respect to the logarithm of the skyglow. The brightest city has pixel values of (255,255,255), and the darkest country site has pixel values of (42,52,67). The calibration bar is intended to linearly represent the sky brightness in terms of magnitudes per square arcsec. The model result is shown in Figures 1 and 2.

Schaaf Sky Quality Scale. Fred Schaaf has provided much helpful discussion that has led to substantial improvements in this image. As part of the calibration process of the image, we are comparing the expected amount of light pollution for various locations with observations of limiting magnitude and sky quality according to the Schaaf scale (Table 1; Schaaf 1994).

Figure 1. Modeled skyglow over the continental USA.

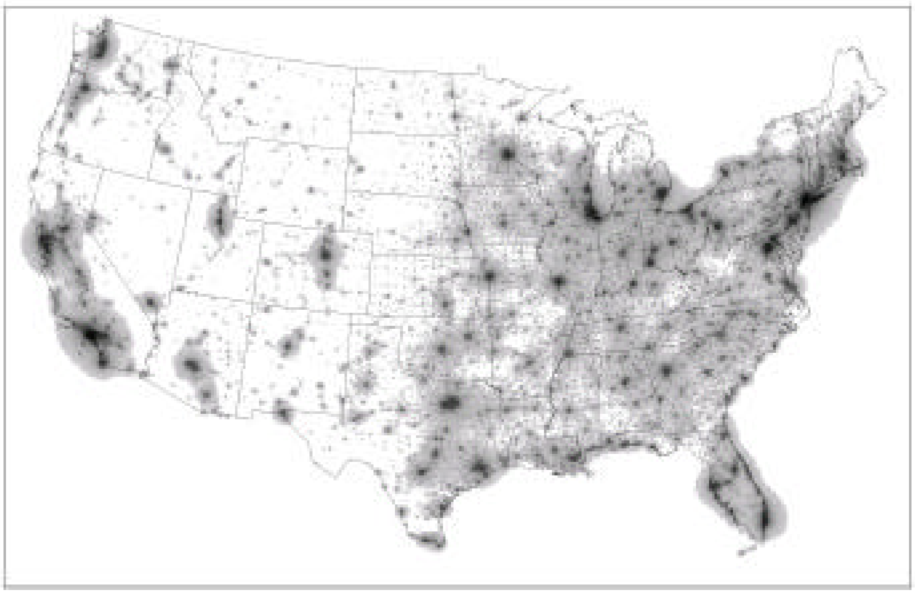

Figure 2. The shadings here are rescaled from Figure 1 to represent the seven-level Schaaf scale.

Table 1. The Schaaf scale and Zenith Limiting Magnitude (ZLM) equivalents. Within the context of this light pollution model, the above conversion can be done between Schaaf scale and ZLM. This has been modified slightly from the original scale so that the verbal sky descriptions in the Schaaf scale are more consistent with modeled limiting magnitudes.

Schaaf Class	*Zenithal Limiting Magnitude*
1	<4.75
2	4.75-5.25
3	5.25-5.75
4	5.75-6.20
5	6.20-6.55
6	6.55-6.76
7	6.76-6.81

Verification of the model with observations. Field data have been received from locations throughout the USA, primarily from the International Meteorological Organization. These data are in the form of zenith limiting magnitude, and can be compared with values predicted by the model for the same location. Figure 3 is a scatter plot of observations received near sunspot maximum compared with predicted limiting magnitude for the site. The graph shows that the predicted values are in relatively good agreement with those observed, especially between magnitudes 5 and 6. For very dark skies, observers typically do not see stars as faint as the model predicts, and for brighter skies, observers consistently see stars fainter than the model predicts.

Future Work

A natural extension of this work would be to incorporate DMSP data, perhaps along with the population data, to gain a better idea of where the light sources are in the USA. This has been done for Europe and may be extended to other parts of the world by Cinzano et. al. (2001). The use of population data from other census decades could provide a time series of light pollution in the USA over many years.

National Park Land Area Analysis

The model may be used to evaluate the effects of light pollution on areas administered by the National Park Service (NPS) for the purpose

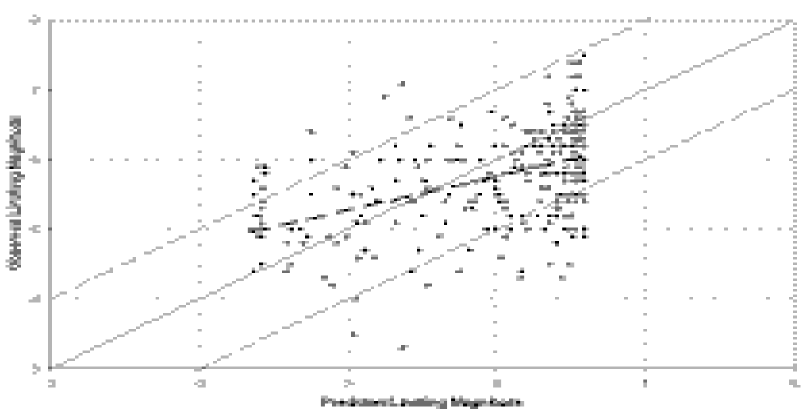

Figure 3. Plot of predicted vs. observed limiting magnitude for observa tions near sunspot maximum. The solid line represents ob served=predicted, the dashed fine lines show one magnitude lower and higher than predicted, and the bold dashed line is the best fit linear regression of the data.

of protecting night sky visibility. When the image generated by the model is imported into a geographic information system such as ArcInfo, and the park boundaries superimposed, a simple intersection of the two themes yields data on the relative proportion of each park that falls within each of the Schaaf scale classes. Figures 4 through 8 show selected regions of the USA (in a negative image for clarity) with NPS areas superimposed upon the light pollution model. The state boundaries are also added, and the maps are produced in Lambert's Conformal Conic Projection.

Examination of these maps reveals that, as of 1990, large areas of the West were predicted to still possess Schaaf class 7 (pristine) skies, while such sites were very rarely east of the Mississippi River. Large areas of class 7 skies are seen in Nevada, Montana, North Dakota, eastern Oregon, southeastern Utah, northern Arizona, western Texas, and Wyoming. These regions were far enough from large urban centers that the influence of light pollution was minimal. Several large and well-known national parks fall within these areas, including Glacier, Yellowstone, Canyonlands, Grand Canyon, and Death Valley.

The GIS analysis produced a table of park areas showing what percentage of the area within each park

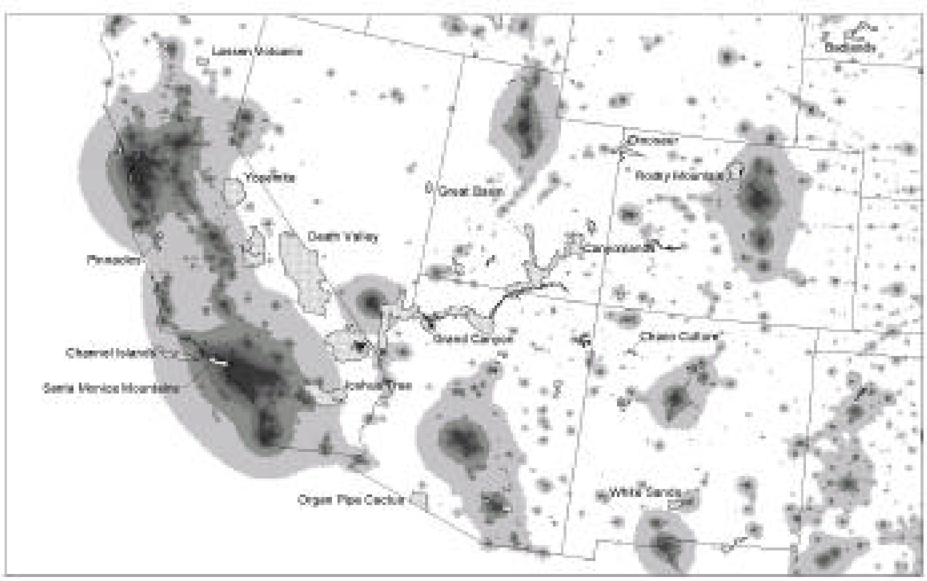

Figure 4. Light pollution and national parks in the Southwest.

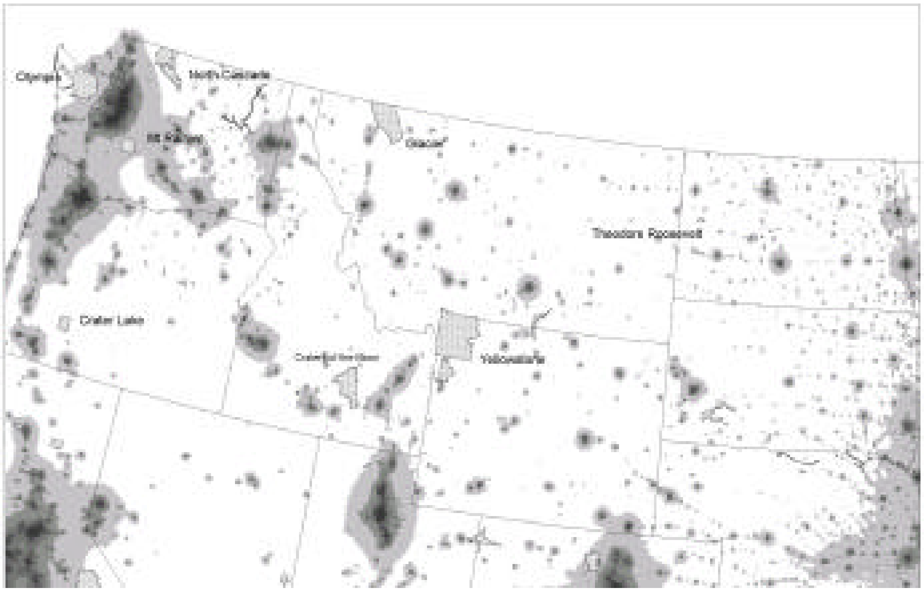

Figure 5. Light pollution and national parks in the Northwest.

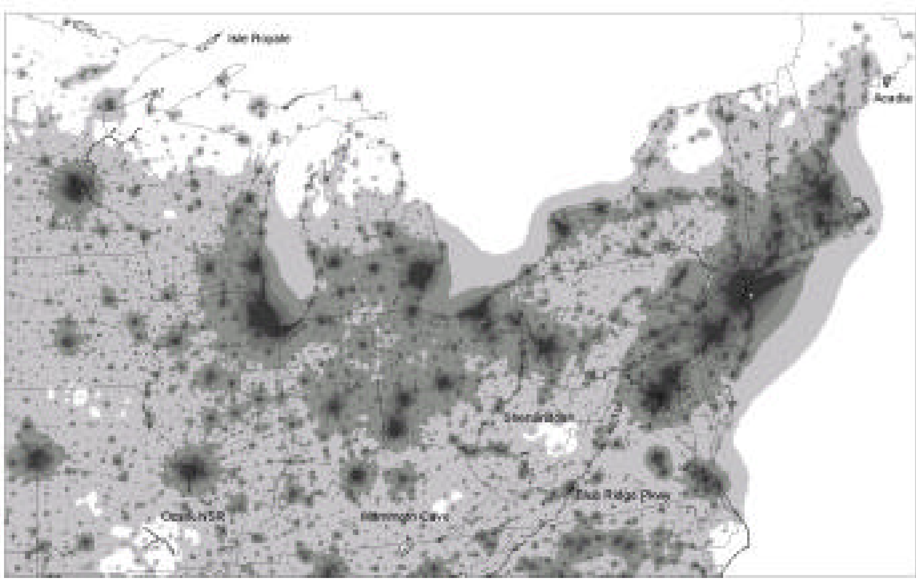

Figure 6. Light pollution and national parks in the Northeast.

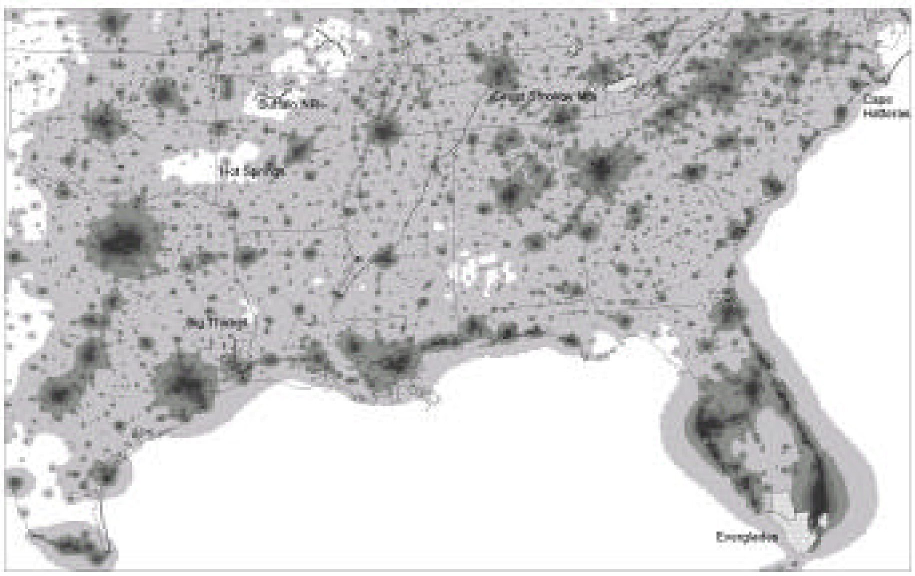

Figure 7. Light pollution and national parks in the Southeast.

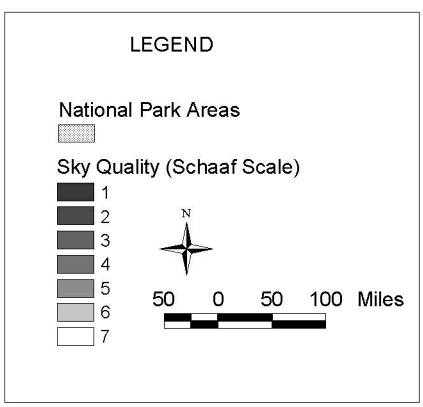

Figure 8. Legend for Figures 4-7.

fell within each of the Schaaf classes. Also, a mean Schaaf class was computed, and the total acreage of each park was calculated (Table 2). Not all park areas are shown: many were edited out for brevity, and the authors apologize in advance if the reader's favorite park was left out. The table is ordered first from darkest to brightest mean Schaaf class, then alphabetically by park name for parks with identical means. Note that

Table 2. Analysis of sky quality at selected NPS areas.

Park name	*Total acres*	*Mean Schaaf class*	*Percentage of land area within each Schaaf class*						
			1	*2*	*3*	*4*	*5*	*6*	*7*
Badlands NP	241,284	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Big Bend NP	827,169	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Canyonlands NP	331,342	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Capitol Reef NP	241,505	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Carlsbad Caverns NP	46,921	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Chaco Culture NHP	34,504	7.00	0.0	0.0	0.0	0.0	0.0	0.5	99.5
Chiricahua NM	12,225	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Crater Lake NP	180,631	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Craters of the Moon NM	750,312	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Devils Tower NM	1,341	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Death Valley NP	3,370,969	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Dinosaur NM	208,650	7.00	0.0	0.0	0.0	0.0	0.0	0.1	99.9
Dry Tortugas NP	72,382	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Gila Cliff Dwellings NM	526	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Glacier NP	1,026,615	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Great Basin NP	76,349	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Great Sand Dunes NP	38,202	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Guadalupe Mountains NP	88,254	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Hovenweep NM	797	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Isle Royale NP	143,269	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Lava Beds NM	46,004	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Lassen Volcanic NP	106,239	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Natural Bridges NM	7,324	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Navajo NMON	597	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
North Cascades NP	510,531	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Organ Pipe Cactus NM	331,119	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Petrified Forest NP	94,430	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Rainbow Bridge NM	161	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Theodore Roosevelt NP	71,048	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Voyageurs NP	208,263	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Wupatki NM	36,164	7.00	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Grand Teton NP	308,640	6.99	0.0	0.0	0.0	0.0	0.0	0.5	99.5
Yellowstone NP	2,197,269	6.99	0.0	0.0	0.0	0.0	0.2	0.3	99.5
Grand Canyon NP	1,197,475	6.98	0.0	0.0	0.0	0.0	0.5	1.2	98.3
Glen Canyon NRA	1,238,424	6.97	0.0	0.0	0.0	0.0	0.5	2.0	97.5
Apostle Islands NL	42,170	6.96	0.0	0.0	0.0	0.0	0.0	3.6	96.4

Table 2. Analysis of sky quality at selected NPS areas (continued)

Bryce Canyon NP	35,761	6.94	0.0	0.0	0.0	0.0	0.0	6.3	93.8
Kings Canyon NP	454,632	6.94	0.0	0.0	0.0	0.0	0.0	5.9	94.1
Zion NP	146,400	6.94	0.0	0.0	0.0	0.0	0.0	5.7	94.4
Ozark NSR	81,346	6.90	0.0	0.0	0.0	0.0	0.1	9.5	90.5
Nez Perce NHP	2,309	6.88	0.0	0.0	0.0	0.0	3.4	5.3	91.3
Buffalo NR	94,619	6.84	0.0	0.0	0.0	0.0	0.0	15.7	84.3
Arches NP	75,738	6.82	0.0	0.0	0.0	0.0	1.8	14.9	83.3
Wind Cave NP	28,134	6.81	0.0	0.0	0.0	0.0	0.0	19.1	81.0
Cape Hatteras NS	30,873	6.79	0.0	0.0	0.0	0.0	0.9	19.1	80.0
Canyon de Chelly NM	91,78	6.77	0.0	0.0	0.0	0.0	5.6	11.6	82.8
Redwood NP	114,563	6.77	0.0	0.0	0.0	0.0	2.9	17.2	79.9
Mesa Verde NP	52,692	6.72	0.0	0.0	0.0	0.0	0.0	28.5	71.5
Acadia NP	38,695	6.70	0.0	0.0	0.0	0.4	0.0	29.0	70.6
Yosemite NP	740,969	6.67	0.0	0.0	0.0	0.0	0.0	32.9	67.1
White Sands NM	145,216	6.63	0.0	0.0	0.0	0.0	0.6	36.2	63.2
Niobrara/Missouri NRs	102,034	6.49	0.0	0.0	0.0	0.0	5.7	39.2	55.1
Sequoia NP	401,384	6.48	0.0	0.0	0.0	0.0	0.0	52.1	47.9
Olympic NP	926,349	6.45	0.0	0.0	0.0	0.0	0.0	54.7	45.3
Lake Mead NRA	1,255,884	6.30	0.0	0.0	0.0	1.2	6.4	53.6	38.8
Coronado NMem	4,895	6.00	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Mount Rainier NP	237,165	6.00	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Mount Rushmore NMem	1,305	6.00	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Sunset Crater Volcano NM	3,021	6.00	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Mammoth Cave NP	50,356	5.99	0.0	0.0	0.0	0.0	0.6	99.4	0.0
Pinnacles NM	26,905	5.99	0.0	0.0	0.0	0.0	1.0	99.1	0.0
Rocky Mountain NP	264,124	5.98	0.0	0.0	0.0	0.8	0.3	98.9	0.0
Assateague Island NS	55,717	5.95	0.0	0.0	0.0	2.0	1.1	96.9	0.0
Bandelier NM	32,660	5.94	0.0	0.0	0.0	0.3	5.2	94.5	0.0
Great Smoky Mountains NP	514,688	5.94	0.0	0.0	0.0	1.0	3.9	95.1	0.0
Big Cypress NPres	758,335	5.85	0.0	0.0	0.0	0.0	14.6	85.4	0.0
Big Thicket NPres	89,793	5.85	0.0	0.0	0.0	2.6	9.8	87.6	0.0
Joshua Tree NP	790,699	5.84	0.0	0.0	0.6	0.2	22.2	68.2	8.8
Shenandoah NP	191,362	5.84	0.0	0.0	0.2	1.7	11.9	86.2	0.0
Channel Islands NP	242,284	5.82	0.0	0.0	0.0	0.0	18.4	81.6	0.0
Tallgrass Prairie NPres	10,762	5.80	0.0	0.0	0.0	0.0	20.1	79.9	0.0
New River Gorge NR	61,009	5.72	0.0	0.0	0.3	3.3	20.0	76.4	0.0

Table 2. Analysis of sky quality at selected NPS areas (continued)

Saint Croix NSR	97,938	5.71	0.0	2.8	9.2	8.5	10.7	31.6	37.2
Everglades NP	1,606,717	5.69	0.0	0.0	0.5	4.7	20.5	74.3	0.0
Blue Ridge Pkwy	89,722	5.65	0.2	2.4	2.9	2.9	10.4	81.2	0.0
Natchez Trace Pkwy	45,681	5.55	0.0	2.6	3.4	5.9	12.7	75.4	0.0
Upper Delaware S&RR	37,454	5.52	0.0	0.0	0.0	1.2	45.8	53.0	0.0
Cape Cod NS	40,202	5.33	0.0	0.0	0.0	12.2	42.8	45.0	0.0
Chickasaw NRA	9,938	5.32	0.0	0.0	11.7	1.3	30.0	57.0	0.0
Saguaro NP	93,733	5.07	0.0	0.0	1.8	11.4	64.9	21.9	0.0
Little River Canyon NPres	13,613	5.05	0.0	0.0	0.0	15.8	63.5	20.8	0.0
Colorado NM	20,193	4.98	0.0	0.0	8.8	8.3	58.7	24.2	0.0
Gulf Islands NS	121,888	4.77	4.5	0.4	13.4	9.3	39.7	32.7	0.0
Delaware Water Gap NRA	67,990	4.71	0.0	2.1	0.0	23.0	74.8	0.0	0.0
Point Reyes NS	66,199	4.59	0.0	0.0	6.6	28.0	65.5	0.0	0.0
Scotts Bluff NM	3,206	4.57	0.0	0.0	21.3	0.0	78.7	0.0	0.0
Gettysburg NMP	5,852	4.38	0.0	0.0	22.6	17.2	60.2	0.0	0.0
Harpers Ferry NHP	2,291	4.07	0.0	0.0	0.0	93.4	6.6	0.0	0.0
Pipestone NM	281	4.00	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Timpanogos Cave NM	245	4.00	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Hot Springs NP	5,701	3.58	0.0	11.9	25.8	54.7	7.7	0.0	0.0
Biscayne NP	183,189	3.43	9.8	12.3	22.4	35.5	19.9	0.0	0.0
Cabrillo NM	138	3.00	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Fort Sumter NM	200	2.95	0.0	4.5	95.5	0.0	0.0	0.0	0.0
Chattahoochee River NRA	8,667	2.93	5.2	40.4	24.5	16.3	13.7	0.0	0.0
Petroglyph NM	7,156	2.88	0.0	17.4	77.6	5.0	0.0	0.0	0.0
Chickamauga & Chatta-nooga NMP	8,181	2.80	0.2	28.0	63.4	8.3	0.0	0.0	0.0
Indiana Dunes NL	13,648	2.69	26.0	10.9	31.4	31.7	0.0	0.0	0.0
Jean Lafitte NHP/Pres	18,855	2.53	17.1	28.7	38.3	15.9	0.0	0.0	0.0
Santa Monica Mountains NRA	152,359	2.27	23.4	33.4	36.5	6.7	0.0	0.0	0.0
Cuyahoga Valley NP	32,211	2.22	11.6	54.7	33.7	0.0	0.0	0.0	0.0
Golden Gate NRA	76,080	2.10	55.4	11.6	5.8	22.1	5.1	0.0	0.0
Valley Forge NHP	3,453	2.00	0.0	100.0	0.0	0.0	0.0	0.0	0.0
National Capital Parks–East	7,440	1.56	43.5	56.5	0.0	0.0	0.0	0.0	0.0
Boston Harbor Islands NRA	1,575	1.03	97.2	2.8	0.0	0.0	0.0	0.0	0.0
Gateway NRA	26,704	1.00	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Independence NHP	51	1.00	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Muir Woods NM	567	1.00	100.0	0.0	0.0	0.0	0.0	0.0	0.0

the stated acreage may vary by as much as 2-3% from the true acreage because of the scale of the park boundary data used for the analysis.

Discussion

There appear to have been many park areas that still possessed pristine (mean Schaaf class 7.00) skies in 1990, according to this model. However, as seen in a previous section, observers have typically reported limiting magnitudes lower than those predicted for such areas, possibly indicating brighter-than-predicted sky quality (see Figure 3). Recent (2001) observations by Dan Duriscoe and Chadwick A. Moore at Death Valley National Park have shown that while the zenithal limiting magnitude may still be "pristine" (6.7 or better), a significant light dome from the city of Las Vegas, Nevada, is now apparent from most of the southeastern part of the park. Rapidly growing cities such as Las Vegas may now be significantly degrading the night sky as it appears from areas that had pristine viewing conditions just eleven years ago. Also, the city of Las Vegas is known to utilize bright advertising lights in great numbers and output. Therefore, the constant used in the model for in equation (3) may be larger than 11,300,000 for this city. The combination of a rapidly growing population and high light output per capita could result in much greater and longer-reaching light pollution than the model predicts. When the 2000 census data are readily available, the model can utilize the updated information and the predicted light pollution distribution should reflect changes in increased population and population migrations over the ten-year period.

Many "wild" national park areas are surrounded by or in close proximity to large urban centers, leading to a degradation of the view of the night sky. Examples are Great Smoky Mountains (mean Schaaf class 5.94) and Saguaro (5.06). Other park areas are very remote from large cities, but a small city is close by, such as Scotts Bluff (4.57).

Management Implications

This model may be used to predict the effect of future population growth on light pollution, thereby identifying future threats to night sky resources in national parks that are now relatively pristine. Verifying the model with actual observations should continue to lead to refinements of the "per capita" constant. Park areas that are both remote from large urban centers and are primarily wilderness parks should be identified as candidates for dark sky preserves. The declaration of this type of status, even if only local or informal, could lead to increased awareness and reduced light outputs by residents and businesses of local small communities. The managers of park lands, especially "dark sky parks," should make every effort to reduce light pollution from in-park facilities and concession activities, setting the very best example possible for their neighbors.

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Thom Bemus

Stargazing

A Driving Force in Ecotourism at Cherry Springs State Park

For most Americans, no longer is the night sky velvety black, bejeweled with twinkling stars, and spanned by the vast arch of the Milky Way. Rather, it usually presents itself as a bright, milky orange sky, awash in the glow of scattered sodium vapor lights from poorly designed light fixtures, virtually devoid of stars. Indeed, the likelihood is remote that anyone younger than a Baby Boomer has ever experienced the true majesty of a dark and star-spangled country sky—and it is entirely possible that many people have never seen anything in the night sky but the moon. It is the twin blights of sprawl and light pollution that have made dark, star-filled skies perhaps the most immediately endangered natural resource in North America today.

Because so few people presently live beneath pristine dark skies, most people's only access to them comes when they are on vacation far away from the city skyglow. For the average visitor to a dark-sky park, stargazing often isn't even on their personal radar. Many city dwellers are so stunned by what they have been missing that by the end of their visit to a dark-sky park, access to a dark sky may well be a major factor in deciding where they will take their next vacation.

There may be more than a quarter of a million active amateur astronomers—stargazers—in North America, and their number is steadily increasing. Most are between the ages of 35 and 65. Many are highly educated and financially secure. Many have been ecotourists for more than 20 years, and gaining access to dark skies is the primary reason that they travel. In their quest, these wanderers often travel to North America's most rural parks, and they may even embark on expeditions to such far-flung locations as South America, Australia, New Zealand, and Africa.

By the mid-1990s, a market had developed for dedicated "astronomy inns." This phenomenon coincided with the active sponsoring of stargazing programs by a handful of Western parks graced by dark night skies. Yet most people either remain unaware of such stargazing opportunities, or don't have access to them because of long distances or prohibitive travel costs.

The nearly universal desire of stargazers is to share the joy they find in the night sky with others, as indicated by the massive public education resources that astronomy clubs all over North America roll out every weekend. In the next few years, there will probably be a tidal wave of amateur astronomers retiring and actively seeking darker skies. Unlike many retirees today, one will be much more likely to find them teaching in a classroom or sharing their telescopes with others under dark country skies than to find them on the golf course. Amateur astronomers love to teach. In fact, they will represent the largest volunteer science education resource ever made available in North America. The National Public Observatory's Stars-In-The-Parks program is designed specifically to facilitate the maximum utilization of this amazing resource by getting educational programs going all over the country.

In 1992, during my own search for skies darker than those I had at home, I discovered a small, highly under-utilized park in rural north-central Pennsylvania called Cherry Springs State Park. This former Civilian Conservation Corps camp is located at a high elevation, and has superbly dark skies and a large open field that is perfect for astronomical observing. As I stargazed there, I realized that parks will soon be the last places with dark skies in many regions, especially the eastern half of the country. I believe deeply that we need to protect these dark-sky enclaves. There is a market for more amateur astronomers to use rural parks such as Cherry Springs as educational sites, and also a market for park visitors to join amateur astronomers for fun and education.

By the spring of 1999, I had established a partnership with the National Public Observatory, an educational not-for-profit organization based in Radium Springs, New Mexico. My responsibility was to assist in the nationwide promotion of the Stars-In-The-Parks concept. It focused on developing a national plan for marrying the dark-sky and facility resources of parks with the volunteer educational expertise and equipment that amateur astronomers could supply, to produce a working program that could be used all over the North America.

But where to start? Cherry Springs popped into my mind immediately as the perfect prototype park in which to test the concept. All I had to do was figure out how to "sell" the idea to park management. After thinking about it for a while, I finally decided to "just ask the park manager—all he can do is say no." I was fortunate to find an enthusiastic and receptive audience in Cherry Springs State Park Manager Chip Harrison, who was more than ready to listen to a plan that would greatly increase park use. We have since forged a partnership that has created a unique stargazing program and ecotourism destination.

We have vastly increased park attendance (and, incidentally, also decreased vandalism and littering). On virtually every dark-of-moon weekend, scores of amateur astronomers observe from the park and share their telescopes and wisdom with anyone who comes to the park. Today, a major astronomy conference, the Black Forest Star Party, is also held at Cherry Springs. This weekend-long gathering of 300 to 400 amateur astronomers is part educational seminar, part trade show, part social gathering, and part observing outing.

The local tourist economy has also seen the benefit of this new park use with nearby stores, restaurants, motels, bed-and-breakfasts, and even other daytime attractions such as the Pennsylvania Lumber Museum all reaping significant dollars from the new influx of tourists. More important, the partnership has itself created still other partnerships that leverage our strengths even further.

The local electric utility, Tri-County Rural Electric Coop, has pitched in by installing full-cutoff shields on outdoor lights in the area for local businesses and individuals to improve the already-excellent sky conditions. These full cut-off shields are purchased with profits from T-shirts sold to stargazers.

Last summer, we initiated regularly scheduled educational observing sessions. Beginning in the fall of 2001, through a new partnership with the local science teachers' association, we will begin providing astronomy education for local school classes. By next year, my wife and I will be living at Cherry Springs as volunteer astronomy educators who will serve not only that park, but also five other nearby state parks. During the seven-month observing season, we will be available on weekends to provide stargazing sessions. The focus of the program will be an ongoing series of lectures and educational activities designed specifically for novice stargazers. Over the next few years, building on the success at Cherry Springs, we hope to bring many parks into the Stars-In-The-Parks program.

The National Public Observatory's Stars-In-The-Parks is all about partnerships that produce tangible and positive benefits for parks, amateur astronomers, and visitors—a true win-win situation for everyone involved.

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Brad Shattuck
G. B. Cornucopia

Chaco's Night Lights

Approximately 100,000 people a year are willing and eager to drive a rough and lengthy washboard road to visit Chaco Culture National Historical Park in northwestern New Mexico's San Juan Basin. When asked why, most say that they want more than anything to "get away from it all." With the nearest city that offers food and services—Farmington, New Mexico—an hour-and-a-half drive away, Chaco certainly seems to fill the bill.

Visitors are often surprised and excited to find that part and parcel of "getting away from it all" includes being treated to some of the most spectacular views of the dark night sky available anywhere in America.

> Once, several years ago, while I was on duty at the front desk, a young woman who had camped the night before approached me and excitedly reported she had seen 'something in the sky last night' and wanted to know what it was. I readied myself for a discussion about UFOs, but she continued, 'It was like a lane of white powder that stretched from one horizon all the way across the sky to the other horizon!' It then became my great joy to report to her that for the first time in her life she had actually seen the 'Milky Way'—a term she had heard before, but had never witnessed!
>
> *— G. B. Cornucopia, park ranger*

Sometimes, way out in the distance, along the horizon, visitors can also spot small, linked domes of light. When they express curiosity about these domes, they are told that these are the skyward-facing lights of distant cities and towns, which are reflected in the earth's atmosphere. Sometimes the light reflected from the domes is bright enough to make it difficult to see the stars in the sky. This competition between townlight and starlight raises questions that have provided the staff of Chaco Culture with the perfect opportunity to weigh in on an issue of increasing concern in communities throughout the USA, as well as in many developed countries around the world—that of light pollution, and the diminishment of the natural darkness of the night sky.

Chaco Culture National Historical Park was created by Congress primarily to protect the remains of the area's rich prehistory—antecedent to the cultures of today's Pueblo peoples, who still live and flourish in the arid Southwest environment. A thousand years ago, a complex civilization reached its apex in Chaco Canyon, producing some of the grandest and most complex prehistoric structures ever found in what is today the USA. Spectacular, multistoried “Great House” structures sometimes cover more than three acres and contain between 500 and 800 rooms—but their purposes remain shrouded in mystery. Sherds of ancient pottery litter the ground, sometimes in mounds several feet high. Whole and fragmentary stone tools used for daily chores and special events are also in evidence. Chaco’s sandstone cliffs bear myriad mysterious pecked and painted drawings, perhaps representing clan symbols, offering clues about activities taking place: celebrating lifeways, planning seasonal ceremonies, or planting crops. Some—of particular relevance to this article—appear to depict celestial bodies or astronomical events such as eclipses, solstices, and equinoxes.

Although overshadowed somewhat by the fame of Chaco’s cultural wealth, the park’s natural history is also rich, and integral to its archaeology. Indeed, the night sky at Chaco has long been recognized as a precious natural resource—one that is in more and more danger of being lost as we spend more and more of our energy on developments that are lit to such a degree that they literally outshine the stars in the sky in terms of brightness. Chaco’s managers have responded by placing shields and motion sensors on lights that are required in the park, and, wherever feasible, by simply doing away with lighting altogether. By designating the night sky as a natural resource in its general management plan of 1993, Chaco has become an inspiration and role model for other national parks, institutions, and communities throughout the USA. Indeed, New Mexico advocates seeking to justify night sky legislation pointed with pride to Chaco as a way of gaining support.

Much of the ceremonial life of many of the peoples here on earth may be timed to the events seen in the heavens above. It has long been known that many New World cultures have amassed large bodies of knowledge concerning astronomy. Sometimes agricultural practices make use of seasonal patterns reflected in the sun’s movement, or of constellations in the night sky, to time activities such as planting or harvesting. The observational powers of people who lived intimately connected to all aspects of their natural environment are known to be acute and multifaceted. In 1970, researchers called “archaeo-astronomers” began bringing their unique perspective into Chaco Canyon, hoping to reveal the astronomical secrets of the ancient builders. Many sites in Chaco Canyon have been selected by such researchers as places that offer examples of ancient knowledge of astronomy. Some researchers go as far as asserting that the architecture found in the great buildings of Chaco is especially aligned to solar and lunar events—not only the individual buildings themselves, but even alignments between buildings that cannot easily be perceived.

While many of these ideas remain controversial, what cannot be questioned is the extreme degree of darkness that today characterizes Chaco Canyon's night sky.

Chaco's active concern about preserving its night sky has had a big impact on the park itself. Because of the extremely high quality of the dark sky visible at the park, groups of amateur astronomers have long been drawn to Chaco during the darkest moon phases of the year for what are traditionally known as "star parties." Often large groups show up, bearing a dizzying array of astronomical equipment with which to fulfill their main obsession in life: peering as long as they can into the darkness of the universe to see everything they can. Astronomical non-profit organizations such as The Albuquerque Astronomical Society (TASS), Rio Rancho Astronomical Society, and International Dark-Sky Association also relish opportunities to indulge their night sky passions and share their observations with park visitors and each other.

There is some friendly competi tion involved. You know, who can show the 'coolest stuff' in the sky to the most people, or who can tell the best night sky stories. It is great to come to Chaco and share something I love to do with people who have never had the chance to see something like ... planets in a telescope. They are amazed that they can actually count some of the moons that surround the planet Jupiter. The re ward of seeing people's eyes widen is reward and payment enough for me.

— Steve M. Johnson, amateur astronomer

Interest in Chaco's dark night sky accelerated and expanded well beyond park boundaries in 1995, when the seeds of what would become Chaco's popular dark sky observatory were sown with the arrival in the Southwest of amateur astronomer John Sefick. In search of dark skies under which he could create a facility where he and others could conduct research into astronomical phenomena such as supernovae, comets, and asteroids, Sefick envisioned an observatory that was both a source of research and education in astronomy and a place to interest people in preservation issues relating to the rapidly disappearing night skies. In the course of his search, Sefick hooked up with members of TASS, who introduced him to Chaco Canyon. After spending several years researching at Chaco, and growing more and more impressed by the interpretive night sky programs the park offered to the public, Sefick knew that he had at last found a home for his observatory. Armed with sufficient resources and an impressive generosity, he approached Chaco Superintendent Charles Wilson with a package he wished to donate to the park that contained several telescopes, a CCD (digital) camera, associated computers, and a modest dome housing a 25-inch reflector telescope. Wilson enthusiastically supported Sefick's efforts, and in short order chose a site near the visitor center, allocated funds for construction, and lined up volunteers, mostly from TASS, who were clamoring to use such a facility. Soon the observatory was a reality—and in May 1998, it was dedicated at a TASS "star party."

Ever since that dedication, a cadre of volunteers have hosted park visitors at a night sky presentation several times a week. They are generous people dedicated to supporting preservation of Chaco Canyon's night sky resources, and attracted by the Night Sky Program's sense of purpose and by the opportunities to enhance their amateur astronomical knowledge and skills and forge close connections to their audiences. These night sky volunteers come from many countries, backgrounds, and age groups, and include everyone from students seeking to expand their astronomical knowledge or to teach people having diverse levels of understanding, to retired people searching for creative outlets

As a volunteer, I have been privi leged to help visitors connect themselves to Chaco. People from all over are filled with the raw beauty of the nature they find here. The surroundings hook them into a sense of timelessness; a feeling that they are seeing something uncorrupted by 'pro gress.' For example, the sand stone mesas, relics of an ancient sea, are striking in the daylight; but in the velvet dark of a Cha coan night, their bold silhouettes frame a sky filled with brilliant stars. It is a sea of ancient star light, the same sea of stars that would have enthralled the Cha coans of long ago. Visitors are ex cited as we explain that the night sky here is an official natural resource, and thus protected. The dark they find here is important to them. What they experience here is so deeply moving that it be comes something that they take back home with them. Some may never experience a night sky as dark as they see in Chaco again. Many more say they will return.

— Liz Churchill, astronomy volunteer

The success of the Chaco Canyon observatory program is most clearly shown in the visiting public's reactions as they become introduced, perhaps for the first time in their lives, to clear views of the vast universe (always there, but rarely accessible): "Wow!" "Beautiful!" "Fantastic!" "Majorly cool!" "I never knew the night sky could be so bright with stars!" These are only a few of the reactions from visitors of all ages who have never before looked through an amateur telescope—least of all looked up above them to see a truly dark night sky.

The real thrill for most Chaco visitors is sometimes just having constellations pointed out in the dark sky above. And there is nothing like seeing a young child climb up a ladder, peer through a telescope eyepiece at the Andromeda galaxy for the first time, and have his imagination explode, and his jaw hit his chest. This is why places like Chaco are so important to so many people.

— Sandy Martin, South Dakota amateur astronomer

As an educational tool, a small-scale observatory such as Chaco's may actually offer advantages over larger institutional facilities.

Late one evening, while I was running the 25-inch telescope, the crowd had dwindled down to two peo ple—a young couple. So I decided to take the opportunity to get to know them a little better, and I asked where they came from. They told me they were from Iowa and were on a two-month road trip here in the Southwest. They had just come from Arizona, where they attended the astronomy program at a prominent observatory. They said they waited in a line of fifty people to look through one telescope. The city lights were so bright that they could only see three things in the sky. They were thoroughly impressed with our program—not only did we have many telescopes to look through, but the sky was amazingly dark and pristine—and it was 'free.' They were having a great time, and said they would be back.

—Angie Richman, park ranger

Research is another value of Chaco's observatory. Through partnerships with the nearby University of New Mexico and the ever-active TASS, an exciting federally funded project is currently under way to accurately quantify the darkness of Chaco's sky. And about to unfold during the coming winter is a search with a robotic telescope for supernovae in distant galaxies.

For many people, seeing a truly dark night sky for the first time is thrill enough. For others, the added knowledge that they are looking up into what is essentially the same sky that was seen by the Chacoans a thousand years ago provides a direct and almost spiritual link between our modern world and the time of the ancients. All who view Chaco's night sky find it fascinating and confirming to realize that even though we may be using new methods and tools such as telescopes and computers to view the night sky today, we are looking to the heavens for at least some of the same reasons that our forbears did: to better understand the nature of the larger world around us, and our place in it. And the awe that these perspectives awaken in visitors provides the main impetus behind continuing efforts at Chaco Canyon National Historical Park to preserve the glory of its dark night sky.

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Mark Nicholas

Light Pollution and Marine Turtle Hatchlings:
The Straw that Breaks the Camel's Back?

Turtles are reptiles that have been tied to the land for oviposition (egg-laying) since the Order Chelonii first appeared some time in the Triassic period (230-180 mya). The Order Chelonia, to which the marine turtles belong, became established by the Jurassic (180-130 mya). The modern marine turtle families appeared in the Cretaceous (130-65 mya; Lutz and Musick 1996). Only seven species remain today, with six listed as endangered and one as threatened. The reasons for their listings are varied, but all are human-caused: loss of habitat, habitat alteration, illegal and legal fishing, boat hits, pollution, etc.

Over the course of time, these marine species evolved certain methods to perpetuate themselves, including laying eggs on certain sandy beaches that are suitable (1) for laying, incubating, and hatching eggs; (2) for hatchlings to emerge from the sand; and (3) for them to find their way to the sea.

The method for sea-finding by hatchling marine turtles occurs principally at night (Hendrickson 1958; Carr and Hirth 1961; Bustard 1967; Neville et al. 1988; Witherington et al. 1990). The cues for orienting in the proper direction appear to be based upon natural light. There are currently several conflicting views on other cues that hatchlings may use to establish a proper direction to the sea (Witherington and Martin 1996), ranging from different-colored photopigments and oil droplets within the retinas of sea turtle eyes, to shape and color cues, and possibly to the slope of the beach. The view that resource management staff observes in the field at Gulf Islands National Seashore's Florida District will be discussed here.

Since water has a higher albedo than land, in the absence of artificial light the horizon is consistently brighter over the water than it is over the land. The water reflects all heavenly light sources, such as the planets and stars. When present in the evening sky, moonlight is also reflected by the surface of the waters.

For species that evolved to hatch during hours of darkness, a particular ability to head for the brightest horizon perpetuated the species best, as this direction also corresponded with the seas the vast majority of the time (Figure 1). To head for darkness resulted in sure death from depredation, exhaustion, or desiccation. As a result, following generations keyed in on this brightest horizon to lead them to the seas, where they would find their niche and repeat the whole process over and over.

In 1879 the invention of the light bulb began a new area of an altered atmospheric condition: light pollution. While humans had been polluting the night sky for several hundred years with candles and lanterns, the over all "candle power" was quite low. Over the years, more and more incandescent light bulbs, as well as newer and brighter varieties, such as fluorescent, mercury vapor, and high-pressure sodium vapor light bulbs, were installed inside and outside of human dwellings. Businesses and roads are also illuminated with ever-increasing wattage and numbers, creating a glow over populated areas.

Florida's coastal population has increased from 0.6 million in 1920 to 10.1 million by 1990. With this urban sprawl into the coastal areas came an increased glow in the night sky. Slowly but surely, the horizon above the land became brighter than

Figure 1. A properly oriented hatchling heads for the Gulf of Mexico.

the horizon over the oceans. In the Pensacola area, only on nights when a three-quarters to full moon has an unobstructed showing in the night sky is there an accurate prehistoric sky, with the brightest horizon being located over the water. This is typically the case for only one to two weeks of the four-week lunar system, with the landward horizon remaining the brightest for two-and-a-half to three of the four weeks of the lunar phase. The actual nights with sufficient natural light available are lower due to cloud cover blocking the moonlight on some nights.

In the decade just past, the Pensacola area saw its construction work force increase 46% from 10,539 in 1990 to 15,391 in 2000 (Livingston and Pooley 2000). Escambia County has grown from a population of 233,794 in 1980 to 282,604 by 1997, a 21% increase. Adjacent Santa Rosa County has grown from 55,988 to 114,481 over the same time frame, a 104% increase (Oregon State University Information Services 1998). But it is not just lights near the beach that are the problem. Lights located inland for several miles emit a collective glow that is easily observed from the local beaches. Some of the worst of the inland collective offenders are gasoline stations. Each station has anywhere from 12 to 36 400-watt metal halide bulbs used to illuminate the store area. Metal halide bulbs are extremely bright and smaller versions are currently being used in the aquarium industry to maintain corals, as the bulbs can simulate sunlight. Other large structures such as shopping malls, condominiums, and sports fields also emit large amounts of light. The lights from several thousand single-family homes also contribute to the illumination of the night sky.

There are currently six large collective glows on the northern horizon observed from the park. They are Perdido Key to the west, Pensacola Naval Air Station and Pensacola to the north, Gulf Breeze and Navarre to the northeast and Navarre Beach to the east.

As a result, marine turtles that hatch under these unnatural lighting conditions continue to orient towards the brightest horizon, since their evolutionary agenda is still locked in an era when “bright” was the way to go. As a result, approximately half the nests in the park experience a high level of hatchling disorientation, and the hatchlings orient and crawl in the wrong direction. In 1999, 33 of 65 nests (51%) that hatched had levels of disorientation where at least 25% of the hatchlings emerging from the nest cued in on the wrong direction. In 2000, 26 of 58 nests (45%) that hatched were disoriented.

At Gulf Islands National Seashore’s Florida District, this alteration of the night sky has been plaguing marine turtles for the last five years. It may have been a problem before that, but accurate monitoring of individual turtle nests has only been going on for the last five to seven years.

The problem was exacerbated by the destruction of the primary dune field in 1995 from Hurricane Opal. These dunes and associated vegetation blocked ambient light levels from the north to some degree.

The park inventories for marine turtle nests every year from May 15 until late September. The federally threatened loggerhead turtles *(Caretta caretta)* are the most common, with a few federally endangered green turtles *(Chelonia mydas)* as well. In the past two years, two new species have been documented as nesting in the park. A Kemp's ridley turtle *(Lepidochelys kempi)* nested in the park in 1998, and the summer of 2000 witnessed a leatherback turtle *(Dermochelys coriace)* nesting in the park. Volunteers and resource management staff patrol the beaches every morning just after dawn on all-terrain vehicles. Over 35 km of beach are patrolled in the park. The tell-tale crawl of the female turtles is easily found on most morning patrols. However, every year a few nests are missed due to the effects of weather obscuring the crawls before the patrols can be completed.

As a result of light pollution levels, the park has been forced to take precautionary measures to guard against hatchling disorientation events. Different ideas to mitigate light pollution have been used by staff in the park's resource management division over the years. For a short period of time, the park attempted to use a black erosion-control fabric fence. It was placed behind the nest and strung out in a V pattern from behind the nest towards the Gulf of Mexico. The fabric simulated a dark landward sky by blocking out the artificial light at hatchling eye level. The problem was that the ends of the V pattern could not extend into the Gulf of Mexico, due to wave action. Once the hatchlings passed the end of the V, they would cue in on the brightest horizon and turn and head the wrong way.

Efforts are now directed at listening to nests on morning patrols by simply placing an ear to the ground above the egg chamber. If the hatchlings are active in their digging effort, the sound is not easily missed. The monitor takes care so that the nest is not crushed in this effort. If the hatchlings are heard and sounds are very loud, hatching typically occurs within one or two evenings. However, due to the fact the hatchlings do not dig continuously in their effort to emerge from the sand, hatchlings can be close to emerging and can go undetected.

"Coning" is also looked for on patrols. This is when a small depression appears in the sand above the egg chamber. This typically occurs 12 to 36 hours before the hatchlings emerge from the nest. It is the result of the hatchling chamber collapsing as it approaches the surface.

Currently the park uses numerous volunteers and resource management staff to "nest sit" when hatching is near. This "timing" is rudimentary at best, since incubation times can vary as much as 10 days for nests laid under similar conditions. Interest by park volunteers can wane after two or three nights of a nest not hatching.

Screening the nests with cages that detain the hatchlings is also part of the effort. But the egg chamber location must be known for this method to be used. As the hatchlings emerge under the screen, they are detained until a pre-dawn patrol releases them. While this method prevents disorientation from occurring, it can expose the hatchlings to several hours of detention during which they expend critical energy in continual escape attempts until they are released from under the cage.

When there is little or no moon, hatchlings that emerge must be moved closer to the surf by the park staff. The hatchlings are then typically released behind a small berm where the beach angles towards the surf at about 10-20 degrees. The berm blocks the brighter northern horizon to a sufficient degree, the hatchlings crawl into the Gulf and then orient themselves so as to swim into the waves (Salmon and Lohmann 1989; Lohmann et al. 1990; Wyneken et al. 1990). This leads them offshore to their post-hatching migration routes.

Marine turtles are currently a heavily managed species at Gulf Islands National Seashore. Since evolution occurs over geological time scales, in the near future no evolutionary adaptation by marine turtles to light pollution is anticipated. There is no immediate reason to suspect that human populations will decrease or lose their need to illuminate the night sky. As a result, marine turtle hatchlings will continue to go in the wrong direction after emerging from their nests. It will take a large commitment by park staff and volunteers to be at the nests when hatchings occur so as to interfere with the unnatural cues provided by the artificial lights to the hatchlings. Current as well as future biologists and volunteers have a great deal of night work ahead of them if these species are going to survive.

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Yellowstone by Night

Yellowstone National Park comprises a unique combination of fascinating scenery, wildlife, thermal features, and cultural history. Once called a "Wonderland," this is more than ever a fragile resource and a wilderness that we strive every day to understand. Paramount to its survival as a wilderness setting is our ability to understand our place within and our impact upon this environment.

In recent years, Yellowstone has recognized the night sky, the *dark* night sky, to be part of this resource. The park is a significant landmark for 22 Native American tribes, some of whom have archaeo-astronomic connections to the geyser basins and Yellowstone Lake. Park interpretive staff and local experts have begun to offer programs in the park, and astronomy groups, universities, and other organizations use the park to view meteor showers, comets, and other spectacular events. The Aurora Borealis can be seen occasionally on the northern horizon. However, around developed areas where access to parking and viewing locations is the best, the night sky can be obscured by light pollution.

Electric light was first used in Yellowstone National Park in the Mammoth Hotel in 1883. Since that time, there has been a steady increase of buildings and facilities to accommodate the increased visitation to and popularity of the park. Today, development still takes up only a small fraction of the overall area of Yellowstone, yet the impacts of this development extend well beyond the buildings and roads that many of us look upon to be the edge of human influence.

Light pollution is just one of these human impacts. It is becoming an increasing threat to the wilderness environment, to a dark night sky. Lights around the Lake Hotel can be seen from backcountry campsites, in an otherwise wilderness setting, on the other side of Yellowstone Lake. Lighting around the Old Faithful Inn glares across the Upper Geyser Basin. It is not reasonable to eliminate these intrusions completely, but there are solutions that can reduce them, such as shielding the bulb from view to reduce intense glare, or preventing light from shining upward into the sky.

Yellowstone National Park has been actively working on night-lighting issues. The general sense is that most lighting problems occur because those designing or installing lights do not understand the impacts of their choices. Yellowstone prides itself for its role in educating others about the environment. The park provides an opportunity each night for the 15,000 people that stay in the park to view the night sky. This is an opportunity to educate a large number, and a wide variety, of people. More and more visitors are aware of the impacts that light pollution has, not only on their own viewing of the night sky but also on their overall wilderness experience. For Yellowstone to be an innovator in this field, it is important that night sky viewing opportunities are provided and are easily accessible near campgrounds and lodging areas. Also, lighting standards for developed areas should not exceed those required for the particular purpose, and light fixtures should direct light only where it is needed, not beyond into the wilderness or up into the sky.

Lowering lighting levels cannot be proposed without addressing safety concerns. Yellowstone experiences its share of crime, which is associated with both developed and remote areas. To add to these problems, there are often large and potentially dangerous wild animals roaming around the buildings and parking areas in the dark—not a comforting prospect for many people who have to venture out at night. Bison and elk particularly are often not wary of people, and will act aggressively when approached, especially when they are with their young. Although this adds a significant safety concern for both visitors and employees, bright light can be a false sense of security when it creates darker and more intense shadows. Yellowstone hopes to demonstrate that lower light levels do not mean an area will be less lit, but that the available light will be used more efficiently, and that the result can be safe and effective.

Addressing light levels in Yellowstone has been a daunting task. Making improvements is not as easy as replacing or removing light bulbs. A simple-looking project to reduce or redirect light output can involve rewiring and entirely new fixtures. Standards have been developed that encourage reduced light output, ground-directed light, energy efficiency, and fixtures that maintain the historic fabric of the park. The strategy has included a multi-faceted approach of innovation and correction, generating design standards to address some of the problems, and lighting design that works in historic areas. An information exhibit has been established which illustrates night-lighting principles, including actual fixtures which are lit so that staff and visitors may see examples of lights that have been developed. The first test area was the Lamar Institute, an environmentally based educational facility which reaches 2,600 students each year, some of whom are also educators. Designing lighting for this area was a way to expose a variety of people to an alternative approach. An existing street lamp, which polluted the night sky over Lamar Valley, was removed and replaced with three 5-watt pathway bollard lights, designed and built in-house, that direct light downward only and cannot be seen from anywhere in the valley. A porch light was designed and built in which the bulb is totally shielded on all four sides creating only downcast light. This design replaced all existing building fixtures in the area. By doing this, the wilderness experience for visitors attending the institute, and those remaining in the valley after dark, was greatly increased.

Concurrently, Yellowstone is working on proposals to correct the light pollution problems at Old Faithful, Lake, and Mammoth. In all areas, the goal is to use light in the most efficient and effective way so that the wilderness setting is not polluted, but light is still available where required for safety purposes. Old Faithful is one of the main developed areas in the park, sited next to a delicate natural geyser basin. Many visitors enjoy exploring this geyser basin at night and find light pollution from the development an annoyance. The proposal at Old Faithful is to reduce the light levels through fixture redesign and replacement. This will make sure the light is directed only toward the Old Faithful Inn and parking where it is needed. The Lake area is a large complex that surrounds the edge of Yellowstone Lake, and, as mentioned above, lighting in this area affects the night sky across the lake. Here there will be parking area lights with hooded fixtures that only allow light to shine downward. In front of the Lake Hotel and at Fort Yellowstone in Mammoth, the outward glare produced by the historic lights will be reduced either by replacing or retrofitting the existing globes. Rustic bollard pathway lights will be installed along the existing path between the Lake Hotel cabins and the Lake Lodge. The bollards will face away from the lake to lessen any possible light pollution.

Yellowstone continues to develop unique fixtures that can be used throughout the park and in other parks where rustic fixtures are desirable. Each of the lighting prototypes is equipped with energy-efficient technology, and is designed for use where dark skies prevail. Unfortunately, night lighting is not a priority when it comes to distributing a limited budget, so it is uncertain as to when the proposals will actually reach fruition. However, in order to be an innovator in this field, Yellowstone National Park hopes to reduce unnecessary lighting in all areas of the park so that it remains as much as possible a wilderness setting—a "Wonderland."

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About the GWS . . .

The George Wright Society was founded in 1980 to serve as a professional association for people who work in protected areas and on public lands. Unlike other organizations, the GWS is not limited to a single discipline or one type of protected area. Our integrative approach cuts across academic fields, agency jurisdictions, and political boundaries.

The GWS organizes and co-sponsors a major U.S. conference on research and management of protected areas, held every two years. We offer the FORUM, a quarterly publication, as a venue for discussion of timely issues related to protected areas, including think-pieces that have a hard time finding a home in subject-oriented, peer-reviewed journals. The GWS also helps sponsor outside symposia and takes part in international initiatives, such as IUCN's Commission on National Parks & Protected Areas.

Who was George Wright?

George Melendez Wright (1904-1936) was one of the first protected area professionals to argue for a holistic approach to solving research and management problems. In 1929 he founded (and funded out of his own pocket) the Wildlife Division of the U.S. National Park Service—the precursor to today's science and resource management programs in the agency. Although just a young man, he quickly became associated with the conservation luminaries of the day and, along with them, influenced planning for public parks and recreation areas nationwide. Even then, Wright realized that protected areas cannot be managed as if they are untouched by events outside their boundaries.

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Following the spirit of George Wright, members of the GWS come from all kinds of professional backgrounds. Our ranks include terrestrial and marine scientists, historians, archaeologists, sociologists, geographers, natural and cultural resource managers, planners, data analysts, and more. Some work in agencies, some for private groups, some in academia. And some are simply supporters of better research and management in protected areas.

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