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Memorandum

To: District Planner, Bureau of Land Management, Kanab Field Office

From: Regional Director, Intermountain Region

Subject: National Park Service comments on DEIS-11/0051, Draft Environmental Impact Statement for the Alton Coal Mine Project, Kane County, Utah

Below and attached are detailed comments on the Bureau of Land Management (BLM) Draft Environmental Impact Statement (DEIS): Alton Coal Tract Lease by Application. This coal tract is located near Bryce Canyon National Park’s southern boundary on BLM lands managed by the Kanab Field Office. The National Park Service (NPS) appreciates working with BLM during the DEIS development to communicate issues identified during scoping, to assist in resource analysis, and to discuss impacts identified in our review of the DEIS. BLM has sought this coordination and NPS would like to continue working with BLM to ensure appropriate impact mitigation and resource monitoring is incorporated and implemented if the proposed coal mine lease is issued.

As directed by the Organic Act (16 USC 1 et seq. Organic Act), Redwoods National Park Act (16 USC 79a-79q), and National Park Service Policy (2006), national parks are responsible for responding to any proposals and changes to adjacent lands that may impact the park’s resources. With the proposed coal mine lease, activities associated with resource extraction in the areas surrounding Bryce Canyon National Park (BRCA) will increase substantially; it is imperative that potential impacts to cultural, natural and recreational resources be examined and minimized to the maximum extent practicable so that energy development does not threaten the values of these lands for current and future generations.

Bryce Canyon National Park was established, in part, for its “unusual scenic beauty,” and the laws establishing and enlarging the park explicitly mandate the preservation of these scenic resources. The park receives 1.3 million visitors annually, most of whom travel on US Highway 89 either coming to or from the park. The park has outstanding resource values that could be severely compromised if adjacent lands are opened to coal mining. Bryce Canyon National Park is the principal visitor attraction to Garfield County, where tourism represents 60% of the
economic base. As such, park visitor expenditures contribute substantially to employment and economic activity of Garfield County.

The proposed action to extract over 44 million tons of recoverable coal at the Alton Coal Tract raises concerns for specific impacts these activities would have on both Bryce Canyon National Park and the surrounding area. The park has determined that both DEIS action alternatives (B and C), as they are currently proposed, would contribute to environmental degradation not only within the tract itself, but would result in adverse effects on surrounding communities, the tourism industry of southern Utah, air quality standards, dark skies conservation, and regional wildlife. Several factors, while subtle in their presentation in the DEIS, affect the determination of impacts as detailed below and in the attachment to this memo:

- the remote location of the Alton Coal Tract: introduction of industrial development to a wildlands landscape and associated natural resource values contributes to impacts to air quality, dark night skies, wildlife habitat and may open the area to further development
- a long haul route with increased heavy truck traffic on US Highway 89 presents safety concerns for tourists, commuters and wildlife on this winding, hilly, 2-lane road
- the NPS disagrees with the definition of “short term” impacts as defined in the DEIS: twenty-five years (or longer) for impacts to natural resources such as wildlife, air and water quality, night sky and vegetation should be considered “long term” at best and permanent in worst case scenarios

Inconsistencies and nonconformance in BLM planning and guidelines raise concerns and should to be addressed by BLM in terms of protection of the applicable resources and related mitigation:

- a land-use conflict analysis contained in the Kanab Field Office Resource Management Plan (KFO RMP, 2008) did not result in the elimination of the Alton Coal Tract for consideration for future leasing; however, several of the seven types of land-use conflicts listed in the RMP are in conflict with the proposed action (Alternative B) or action alternative (Alternative C)
- coal mining unsuitability determinations for several criteria listed in 43 CFR 3461.5

The primary areas of concern related to the proposed action and potential impacts to park resources are:

1) **Air Quality & Scenic Values** – The impact to Bryce Canyon National Park as a Class I area from mining operations include degradation of visibility and increased deposition from several pollutants (especially fugitive dust and NOx). Exceedances of the National Ambient Air Quality Standards at the 300-foot overburden mining scenario are of critical concern. The NPS Air Resources Division has determined that modeling and analysis in the DEIS is incomplete and/or not in accord with established standards.

2) **Night Skies** – The impact to night skies resulting from the light dome (“sky glow”) from night mining operations, the lighting scenarios and criteria proposed under Alternatives B and C, and the ecological impacts from night lighting are primary concerns to night sky protection at Bryce Canyon National Park and regionally. There are inconsistencies between lighting scenarios, and therefore predicted impacts,
between those modeled in DEIS Appendix I and the impact analysis in the body of the DEIS.

3) **Natural Soundscapes** – The impact to the natural ambient soundscape in Bryce Canyon National Park from blasting operations could be substantial in certain areas. Deterioration of the soundscape and related impacts on natural resources and visitor experience is a primary concern. However, this topic was not analyzed to determine the extent or scope of the impact within the park.

**Further Analysis**
As stated immediately above, for the three areas of primary concern to Bryce Canyon National Park, resource impact analysis is incomplete, missing or not in accord with national standards. Therefore the potential exists that impacts presented in the DEIS may be understated and/or lack sufficient information for NPS and the public to judge the level of impact. Therefore Bryce Canyon National Park recommends that BLM complete the required analyses and publish them as a supplement to the DEIS, as opposed to making corrections in the Final EIS, allowing agencies time to work with BLM on these analyses and providing the public with a chance to review a complete analysis prior to issuance of the Final EIS. The NPS stands ready to assist the BLM in these analyses.

**Recommendation of Preferred Alternative**
Based on the proximity of the Alton Coal Tract to Bryce Canyon National Park and the combined impact to air resources/air quality-related values, night sky resources at the park and in the region, and the park’s natural soundscape, the NPS considers large scale coal extraction, as proposed in Alternatives B and C, an activity that could and will likely result in negative impacts to park resources and visitors, and potentially diminish tourism in the area. Given these concerns and the fact that several key resource impact analyses are incomplete, missing or not in accord with national standards, the NPS recommends to BLM that Alternative A (No Action) is our preferred alternative at this juncture.

Specific and expanded comments related to these topics are addressed in the attachment to this memorandum. Suggested mitigation measures are included under these analysis topics to guide the BLM in decision-making related to appropriate Standard and Special Lease Stipulations for the tract.

**Continued NPS Participation in Planning, Monitoring and Mitigation**
The park seeks the opportunity to assist BLM in developing additional mitigation and monitoring stipulations, in the event that the BLM approves the lease application.

The DEIS did not provide sufficient details on the mining and development plan for the tract (e.g., location of facilities, location of Route 116 re-route, the mining sequence for each section, and reclamation efforts) to fully comment on those activities. In order to avoid and mitigate potential adverse impacts on park resources, Bryce Canyon National Park requests continued participation in the planning and regulatory processes for the Alton Coal project. Specifically, the park requests the opportunity to review and comment on the permit application package (PAP) and the Resource Recovery and Protection Plan (R2P2) if the Alton Coal Tract is leased,
as well as the final mining and blasting plans. Additionally, the park requests the opportunity to review any subsequent analysis of the project as required under the National Environmental Policy Act including site-specific management plans (such as the Cultural Resource Management Plan, Revegetation Plan, and Dust Control Plan), cooperation with the BLM in the development of appropriate mitigation and monitoring requirements to reduce negative resource impacts in the region, and cooperative development of any associated Standard and Special Lease Stipulations that would be attached to the Lease by Application Permit.

Cooperative conservation beyond park boundaries is a necessary and critical component of the NPS mission to fulfill its mandate to conserve the natural and cultural resources of parks unimpaired for future generations (NPS, 2006). We value the opportunity to work with the BLM to anticipate, avoid and resolve potential resource conflicts with the park and address mutual interests in the quality of life of small communities and tourism in the region.

The BLM is commended for its initial impact analysis in the DEIS. The park was especially impressed with the effort to analyze the potential impacts to the night sky that may result from the proposed lease. It is our hope that this impact topic may ultimately become a standard component of the NEPA process for similar proposed development on federal lands. We are also encouraged at the history of open communication and collaboration among the BLM KFO and the park to address critical issues early and with our input. If you have any questions about our comments or proposed mitigation measures to reduce impacts to park resources, please contact Jeff Bradybaugh, Superintendent, Bryce Canyon National Park, at (435) 834-4700.

John Wessels

Attachments (3)

cc:
Superintendent, ZION, Jock Whitworth
Superintendent, CEBR, Paul Roelandt
Superintendent, GRCA, Dave Uberaga
Associate Regional Director, Resource Stewardship and Science, Intermountain Region, Tammy Whittington
NPS Utah State Coordinator, Dennis Davis
Physical Resources Program Supervisor, Intermountain Region, John Reber
External Minerals and Energy Program, NPS - Geologic Resources Division, Kerry Moss
Air Resource Field Specialist, Intermountain Region, Michael George
Night Sky Program Manager, NPS - Natural Sounds and Night Skies Division, Chad Moore
Environmental Protection Specialist, NPS - Air Resources Division, Andrea Stacey
Meteorologist, NPS - Air Resources Division, John Notar
Physical Scientist, Intermountain Region, Theresa Ely
Biologist, BRCA, Sarah Haas
Environmental Protection Assistant, Intermountain Region, Crystal Salas
Environmental Protection Specialist, WASO-EQD, Thomas Flanagan
Regional Environmental Officer, DOI, Robert Stewart
attachment 1

Bryce Canyon National Park Detailed Comments on the Draft Environmental Impact Statement for the Alton Coal Tract Lease by Application (BLM, UT)

Alternatives Analysis

Coal Planning Screening Procedures (Section 1.8)
A final decision on site-specific unsuitability determinations for Criteria 2, 3, 9, 15, 16, 18, and 19 (as listed in 43 CFR 3461.5) were deferred in the DEIS until receipt of a Lease by Application (§1.8.1.1.2). Most of these Criteria may be addressed via administrative procedures during the LBA process (e.g., Criteria 2, 3, 9, 16, 18, 19). However, the final determination for those Criteria should be included in the final decision document released by the BLM. Criteria 15 (related to habitat impacts to species of wildlife of high interest to the state) identifies several species (including the greater sage grouse and pygmy rabbit) that occur within the tract boundaries and are of high interest to the state. Additionally, several sections of the Kanab Field Office Resource Management Plan [KFO RMP, 2008] are in conflict with the proposed action. The BLM should address, in detail, what mitigation measures would be included in an exception, modification or waiver to KFO RMP Special Status Species lease stipulations in the event of a lease. This information should be made available to adjacent land management agencies and the general public to evaluate if the impacts to species of high interest to the state are acceptable under the terms and conditions outlined in an exemption, modification or waiver. Specifically, any exemption, modification or waiver of a stipulation to allow approval of the Alton Coal LBA must “show that (1) the circumstances or relative resource values in the area had changed following issuance of the lease, (2) less restrictive requirements could be developed to protect the resource of concern, and (3) operations could be conducted without causing unacceptable impacts” (per KFO RMO, Appendix C).

A land-use conflict analysis (contained in the KFO RMP, 2008) did not result in the elimination of the Alton Coal tract for consideration for future leasing. However, several of the seven types of land-use conflicts listed in that document (recreational, wildlife, livestock grazing, water resource, air resource, cultural resource, and paleontological resource) as well as other impact topics as analyzed in the DEIS, appear to be in conflict with the proposed action or action alternative based on information presented in the DEIS. The BLM should clearly state how and why the multiple land-use conflict analysis did not result in the elimination of the Alton Coal tract from further consideration of leasing. Impact significance levels (ranging from negligible to substantial, as defined in Section 4.1) were not clearly indicated under each analysis topic in Chapter 4. Therefore, it is difficult to determine if the level of impact as described in the DEIS constitute a land-use conflict that would preclude development of the Alton Coal tract. The BLM should provide a clear, concise summary of the impact significance (including level and type of impact, permanency, and duration) for the public to evaluate. Table 2.5 in the DEIS describes the impacts per topic but generally fails to rate or categorize the impact in a clear manner.

Alternative C represents, in part, a reasonable alternative to the proposed action to reduce the extent of impacts to local greater sage-grouse populations and is consistent with the BLM’s commitment to expand the use of new science and mapping technologies to “improve land-use
planning and develop additional measures to conserve sage-grouse habitat while ensuring that energy production, recreational access and other uses of federal lands continue as appropriate” (U.S. Department of the Interior News Release, March 5, 2010). Based on the determination of the greater sage-grouse as a candidate species (warranted but precluded from full listing, 3/5/2010) under the Endangered Species Act, increased efforts on the part of all federal land management agencies to protect the species are imperative. Efforts to conserve the species throughout its range require a coordinated effort and a continued commitment from all states and agencies that contain the species and its required sagebrush habitat (News Release: “Salazar, Mead Reaffirm Commitment toward Development of Landscape Level Greater Sage-Grouse Conservation Strategy in the West”, December 9, 2011). Additionally, Alternative C would resolve some conflicts with Unsuitability Criterion Number 15 and the KFO RMP (2008) and may preclude the necessity of granting an exception, modification, or waiver to the proposed action.

It is unclear why Alternative C leads to more “projected surface disturbance during active mining” (Pg 2-35, Table 2.4). This impact, and the need for two active pits, should be further explained under §2.4. It seems reasonable that the BLM could pursue modifications to Alternative C that would not require dual pit operations to accommodate the external overburden disposal area (EODA). A systematic, strip and recover method with a designated (but possibly reduced size) EODA and accelerated reclamation efforts to restore overburden should remove the need for dual pits of the same disturbance footprint. The rationale that seasonal timing restrictions in Block S would lead to equal sizes of extraction and EODA pit areas is not well developed or justified in the DEIS.

If the BLM’s conclusion that the need for two simultaneous open pits could not be avoided due to timing restrictions in Block S, the BLM should strongly consider modifying Alternative B to improve protection of the Alton-Sink Valley sage-grouse lek. Based on the importance of this lek site as the southernmost active lek in North America and the link between lek site fidelity to successful breeding of the species, lek protection should be a primary consideration for the BLM, as outlined in the BLM KFO RMP (2008). Stipulations and timing restrictions in that document, especially related to lek preservation (SSS-54 and SSS-55), are critical to protecting the species from further decline. Neither of the action alternatives adequately incorporates actions that would protect the greater sage-grouse on the proposed tract. Reclamation and habitat enhancement efforts, though important for sage-grouse and other wildlife species, do not compensate for the destruction of lekking grounds. The loss of the Alton-Sink Valley lek will contribute to local cumulative detrimental impacts to the species (especially in conjunction with the loss of breeding grounds on the private Coal Hollow Mine site) and may contribute to an acceleration of the species’ listing. This impact should be carefully considered, re-evaluated and weighed against the minimal regional socioeconomic benefits associated with this project (annual recovery value of the tract = .05% of 2010 Utah GDP [all industries]; total recovery value of the tract = 1.4% of 2010 Utah GDP [all industries], U.S. Department of Commerce).

**Alternative J**, which would evaluate alternative coal transportation, was dismissed for reasons which may not meet the law, spirit, or intent of NEPA. The fact that the mine on the adjacent private land (Coal Hollow Mine) requires 153 coal truck round-trips does not prove that those trucks will, or do not currently, have significant impacts to humans and wildlife. No previous
analysis of truck hauling was conducted for the Coal Hollow Mine by Utah Division of Oil, Gas and Mining based on their claim that those hauling activities did not fall under their jurisdiction (public scoping meeting for Coal Hollow Mine project in Panguitch, UT, 2010). BLM should consider how these effects relate to this proposal, and analyze those effects, whether they are direct, indirect, or cumulative impacts.

**Alternative O**, which would restrict mining operations to daylight hours, was dismissed because “mining and transporting 2 million tons of coal annually, during daylight hours only, would result in greater impacts than allowing nighttime operations” (due to increases in equipment use, number of open pits, and volume of trucks, §2.6.1.12). The BLM is directed to “achieve maximum economic recovery of the tract’s coal resources in the context of applicable laws, regulations, and leasing stipulations” (ES-1) but is under no mandate to extract coal at a rate of 2 million tons per year. A reduction in the annual tonnage of extractable coal in order to accommodate only daylight work hours may extend the life of the mine to reach the maximum recoverable coal in the tract. However, by limiting operational hours to daylight only, impacts to night skies, air quality (from diesel generator operation), public safety and regional wildlife would be reduced or essentially eliminated. The rationale to target 2 million tons of coal/year within all alternatives is not validated or explained. Reconsideration of daylight-only hours of operation is warranted. NPS requests that Alternative O be analyzed as a viable action alternative utilizing pit opening, pit reclamation and other activities conducted in a manner to minimize resource impacts, incorporating NPS comments on the action alternatives B and C as presented in these comments. This may open any opportunity for demonstration of an environmentally protective and economically sustainable DEIS alternative.

**Primary Resource Impact Concerns for Bryce Canyon National Park**

**Air Quality & Air Quality Related Values**

Bryce Canyon National Park and nearby Zion and Capitol Reef National Parks are identified as Class I areas in the Clean Air Act (CAA), providing these areas with an additional measure of protection from air quality deterioration. The NPS is concerned about the potential impacts to ambient air quality and Air Quality Related Values (AQRVs), including visibility, from mining activities associated with the proposed action. This includes dust plumes from haul roads, surface mining, coal preparation, and load-out activities, as well as the cumulative impacts from the off-site distribution and use of coal in coal-fired power plants. These direct and indirect effects associated with the combustion of coal from the Alton mine could negatively impact the nearby Class I air sheds.

The park is elevated above surrounding terrain. It is unlikely that the proposed coal mine would be directly visible from the park due to the terrain between the park and the proposed site. However, disturbances (blasting, removal of overburden and dirt haul roads) that cause dust plumes may be visible. These dust plumes could also affect day and night visibility from Bryce Canyon since the prevailing winds come from the south and west. The DEIS did not address impacts to the scenic values of the Highway 89 corridor, which is a primary travel route for visitors to the area as discussed under the tourism section. Additionally, the viewshed analysis in
the DEIS was concentrated within the tract and does not reflect landscape impact or the potential visibility from Bryce Canyon of dust plumes generated on the tract.

**AQRV Effects**

When reporting the effects to AQRVs (i.e. visibility and deposition) in park service units (including Bryce Canyon National Park, Zion National Park and Grand Canyon National Park), the DEIS should use the criteria, including applicable thresholds (such as the Deposition Analysis Threshold), laid out in the latest Federal Land Managers’ Air Quality Related Values Workgroup (FLAG) report published in 2010. The thresholds identified in the FLAG 2010 report are more applicable to NPS areas, and should be used when evaluating impacts to these parks. Specifically, the use of the “green line” analysis adapted from Fox et al. (1989) presented in §4.3.3.3, Table 4.17, does not provide an adequate assessment of the impact of sulfur and nitrogen deposition on NPS units. Recent research on deposition effects in sensitive ecosystems has shown that the screening numbers presented in the Fox 1989 document are two to three times higher than what is thought to be harmful levels of deposition, and recently published science is readily available providing a much better basis for assessing air pollution impacts to natural resources.

Use of the 2010 FLAG guidance to assess the modeled impacts in nearby parks would provide the public with better information toward understanding how this project might affect valued resources at the parks, and how the NPS views those effects. For example, although not reported, the NPS thresholds for nitrogen deposition and visibility are exceeded in some cases, especially for the 300 feet overburden option, as presented in Table 4.17 of the DEIS and Table 4.32 in Appendix K. We would like to clarify that the Deposition Analysis Threshold (DAT) is only used to determine whether the predicted impacts warrant further evaluation, including an assessment of whether the park is sensitive to, or affected by deposition. While there is not specific information for Bryce Canyon National Park, recent published research for other arid areas has indicated that nitrogen deposition stimulates productivity of exotic grass species and induces other changes in natural species composition. This suggests the potential for adverse changes in ecosystems in Bryce Canyon, and the NPS is concerned about the predicted nitrogen deposition levels for the 300 foot overburden option in particular. However, based on Table 4.17, there may also be questions related to nitrogen deposition impacts for the 200 feet overburden option.

Due to our concerns regarding nitrogen deposition and potential visibility effects, we offer the following recommendations. First, due the substantially higher AQRV and air quality impacts predicted for the 300 foot overburden option relative to the 200 feet overburden option, we recommend that the 200 feet overburden option is preferred from an air quality perspective. The relevance of the recommendation is further accentuated by the Aermod modeling results for National Ambient Air Quality Standards in Tables 4.5 (24-hour PM$_{10}$) and 4.7 (NO$_2$), which show exceedances when the 300 feet option is assessed. Second, we request that BLM evaluate the options for reducing NO$_x$ emissions relative to control effectiveness and cost in consultation with the Utah Technical Advisory Committee, of which NPS is a member. Given that there are air quality and AQRV concerns related to the 200 feet overburden option in addition to the 300 foot overburden option, additional NO$_x$ emissions reductions/mitigations may be in order.
Detailed Comments on Air Quality Modeling Results Reported in Appendix K: Air Resources Impact Assessment Technical Report for the Alton Coal Lease by Application Draft Environmental Impact Statement

The NPS reviewed the modeling report and has found several issues with the modeling analysis. We recommend that the BLM not release the Final EIS until the following issues are either corrected or addressed:

Page 5: The outdated Mobile 6 emissions model was used to calculate mobile source emissions rather than the current EPA recommended emissions model MOVES. BLM should confirm the use of Mobile 6 for this analysis with EPA Region 8.

Page 9 of Appendix K states: “Due to the timing of these regulatory changes in relation to the project analysis, assessment of the new 1-hour NO2 and SO2 standards was not incorporated in the draft EIS.” The new draft EIS should address the 1-hour NO2 and SO2 National Ambient Air Quality Standards (NAAQS). These NAAQS are regulatory standards and the NEPA document should assess whether the proposed action, or the action alternative, will conform to these requirements. The NPS is very concerned with the lack of a 1-hour NO2 NAAQS impact analysis considering that the annual NO2 NAAQS is predicted to be violated in Table 3.8 for the 300 foot overburden removal scenario. The annual NO2 NAAQS is usually only violated in the very largest urban areas in the country. In addition, the NAAQS for the 3-hour and 24-hour SO2 no longer exist, and should be deleted from the numerous tables where they are referenced.

Page 15 Tables 3.3 and 3.4: Impacts to the PM10 NAAQS are predicted to violate the 24-hour standard for Alternatives B and C with the 300 foot overburden removal and Alternative C with the 200 foot overburden removal. BLM should consider additional mitigation for these Alternative scenarios.

Section 3.2 Near-Field VISCREEN Analysis: The NPS noted several issues with the data used in the VISCREEN analysis for Bryce Canyon. These issues should be corrected and VISCREEN should be re-run. First, the background visual range used in the draft EIS was obtained from the FLM’s FLAG 2000 Report. This has been superseded by the release of the FLAG 2010 document. The correct annual background visual range for Bryce Canyon NP is 272 km, found in Table 10 of the FLAG 2010 report. Second, the VISCREEN section identifies the emissions modeled for the 300 foot overburden removal scenario (200 tons per year [TPY] of PM10 and 550 TPY NO2), however, it does not identify the emissions modeled for the 200 foot overburden removal scenario. Please state the emission totals modeled for the 200 foot overburden removal scenario. Finally, the VISCREEN model will also analyze visible plume impacts from soot and primary SO4 emissions, which were not included. Because of the numerous diesel emission sources such as bulldozers, trucks, and electrical generators, the soot/elemental carbon and primary SO4 emissions from these types of sources need to be included in the VISCREEN analysis.

Section 4.1 Modeling Methodology: This section pertains to the far field air quality impact analysis, which used the EPA Guideline long-range transport model CALPUFF and its
associated post processing models POSTUTIL and CALPOST. We have several recommendations regarding the CALPUFF modeling:

- Page 38 references the FLAG 2000 report. As mentioned previously, the FLAG document was updated in 2010. The CALPUFF far field analysis should follow the revised guidance. Additionally, page 39 states: “One slight difference from the near-field modeling is that the near-field modeling included the use of "AREAPOLY" sources - irregular shaped area sources with multiple vertices. CALPUFF has no areapoly type of input.” This statement is incorrect, CALPUFF allows area source modeling of POLYGONS (source subgroup 14) and these types of area sources should have been modeled for the Alton EIS alternatives.

- Section 4.2.3 Receptors page 41 states: Bryce Canyon receptors were included in the CALPUFF receptor list, but no post-processing was performed because the entire area is well within 50 km. This statement is incorrect. The NPS’s GIS system indicated that the northeast portion of Bryce Canyon National Park is 58 km from the nearest part of the Alton coal lease area. Therefore, a visible haze analysis needs to be performed for the areas of Bryce Canyon that are greater than 50 km from the proposed action.

- The EIS does not state what emissions were included in the far field analysis. The CALPUFF modeling should include SO₂, SO₄, NOₓ, PM₂.₅ (fine) and PM₁₀ (coarse) elemental carbon/soot and organic carbon emissions. These species are required to correctly calculate far field visibility impacts. BLM should verify whether these species were modeled.

- The CALPOST/visible haze analysis was based on the FLAG 2000 report. The haze analysis recommendations changed in FLAG 2010. The updated FLAG procedures require the use of CALPOST version 6.221 (July 24, 2008 version) along with the revised IMPROVE visibility equation, which is incorporated in CALPOST 6.221, and the use of Method 8 Mode 5. Background concentrations for each Class I area are found in FLAG 2010 Table 6. Monthly f(RH) values for each Class I areas for Large and Small (NH₄) SO₄ and NH₄NO₃ are provided in FLAG 2010 Tables 7 and 8. Monthly f(RH) values for Sea Salt for each Class I area are provided in Table 9.

Given the shortcoming of air quality impact analysis in the DEIS as discussed above, BLM must re-calculate appropriate models and re-analyze impacts based on the current thresholds and regulations. NPS requests that BLM publish results as a supplement to this DEIS. The NPS Air Resources Division is available to assist BLM as needed.

**Suggested Mitigation/Lease Stipulations for Impacts to Air Quality & Scenic Values**

The NPS recommends that BLM implement the following mitigations, lease stipulations and potential adaptive management strategies to address NPS concerns related to air quality and AQRV impacts in Bryce Canyon National Park:

1. Establish off-site air monitoring for NOₓ and PM₁₀ including a station in the southern portion of Bryce Canyon National Park.
2. Restrict mining to the 200-foot overburden level.
3. Model thresholds as outlined in the Federal Land Managers’ Air Quality Related Values Workgroup (2010) and adjust mining activities to remain below established thresholds for all pollutants.

4. Establish particulate matter monitoring in or near Bryce Canyon National Park prior to mine operations commencing and operate the monitoring throughout the life of the project. Develop an adaptive management plan that adopts supplemental contingency measures in the EIS in case air quality at the park is worsened by the proposed mining.

5. Employ applicable particulate pollution control technologies including optimizing use of watering or chemical dust suppression on haul roads and exposed soil through monitoring weather patterns to anticipate high wind events. [Note: the impact of chemical dust suppressants on the environment should be analyzed by the BLM as part of the action alternative prior to finalization of the EIS.]

6. Implement required measures (as outlined in Table 2.3) as part of the Standard and Special Lease Stipulations to reduce public exposure to NO₂ from blasting clouds.

7. Require use of the most current Tier diesel engine available when operations commence on federal lands as a means of controlling NOₓ.

Night Skies

Bryce Canyon National Park lies on the western edge of the Colorado Plateau, one of the last areas of natural night skies one can view in the contiguous USA, with nearly unmatched night sky quality. Night sky quality is principally degraded by light pollution – emissions from outdoor lights that cause direct glare and reduce the contrast of the night sky – but atmospheric clarity also plays a role. The combination of clear air (free of aerosols and water vapor that reduce visibility), high elevation, and a sparse human population in the immediate vicinity of the park results in a view of the night sky that is near pristine as well as vulnerable to degradation. Photometric measurements taken within the park show that the zenithal sky condition is virtually unaltered, attaining the theoretical natural darkness of 21.95 magnitudes per square arc-second at Yovimpa Point (the darkest location in the park and the closest to the proposed mine site). The park has collected precise data on night sky brightness and existing light pollution from Yovimpa Point in the south portion of the park, as well as from Bryce Point and Inspiration Point in the northern portion. Data collected at Cedar Breaks National Monument and Zion National Park compliment the Bryce Canyon data.

The night skies of Bryce Canyon are a popular feature of the park, sought by thousands of park visitors each year. Ranger-led astronomy programs are extremely well attended, particularly during the warmer months, but these programs are held year-round and the park is known both nationally and internationally for these programs. In addition, the Director of the National Park Service has recently issued a “Call to Action” as a guidance document to prepare the NPS for a second century of stewardship and engagement in anticipation of the NPS Centennial celebration in 2016. Action number 27: “Starry, Starry Night”, directs the NPS to “lead the way in protecting natural darkness as a precious resource and create a model for dark sky protection by establishing America’s first Dark Sky Cooperative on the Colorado Plateau in collaboration with other federal agencies, partners, and local communities.” The area surrounding Bryce Canyon National Park is integral to this effort and is a priority conservation issue for the park.
The degree of impact to night skies from the proposed Alton Coal project is highly dependent on the combined brightness of the facility lights at the mining operation, the amount of airborne particulates generated by mine and mine-related activities, and the mitigation measures that are applied. Impacts could potentially extend to the northern portions of the park and substantially change the character of the nighttime environment at Yovimpa Point and other key viewpoints. Concerns also extend to the nocturnal wildlife of the park and surrounding area. The DEIS states that, “Aesthetic resources would be impacted in the short term during the active mining period (life of the mine)” (§4.2, p 4-6). An entire generation of local residents and park visitors will experience impacted night skies from Yovimpa Point, and the consequences of the projected 25-year mining duration should not be considered “short term.” Impacts from night sky pollution to the landscape and wildlife should also be considered long-term as the cumulative effects of 25 years of those impacts will likely be permanent for wildlife. Returning the greater region to “pre-mine” conditions is more complicated than simply turning the lights off following the mine closure. Four principal areas of concern are outlined below related to impacts to Bryce Canyon National Park night skies.

1. **Light Dome and Expansive Vistas**

Appendix I of the DEIS contains a report regarding night sky impacts (issued to SWCA Environmental Consultants from its consultant, Dark Sky Partners, LLC [DSP]), dated April 2009. As “suggested” to DSP by Alton Coal Development (ACD), DSP addressed two nighttime lighting scenarios, “typical lighting and… brightest expected lighting” (“FINAL REPORT, Prepared by Dark Sky Partners, LLC for SWCA Environmental Consultants,” Executive Summary, p. 3; italics per original). Among its conclusions, DSP writes, “Though the skyglow impacts of the potential lighting appear small, particularly when considering the typical lighting expected to be used 90% of the time that the mine is active, the unusually pristine nature of the nighttime landscapes in this region, combined with the high resource value attached to natural nightscapes by BCNP [BRCA] mean that even small impacts may be of concern” (“FINAL REPORT, Prepared by Dark Sky Partners, LLC for SWCA Environmental Consultants,” p. 25; italics added). This is the essential conclusion of the DEIS relating to light pollution and its importance cannot be overstated.

The DEIS states: “For the duration of active mining, the typical mine lighting scenario would result in a 1% increase in night sky brightness at an altitude of 10° above the horizon and a 10% increase 1° above the horizon visible from Yovimpa Point” (Section 4.2.4.2, P. 4-15). While this is a partial summary of findings described by DSP, the data quoted are for the typical and not the brightest expected lighting conditions as defined by DSP. According to DSP, “Under the brightest lighting condition the sky would brighten by about 3% at zenith angle of 80° [altitude of 10° above the horizon], and by 31% at a zenith angle of 89° [altitude of 1° above the horizon]” (FINAL REPORT, p. 14). The greater potential impact for the brightest lighting condition, especially given the concerns noted herein, is a significant threat to the high-value nighttime resource of BRCA’s naturally dark skies and should be the lighting condition addressed in the DEIS, not the “typical” lighting condition.

“Skyglow” is not the only physical effect of artificial lighting. In fact, the consequences of skyglow may be outweighed by the impacts to safety from direct glare due to poorly aimed and/or excessive lighting (“light trespass”). This safety concern and others (see below) have not been addressed in the DEIS. Skyglow is dismissed as “less than several small towns”. Skyglow is a cumulative effect and whether it is less or more than small towns is immaterial – the mine would constitute a new and additional impact. The DEIS does not state the cumulative total skyglow, what is an acceptable skyglow level, nor what the baseline criteria should be against which to measure potential impacts. Light sources in southern Utah
have increased in the last few decades and will continue to increase, so the question is not necessarily how much skyglow there is in the first year, but also, for example, what will be the cumulative escaped light in years 20 to 25 of the mine lease. The number of vehicles with headlights on highway 89 during nighttime hours will also increase significantly. The impact of the additional headlights from additional truck traffic was not analyzed in the DEIS.

Both DSP’s report to SWCA and the DEIS reference only quantitative data for the proposed lease. However, perceptions of the night sky, the existence or the extent of light pollution and the clarity of the atmosphere are equally qualitative in nature, and for many, such as the thousands of visitors who come to BRCA to enjoy the night skies, qualitative criteria are as significant as the quantitative measures included in the DEIS. BLM must evaluate qualitative criteria as part of the NEPA analysis.

Below are examples of the more significant qualitative criteria that should also be addressed, but this list is by no means exhaustive:

- **Natural Darkness Experience**: Relates to the quality of the resource. For example, the absence of light pollution, the extended vistas and the clarity of the atmosphere all contribute to an unequalled dark sky site. Yovimpa Point is not just one of the best places in North America to set up a telescope or enjoy a pristine night sky; it is the ultimate location for a natural darkness wilderness immersion experience. Here, like very few places elsewhere, one can trace the entire Milky Way, from horizon to horizon.

- **Accessibility**: Ability of the public to reach a location with high quality dark skies. NPS Night Sky Team data demonstrate that Yovimpa Point is either the second or the third darkest place in the contiguous US that the average citizen can reach in a passenger car. Natural Bridges National Monument is number one, and Capitol Reef National Park is number two, but only if one is prepared to drive on dirt roads. The road to Yovimpa Point is paved and the parking area and trail are fully accessible. Bryce Canyon rangers go out of their way to accommodate persons with disabilities at Yovimpa Point, as well as at other astronomy venues in the Park.

- **Night-time Visual Range**: Daytime visual range distances are measurable, and the quality of the sky (extent of both aerosols and light pollution) affects nighttime visual range. Looking east from Yovimpa Point one can see far beyond Navajo Mountain to the “horn” of Black Mesa’s northeast tip — a distance of 198 km. Looking south one can see over the top of the Grand Canyon to Humphrey Peak — a staggering distance of 241 km. While these data are for daytime conditions, they translate into similar qualities of the clarity and darkness of the night sky. Bryce Canyon National Park, particularly at Yovimpa Point, offers the ultimate nighttime wilderness experience. The broad panorama, with very low horizons that are largely devoid of intrusive light domes from distant developments, is unmatched. Yovimpa Point is one of the best and few-remaining locations in the continental USA to experience near-pristine dark night skies.

BRCA is more than just an astronomer’s Mecca; it is the proverbial last Bald Eagle. To extend the metaphor, while the proposed Alton Coal Mine expansion will only increase the lowest one or two degrees of sky brightness by 31 percent (as analyzed by DSP for the brightest lighting condition), it could also be said that a Bald Eagle could still soar with a 31 percent reduction in primary wing feathers. However, if it were the last (or even the third to the last) Bald Eagle, it would certainly be folly to pluck even a single feather.

2. **Lighting Scenarios**

As directed by ACD, DSP addressed two alternatives, “typical lighting and…brightest expected lighting” (“FINAL REPORT,” p. 3; italics per original). In its report, DSP cited a number of assumptions that they were compelled to make due to insufficient data, either from ACD or from lighting product
manufacturers. According to Chad Moore, NPS Night Skies Program Manager, who consulted with DSP for its investigation, the model upon which DSP’s analysis is based was a single movable pole with four, 1,000-watt metal halide lamps. At the direction of ACD, DSP developed the following lighting scenarios (Final Report, Table 2):

**Typical Lighting Condition**
- Fixed: 4 individual lamps
- Portable: 1 portable light tower with 4 lamps
- Total: 8 lamps

**Brightest Lighting Condition**
- Fixed: 6 individual lamps
- Portable: 3 portable light towers with 4 lamps each
- Total: 18 lamps

Both scenarios included the same estimated contribution from the headlights of on-site truck and equipment use. All of DSP’s findings and recommendations, as well as related statements made in the DEIS are based on these two theoretical scenarios.

However, Section 4.2.4.2 of the DEIS indicates that, “…three types of artificial lighting are proposed during nighttime operations and would include one to four portable light towers located at each active pit and two to six fixed position light poles permanently located at the 36-acre centralized mine facilities. Portable light towers would be diesel powered with four to six lights (1,000 watts each) per tower… Fixed-position light poles would have similar dimensions as lights to the portable light towers.” These discrepancies are summarized thus:

<table>
<thead>
<tr>
<th>In DSP Report:</th>
<th>In the DEIS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical = 8 lamps</td>
<td>Minimum = 12 lamps</td>
</tr>
<tr>
<td>Brightest = 18 lamps</td>
<td>Maximum = 48 lamps</td>
</tr>
</tbody>
</table>

In the DEIS, the minimum (typical?) lighting condition would then consist of a total of 12, 1,000-watt metal halide lamps (versus 8 modeled by DSP), while the maximum (brightest?) lighting condition would consist of as many as 48, 1,000-watt metal halide lamps (versus 18 modeled by DSP). In addition, this analysis does not account for the possibility that multiple pits may be operating simultaneously. Since increased lighting has an additive effect, the minimum lighting condition proposed in the DEIS is *one and one-half times* the “typical” lighting condition analyzed by DSP, while the maximum lighting condition is *more than two and one-half times* that analyzed by DSP as the “brightest” condition. The data cited in the DEIS from DSP’s analysis are, therefore, entirely unrelated to the expected nighttime lighting for the proposed alternative.

As a consequence of the above, assigning a level of impact from the DSP Report to the minimum or maximum scenarios detailed in the DEIS is inaccurate and may significantly underreport the impacts to night sky resources. BLM must re-calculate the model and re-analyze impacts based on the significantly greater levels of illumination specified in the DEIS. NPS requests that BLM publish results as a supplement to this DEIS. The NPS Night Sky Team is available to assist BLM as needed.

Similar inconsistencies are noted elsewhere in the DEIS. For example, Section 4.2.4.2, P. 4-15 states, “Under the brightest scenario, and assuming that 24 of the portable mine lighting fixtures were aimed directly at Cedar Break National Monument [CEBR], they would appear to be approximately as bright as the planet Venus.” In fact, DSP actually reported, “Thought a precise calculation of the brightness of these lights would require detailed specification of the fixtures’ photometric properties, aiming configuration and other details, an order-of-magnitude calculation yields that the lights would appear *significantly brighter* than the planet Venus, the
brightest object in the night sky after the moon. This calculation assumes the Brightest Case lighting described in Table 2…” (FINAL REPORT, p. 22, italics added). As noted above, the brightest lighting condition per Table 2 of DSP’s report assumes only a total of 18 individual lamps, yet even that condition would result in a light source visible from CEBR “significantly brighter than the planet Venus.” Note also the caveats cited by DSP that limit the accuracy of its analysis: no photometric properties of the specific lamp type were available, assumptions were made about the aiming configuration of the light towers, and “other details” were not available. No further explanation is given regarding these other details.

3. Lighting Criteria

Dark Sky Partners reported that only some of the criteria used for its modeling of the extent and quantity of the proposed nighttime lighting were available, and these were provided by Alton Coal Development. Absent more specific and detailed information, DSP had to make a number of assumptions about the proposed lease site and operations. The variables in the information available to DSP introduce significant uncertainty in the methodology and findings reported by DSP. Furthermore, the DEIS consistently avoids reference to the “brightest” expected lighting conditions, the impacts of which may be detectable and significant, and instead quotes or reports only DSP’s findings that relate solely to the “typical” expected lighting conditions.

The DSP reports that the “typical” lighting condition was to be expected 90 percent of the time and the “brightest” lighting condition 10 percent of the time. Further definition of these parameters is necessary. For example, it is not clear whether the brightest condition would occur on a nightly basis, on a weekly basis, on a monthly basis, or at some other unknown interval. Neither are there specifications or lease stipulations prescribed in the DEIS that would ensure that the brightest lighting condition will not be experienced 20 percent of the time, or 50 percent of the time, or indeed eventually become the normal lighting condition at the tract.

4. Ecological Impacts

DEIS Paragraph 4.2.1 assumes that lighting impacts to dark nighttime skies are solely aesthetic. While the aesthetic value of clear, dark, pristine nighttime skies is indeed important to BRCA, ecological and environmental impacts to natural resources are of concern. These include impacts to land mammals, bats, birds, reptiles, amphibians, invertebrates, fishes and plants, such as are described in Ecological Consequences of Artificial Night Lighting (Catherine Rich and Travis Longcore, Island Press, 2006, http://www.urbanwildlands.org/ecnlbook.html), none of which have been addressed in the DEIS.

Neither the Dark Sky Partners study nor the DEIS address the ecological impact of the total light output of 1.83 million lumens for the brightest lighting condition or even the 740 thousand lumens for the typical lighting condition proposed for nighttime operations (FINAL REPORT, Table 2). More study and consideration should be given to these impacts. The DEIS does state that the proposed action might have the effect of displacing nearby roosting bats and alter foraging behavior, but this speculation, though logical, understates how detrimental light pollution is to insectivorous bat species, as detailed in available scientific literature. Additional comments on the impacts of night lighting on wildlife are listed below under the Wildlife section.
Suggested Mitigation/Lease Stipulations for Impacts to Night Skies

Dark Sky Partners cited a number of mitigations for reducing skyglow in their report and suggested the use of high-pressure sodium and/or low-pressure sodium lamp types, given that, “…the visible skyglow produced by metal halide lighting is approximately 3 times that produced by high-pressure sodium lighting, and 12 times that produced by low-pressure sodium lighting, on a lumen-for-lumen basis” (FINAL REPORT, p. 23). No reason is given in the DEIS for not endorsing this specific recommendation.

While both the DSP report and the DEIS do recommend the use of “portable fixture shielding” as a mitigation measure, there is no further definition of what such shielding might be. “Full cutoff lighting” is the term in general use in the lighting industry. More data for both the specific lighting type and the “shielding” to be employed are required. The NPS can provide information regarding specific technology currently available.

Dark Sky Partners recommended that fixtures be aimed to reduce impacts. Specific criteria (e.g. “30 degrees below horizontal, minimum”) should be provided. DSP also recommended the reduction or elimination of nighttime lighting at the headquarters building, yet this simple measure is not mentioned in the DEIS.

One would expect that the DEIS would include all of DSP’s recommended mitigations, especially because (1) the potential effect of the expected lighting is not considered negligible but minor under certain conditions, and (2) as stated by DSP, even small impacts may be of concern for the resources at BRCA and the greater region.

Below are suggested mitigations that should be considered:

1. Limit mining activities to daylight hours only.
2. Locate permanent operations of facilities, such as loading areas, in a big box-type building; some light may escape but much less than if all operations are out-of-doors.
3. Mining at a rate of one million tons per year is an alternative that is not considered in the DEIS. Many impacts, including numbers of trucks, light pollution, trucks rolling at crucial animal movement hours, linear feet of riparian area disturbed, etc. would be ameliorated if the mining were simply operated at a lower rate.

Following are mitigations of such significance that they should be included in the special lease stipulations with accompanying provisions for monitoring and enforcement:

1. Require lessee to provide a comprehensive lighting plan. The lighting plan should include all relevant special lease stipulations with specific direction for maintaining control and ensuring that stipulations are met on a consistent basis.
2. Limit quantities of light sources to those modeled by Dark Sky Partners.
3. Prohibit the use of metal halide lights. Limit lighting (lamp type) to low-pressure sodium, high-pressure sodium or a combination of the two. If health and safety regulations do not allow the use of either light source (as may be the case at an industrial site due to color rendition and/or visual acuity under these light sources), require the use of LED lights. LED lights may be filtered to remove some of the more offending frequencies and are a better choice for night lighting.
4. Allow only manufactured (i.e. not shop-built on site, for example) full cutoff light fixtures.
5. Restrict all lighting, except truck and movable equipment lights, to a minimum throw angle of minus 30 degrees (that is 30 degrees below the theoretical horizon and not the actual horizon).
6. Restrict lighting to operational areas, only. For example, when the headquarters building or other facilities are not in use, lights should not be on.

7. Require that any security systems that may be employed at the site not be dependent on continuous nighttime lighting. Motion-activated lights, for example, can significantly reduce unnecessary lighting and the potential to add to the Alton Coal Tract light dome.

8. Require measures to reduce dust on site and on utility roads. (Reduction of dust is discussed elsewhere in these comments.)

**Soundscapes**

Providing for natural quiet and solitude is a NPS objective supported by NPS Management Policies (2006) and Director's Order #47 (Soundscape Preservation and Noise Management, signed on December 1, 2000). Bryce Canyon National Park is recognized for its scenic vistas and outstanding visitor experience including the importance of the natural quiet that the park can offer. Maintaining natural soundscapes has been repeatedly identified as an objective in numerous Bryce Canyon planning documents including the General Management Plan (1987), Statement for Management (1989), and Resource Management Plan (1995). At Bryce Canyon National Park, the soundscape has been studied for more than 10 years with intensive monitoring over the last three summers (2009 – 2011) at locations throughout the park, including Yovimpa Point. The baseline conditions for the park are well documented and can be used to assist the BLM with soundscape analyses and future monitoring of the soundscape as a result of coal mining operations. The park has a natural soundscape with ambient noise levels that are sometimes below the threshold or "noise floors" of measuring equipment. In the absence of strong winds or human-caused sounds, ambient sound levels frequently fall below 20 dBA, comparable to the quiet of a high quality recording studio (Foch and Oliver, 1980). These conditions provide a superb environment for experiencing the natural sounds of the park.

The effects of blasting activities on the soundscape of Bryce Canyon National Park were not analyzed in the DEIS. The DEIS states: “Although mining activities may be noticeable to those visiting the nearby Dixie National Forest, Bryce Canyon National Park, and Grand Staircase-Escalante National Monument, it is not anticipated that the increased traffic, noise, and dust resulting from the mine would decrease the overall experience of visitors enough to affect visitation to these areas” (§4.8.4.1). This statement in the DEIS is not justified without appropriate soundscape analysis. Information presented below serves as a basis for NPS to request that BLM conduct soundscape analyses using appropriate metrics, also described below. NPS requests that BLM publish results as a supplement to this DEIS. The NPS Natural Sounds Program Office would be pleased to assist BLM in this analysis, including assistance with noise modeling related to blasting activities.

In the 1980’s staff from Bryce Canyon documented hearing explosions in the Yovimpa Point area of the park. These explosions were also measured on noise monitoring equipment in the same vicinity. After investigation it was determined that the explosions were originating from oil and gas exploration on the Dixie National Forest in the Mount Dutton area (~35 air miles from Yovimpa Point). This is a significantly greater distance than the ~12 miles between the proposed coal mine and the park boundary. Blasting operations, as well as some haul truck noise, will likely be audible from Bryce Canyon’s south end and possibly other areas of the park (Technical Report on Sound Levels in Bryce Canyon National Park and the Noise Impact of the Proposed...
Alton Coal Mine, Dr. James Foch and Geoff Oliver, 1980). The Foch report predicted that haul truck noise and blasting were predicted to produce noise levels at Yovimpa Point ranging from 28 to 67 dBA (trucks) and as high as 86 dBA for blasting operations.

The analysis on soundscape impacts in the DEIS (§4.2.2) focuses on the effect to the human environment at noise-sensitive receptors near the tract and along the haul route. The metric used for noise level analysis was Ldn (day-night sound level) which is commonly used for determining annoyance to the human environment. However, this metric is not sufficient for assessing impacts to the soundscape including analyses of changes to the natural ambient at locations outside of the tract and along haul routes. The National Park Service has developed standards for monitoring intrinsic and extrinsic sounds in national park units with sound pressure level (intensity) recorded in decibels and the frequency (pitch) of sound recorded in hertz (see attached Acoustical Sampling & Analysis Guide). Sound equipment used in the parks allows for recording of sounds from 20 to 20,000 Hz, which approximately represents the human hearing range. The following metrics would be more appropriate to assess impacts to the soundscape and are recommended for use in a soundscape analysis required for this DEIS as well as inclusion in a soundscape monitoring plan as part of project mitigation related to the proposed action: A-Weighted Sound Levels (dBA), Existing Ambient Sound Level (L50), Natural Ambient Sound Level (Lnat), Leq (Equivalent Sound Level), Lmax/min (maximum/minimum sound pressure level for a given period).

Bryce Canyon National Park is generally an extremely quiet area and should be considered a “noise-sensitive receptor” due to its recreational value. Impacts from noise on visitors to national park units have been well documented (http://www.nature.nps.gov/naturalsounds/pdf_docs/VisitorExperience_Soundscapes_AnnotatedBiblio_29Aug11.pdf) and are a critical concern to Bryce Canyon. The location of the park in relation to the proposed coal tract would likely enhance long-range sound propagation from mining activities due to meteorological conditions in the park (Foch and Oliver, 1980). Monitoring of blasting impacts and the associated impacts on the park’s soundscape should be analyzed first as part of the DEIS process and incorporated as part of a project mitigation and impact monitoring strategy with appropriate actions outlined if sound or frequency levels are exceeded.

Noise impacts of the proposed action on wildlife were not adequately addressed in the DEIS (refer to http://www1.nrintra.nps.gov/naturalsounds/documents/wildlifebiblio_Aug08.pdf for more information as well as http://wfae.proscenia.net/library/articles/radle_effect_noise_wildlife.pdf for an annotated bibliography on the impact of noise on wildlife). Most research indicates that noise can affect an animal’s physiology and behavior, and if it becomes a chronic stress, can be injurious to an animal’s energy budget, reproductive success, and long-term survival (Bayne et al., 2008; Radle, 1997). Prolonged exposure to noise has been shown to cause wildlife to avoid certain areas, reducing already limited potential habitat (Lynch et al., 2011). Studies of songbird behavior and ecology near oil and gas development found a significant reduction in pairing success, bird density, and bird species diversity caused by noise (Habib et al. 2007; Bayne et al. 2008). Although the DEIS states that noise impacts will affect wildlife (§4.17) there is no attempt to quantify or describe the extent or magnitude of those impacts.
Suggested Mitigation/Lease Stipulations for Impacts to Soundscapes

1. Develop a Mine Blasting Plan in conjunction with the National Park Service to ensure timing and intensity of sounds are limited in scope to mitigate impacts to the park’s soundscape and visitor experience.
2. Restrict blasting operations to pre-determined times of the day not to exceed more than 2 hours total during a 24-hour period.
3. Establish 55 dBA as the maximum background noise level acceptable from coal mining operations (blasting and haul routes) as detected within Bryce Canyon to ensure normal speech intelligibility and avoid outdoor activity interference and annoyance (EPA Noise Effects Handbook, 1981).
4. Develop a Soundscape Monitoring Plan that establishes monitoring locations within Bryce Canyon National Park to assess impacts to the soundscape using NPS Natural Sounds Program protocol monitoring.
5. Determine appropriate response and management strategies if established dBA thresholds are exceeded.

Secondary Resource Impact Concerns for Bryce Canyon National Park and the Regional Environment

Tourism

The Utah Heritage Highway 89/Mormon Pioneer National Heritage Area was created by an act of Congress on July 24, 2006. The Boulder Mountain Loop of the Utah Heritage Highway includes the communities and scenic areas along Utah Scenic Byways 12 and 24, and begins and ends on US HW89. Bryce Canyon National Park is one of the premier scenic resources included in the Boulder Mountain Loop. In addition, as a signatory to the Mormon Pioneer National Heritage Area Management Plan, the Department of the Interior, together with the National Park Service and Bryce Canyon National Park, are concerned with the impact of proposals such as the development of the Alton Coal Mine and the resulting increase in truck traffic along the Utah Heritage Highway 89 corridor.

The DEIS states that impacts to tourism in the region from mining activities would be negligible. However, the effect of increased traffic loads on surrounding highways (especially on highways 89 and 20) to the tourism industry has not been adequately addressed. In addition to its recent designation as a National Heritage area, US HW89 is the main artery for tourists to travel between Grand Canyon National Park, Zion National Park, Bryce Canyon National Park, the Dixie National Forest and several state parks, and to destinations further north, such as Salt Lake City. Tourism traffic not only includes cars but also towed vehicles and larger recreational vehicles. Highways 89 and 20 are winding, 2-lane routes traversing hills, canyons and mountains. Continuous 24-hour dual trailer heavy truck traffic on these routes, under the best of conditions, poses a safety risk for commuters and visitors to the area. Increased heavy truck traffic would have a negative impact on visitors to the area who would not be able to fully appreciate the designation of this corridor as a National Heritage Area.
Section 2.3.2.11 (Traffic Estimates)
“Under the Proposed Action, there would be an estimated 153 trucks travelling daily to and from the tract and reasonably foreseeable coal loadout location (the transportation route and loadout location are described in §2.5.4 Reasonably Foreseeable Coal Loadout Location and Transportation Route). Loaded trucks, specifically designed to reduce loss of coal dust and larger coal particles while traveling, would carry approximately 42 tons of coal each.”

The DEIS does not adequately consider the impact of increased truck traffic within the Panguitch Historic District, listed on the National Register of Historic Places in 2006. The Panguitch Historic District is listed under Criterion A and Criterion B of the Applicable National Register Criteria. At the least, the impact of additional heavy truck traffic through the historic district should be considered in relation to Criterion A, which states: “Property is associated with events that have made a significant contribution to the broad patterns of our history.” The BLM through this NEPA/DEIS process should investigate whether 153 round trip vehicles per day (trucks passing a given point 306 times per day, or about one truck every 4.7 minutes) pose an impact when considered in light of the National Register Criteria, and if the impact is greater than negligible, mitigations should be required of the mine and trucking operators to reduce the impact.

Wildlife

The DEIS discusses mining operations and associated activities on the Alton Coal Tracts as having “short-term” impacts to wildlife and other resources. The use of “short-term” is not appropriate for addressing impacts to wildlife species when defined as a 25-year period. A time period of 15 – 30 years to successfully reclaim disturbed areas, constitutes the same number of generations for most wildlife species (some with even faster breeding cycles). The loss of available habitat (including crucial summer and year-long habitats for mule deer and elk), impacts associated with night lighting, disruption of migration corridors and routes, water source removal or contamination, and the disruption to inter-generational wildlife survival knowledge constitutes a long-term, probably permanent, impact to wildlife populations. The claim that restoration measures would result in greater long-term beneficial impacts to several species or species groups associated with sagebrush habitat (as compared to Alternative A) by increasing the quality and quantity of foraging habitats is presumptive and is not supported by scientific studies that compare restored habitat to intact reference sites. BLM must reconsider the definitions of short- and long-term impacts, as developed in this DEIS and present pertinent information supporting the assessment of short- and long-term impacts to wildlife.

Section 4.17.1.2
It is unclear which, if any, of the lease stipulations listed would be incorporated as part of the final Standard and Special Lease Stipulations as listed in Table 2.3 (which currently lists no stipulations for wildlife). Revegetation should focus on the use of native vegetation throughout the tract in order to restore the genetic and ecological integrity of native ecosystems, including wildlife communities, following project completion. Additionally, the impact of chemical treatment of weeds and use of chemical suppressants to control dust on wildlife and their habitat were not addressed adequately in the DEIS.
The list of stipulations on pg 4-134 includes “Avoid disturbance to individuals, populations, and habitats of threatened, endangered, proposed, and candidate species”. Although there is a lack of specific language in the DEIS on mitigation measures to meet this objective, the proposed action alternative would have a direct impact on the greater sage-grouse and therefore could not satisfy this stipulation. Most of the Standard and Special Lease Stipulations listed in Table 2.3 relate to reclamation, not to avoidance. Reclamation efforts 25 years (or more) after disturbance on a site that once contained greater sage-grouse brooding, rearing or breeding habitat should be considered a long-term, potentially irreversible disturbance. BLM must address these impacts to greater sage grouse wholly in this NEPA/DEIS process and given the species status, consider avoidance and mitigation measures to meet agency and Department goals for grouse population and habitat protection and recovery.

The DEIS does not indicate how it would conform to the Migratory Bird Treaty Act of 1918, which prohibits direct take and destruction of occupied nests. The BLM should incorporate vegetation removal during the non-breeding season (as stated under §4.17.6.2, ¶3) within lease stipulations to reduce negative impacts to species within the tract and to ensure compliance with the MBTA.

Section 4.17.5
Concerns related to the protection of the greater sage-grouse were also discussed above under “Alternatives Analysis Comments”. The DEIS indicates that 900 acres within the tract have been previously treated for pinyon-juniper removal to enhance sage-grouse habitat with positive results. It is unclear if that treatment area would be within the coal mining zone. It would be unfortunate to lose successful efforts to promote sage-grouse conservation in the area. Tracts previously treated for sage-grouse benefits should be removed from the lease area. The DEIS states that “retention of the Alton sage-grouse population would require…the avoidance of 1) intact sagebrush stands and other seasonal sage-grouse habitats, such as the agricultural and wet meadow habitats in Block NW that are used as summer brood-rearing habitats, and 2) sagebrush nesting, brood-rearing, and wintering habitats in Block S” (pg 4-138). The tradeoff of decreased minable acreage seems appropriate for this level of protection of the sage-grouse, in line with current KFO BLM policies and conservation efforts underway throughout the western United States.

Section 4.17.7
The wildlife road kill expected from over a million truck loads over the length of the haul route, especially at dusk and dawn, may be unacceptable. An analysis of the effect of that level of by-kill over 25 years should be modeled and clearly presented to the public. The Paunsaugunt Plateau is one of two "premium limited entry" deer units in the state of Utah, in which the Utah Division of Wildlife Resources manages for the highest quality of bucks. A large portion of the haul transportation route would be adjacent to crucial winter mule deer habitat (81%) as well as crucial habitats for other large ungulates (elk and pronghorn). Data on roadkill numbers, prior to initiation of the Coal Hollow Mine operations, may be indicative and should be presented with an economic analysis of the impacts on the Paunsaugunt unit. Hunting for deer and other wildlife are an important cultural activity in the region, with nation-wide interest in the Paunsaugunt unit. The transportation analysis (Appendix H) lists wildlife-related crashes as the number one type of single-vehicle accident along the HW 89 section of the haul route, twice as
high as the next type of accidents. The BLM should strongly consider the economic and human safety impact of increased heavy truck traffic along the haul route, especially on the HW 89 section. Limiting hauling to daylight hours, or avoiding crepuscular periods, may reduce wildlife roadkill and human injury numbers and should be considered in any leasing decision or associated stipulations. Alternatively, haul trucks could run in 10-truck convoys which could decrease risks to both human and animal safety.

Section 4.17.6.3.2.4
The DEIS presented a cursory analysis of impacts to bat species from the proposed action (see also the Ecological Impacts section under the Night Skies discussion). The impacts of light pollution on bat species has been well documented (refer to the attached study “Bats and Light Pollution,” Elena Patriarca and Paolo Debernardi, 2010, for a summary and analysis of peer-reviewed studies). While researchers identify more than 10 impact categories, the central problem is a result of how bright lights (especially metal halides, which according to the DEIS will be used exclusively) create insect swarms, drawing tens of thousands (representing scores of species) from tens of km away.

Artificial light-induced insect swarms impact bat species in a variety of ways:
• Reducing total volume of prey (flying insects) through direct mortality by lights and decline in reproductive productivity caused by the disorienting/preoccupying effects of light
• Light will draw insects away from water where normally encountered, requiring bats to make separate flights to drink – a highly energetic process of skimming one drop of water with each pass over flat water or licking smaller drops (decreased in size and number with length of commute) off of their fur upon returning to safety of roost.
• Concentrating prey far away from roosts and nurseries creating:
  o Decreased nursing frequency and milk production due to time and energy cost of longer distance commutes between nursery and swarms.
  o Impact of extended commute may reduce overall health including resistance to communicable diseases like white-nose fungus.
• Increased competition for food, roosting and nursery sites between smaller and larger bat species.

The single largest impact from artificial lighting is likely to be the displacement of smaller, slow-flying bats by the region’s larger-fast-flying species. This effect has been documented in the various studies summarized in the Patriarca and Debernardi (2010) study.

In addition to impacts associated with bat species, flying insects are the basis for not only most carnivorous food chains in the region, but are also key in the pollination of hundreds of regional plant species. The role insects play in pollination also makes them key to many herbivorous aspects of ecological food webs. To overlook the proposed mine’s impact on insects is to ignore a potentially adverse effect, especially when considered over the proposed 25-year life of the mine. BLM must consider in this NEPA/DEIS process that in an area so devoid of artificial light (as explained above under the Night Skies section), this single coal mine could have a pronounced ecological impact on an otherwise near pristine food web.
Section 4.17.7.2.2.3
Recovery efforts for the federally listed Utah prairie dog have been occurring along portions of the haul route for several years. Impacts from additional haul trucks in the form of road-kill and noise disturbance was not quantified in the DEIS but will likely contribute to colony impacts along the transportation route. The BLM should consider developing a road impact monitoring program from the Utah prairie dog as well as other wildlife species along the haul route. The monitoring program should include a standardized reporting protocol for truck drivers as well as regular surveys for road kill. Additional data, from Utah DWR and DOT could provide supplemental information. Tracking road kill, especially of small to medium sized mammals and birds, will likely be lost if requirements are not included in the Standard and Special Lease Stipulations and applied to truck operators. The BLM has an opportunity to gather important information on the ecological impacts to long-haul coal mining operations. This data could inform future mitigation measures if an adaptive management approach is incorporated into the Standard and Special Lease Stipulations.

Section 4.17.8
The DEIS lists 4 potential mitigation measures for wildlife and special status species. Two of the listed mitigation measures relate to monitoring activities. Monitoring by itself does not reduce impacts to wildlife species; specific thresholds and management actions related to threshold exceedances should be incorporated into Standard and Special Lease Stipulations and the final EIS and Record of Decision. The BLM should also consider providing wildlife-compatible alternative water sources (e.g., stock tanks or guzzlers) and/or creating/restoring wetland habitat adjacent to areas where currently available water for wildlife is located.

Water Quality
Although the watershed directly associated with Bryce Canyon should not be affected by the proposed coal mine, concerns for water quality arise from ground disturbing activities within the Robinson Creek and Kanab Creek watersheds within the boundaries of the proposed mine tracts. Waters from these creeks eventually reach the Colorado River within Grand Canyon National Park. The potential for water contamination from spills and natural overland flow (rain runoff) should also be addressed by BLM in this NEPA/DEIS process. This analysis should include the Sevier watershed along the proposed haul route.

Surface Water
Over 8 miles of the haul route are within 100 feet of a perennial stream. It should be assumed that every one of the over one million proposed truck loads will lose some fugitive coal and that will end up in these streams. Several of these streams already exceed the state of Utah standard of 1200 mg/L total dissolved solids (TDS) (pg 4-125); other Utah streams are close to the limit. The cumulative impact of fugitive dust seems likely to cause the State of Utah water quality standards to be violated. Stream monitoring should be incorporated in lease stipulations and mitigation should be incorporated to reduce the chance of violation with associated management actions if violations are detected.

Over 8.4 million truck miles will be driven within 100 feet of perennial streams. The DEIS did not state the accident rate for similar trucks driving on roads that will at times be icy. The
analysis should include a reasonable determination on how spilled contents from haul trucks would affect stream quality within the tract and along the haul route. Even if a truck merely rolls off the road prism and comes to rest on a stream bank or floodplain, fuel and oil could penetrate the floodplain soils and could move into the stream during spring runoff. In reality, a loaded coal truck (50,000- to 75,000 lbs) traveling at the speed limit has enough momentum to travel at least 50 (but possibly 100+) feet outside of the road corridor in the event of an accident due to icy road conditions or driver error. Stream monitoring should be incorporated in lease stipulations and spill prevention and response plans developed prior to any mining activity on the proposed lease tracts.

Shallow Ground Water and Alluvial Valley Floors

Reclamation bonds have been successfully employed at other mines to require mining operations to re-vegetate an area using native plants. Since coal mining pits may occur in the alluvial valley floor, the analysis should consider how the bond will require reclamation of the permeability and water retention ability of the valley soil be maintained. If 100 feet of alluvial material is excavated as overburden it is reasonable to assume it will desiccate before it is replaced. The affected environment section does not state the current moisture content or permeability of the alluvium. The analysis does not include an estimate for how long it will take for successful restoration of the alluvial valley floors. The public should have access to this analysis to make an educated determination if it is acceptable. Alluvial floor issues are important to long-term ecosystem health. Impacts to these systems are not adequately addressed in the DEIS. BLM must consider in this NEPA/DEIS process the impacts to alluvial soils and their potential for reclamation. A suggested mitigation measure would be to remove the alluvial valley sections from the lease area.

Riparian Area

Very little of the land in southern Utah is riparian. Riparian areas are crucial to species diversity and population resilience in dry areas such as southern Utah and the arid southwest. Several drought years over the life of the 25-year mine operation period should be anticipated. During those dry years upland forage and browse species put on very little new growth and therefore provide less nutritious food for ungulates and other wildlife species. Many animal populations move to the riparian corridor to obtain food under drought conditions, but if that riparian area has been removed (or are intact, but completely surrounded by pit mines, fences and lights) the animal populations may be expected to decline.

The DEIS suggests that Robinson Creek may be re-routed. While this new structure will perform the task of moving water across the lease area, its biological function will be seriously diminished.

If the tracts are leased, three potential mitigation strategies include:

1. Do not allow processing facilities to be placed in the riparian corridor, or within 300 feet. Furthermore, any disturbance that will be in use for more than 18 months (roads, processing facility, top soil storage area, mine offices) should be at least 300 feet from the riparian corridor.
2. Require that either the entire left or right bank of the affected streams within the tract (Robinson, Kanab and unnamed) remain intact with suitable plant material to maintain riparian function (e.g., the left bank could not be mined until all restoration metrics specified in the bond on the right bank had been met). This also requires appropriate wildlife-approved fencing within the tract.

3. Crossing of the streams and riparian areas should be constructed using temporary bailey bridges that avoid the entire 100 year floodplain. Large culverts would allow water to pass but would be a barrier to small terrestrial wildlife moving up the stream corridor.

**Soils (§3.13.1; §4.13; §4.18.3.19)**

This DEIS devoted several pages to soil, but misrepresented how soils function in a xeric environment. Biologic crust is essential for developing the thin A-horizon because it retards wind erosion and also diminishes water erosion. Biological crust can trap air-borne moisture and nutrients. The thin A-horizon captures the limited moisture from brief rain events and the dry snow which is typical in this area. The analysis failed to map the extent of biologic crust on the tract. Biologic crust is an irretrievable resource which will be completely destroyed. Without it, the A-horizon will develop on a geologic time scale rather than a typical soil time scale.

BLM must consider in this NEPA/DEIS process how to conserve biological crusts where feasible and should include lease stipulations to ensure that preservation of the A-horizon would be conducted via suitable salvage and reclamation techniques in order to provide soil to support future plant growth. Mitigation bullet #1 (§4.13.5) is not adequate. Damage to biological crusts from heavy equipment is generally permanent.

**Faults (§4.6.3.2.1)**

While the Colorado Plateau is not known to be particularly seismically active, this may be due to a paucity of data and almost no written records prior to the 1870 arrival of settlers. The margin between the Colorado Plateau and the Basin and Range has experienced regular significant seismic events. The Plateau margin is not a fixed line but a belt of land and Alton coal tract sits within that belt of activity. Geologic events elevated the Claron formation that forms the cliff around Yovimpa Point (~12 miles away) by approximately 2,000 ft. in the last 10 million years. That indicates 1 foot of uplift every 5,000 years which implies a seismically active area. All underground mining poses risks; these risks have not been adequately investigated in the DEIS to place people underground. BLM should consider in this NEPA/DEIS process only allowing surface mining at this time due to insufficient analysis of safety consequences of underground mining.

**Cultural Resources**

The DEIS states that upwards of 74 archeological sites eligible for listing under the National Register of Historic Places (NHRP) could be partially/completely destroyed by the activities of the mining operation, yet no clear plan of action has been produced to address the loss of these sites. Actual mitigation plans to reduce the impacts have yet to be developed. A Cultural Resources Management Plan (CRMP) was developed for areas adjacent to the proposed lease
tract and it is implied in 4.4.3 (Analysis Assumptions) that the same procedures will follow for resources within the lease tract, but that document was not made available within the DEIS. BLM must consider in this NEPA/DEIS process the consequences of loss and appropriate salvage, mitigation and management of cultural sites contained within the proposed lease tracts as required by federal and state law. When a CRMP is developed, it should be made available for public review.

**Traditional Cultural Properties** (§3.4.3; Pg 2-40)

The DEIS references adverse effects on Traditional Cultural Properties (TCPs). It does not appear that these properties have been identified. The DEIS is not NEPA compliant unless specific impacts to each TCP have been evaluated. The DEIS states “Tribes would review the CRMP” however it is unclear when the CRMP would be developed (implied in 4.4.3 Analysis Assumptions). Similar to other resources, the DEIS should identify effects, not simply state that impacts will be addressed in the future with additional documents that may not require public review. Once the final EIS is published and the Record of Decision is signed, American Indian tribes with interest in the area may have little recourse. This directly relates to guidance from the Secretary of the Interior that federal consultations with tribes should be on a government-to-government basis prior to decision-making. BLM must, through tribal consultation, identify and consider in this NEPA/DEIS process the consequences of loss and appropriate management of tribal cultural sites contained within the proposed lease tracts in compliance with recent Secretarial Orders on tribal consultation and the federal government’s trust responsibilities with American Indian tribes.

**Paleontology** (§4.10.1)

The DEIS makes reference to the presence of “qualified paleontological monitors”. The requirements of a ‘qualified monitor’ and an appropriate monitoring plan are lacking in the document. The third mitigation measure of a $100,000 donation to “support scientific research on Late Cretaceous paleontology on the Paunsaugunt Plateau within the BLM-KFO” does not seem sufficient based on the loss of significant paleontological resources. The BLM must consider extensive pre-mining surveys to inventory the area and recover any significant paleontological resources located in compliance with the Paleontological Resources Protection Act (16 USC 470-aaa-1) and discuss relevant impacts, protection and mitigation through this NEPA/DEIS process. Section 4.10.5 states there are no mitigations, but there are three mitigation measures listed under the regulatory framework (4.10.1) and two listed in Table 2.3 under Special Lease Stipulations (pg 2-12).

**Vegetation & Wetlands**

§4.15.3.2.1.1 states that “annual and perennial grasses are not considered a native vegetation community” in the project area. This determination seems unfounded and should be further explained. The presence of native grassland communities throughout the Colorado Plateau and Great Basin area is quite common and is recognized as a vegetative community.
Wetlands may be present in the project area but have not been delineated. Without knowing the exact location and extent of the wetlands it is difficult to determine the effects of an action on wetlands. Additionally, activities not directly in wetland habitat can impact a wetland by altering the local hydrology. More information is needed to evaluate potential effects. BLM must conduct a wetland delineation in compliance with existing law through this NEPA/DEIS process before making an impact determination.

The DEIS does not discuss what Best Management Practices (BMPs) would be implemented to prevent the introduction of weed species (§4.15.3.2.4). It is unrealistic to assume that no new weed species will be introduced as a result of ground disturbance activities. Even with BMPs in place, the large amount of vehicle traffic in and out of the project area provides ample opportunities for the transport of weeds. Even if BMPs were 100% effective in preventing the spread of weeds via vehicles there is still a potential for wind introduction. Many weed species are wind dispersed and disturbed soils at the project site provide prime locations for establishment.

A general description of revegetation techniques is mentioned in the DEIS (§4.15.3.3.6). However, because of the large area (~1500 ac) being proposed for rehabilitation following mining, a well developed revegetation plan should be developed. Use of non-native seeds is not mentioned under the Vegetation section (4.15) but is listed under §4.9.5 - Potential Mitigation Measures (Livestock Grazing §4.9). The use of seed mixtures with non-native seed should not be acceptable for the reclamation plan. Due to the high probability of non-native species establishing onto disturbed surfaces (including “reclaimed” acres), the BLM should consider use of only native seed mixtures to promote the re-establishment of native vegetative communities. Impacts to vegetation in the tract will be extensive; reclamation activities focused on native plant species recovery will assist with restoration of a highly damaged landscape.

**Hazardous Material and Hazardous and Solid Waste** (§4.7.3)

The DEIS does not specify quantities of hazardous materials (for example diesel fuel) that will be stored on site or the number, size, or containment strategies for storage containers proposed. These details, and their associated impacts, should be disclosed for public review prior to project implementation as those facilities would be located on federal lands and must meet federal and state regulations and public Right-To Know statutes.
ACOUSTICAL SAMPLING & ANALYSIS GUIDE

CHANGE HISTORY

Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures included in the plan.

The following revisions have occurred to this plan since DAY MONTH, YEAR

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1.0 INTRODUCTION

This acoustical protocol was developed for national parks, including those that may apply for Air Tour Management Plan (ATMP) acoustical monitoring and analysis via the NPS Servicewide Comprehensive Call (SCC) funding or their park contractors. To apply for such funding, a park must be on the current ATMP park list issued by the FAA. This guide meets the specifications of the FAA/NPS Implementation Plan for ATMP development.

To meet the needs of an ATMP or other park planning, park acoustical resources must be characterized in relation to desired future conditions and noise sources must be documented to support cumulative impact assessments. In addition to these necessities, park units may want to document specific elements of the natural, cultural, and/or historic soundscape that are deemed especially significant as park resources or as elements of visitor experience.

2.0 SITE SELECTION

2.1 Identification of Acoustical Sampling Areas

Areas of like vegetation, land cover, topography, elevation, and climate often possess similar acoustical characteristics, including sound sources, sound levels, propagation and attenuation properties. Most park units have identified and created digital maps of primary vegetation and
topographic types; these should be reviewed in order to determine the potential number and types of different sampling areas in that park.

The acoustical sampling plan should allocate effort to document conditions and potential impacts to the largest fraction of the affected park environment that is feasible. Acoustical data will be analyzed by site and by sampling area. Inclusion of data from dissimilar ecosystems and acoustical environments within a unit of analysis should be avoided.

2.2 Monitoring Site Selection

Monitoring sites should be selected to ensure that at least one site is placed in each of the significant sampling areas of the park. The significance of a sampling area will be determined by the proportion of the park unit area that it covers, the importance of the resources it contains, and the role that it plays in visitor experience.

Secondary site selection considerations include, in rough order of priority:

- Park management zones, specific soundscape objectives for those zones, and associated need for baseline acoustical data;
- Specific sound-sensitive areas, such as endangered species habitat or sites of historical or cultural significance;
- Specific acoustical data needs, such as air tour aircraft and model verification and validation; a localized sound source such as a waterfall or river rapid);
- Visual considerations (security, solar exposure, visibility, etc.); and
- Measurement equipment availability, power requirements, and site access considerations.

Specific park management and soundscape objectives need to be discussed with local NPS personnel. The number of sites, site locations, and deployment schedules will be coordinated with NPS Natural Sounds Program and park staff through some combination of correspondence, teleconferences, and on-site meetings.

3.0 EQUIPMENT

The following are minimum standards for acoustical equipment. In situations where these standards are not followed, any deviation should be explicitly documented and justified.

*Sound Level Meter*

All sound level meters (SLMs) must meet or exceed requirements of ANSI S1.4-1983 (R2006) for Type 1 classification and IEC 61672:2003 for Class 1 performance. Each SLM should perform true numeric integration and averaging. In addition, all sound level meters
must meet or exceed the Class 1 requirements of ANSI S1.11-2004 and IEC 61260:1995 for one-third octave band spectra.

**Calibrator**
Use of a stable calibrator is required. All calibrators must meet minimum requirements of ANSI S1.4-1983 (R2006) and IEC 60942:2003 for Class 1 performance.

**Digital Audio Recorder**
A high quality, continuous digital audio recording system, such as the Edirol R-09 or Zoom H2, is required. The recording system should use an analog audio output from a Class 1 SLM and be capable of recording sounds with a dynamic range in excess of 90 dB. Recording instruments should have a signal-to-noise ratio greater than 90 dB (before compression). A quality audio recorder should provide accurate frequency response between 20 Hz and 20,000 Hz. However, atmospheric absorption substantially limits the long-distance propagation of high frequency sounds: absorption coefficients can exceed 20 dB per 100 m above 10 kHz. An upper frequency limit of 14 kHz may be acceptable for continuous recordings if there are no nearby sounds with high frequency content. If lossy audio compression is used to save storage space, the sampling plan should include explicit consideration of the performance characteristics of the selected compression algorithm and bitrate.

**Equipment Calibration**
All sound level meters, microphones, preamplifiers, and calibrators need to be calibrated annually by an ISO 17025 certified, NVLAP accredited, and/or other NIST-traceable acoustical calibration facility. All calibration documents must be up-to-date with copies provided to NPS as part of an acoustical report.

**Microphone Type**
A random incidence microphone is recommended for acoustical measurements in most park settings. Microphones can be polarized or pre-polarized, but pre-polarized microphones are better suited for humid environments.

**Microphone Simulator**
A microphone simulator is required in order to establish the electronic noise floor of the measurement system absent the microphone.

**Windscreen**
In most park settings, a porous windscreen will be required. In exposed, windy locations, larger diameter windscreens may be required, possibly including a hairy fairing to further suppress turbulence around the windscreen.

**Meteorological**
An anemometer capable of logging wind speed and time stamps is required. In addition, logging of wind direction may be important when sounds are expected to be present along specific compass bearings.
Instrument Clocks
The SLMs, digital recorders, and meteorological equipment should be set up to enable synchronization such that events of interest can be unambiguously cross-referenced across data sets. This can be achieved either through the stability of the instrument clocks or provisions to track and compensate for clock drift. An authoritative time reference like GPS, WWV radio, or NIST Internet Time Service should be utilized to set system clocks.

4.0 DATA COLLECTION

Basic measures of park acoustical conditions are the existing ambient sound level and the natural ambient sound level that omits sound sources that are not intrinsic to the park’s purpose. Section 8.2.3 of the NPS 2006 Management Policies specifies: “The natural ambient sound level – that is, the environment of sound that exists in the absence of human-caused noise – is the baseline condition, and the standard against which current conditions in a soundscape will be measured and evaluated.” In addition to characterizing natural ambient sound levels, acoustical monitoring must document the different kinds of noise sources affecting the park, their sound levels and frequency content, and their patterns of occurrence.

4.1 Required Data

The types of data to be collected are discussed below, including specific formats, source identification, meteorological, measurement location, instrumentation, and observer logs.

Sound Level Data
Continuous, A-weighted sound levels and unweighted, one-third octave band spectra from at least 20 to 12,500 Hz must be collected at one second intervals (1-second Leq), and the data stream must enable assignment of each record to a specific time. In order to maintain compliance with measurement standards for specific expected noise sources, if possible, an A-weighted sound level with “Fast” setting, representing a 125 ms exponential time constant, should also be sampled frequently enough to enable calculation of accurate hourly percentile levels. The intrinsic noise level of the system should be below 20 dBA, and systems with extremely low noise specifications may be required in some park units.

Meteorological Data
Continuous wind speed data must be collected, and the time of each measurement must be available in the data records. Wind direction, outside air temperature, and humidity may be useful for some purposes; they affect sound propagation as well as wildlife activity patterns.

Digital Audio Recording
High quality, continuous digital audio recordings are required. Some mechanism for assigning a time to each digital sample must be implemented. Audio recorders must meet the specifications of section 3.0.
Source Identification/Observer Logging
During sound level data collection, investigators with normal hearing should conduct observer logging for several hours (at least 2.5 percent of the measurement duration for that location). During that time, all sources of sound will be logged. When logging, observers should be located at least 50 ft (15 m) from the acoustical measurement system and in the same vegetation type (sampling area) as the system. Sound types to be logged should be obtained from the NPS Natural Sounds Program; logging software for Palm PDAs can be provided upon request.

Site Information
Characteristics of the site, such as GPS position, NLCD land cover type, the NatureServe Ecological Domain, Ecological Division, and Ecological System (if defined) must be documented. Noting the vegetation type as classified by the park will be useful as a cross-reference. Photographs documenting the site, the equipment setup, and its surroundings must be taken.

4.2 Equipment Setup Guidelines

The following are minimum required setup procedures. In situations where these protocols do not apply, any deviation should be documented and justified.

Site Selection
Acoustical monitoring equipment must be placed in a location representative of the sampling area (or specific acoustical issue) under study. Wherever possible, sites exposed to the wind should be avoided. If the sole purpose of the site is to document natural ambient sound levels, then the site should be as free from external noise influences as possible. Contamination of data due to equipment-generated sound should be avoided. For example, anemometer noise should be negligible at the measurement microphone, and all equipment wiring should be secured to prevent cable slap noise. Hard, flat equipment surfaces, such as solar panels, should be situated away from the microphone to reduce the potential reflection of sounds. For every measurement site, parameters of that site must be recorded, including latitude and longitude, elevation, vegetation type, land cover, exposure, distance to sound sources (natural and non-natural), and other appropriate descriptive information. Photographs of the site and surrounding area must be taken.

Microphone Placement
Generally, to attain symmetrical frequency response in the horizontal plane, the microphone diaphragm should be oriented vertically (microphone grid facing the sky). The microphone is usually placed at 5 ft (1.5 m) above the ground surface, to mimic a typical ear height for a human listener. However, in very windy locations it may be advisable to mount the microphone much closer to the ground. For winter deployments, snow surface height can vary considerably and it may be appropriate to place a microphone higher than 5 ft above the ground. Microphone height and placement must be documented via onsite pictures and GPS coordinates.
**Windscreen Use**
In most park settings, a porous windscreen should be used to cover the microphone and minimize the measurement artifacts of wind blowing past the microphone. The effect of the windscreen on sound level measurements should be known and reported to within ± 0.5 dB in each one-third octave-band. When windscreen attenuation exceeds 0.5 dB in any frequency band, the data should be adjusted to correct for this attenuation. A bird spike should be used to prevent the windscreen from being used as a perch.

**Field Calibration**
Field calibration is required at the beginning and end of each site deployment, and it is recommended for every site visit. Calibrator readings should account for all manufacturer-recommended adjustments, e.g. atmospheric pressure, coupler volume corrections, etc. Any required corrections should be made and the changes noted. This information must be provided to NPS along with measurement data.

**Noise Floor**
A microphone simulator must be used to establish the electronic noise floor of the entire electrical system absent of the microphone. A log must be kept that documents calibration and noise measurement. A copy of this log must be provided to NPS.

**SLM Time Response**
The SLM time response should be set to enable logging of 1-second $L_{eq}$ data and maintain compliance with noise standards where possible. If possible, an A-weighted sound level with “Fast” setting, representing a 125 ms exponential time constant, should also be sampled. However, when measuring brief impulsive sound events such as sonic booms, a faster time response setting and more frequent data (many readings per second) may be necessary.

**Digital Audio Setup**
Digital audio recordings must be continuous and high quality, using a Class 1 SLM output. If lossy audio compression is used, the performance characteristics of the compression algorithm and the selected bitrate should be specified (especially frequency response).

**Clock Synchronization**
Provision must be made to synchronize data collected by different instruments at the monitoring station. The accuracy of synchronization must be adequate to permit unambiguous identification of events of interest across all devices. It is recommended that system clocks be set using an authoritative time reference, like GPS or WWV. Interim and end of deployment time differences can be noted to document clock drift among the instruments.

**Site Visits**
At the start of data collection, each system deployed at a site will be checked to ensure all components are functioning properly. In addition, visits to each site (approximately once per week or as weather permits) are recommended to ensure the system is running, perform observer logging, download data, recalibrate the system, and check clock synchronization.
4.3 Temporal Measurement Considerations (Daily, Seasonal, Duration)

Temporal sampling must span times of probable acoustical variation, such as diel and seasonal cycles, a representative sample of weather conditions, and possibly changes related to local phenology. To the extent possible, the acoustical sampling plan must take into consideration these sources of variability in the sampling areas.

**Time of Day**
Ambient sound levels can be expected to vary as a function of time-of-day according to wind, rain, temperature profiles, visitor activity, and biological factors.

**Season**
Ambient sound levels may differ by season due to weather, visitor activity, and biological factors. Acoustical data should be collected during a representative seasonal month when air tours occur, typically between May-August for summer, and between November-February for winter. The NPS Natural Sounds Program should be consulted on a park-by-park basis to discuss seasonal sampling options.

**Duration**
In order to limit measurement uncertainty, ambient sound levels should be sampled for at least 25 days in winter and 25 days in summer. In some situations, shorter or longer monitoring periods may be indicated. Like all other aspects of the acoustical sampling plan, monitoring periods should be designed using the best available information and discussions with park unit staff.

**Margin of Error**
The goal is to collect data so that there will be no more than a ± 3 dB difference between the average (or expected) ambient sound level and the ambient sound level measured from the sample period.

4.4 Data Formats

As per its interpretation of the Museum Properties Act of 1955, the National Park Service requires that copies of all data, pictures, and reports that are generated as a result of research activities occurring in National Parks remain the property of the National Park Service. All raw data described in sections 4.1 and 4.2 must be provided to NPS in a convenient, computer readable format. For large data sets, an external hard disk drive will often offer the simplest mode of transport.

**Sound Level Data**
Continuous A-weighted sound levels and unweighted one-third octave band sound levels at one second intervals (1-second Leq) must be provided in a convenient, computer-readable format. In addition, other data, such “Fast” A-weighted sound levels, should also be provided. An acceptable format protocol will be provided upon request from the NPS Natural Sounds Program. If 1/3 octave band data are acquired using a Larson Davis 824 or 831, the NSP...
office is able to offer useful utilities for converting and viewing the data. A-weighted sound levels may be collected in the field, or computed from the one-third octave data.

*Digital Audio Recordings*

High quality, continuous digital audio recordings must be provided in a computer-readable digital audio format. Acceptable formats include WAV, MP3, or WMA. The NPS Natural Sounds Program may be contacted for utilities intended for viewing one-third octave band spectra while listening to digital audio recordings.

5.0 DATA ANALYSIS

5.1 Data Processing

Several quality assurance checks must be applied to the acoustical data prior to data reduction to ensure that any questionable data is identified and that “good” data can be analyzed for a minimum of 25 total days. The following checks should be used; any data with the following characteristics should be considered questionable and discarded:

- Data taken when battery readings were less than the minimum recommended voltage;
- Data taken when internal temperature readings exceeded the equipment manufacturer’s maximum operating temperature limit;
- Data taken when 1-second average wind speeds indicate an anemometer error;
- Data with 1-second sound levels that exceed the manufacturer’s recommended maximum level for a given gain setting;
- Data which indicates a problem with the sound-level sample;
- Data that were contaminated by field personnel (e.g., operator noise);
- Data taken when 1-second average wind speeds were greater than 11 mph (5 m/s), the maximum acceptable wind speed threshold;
- Data in any given hour, for which greater than 25 percent of the samples are lost due to the above factors. Any hour with ≥ 75 percent “good” data is acceptable for data analysis.

Acoustical data adjustments are discouraged, but may be necessary in some circumstances. The following is a list of adjustments which may be applied to the data:

- Gain adjustments, if any;
- Calibration adjustments to account for calibration drift as measured at the start and end of a data collection period;
- Microphone frequency response adjustments as recommended by a microphone calibration facility (these adjustments must be documented in detail);
- Windscreen frequency response adjustments as recommended by the manufacturer; these adjustments must be explicitly documented.
5.2 Data Analysis

The most laborious component of the analysis is measuring the fraction of the data in which noise sources are detectable. Historically, this was done by listening to samples of audio recordings. For example, ten seconds of digital audio data were recorded every two minutes in some equipment packages. Analysts attentively listened to a randomly selected sample of eight days of these data. Attentive listening is often aided by simultaneous visual review of spectrograms using software like Adobe Audition. The Natural Sounds Program also uses a macro-enabled Excel spreadsheet to expedite this mode of data analysis. Attentive listening yields the most detailed information regarding the number and identities of noise sources. In quiet, backcountry environments, noise events may be rare and recognizable, so that a more rapid assessment may be realized using software to mark events in spectrograms made from the 1/3rd octave spectral or digital audio data. This form of analysis can be ten times more rapid than attentive listening.

Existing Ambient Sound Level (\( L_{\text{Existing}} \))

Existing ambient sounds are all sounds in a given area (includes all natural sounds as well as all mechanical, electrical and other human-caused sounds). The existing ambient sound level should be calculated on the “good” data sample after data processing as described in sections 5.1 and 5.2. The summary statistic is the median sound level (\( L_{50} \), applied to each 1/3rd octave spectral band.

Natural Ambient Sound Level (\( L_{\text{Natural}} \))

Natural ambient comprises all sounds intrinsic to the park unit’s purpose, excluding extrinsic noise (e.g., transportation noise, infrastructure noise, possibly noise from visitors). Note that some human-caused sounds may be intrinsic to a cultural or historic park unit’s purpose. In order to calculate natural ambient sound levels for each hour of the day, sound data must be analyzed to determine the percent time audible for extrinsic noise. If \( A \) is the percent time audible, then the \( L_{\text{Natural}} \) estimate will be \( L_{50} + A/2 \). Thus, if noise is audible 16% of the time, then:

\[
L_{\text{Natural}} = L_{50} + 16/2 = L_{58}
\]

Note that \( L_{58} \) is the 42nd percentile order statistic (smaller than the median; see the next section).

Existing Ambient Sound Level without Air Tours (\( L_{\text{Existing w/o AirTours}} \))

The existing ambient without source of interest (air tour aircraft noise) is calculated in a manner similar to natural ambient, but the percent time audible of the source of interest is used in the calculation.

5.3 Metrics

The following metrics should be used to describe the ambient and sound levels as defined in section 5.2. The NPS Natural Sounds Program can provide software that expedites calculation of these metrics. It is important to note that NPS focuses on one-third octave spectra, rather than A-weighted sound levels that integrate energy across the audio spectrum. A-weighted metrics are widely used to characterize transportation noise, in which most of the sound energy is concentrated at low frequencies (often below 1000 Hz). If a park unit wishes to
compute A-weighted summary statistics for natural environments, to be compared with transportation noise sources, it is crucial that the environmental A-weighted metrics be bandlimited to the same range of frequencies in which the transportation noise is concentrated. Otherwise, sound energy far outside the noise spectrum – sounds from birds, insects, and other high frequency sources – will inappropriately inflate the environmental A-weighted sound levels.

*Equivalent Continuous Sound Level* (*$L_{eq}$*)

The equivalent continuous sound level is the level of a steady sound that would have the same time-mean-square sound pressure as the time-varying sound under measurement in a given time period. For example, the hourly $L_{eq}$ is a logarithmic measure related to the average sound energy (not the average sound level) observed over a one hour measurement period.

*Percentile Level* (*$L_{10}$*, *$L_{50}$*, *$L_{90}$*)

The $x$-percentile-exceeded sound level is the sound level that is exceeded $x$ percent of the measurement period. For example, the hourly $L_{10}$ is the sound level that is exceeded 10 percent of a measurement hour. The hourly $L_{50}$ is the sound level that is exceeded 50 percent of the measurement hour. The $L_{50}$ is also known as the median sound level. Similarly, the hourly $L_{90}$ is the sound level that is exceeded 90 percent of a given measurement hour.

*Source Identification Data*

After listener judgments are used to identify and categorize audible sounds, the resulting data should be used to create a table of sound sources and statistics summarizing their occurrence.

*Noise Free Interval* (*NFI*)

This metric is the length of the continuous time period during which only natural sounds are audible.

*Number of Events Per Hour* (*NEH*)

This metric will be applied to the number of air tour operations audible within a specified time period, generally each hour during the day.

*Time Above Ambient* (%TAA) – (*un-weighted spectra*)

This is the percentage of time that aircraft sound levels exceed the baseline ambient sound spectrum levels in a given area during a given time period. This will be calculated for each un-weighted one-third octave band from 20 to 20,000 Hz.

5.4  **Modeling**

The latest version of FAA’s Integrated Noise Model (INM) will be used for ATMP modeling of the acoustical environment within the park. Ambient maps will be developed using measured data as the base layer. At minimum, ambient maps will be developed for the natural ambient sound level and the existing ambient sound level without air tours as described in section 5.2.
Ambient maps should be created using Geographic Information System (GIS) data and software developed by the Volpe Center. Specific software requests can be made to the NPS Natural Sounds Program.

The two primary input parameters required in the INM modeling effort are the baseline ambient sound level maps and aircraft type, route, and schedule data, which can be obtained from the park or NSP office. These data are utilized by INM to compute appropriate metrics (1) as contours; (2) as points located on a regular grid spaced at consistent intervals apart; and/or (3) at user-specified sensitive locations, such as an endangered species habitat. An average day of air tour operations during the peak seasonal month (PMAD) will be used for modeling purposes.

INM’s output data, presented in a series of graphics and tables, will be used in the modeling the existing environment, as well as aircraft impacts and changes resulting from the various alternatives being considered. Modeling will also allow assessment of changes in operating conditions, including the number and frequency of operations, routes, altitudes, and aircraft technologies, as well as geographic and/or temporal restrictions. The following descriptors will be calculated for use in aircraft noise assessment.

- **Time Audible (%TA)** – The percentage of time that aircraft sound levels are audible, including the percentage of the park area within which aircraft are audible. This metric will be modeled twice, once for Existing Ambient without Air Tours and once for Natural Ambient;

- **Time Above Ambient (%TAA)** – (A-weighted) The percentage time that aircraft sound levels (in A-weighted decibels) exceed than baseline ambient sound levels in a given area during a given time period. This metric will be modeled twice, once for Existing Ambient without Air Tours and once for Natural Ambient;

- **Equivalent Continuous A-Weighted Sound Level (L_{Aeq})** – The A-weighted level of a steady sound that would have the same time-mean-square A-weighted sound pressure as the time-varying sound under measurement in a given time period. For example, the hourly $L_{Aeq}$ is a logarithmic measure related to the average A-weighted sound energy (not the average A-weighted sound level) observed over a one hour measurement period;

- **Change in Exposure ($\Delta L$)** – The algebraic difference (in A-weighted decibels) between aircraft sound levels and baseline ambient sound levels during a given time period. This metric will be modeled twice, once for Existing Ambient without Source of Interest and once for Natural Ambient;

- **Maximum Sound Level ($L_{max}$)** – The maximum sound level (in A-weighted decibels) associated with the loudest aircraft event occurring during a modeling assessment. Note: The FAA and NPS have agreed to compute this metric at user-specified sensitive locations, such as an endangered species habitat.
6.0 INDICATORS & STANDARDS

Indicators and standards will generally be identified by the NPS Natural Sounds Program and park staff. Natural Sounds Program contacts include Frank Turina, Vicki McCusker, and Lelaina Marin.

7.0 IMPACT ASSESSMENT

Impact assessment will typically be accomplished via collaboration between NPS Natural Sounds Program and park staff. Natural Sounds Program contacts include Frank Turina, Vicki McCusker, and Lelaina Marin.
Bats and light pollution

Elena Patriarca, Paolo Debernardi

This document has been updated to December 2010 in the framework of the project Bats and lighting of monumental buildings, promoted by UNEP/EUROBATS - Agreement on the conservation of populations of European bats with the financial support of Ministero dell’Ambiente e della Tutela del Territorio e del Mare of Italy and Ministère de l’Écologie, de l’Énergie, du Développement durable et de la Mer of France (EUROBATS Projects Initiative: http://www.eurobats.org/EPI/EPI.html).
1. **INTRODUCTION**

Throughout evolution living organisms have adapted to the natural variations in available light. In the last 150-200 years, however, artificial light has profoundly changed nighttime light conditions. These changes affect both terrestrial and aquatic habitats and have potentially very widespread consequences on wildlife, which are difficult to characterise precisely. It also must be said that very little study has been dedicated to the subject, which results in poor knowledge on the real effects of artificial light on organisms, species and ecosystems.

This document will discuss the relationship between artificial light and bats, with the inclusion of considerations about insects, due to their being bat’s main food source. We will summarise the information available, and will evidence potential problems relative to the critical aspects that have so far not been dealt with sufficiently, in so as not to let us evaluate their actual relevance to the problem objectively and fully. We will propose measures which could be adopted in order to minimise certified or potential problems (the precautionary principle obliges to take also the latter into account), and we will formulate suggestions to better the legal framework.

Among mammals, bats (chiroptera) represent one of the orders with the richest number of species (in Italy it is the richest). Bats are particularly exposed to light pollution due to their nocturnal habits. They have a high conservation interest (many species are threatened) and an important ecological role (being the principal predators of nighttime insects).

Insects make up the zoological class with the greatest number of species, most of which are nocturnal. They are the organisms that have the biggest impact on the functions of terrestrial ecosystems due to their many ecological roles (pollinators, prey, predators, decomposers, leaf eaters, etc.).

2. **THE EFFECTS OF ARTIFICIAL LIGHTING ON BATS**

2.1. **Facilitation of foraging**

Various species of bats often forage (hunt) in areas that are artificially lighted. *Tadarida teniotis*, a relatively large, fast flying bat, hunts high up above buildings and often above the highest street lamps and sport field lights. Its presence can be detected by the short acute cries, audible to the human ear, emitted at regular intervals, but the light glare and the height at which the individuals of this species fly makes it difficult to actually see them. Other species, for example *Eptesicus nilssonii* and *Nyctalus noctula*, fly back and forth in straight flight along rows of streetlights, keeping just above them and every so often entering into the light cones to catch their prey. Some smaller species, like *Pipistrellus kuhlii* and *Pipistrellus pipistrellus*, are much easier to be seen: they fly relatively fast, with many directional changes and use lighted areas profusely, often flying around a single lamppost.

Light, in particular that of certain wavelengths, has a very attractive effect on many species of insects. Under streetlights with the more attractive light a greater concentration of insects gathers (see 3.1) and bat activity is more intense (Rydell, 1992; Blake et al., 1994).

Besides being facilitated by the high concentration of insects, bat foraging is also favoured by behavioural alterations shown by many insects when exposed to light. Tympanate moths have special auditory organs (“tympani”) which consent them to hear the ultrasounds emitted by bats, and to therefore adopt evasive responses in order avoid capture: they can adopt flying trajectories that are difficult to follow, they can let themselves fall as if they were inanimate objects, they can
stop flying temporarily or even emit sounds that deter attack. It has been observed that these moths, when flying around light sources, continue to fly normally also in the presence of bats (Acharya and Fenton, 1999) and it has been demonstrated experimentally that certain moths, when exposed to the light of mercury vapour lamps, adopt defensive behaviour much less frequently than normal (Svensson and Rydell, 1998).

Some studies have shown that bats’ foraging at artificial light sources can be benefited. Research conducted in Sweden on *Eptesicus nilssonii*, for example, have demonstrated the food intake at lights can be much higher than in other places, in particular thanks to the capture of moths (Rydell, 1992). In Switzerland it has been hypothesized that one reason for the local demographic expansion of *Pipistrellus pipistrellus* is the concentration of insects under street lamps, where this species regularly feed (Arlettaz et al., 1999).

In general terms, we could hypothesise that the presence of artificial lighting which attracts bat’s prey is profitable to bats which forage there, provided the advantages are not outdone by the negative consequences of artificial lighting (we will discuss this in greater detail later). In particular, it is relevant that the negative impact of lighting on prey does not cause a fall in their numbers with a consequent negative impact on the bats themselves.

These considerations cannot be applied, in any case, to bats that do not feed near lighting.

2.2. Increased risk linked to some mortality factors

Foraging in illuminated areas exposes bats to an increased risk of being caught by predators: in lighted areas nocturnal (owls, cats) and diurnal (hawks, crows, gulls) predators both can be present. At streetlights bats also risk death from being hit by vehicles (Rydell, 1991; Brinkmann et al., 2008).

2.3. Reduction in night activity environments, interference in transits

Several species of bats do not forage at streetlamps and are rarely seen in illuminated areas. Among these we find species of great conservation interest, in particular belonging to the *Rhinolophus* and *Myotis* genera (Reinhold, 1993; Fure, 2006; Rydell, 2006; Stone et al., 2009). This light avoiding behaviour has been related to the need to minimise risk of predation (Jones, 2000), in analogy with the anti-predatory explanations for bat activity patterns essentially restricted to twilight and night (Speakman, 1991; Jones and Rydell, 1994; Rydell and Speakman, 1995; Rydell et al., 1996; Duvergé et al., 2000; Petzelkova and Zukal, 2001).

It is also possible that this phenomenon is conditioned by bat sensorial capabilities.

Various data indicate that a bat’s vision is better in dim light than in bright light (for a review: Eklöf, 2003).

It has long been believed that the retina of microchiropteran bats contains exclusively rods, the photoreceptors at the basis of “scotopic” vision (which occurs under low light conditions and does not permit colour vision). Successively this assumption has been put in doubt from contrasting evidence, and recently it has been demonstrated how at least some species (among which
Rhinolophus ferrumequinum) possess a significant number of cones, (Kim *et al.*, 2008; Muller *et al.*, 2009). According to Peichl (2005) the presence of cones could pertain to all microbats. This characteristic is necessary for daylight vision, colour and UV (ultraviolet) perception. For what concerns UV perception it must be specified that it depends also on the presence of UV-transmissive ocular media (cornea, lens, vitreous). UV sensitivity has been demonstrated in the two species of phyllostomid bats taken into consideration by Muller *et al.* (2009), but it is probably diffuse among microbats, as suggested by genetic evidence (Wang *et al.*, 2004; Zhao *et al.*, 2009).

The little electrophysiological data available suggests that the cones in bats efficiently contribute to vision at intermediate light levels (mesopic vision) but become increasingly saturated at daylight levels (Muller *et al.*, 2009). The discovery of cones does not devaluate, therefore, the hypothesis that bat visual sensitivity is less in bright light, and as Fure (2006) proposed, can condition light-avoidance behaviour.

It also highlights the possibility that lamps which emit UV radiation can cause problems to those bats which can perceive them, even if only because they change the natural presence of UV in the environment (that means their perceived environment changes). It has also been suggested that if bats do not have an eye filter that blocks out the UV radiation, the UV coming from the lamps can disturb their vision and cause damage to their retina (Fure, 2006).

The possibility that artificial light interferes with bat sensorial capabilities other than vision should also be taken into consideration.

It has been reported that individuals belonging to the American species *Myotis lucifugus* showed a drastic worsening in their ability to avoid a large obstacle under artificial lighting conditions (McGuire and Fenton, 2010). The Authors of these observations did not verify if the problem was due to the bats switching over from using echolocation to using the less reliable vision (when light was turned on) or if the light caused a decrease in the bat’s ability to echolocate. The first hypothesis seems supported by results of experiments with other species of bats (review in: Eklof, 2003), but the second is suggested by the fact that at least some of the monitored bats showed a change in their echolocation emissions (by shortening inter-call interval) when in light.

In order to consider all the information on the subject of possible interaction between artificial light and perception, we must mention the ability to detect the Earth’s magnetic field, which has been recently demonstrated in bats (Holland *et al.*, 2006; Wang *et al.*, 2007).

Trails on homing (returning to roost after being released at a distance) have showed that *Myotis myotis* uses an internal “magnetic compass” after having calibrated it with sunset cues (Holland *et al.*, 2010). This discovery is surprising as *Myotis myotis* takes up activity well after sunset, when the presence of the sun in the sky is but a glow on the horizon.

Researchers have set up experiments in order to exclude the possibility of sunlight getting to the animals in a polarized form (it is known that birds use polarized light to calibrate their magnetic orientation mechanism), but this did not impede the calibration. This does not exclude the possibility that in natural conditions, that is in the presence of polarized light, bats can use this type of information, but at present it is neither known if bats are sensitive to polarized light, nor if other mammals are (Horvath and Varju, 2004).

What has been discussed suggests that interactions between information relative to light and information relative to the magnetic field can be relevant to bats also in longer distance movements, i.e. in migrations (various species of bats seasonally migrate over short to long distances). Therefore, it becomes also necessary to consider the possibility that artificial light may interfere with bat movements determining errors in magnetic based orientation.

Whatever the reasons, experimental evidence has been collected that shows that artificial light can negatively condition bat use of the environment during night activity.
Under experimental lighting conditions it has been shown that individuals of *Myotis dasycneme* reacted to the light (from halogen lamps) by momentarily modifying their normal flight trajectories (Kuijper et al., 2008).

For the species *Rhinolophus hipposideros* a dramatic reduction in activity (bat passes) in proximity of lighting (high-pressure sodium lamps) was recorded, and the onset of commuting behaviour (evening transferral from roost to foraging areas) was found to be delayed in the presence of lighting. It was also found that the numbers of bat passes reduced dramatically even when passing along a hedge which was illuminated on the other side, indicating that low levels of light (on average 4.17 lux) have a negative effect (Stone et al., 2009).

Activity (bat passes) of *Myotis lucifugus* has been noted to be significantly lower when the area crossed was lighted to when the lights were turned off (McGuire and Fenton, 2010). Artificial lights therefore can act as barriers that reduce habitat availability and obliges bats to change their flight routes to alternative ones, with possible negative consequences, as increased energetic costs (longer and more bendy travel distances) and higher risk due to hostile conditions (predators, exposure to bad weather conditions).

### 2.4. Lowering of quality of roosting sites

Bats use large roosting sites (caves, abandoned mines, rooms in buildings) that are prevalently characterised by darkness, or small roosts (cavities or splits in rocky cliffs, buildings and trees; spaces behind shielding objects such as loose bark of dead trees or shutters left open in buildings), all these at least to some extent protected from light. Some species, such as *Myotis emarginatus* and *Rhinolophus ferrumequinum*, show a certain tolerance in respect to light levels recorded in their roosts and can be found in sites that are in total darkness and in sites which are moderately lit. This does not mean that dark sites and moderately lit site are the same to them. We have observed more than once the dispersion of reproductive colonies of *Myotis emarginatus* that roosted in dim lighted stables due to the predation by magpies (Debernardi et al., 2010); this suggests that non dark sites are a suboptimal choice for bats, exposing them to higher predation risks.

Artificial lighting inside roost sites represents a factor that alters one of their most usual characteristics. Among disturbing factors due to visitor presence inside a cave (light, noise, number of people), light intensity was found to determine the greatest agitation in a maternity colony of the American species *Myotis velifer* (Mann et al., 2002). Full illumination of roosts has been shown to cause sudden and dramatic decreases in numbers of bats present (Laidlaw and Fenton, 1971) and it is considered to be one of the reasons why bats abandon caves open to tourists.

External lighting of roosts can also have negative effects, above all if it intercepts the accesses and passage ways that the bats use when coming and going from the sites.

In several species of bats “light sampling” behaviour has been described: at the beginning of the evening activity, some bats can be seen flying out from the dark internal part of their roost to the lighter areas closer to the entrances or briefly venturing out and then returning back into the roost darkness (Erkert, 1982; Fure, 2006). Light sampling behaviour is shown by just a part of the individuals of the colonies, despite this, the evening emergence from the roost appears to be highly synchronised. In the Asiatic species *Hipposideros speoris* it has been demonstrated that synchronisation is due to social contacts among individuals (Marimuthu et al., 1981).

Many Authors have suggested that the need to avoid leaving the roost too early is related to higher risks of predation (see, for example, Duvergè et al., 2000), but it is also possible that sensorial capabilities discussed in 2.3 play a role in the timing of evening emergence.
Studies and local surveys have shown that external artificial lighting delays the onset and sometimes also slows down the evening emergence of bats and, as a consequence, shortens their feeding time (Downs et al., 2003; Verkem and Moermans, 2002; Theiler, 2004; Beck, 2005; Krattli and SSF, 2005; Boldogh et al., 2007), causing the loss of a time span that is particularly rich in small aerial insect prey (Racey and Swift, 1985; Rydell et al., 1996). It is worth mentioning that, as far as we know, the studies about roost lighting show that all the species considered are sensitive to lighting, including species like Pipistrellus pygmaeus that forage under street lamps (Bartonicka et al., 2008).

In maternity colonies of Myotis emarginatus and M. (blythii) oxignathus roosting in buildings illuminated from the outside, young bats were found to be smaller that young bats from colonies roosting in non-illuminated buildings (Boldogh et al., 2007). This is a relevant factor as it is very important for bats to reach a certain body weight before the winter in order to permit them to survive hibernation.

As internal roost lighting, also external illumination can cause decreases in colony sizes and can lead to desertion of roosts (Beck, 2005).

The consequences of roost abandonment may be worsened because of the phylopatric behaviour described in many species of bats: females born in one roost tend to return to their birth place to give birth themselves and when their original roost has become unsuitable they may have difficulty in finding an alternative reproductive site.

Experience of lighting from outside roosts of Pipistrellus pygmaeus (Downs et al., 2003) and from inside roosts of Myotis velifer (Mann et al., 2002) have shown the disturbance experienced by the bats was primarily due to the light intensity and secondarily to the spectral characteristics of the light, this being more incisive when white light was used, intermediate with blue light and lesser with red light.

2.5. Biological rhythm alteration

We have seen that bat nocturnal activity can be delayed due to artificial lighting at their roosts. The alteration of the natural light/dark conditions in reality has a potentially much larger influence, for the understanding of which we must recall a few concepts of chronobiology.

Numerous biochemical, physiological and behavioural processes in organisms vary cyclically (that is they repeat at regular intervals) depending on internal biological factors which are synchronised, or “entrained”, to the outer temporal rhythms by external stimuli called zeitgebers (“time-givers”). The “anatomic mechanism” that controls internal factors and synchronises them to the environment cues is called the biological clock.

The biological rhythms that have a cycle of about 24 hours (e.g. some patterns in body temperature, hormone release, sleep/wake cycle, etc.) are called circadian rhythms, and circannual rhythms those which have an approximately yearly cycle (e.g. the seasonal reproductive cycle, moulting, hibernation, migrations, feeding and fat energy storage, etc.).

The variations of light in the natural environment during the 24 hours and (in those areas of the planet that experience seasonality) the progressive variations in the length of the day and night during the year represent the most important information for the synchronisation of biological clocks in living organisms. By consequence, we can hypothesise that artificial light can interfere with these regulation processes, determining alterations in the controlled functions.

Unfortunately knowledge on the functioning of biological clocks in the different species, the relevant environmental parameters (for what concerns light: variations of light intensity, spectral characteristics, length of exposure, etc.) and mechanisms (anatomic, physiological, ethological, etc.) with which organisms respond to such stimuli is still very limited.
In mammals, the primary biological clock is located in the suprachiasmatic nuclei of the hypothalamus, but numerous peripheral “oscillators” interact more or less intensely with this central pacemaker, contributing to the expression of the rhythms.

The suprachiasmatic nuclei receive information on light (quantity and quality of the light, length of the light phases in relation to the dark phases) through the eyes. Long known retinal photoreceptors, rods and cones, are involved in the process, but recent research has shown that the most central role in it is of a recently discovered photoreceptor (Berson et al., 2002; Hattar et al., 2002), corresponding to the cells that have been named “intrinsically photosensitive retinal ganglion cells” or “melanopsin-expressing retinal ganglion cells” (from their photosensitive pigment). This “new” photoreceptor has been found in every mammalian species so far examined, that is various species belonging to the orders of lagomorphs, rodents, carnivores and primates (Do and Yau, 2010). According to nine different in vivo studies conducted in rodents and primates (including man) their physiological responses peak when exposed to light at a wavelength between 459 and 484 nm, that is in the blue region of the visible spectre (Brainard and Hanifin, 2005 for a review). Various studies have provided compelling evidence that it is melanopsin that mediates the phototransduction (in particular Melyan et al., 2005; Qiu et al., 2005; Panda et al., 2005) although further study is required for a full comprehension of the photochemical characteristics of this molecule (Brainard et al., 2008; Do and Yau, 2010).

The intrinsically photosensitive retinal ganglion cells reach, through their axons, over a dozen regions in the brain, among which the suprachiasmatic nuclei and the ventral subparaventricular zone, which is implicated in the “negative masking” phenomenon (a reduction in locomotor activity, caused by light, in nocturnal species).

The suprachiasmatic nuclei are in turn connected to other regions in the brain and with peripheral systems. Their relation with the pineal gland merits a particular mention here. The suprachiasmatic nuclei communicate to the gland information on external lighting received from the retina and this conditions the secretion of a neurohormone, melatonin. This molecule is in fact produced only during the night, in both nocturnal and diurnal mammals (Challet, 2007), and its secretion is suppressed by exposure to light. In humans the suppression is already significant at a wavelength of 420 nm and peaks between 446 and 477 nm (blue light) (Brainard et al., 2008).

Melatonin therefore transforms information about occurrence and duration of darkness into an endocrine signal and by interacting with glands and target organs, it has an important role in conditioning circadian and circannual rhythms (see, for example: Paul et al., 2008; Zawilska et al., 2009). Moreover, the molecule, secreted under the direct dependence of the suprachiasmatic nuclei, influences the nuclei themselves acting through specific receptors located in the area and contributes in this way to the synchronisation of the biological clock.

The above mentioned subject is at present object of exceptionally intense research. A strong stimulus to better knowledge is given by the fact that exposure to light at night, above all due to the suppression of melatonin production (but not only), has been put in relation to numerous pathologies, among which some forms of cancer (melatonin also has antioxidant and oncostatic properties) (see, for example: Pauley, 2004; Navara and Nelson, 2007; Stevens et al., 2007). Notwithstanding this, a full understanding of the mechanisms that regulate circadian and circannual rhythms in mammals is still far off. In particular, as regards bats, at the time we are writing (November 2009) we do not know of any published work about the possible presence of the “new” retinal photoreceptor.

The information concerning the role of light in conditioning biological rhythms in microbats is fragmentary and prevalently relative to species from outside Europe. Just in a microbat, the neotropical species Molossus molossus, it has been observed the lowest illuminance threshold ($10^{-5}$ lux) for photic entrainment of circadian activity rhythms found thus far.
in vertebrates (Erkert, 2004); in this specific case the mediation by rods is retained probable, these being the most sensitive receptors at low light intensities. *Hipposideros speoris*, an Asiatic species which uses underground roosts, is probably the most studied microbat for what concerns the expression of circadian rhythms. Continuous lighting inside a cave-roost was found to suppress the synchronisation of activity/rest rhythm, normally activated by social contacts (Marimuthu and Chandrashekaran, 1983). When individuals were exposed to monochromatic light impulses, phase shifting was observed which suggested the presence of two photoreceptors that condition the circadian rhythm of activity: one more important for the regulation of the onset of evening activity, with a peak of sensitivity at 430 nm (when light of this wavelength was used a evident delay of evening phase shifting was observed), the other relevant to mediate the return to rest (evoking advance phase shifts), with a peak sensitivity at 520 nm. The white light produced by fluorescent lamps, even if presenting both spectral components, principally provoked a delay in the evening, as if it more greatly stimulated the short wavelength sensitive photoreceptors (Joshi and Chandrashekaran, 1985).

Indian individuals of *Taphozous nudiventris* roosting in rock crevices, showed a greater response in phase shifting for wavelengths higher than 600 nm (Sripathi, 1982). This data, together with results from electrotocinograms (which measured the electrical responses of the retina to light stimuli of various wavelengths) conducted on a few species of bats that showed peaks of retinal sensitivity at 500 and 570 nm (Hope and Bhatnagar, 1979a) have brought various Authors to suggest a possible correspondence between retinal sensitivity to higher wavelengths and the use of roosts which are more exposed to light (Hope and Bhatnagar, 1979a, b; Joshi and Chandrashekaran, 1985). However, the fact that the sensitivity to wavelengths lower that 440 nm was not verified by at least a part of the studies considered has recently been underlined (Muller *et al.*, 2009).

In reference to the eventuality that illumination determines alterations in biological rhythms interfering with the secretion of melatonin, it can be said that this problem is certainly potentially relevant also for bats. Even if the data available on the subject is very limited, it has been suggested, for example, that in some species of microbats melatonin may condition the reproductive activity (Kawamoto, 2003), sperm storage (Beasley *et al.*, 1984), delayed ovulation (Srivastava and Krishna, 2010a), delayed implantation (Haldar and Yadav, 2006) and glucose metabolism during hibernation (Srivastava and Krishna, 2010b); more general functions on the regulation of circadian and circannual rhythms have been hypothesised basing on the distribution of melatonin receptors in the brain (Schwartz *et al.*, 2009).

### 2.6. Alteration in competition

The fact that some species of bats avoid artificially lighted areas, while others frequent them, in particular for foraging, renders the latter potentially more competitive in using illuminated areas.

In Switzerland, it has been suggested that this has contributed to a possible case of competitive exclusion between *Pipistrellus pipistrellus* and *Rhinolophus hipposideros*. The first species, foraging under street lamps, may have exploited trophic resources being essential for the other species in periods of low prey availability (Arlettaz *et al.*, 2000). It must be underlined that the Authors of the work are extremely cautious in suggesting this hypothesis. We add, that due to the lack of a quantification of the relevance for *R. hipposideros* of the decrease in prey availability caused solely by the street lights (that is even if there was no *P. pipistrellus* to prey on...
them) it is difficult to clarify the role of the competitive species (the street lamps alone may have been sufficient to determine the exclusion).

Competition due to artificial lighting can be speculated also among bats and species belonging to other zoological groups. A possibility has been suggested by Allegri (2007), who observed large flocks (up to 300 individuals) of gulls (Larus ridibundus), preying upon moths attracted to a high mast light tower equipped with metal halide lamps and to some lower street lamps.

2.7. **Impoverishment (quantitative/qualitative) of food resources**

European bats fundamentally feed on invertebrates, above all insects. The effects of artificial light on these components is therefore relevant. An eventual demographic decrease in insect population would mean a decrease in the abundance of potential prey, while a differential impact on diverse species of insects would determine variations in the relative availability of prey species (rarefaction of sensitive species).

Following we will briefly outline some aspects of this problem, however, also in this case, we must underline that many topics have been little studied and therefore the information available is far from complete.

3. **THE EFFECTS OF ARTIFICIAL LIGHTING ON INSECTS**

3.1. **Mortality and deviation from natural behaviour and habitats due to the attractive effect of light**

The most well known effect of artificial light at night is its attraction (positive phototaxis) of insects. It largely affects many orders of insects, among which lepidopters, coleopters, dipters, hemipters, neopters, tricopters, hymenopters and ortopters. It can vary according to different factors such as species, biological stage, sex, amount of environmental light as a whole (attraction diminishes as the contrast is less marked between the source of light and the background light) and other environmental characteristics (for a detailed discussion on this subject with particular reference to moths see: Frank, 2006).

Several theories have tried to explain flight-to-light behaviour. According to one of these, artificial light sources are mistaken for natural ones (in particular the moon) which are used as a reference in the movements. Other theories postulate that artificial light disturbs insect vision in some way.

The most evident consequence of flight-to-light behaviour is direct death. It can be provoked by burns, being caught inside the lamp housing, loss of energy due to over activity at the light source, or being captured by predators attracted to the site by the high concentration of insects (various species of bats, geckoes, toads, nocturnal spiders, etc.) and eventually by visibility conditions (diurnal predators as sea gulls, kestrels, swallows, diurnal spiders, etc.).
When attracted to artificial light sources, insects deviate from their natural habitats and from their natural behaviour and also this can lead to demographic losses. Migrating or dispersing insects can be taken by artificial lights to hostile environments: as an example, there are accounts of swarms of insects on oil platforms ten kilometres from land (Wolf et al., 1986).

Many times flight to light determines a decrease in reproductive success. About this, cases of insects that reproduce in water habitats such as mayflies, stoneflies and caddisflies, deserve a special comment.

Literature describes, for example, mass swarming flights of the mayfly *Ephoron virgo* attracted to street lamps near water bodies. The adult-stage span of these insects lasts only a few hours, during which females must lay their eggs on water. Being attracted to the light they end up laying their eggs on the road below the street lights; an estimated 1.5 million individuals were found dead in one night on the road surface of a bridge, after having deposited eggs destined to be lost (Tobias, 1996).

Some years ago it was discovered that asphalted surfaces and other dark and/or smooth surfaces of man-made objects polarize light in a similar way that water does. The phenomenon, recently termed “polarized light pollution”, fools mayflies and many other water insect species (Kriska et al., 1998; Horvath et al., 2009; for more information see also: Labhart and Meyer, 2002; Horváth and Varjú, 2004; Horváth et al., 2010).

The *Ephoron virgo* case should therefore probably be attributed to a kind of synergy between two forms of alterations of the natural light conditions: the mayflies are attracted first by the street lights, and once there, they are confused by the polarized light caused by the light reflecting on the tarmac.

In section 2.1 we discussed behaviour changes shown by tympanate moths around street lights. In artificially illuminated areas also other forms of behavioural alterations have been described. Insects attracted, often remain quiescent in illuminated areas for long periods of time. This is particularly true for most species of moths. When we consider that an adult moth’s life span often is of barely a few days, we can easily understand how even a few hours of lost activity time can have negative consequences. Moreover, moths can remain still in the areas which have been illuminated at night also during the day, and this exposes them to diurnal predators.

Species attracted to artificial lights include many insects which are predators or parasitoids of other insects (parasitoids are parasites that consume and kill their hosts) (Frick and Tallamy, 1996; Sustek, 1999). Given that predators and parasitoids are biological regulators for the species they prey on or live on, this phenomenon may have repercussions on the compositions of insect communities.

The attractive effect of light tends to increase as the wavelength decreases. In many orders of insects the maximum attraction has been recorded for UV light (prevalently around 350 nm), high attraction levels shown for blue light (420-490 nm) and blue-green light (about 500 nm) and lower attraction levels for light of higher wavelengths (Ashfaq et al., 2005; Mikkola, 1972; Robinson, 2005). This trend, however, cannot be generalised. Certain dipters which reproduce in water, for example, are more attracted to yellow light (575-585 nm) than to blue light (Scheibe, 2000).

Various works have considered the attractive power of different lamp types. In the arena of lamps currently used for public lighting the following white light or whitish light lamps emit decreasing amounts of UV radiation: high-pressure mercury vapour lamps (widely used for a long time in Italy and still today relatively common), metal halide lamps (these are frequently used in sport centres and for decorative lighting), fluorescent tubes and the white light variety of high-pressure sodium vapour lamps.

Today, especially for street lighting, high-pressure sodium vapour lamps are generally preferred. In their standard type they produce a bright pinkish-yellow light, with a marginal UV component (fig.
1). These lamps have a significantly less attractive effect for insects than formerly mentioned lamps. According to a German study, they attract about 40% less insects than their sodium-xenon white variant (Eisenbeis and Hassel, 2000). When compared with mercury lamps, standard high-pressure sodium lamps result even more advantageous: six different studies in Germany have shown they attract on average 57% less insects, and in particular their effect on moths is greatly reduced (Eisenbeis, 2006).

An even more reduced attractive effect, which is almost nil for a great number of species of insects is shown by low-pressure sodium vapour lamps (Schanowsi and Spath, 1994; Rydell, 1992; Rydell and Racey, 1995). These latter lamps do not produce UV and emit a practically monochromatic, yellow-orange light (589-590 nm), that does not permit the perception of colour (in Italy they are rarely used, mostly for out of town roads, industrial areas and foggy areas).

Recently, some results from a first survey about insects and LED lamps have been released (Eisenbeis, 2010). At present such lamps are used only very rarely (in Italy and elsewhere) due to their non competitive prices. They do not produce UV, but have strong emissions in the blue region of the spectrum (especially the “cool white” type). The preliminary results show a very scarce insect attractiveness, which can be compared to that of the low-pressure sodium lamps. On one hand this confirms the importance for the absence of UV in order to reduce insect attraction, on the other hand it is surprising as the significant emissions of blue light suggested higher attractiveness. The complete publication of this work will permit the evaluation of this type of lighting more precisely.

3.2. Habitat loss and interference with movements due to the repulsive effect

If the attractive effect of light is directly perceivable, the same is not true for the opposite: the repulsive effect on other species of insects or insects in other biological stages (larval and adult stages can differ in their responses to light) is far more difficult to monitor. Flight-from-light behaviour is prevalently thought to be linked to the risk of predation, which is in general greater in lighted conditions. It can be manifested in various ways, for example (when light is brighter) with an inhibition of certain behaviours, a general reduction in activity or a limitation of activity to darker areas.

Examples worth of note for light avoidance (negative phototaxis) are the movements of aquatic invertebrates, that in freshwater habitats include the larvae of many insect species. The levels of illumination at the surface of various North American lakes due to artificial light sources (measured on new moon nights) have been registered to greatly exceed natural values observed on full moon nights. It has been experimentally shown that this can suppress the zooplankton vertical migration (that is the ascending of plankton at dusk for foraging and its return to greater depths at sunrise, in order to decrease predation risk). One of the species most effected is the chaoborid dipter Chaoborus punctipennis, which exhibits negative phototaxis even at light intensities inferior to that of the stars (Moore et al., 2006). In flowing water, light conditions the “drift” behaviour of macroinvertebrates that live on streambeds, including, at their larval stage, insects of various orders (ephemeropters, plecopters, tricopters, dipters, etc.). During the day these organisms scarcely move, while after sunset, in low light conditions, they leave the streambed and drift downstream to look for new foraging areas. The onset of the evening drift is conditioned by the progressive decrease in light intensity and on full moon nights the phenomenon is greatly reduced. This has suggested that macroinvertebrate drift can be retarded or even suppressed due to artificial light sources, that often produce lighting levels exceeding those recorded on full moon nights (Moore et al., 2006).

The above account on insects with aquatic larvae is pertinent to the problem of the impact of lighting on bats as these larvae are potential prey for bats when they reach the adult stage (they become flying insects) and in some cases even before (Myotis daubentontii and Myotis capaccini can take pupae from the water surface).

As in aquatic habitats, it can be speculated that also in terrestrial habitats, for insects characterised by negative phototactic behaviour, artificial lighting may determine negative consequences such as loss of feeding sites, reproduction sites, and transit corridors (with relative effects on their life expectancy, species dispersal, etc.). Just like the attractive effect, light avoidance can be expected to be influenced by not only the intensity but also the spectrum of the light. For aquatic environments this is evident as the wavelength conditions light penetration in water, but available information for terrestrial environments is inconclusive.

3.3. Other interferences

The inhibition of activity of insects in illuminated areas, as reported for insects attracted to light that then remain inactive for long periods, has been also described for light sources without attractive effect, as in the case of low-pressure sodium lamps (Uffen, 1994). Unfortunately there is no quantitative data to evaluate this phenomenon. These lamps on the one hand very rarely elicit flight to light and this mitigates their effect (if the insects are not attracted to the light they risk less becoming victims to the inhibition of activity), on the other hand they are large and difficult to
shield (Emery, 2008) and this provokes light spillage, with potential negative effects on a broader area of that to be lit.

We have mentioned only the most evident aspects of the interaction between artificial light and insects. Also for insects, light represents the most important environmental reference in the conditioning of many physiological and metabolic phenomena, circadian activity rhythms, reproductive behaviour, development and life cycle (including diapausa phenomena), etc. Consequently, artificial light presents the potential to interfere in a very wide range of biological processes. Given the complexity of the subject and the nature of this paper we will not dwell on these aspects.

3.4. Considerations on the impact of artificial lighting on diverse groups of insects

Some groups of insects, in particular belonging to dipters, coleopters and nocturnal lepidopters, are more exposed to the above mentioned risks. Artificial lighting can be particularly negative in certain ecological situations, for example in wetland areas where mass swarms of insects, that depend on water for reproduction, gather. Some species are more sensitive than others due to their migrating behaviour (route disruption of large swarms), their reproductive strategy (k-selected species) or because they are rare and/or have fragmented habitats.

According to Frank (2006) the most widespread and serious impact that artificial light has on moths probably is disruption of dispersal of threatened species. Generally these are species with fragmented habitats due to anthropization, whose survival strongly depends on the possibility to move from one fragment of suitable habitat to another. Lighting is typically located in the territorial matrix among suitable habitat fragments, where it acts as a barrier that limits the probability of a successful dispersal.

The potential interactions between artificial light and insects is extremely vast, the basic knowledge on the mechanisms with which organisms respond to light (including natural light) is very incomplete, and the ecological processes in which insects have a key role are so numerous, that the exact comprehension of the consequences of artificial lighting on this zoological component is still a far off objective.

If insects were in good conservation state we could possible ignore the problem, but unfortunately it is not so. The results of the two most important long term surveys inherent to insects so far conducted – Hungarian Light-trap Network in Hungaria and Rothamsted Insect Survey in Great Britain– provided evidence of alarming demographic declines (Szentkiralyi F., 2002; Conrad et al., 2006).

In particular, the data collected in Great Britain in the period 1968-2002 relative to 337 species of macromoths, considered common and widespread in the country, highlighted declines for two-thirds of them, and in the last ten years of the study period 21% of the species showed demographic losses superior to 30%. The Authors of the study see in these results the evidence of a more general insect biodiversity crisis (Conrad et al., 2006).

It is not known how important the role of artificial lighting is in the loss of insect biodiversity, but a precautionary conservation approach calls for the adoption of efficient measures to minimise the probability that this phenomenon have a significant impact.

4. HOW TO MINIMIZE PROBLEMS

In the preceding paragraphs we listed various negative effects that night artificial lighting has on bats and their prey. In some cases these effects have been ascertained, in other cases they still have
to be verified, but it is however necessary to take them into consideration as they are possible negative effects (precautionary principle).
In order to minimise these problems, the fundamental rules that must be respected are to keep the lighting to a strictly necessary minimum and to choose type of lamps that potentially disturb less. Often lighting is used where it is not necessary or in an irrational way: with light dispersing out of the area to be lit, lighting at times when it is not necessary, and using light bulb types with high energy consumption and high running costs. It is therefore necessary to rationally establish “where”, “how”, and “when” it is right to have lighting and, while doing this, to take into consideration (together with the anthropic needs) the ecological consequences of lighting, a concern rarely taken into consideration.

4.1. Where to have lighting

No lighting would always be the best choice for what concerns the biocenoses, but for various anthropic reasons, the opposite can become necessary, foremost for security and safety. This is not the place to discuss such matter, it is however right to note that it is often tackled irrationally, not basing on objective data but on generic and unfounded assumptions: we speak of “perception of security” rather than “security”.

It is common opinion that the more a street is lit up the safer it is, but there are studies that show how real conditions are a lot more complex. Lighting reduces road accidents, but serious accidents, including mortal accidents, are often more frequent on illuminated roads than on unlit ones (see, for example: Direction Interdépartementale des Routes Nord, 2007).

In Italy, it is common opinion that well lit town parks discourage crime, but a simple, practical consideration could put this belief in doubt: in the dark it is easier for police to individuate presences of people who need to use their own light source. In contrast to Italian ones, other European cities close their parks at night and keep them in darkness.

With this, we do not want to say it is wrong to use lighting when it effectively increases security and safety, but we ask to better evaluate cases when light is not strictly necessary or is of secondary importance, and its effects could be of disturbance.

Preserving darkness at the local level is of limited importance to astronomers, since lighting at great distances can negatively affect sky observation. For the ecologist, on the contrary, local lighting or darkness is of utmost importance: local conditions affect biotic communities and it is important to preserve areas from light pollution starting from those of higher ecological and naturalistic value.

How to recognise the areas which is more important to keep in natural darkness to the benefit of the conservation of bats?

Surveys on nighttime activity of bats can give useful information for the respectful planning of lighting, for example furnishing information about the location of the principle foraging areas and the “corridors” used for commuting between such areas and roost sites.

Today, the quickest way to collect data of this type is by using the bat detector. This instrument has advantages (many species are easily recorded; it is a non invasive technique and a faster way of collecting data than with other methods; the survey can be carried out even by a single recorder) and defects (some species emit calls which are difficult to reveal; calls of many species are similar, so that species identification can be difficult or even impossible; multiple recordings can refer to the same individual) and the operator must be aware of these limitations.

The radiotracking technique gives better defined results (it precisely characterises the movements of defined individuals) but is limited by the fact that the number of monitored bats is always low, the survey normally requires more operators and it is time consuming.

Unfortunately, apart for specific areas (usually protected areas), surveys are rarely promoted to understand how bats use territory. In most situations, when deciding about lighting, decisions
should therefore be taken according to more general knowledge, derived from literature and concerning the habitat preferences and movement behaviour of bats. As these characteristics are often similar for different species of bats, it is possible to identify areas of general value for the bat fauna.

Among the foraging areas that deserve priority efforts to preserve natural darkness, there are still-water wetland habitats (lakes, ponds, oxbows and slow flowing water), woodland areas and their margins, eco-mosaics characterised by meadows and grassland alternated by tree/shrub vegetation.

The corridors that bats use for their habitual transits can be preliminary identified by landscape linear features such as forest margins, riparian vegetation, tree lines and hedgerows (bats tend to avoid open spaces, and prefer to fly coasting linear elements). Whenever these corridors come to cross illuminated infrastructures, if something can be interposed between the lighted area and the corridors such as a line of trees and shrubs, this could help to keep the corridors in darkness and help to facilitate the passage of bats in appropriate points such as overpasses and underpasses. It has also been suggested to keep 10 m unlit stretches of road on each side of bat flight routes (BCT and ILE, 2009). For more information: Limpens et al., 2004; Brinkmann et al., 2008; Highways Agency, 2006.

If roost sites hosting bat colonies of major conservation concern are known, it is of particular importance to keep darkness inside them, at bat access points and, as much as possible, in the surrounding areas, in particular along the linear elements that can represent flight routes (tree lines, hedges, rows of buildings, etc.). Frequently, important bat roosts are inside monumental buildings (castles, palaces, towers, forts, churches, etc.) or in other historical, artistic or archaeological sites (old bridges, necropolises, ancient aqueducts, rock dwellings, etc.) which are part of our Cultural heritage. Thanks to the presence of rooms unused or rarely used by man, in the dark and with a microclimate consonant to bats, such buildings and sites are particularly suited to various species of rare and threatened bats for daytime rest, reproduction, and, more rarely, hibernation.

In the last decades there has been an increase in the illuminating of Cultural heritage buildings and sites, in order to render them even more appreciable. In section 2.4 it has been underlined how roost lighting can have a strong negative effect on bats, either if external or internal (for example in the case of towers and bell towers) or with light beams restricted under bridges, arches and galleries. Moreover, lighting can constitute a violation of the international legislation which forbids the disturbance of bats and the deterioration of their breeding or resting sites (Bern Convention, ch. III, art.6; Agreement on the conservation of populations of European bats, art. III; 92/43/EEC Habitats Directive, art. 12). According to legislation, serious interferences such as a damage to an important bat colony during reproduction or hibernation, can be sanctioned as with environmental damage (2004/35/EC and 2008/35/EC Directives).

For conservation reasons and to guarantee the respect of the law, it is therefore advisable that the decorative lighting of buildings and sites of Cultural heritage which are potential roost sites be preceded by an inspection for bat usage of them. Such a survey need not take a lot of time but must be undertaken by an expert, as not only the presence of bats in act (sometimes evident also to a non expert) but also traces of frequentation in other periods of the year must be checked for. If usage
by bats is ascertained, lighting will have to be excluded during the period of bat presence or at least limited accordingly, so that there is no light inside roosts, at bat accesses and along their transit routes. Care must be taken also to contemplate “false negatives” in surveys, due, for instance, to the location of bats inside crevices or other spaces difficult to inspect. In these cases, i.e. if bat presence is detected at a later date, measures will have to be taken in order to exclude damaging interference, changing previous decisions if necessary. Analogue conservation attentions should be taken to restore darkness at buildings/sites known to have been used by bat colonies in the past. For what regards lighting for security reasons in connection to scaffolding in restructuring sites, the interference to bats can be annulled using alternative solutions, such as scaffolding with an alarm system or short circuit video based on infrared lighting. Buildings and sites of Cultural heritage where natural darkness is preserved or partial lighting have been adopted for bat conservation reasons are described at [http://www.centroregionalechirotteri.org/introd_eurobats_it.html](http://www.centroregionalechirotteri.org/introd_eurobats_it.html)

If you know about other similar virtuous cases we ask you to submit them for their insertion onto the same web page.

### 4.2. How to light

For all the different reasons to contrast light pollution, lighting should be undertaken in such a way as not to go significantly over the minimum requirements given in the safety regulations.

For what concerns the need to avoid the dispersion of light out of the designed area to be lit, there is a vast reference literature that considers the way the lighting is installed, the accessories to reduce light spillage, the height and orientation and the distribution of the intensity of the light. For more in depth information see the website [www.cielobuio.org](http://www.cielobuio.org) (click on “5 concetti fondamentali dell’illuminazione” and see, in particular, the first criterion, currently at: [http://www.cielobuio.org/index.php?option=com_content&view=article&id=1050&Itemid=40](http://www.cielobuio.org/index.php?option=com_content&view=article&id=1050&Itemid=40)).

The need for energy conservation and to limit CO₂ emissions, makes it important to choose energy saving lamps with high luminous efficiency (lumens per watt). It goes without saying that performance measurements must consider parameters during usage, taking into account eventual shielding accessories, lenses, etc. At present (2010) the most efficient lamps are low-pressure sodium lamps (90-200 lm/W) followed by high-pressure sodium lamps (90-130 lm/W). The current tendency in public lighting is for high-pressure sodium lights because low-pressure sodium lamps do not permit chromatic vision and have a limited use, mainly restricted to suburban areas (it has been stressed, however, that the chromatic
vision often is not necessary and the use of low-pressure sodium lamps could be much more widespread: IDA, 2002; on the other hand it must be said that, being scarcely used, it is expected these lamps will go out of production in a few years time).

Public illumination also uses less efficient lamp types, as mercury vapour lamps (with a luminous efficiency of only 30-60 lm/W and with high waste disposal costs), fluorescent tubes (70-90 lm/W) and metal halide lamps (60-120 lm/W). The latter are employed for special uses such as lighting in sport centres and for monuments, as they have a high intensity for unit of surface area.

Recently, locally, LED lighting has been used for monumental buildings, parking lots of large commercial centres and in pilot projects for public street lighting. LED technology has been developed only since the early 1990s, but the perfectioning of the bulbs and their gains in efficiency have had exponential growth in a few years. Today LED lamps, emitting white light, are marketed by several companies for public lighting; their luminous effectiveness is close to that of the low-pressure sodium lamps, but they cannot be considered competitive yet due to their high installation cost (they require a narrow pole spacing) (CieloBuio, 2008; Radetsky, 2010). However it is probable that with future technological developments LED technology will become the most advantageous lighting from an energetic point of view.

The choice of lamp type conditions also the possibility to control the light flow, reducing it when a less intensive illumination is sufficient. This also is a way in which to contain energy consumption and light pollution. Low-pressure sodium lamps are not suitable for this purpose, while high-pressure sodium lamps are and, in perspective, LED lamps are also suitable. LEDs also have the advantage of lighting up immediately, which could allow, wherever possible, an energy saving use through lighting activation by movement sensors.

In parallel to the need for energy saving, the choice in lamps must be oriented in such a way to minimise eventual conflict with natural environment components and other anthropic needs and interests (health, astronomical observation, cultural and recreation activities in night sky observation).

Considering conservation of insects, bat’s main food source, and in particular to avoid problems due to the attractive effect of light (see 3.1), the results of surveys carried out by Eisenbeis et al. in Germany (2006; 2010) direct towards the use of LEDs (it must be clarified that the published preliminary data do not explain if there are differences, with respect to insect attraction, between cool-white and warm-white light LEDs) or low-pressure sodium lamps and, as a second choice, to high-pressure sodium lamps (in their standard models). High-pressure sodium-xenon lamps, metal halide lamps and mercury lamps, probably due to their UV emissions, have been found to be progressively more attractive (and therefore negative) to insects.

The possibility that UV emissions can be perceived by bats (at least by some species) and can interfere with their vision (see 2.3) must be also taken into account. Numerous works of the last few years point out potential problems in the use of white light lamps at night and particularly of those emitting rich-in-blue white light, such as cool white LEDs. As far as biological aspects are concerned (but there are also negative effects on astronomy), compared to both low- and high-pressure sodium lamps, white light lamps and particularly cool white LEDs show a greater potentiality of impact on a wide spectrum of animals behaviours, biological functions and rhythms. Potential negative effects are relevant also to bats (see 2.4 and 2.5) and human health (2.5; ANSES, 2010).

Even if we still need to further our understanding in this area to better comprehend the relationships between causes and effects, the opportunity to follow a precautionary approach discourages the night use of lamps which produce white light (it always contain the blue component) and in particular that of cool white LED lamps.
A further criteria to be taken into consideration when choosing lamp types, concerns containment and dispersion of the light emitted. Generalising, the more light spill away from the area to be lit, the higher the probability of negative consequences also at a distance from the light source. In this case the low-pressure sodium lamps, which have the advantages mentioned earlier, are not suitable due to their large size, that makes the emitted light hard to control. As has been said, this kind of lamp has almost no attractive effect on insects, but it may interfere with insects in other ways: through repulsive effect or by inhibiting activity (see 3.2 and 3.3). Unfortunately it is not known to what extent these potential negative effects are related to the intensity of the lighting and how much they are conditioned by the spectral characteristics of the light.

At the present state of knowledge, mediating the considerations stated above, we suggest:
- the use of high luminous efficiency lamps with low or inexistent emission of ultraviolet or blue light, or lamps filtered to obtain an analogous effect, for public lighting (at present this means preferring the use of low- or high-pressure sodium lamps (the latter in their standard models);
- the exclusion of other types of lamps in all cases where it is not strictly necessary (the aesthetic appearance rarely is a necessity);
- an increase in research to better understand the biologic effects of LED lighting;
- to direct lighting technology taking into consideration the results of such research and, if the negative effects of white LEDs are confirmed, orient production towards LEDs of other colours, with a lower environmental impact.

4.3. When to use lighting

The rationalization of lighting dictates that, first of all, lighting should be avoided when it is not significantly useful. For bat conservation, the decision about “when” to light, should also take into consideration the differential impact that lighting has on bats during different times of the year and the night. During hibernation, artificial lighting has a lesser potential to interfere with bats and insects, whose activity is down to a minimum, even if it is possible that it plays a negative role towards the species of insects that are active in the winter and may also effects bats during their winter arousals. Of course the lighting of bat roosting sites need not be limited when the bats are not present, but when they return it becomes necessary.

In general terms, and above all during periods of full bat activity, any limitation of lighting is to be considered a positive move, but it should also be said that the part of the night which is the most important for bat foraging is during twilight and the early hours of darkness, when excluding lighting can be impossible for anthropic reasons. However, the traffic flows recorded in some Italian towns show how it could be possible to reduce lighting in time slots of interest for the protection of bats. In the city of Turin, for example, traffic is very limited after 9 pm, therefore a correspondent reduction in lighting along certain roads does not seem unproposable (CieloBuio, 2006).

In the case of extreme weather conditions (heavy and persistent rain, strong winds), which impedes bat activity, there is no need to limit lighting for bat conservation.
5. PROPOSALS FOR THE IMPROVEMENT OF LEGISLATION IN THE MATTER OF LIGHT POLLUTION

Artificial night lighting is a relevant environmental factor, which has unfortunately been overlooked for too long by ecologists; knowledge on its effects on living organisms is therefore still fragmentary. This fact has influenced Italian legislation, which is lacking on the front of the protection of the biocenoses despite light pollution matter has been largely afforded: at present there is no (national) outline law on the subject, but the majority of local administrations with legislative power have introduced specific local laws (17 of the 19 Regions have adopted laws hereafter named “regional laws” and 1 of the 2 Autonomous Provinces has adopted a “provincial law”).

The following notes mainly recall concepts already elaborated together with CieloBuio and exposed in CRC (2009). They are aimed at evidencing provisions relevant for the protection of biotic communities, with particular reference to bats and insects. In part these are already present in some Italian laws (regional/provincial), in part these are further dispositions that are not contemplated in the current laws. We suggest the adoption of these provisions in the existing legislation or in new laws when discussed.

When writing, we took into account also the need to save energy, to protect the night landscape and the possibility of making astronomical observations.

Given the vastness of the subject and the limits on present knowledge on the ecological effects of light pollution, we want to underline the necessity for future updating of this text.

As species react to artificial light in many different ways, and on occasions even show opposite reactions, in order to better respect biotic communities a great deal of work remains task of the territorial planning, which must consider local specific requirements.

Juridical definition of light pollution

According to the most used acceptation in Italian legislation, light pollution is every irradiance of artificial light outside competence areas (the area to be lit) and in particular off the horizontal plain. This definition takes into consideration the “astronomic” problem connected with lighting, but it is insufficient from an ecological point of view: it does not consider the negative effects that light has on many species (from attraction, repulsion, alteration of biological rhythms, etc.), even if well directed on the area to be illuminated and not dispersed upwards.

Taking into account the physical definition of light pollution proposed by Cinzano et al., 2000 (“an alteration of the natural quantity of light in the external environment due to the introduction of artificial light”) and the ecological definition by Longcore and Rich, 2004 (“artificial light that alters the natural patterns of light and dark in ecosystems”), we suggest to use the following definition: “Light pollution is any alteration of the natural quantity of light due to the introduction of artificial light, in particular if this light is dispersed off the horizontal plain and/or induces negative effects on living organisms.”

This definition transposes the more general definition of light pollution and brings attention to the problems that this phenomenon determines, both for astronomy and ecology.

This new definition makes it necessary to consider internal and inside lighting as possible pollution sources. In the existing laws in many Italian Regions, it is on the contrary specifically affirmed that such lighting is not polluting. Unfortunately, lighting on the inside of a bell tower or under the arches of a bridge can have a devastating effect on bats!
The objective for environmental protection and provisions to direct territorial management to the same aim

Some of the current Regional laws about light pollution identify protection of ecological equilibria as one of their objectives. We suggest that this element be introduced in all laws on the subject, together with general provisions on territorial management, as follows: “an objective of the present law is the respect of ecological equilibria, to be put into practice by protecting natural darkness, in particular where ecosystems characterized by good naturalness, ecological corridors and relevant feeding, resting and reproduction sites and movement routes are present”.

Provisions for the spatial containment of lighting

It should be recommend that the applicable instruments of the laws (regulations, guidelines, lighting plans, etc.) orient towards the identification of the territorial areas where it is a priority to limit artificial lighting, taking ecological criteria in good consideration. Habitat types where to safeguard natural darkness for the conservation of bats as a priority have been described in 4.1. They are environmental typologies of a primary importance not only for bats but also for many other species; this measure is therefore relevant for the more general aim of the protection of biodiversity and ecological equilibria.

It has also been stressed that it is very important to conserve darkness inside and around buildings and sites of Cultural heritage which are used as roost sites by bats. Existing laws dictate that bats and their roosts must be protected, but those charged with the management of our Cultural heritage often do not know about this, neither have idea of the potential interference that lighting projects can have.

In order to make it easier to respect norms which are often unintentionally ignored and to avoid unlawful actions to the damage of public interest (fauna is protected in the interests of the national and international community: art. 1, L. 157/1992, i.e. the Italian law on wildlife protection and hunting activity), often performed using public money, we suggest the introduction of the following in laws on light pollution:

“Decorative night lighting of buildings and sites of Cultural heritage, which house bat roosting sites, by the use of internal or external floodlights, must be subordinated to a bat survey aimed at assessing if the lighting is compatible with laws and regulations on the protection of bats and, whenever necessary and possible, at suggesting corrective measures to be taken in order to guarantee the respect of the current legislation. In cases in which the lighting results incompatible with bat conservation and it is not possible to enact sufficient mitigation measures, it will be necessary to renounce to the lighting project altogether.”

Provisions for the temporal containment of lighting

The applicable instruments of the laws (regulations, guidelines, lighting plans, etc.), when deciding about lighting, should take into account its effects on biocenoses during the different times of the day and the year. For what regards bats and insects, we have discussed the problem in section 4.3.

In some Italian regional laws there is already a limitation on the times permitted for lighting, but it is seldom applied. Moreover, the limitation is for the central hours of the night, while it would be much better for bats to have a limitation at twilight and the early hours of the night.
Provisions for the modality of illumination

The modality for illumination conditions the dispersion of light, that is the loss of light outside the designed area. This loss is a waste of energy and the light radiation that is lost upwards determines the brightening of the night sky above populated areas known as “sky glow”. This creates conditions in which it is difficult make astronomical observations and can interfere negatively on the behaviour of living organisms.

Various Italian regional laws have fixed successful criteria to minimise the problem of light dispersion. In particular they call for: “the luminaires, where installed, must have a maximum luminous intensity at a gamma angle of ≥ 90°(that is horizontally or upwards) between 0.00 and 0.49 cd/Klm”. Over more, in order to control indirect light flow, “the average luminance level on the surface to be illuminated and the illuminance shall be no more than the minimum defined by technical safety norms”.

As the lighting needs can change from hour to hour (in particular on roads, depending on the traffic), it is almost always a good thing that the lighting systems be equipped by devices able to reduce lighting flux when possible.

It is also necessary to consider the characteristics of the light produced. If the choice of lamp to be used was based solely on energy saving and lighting requirements it would be sufficient to chose “the ones with the highest efficiency in relation to the available technology”, apart from those cases where exceptions can be permitted for special illumination needs (e.g. where lighting with a high chromatic level is needed). These criteria however are insufficient when the protection of the biotic communities is considered.

In section 4.2, considerations on the impact of different lamps on bats and insects have been set out. The urgency and importance for further research on the matter has also been underlined, in order to obtain more precise data on which to base legislation.

That said, and allowing for the possibility of derogations that are adequately justified, for what concerns the lamps more widely used, (mostly for street lighting), we suggest to insert a reference to systems equipped with “lamps characterised with high luminous efficiency and low or no emissions of wavelengths inferior to 500 nm, or filtered at source in such a way as to have a similar result” in the laws.

Such a provision is coherent with the guidelines recently developed by International Dark-Sky Association in order to safeguard the possibility of astronomical observation (IDA, 2010).

Provisions for what concerns information and awareness

The general public is still very unaware of the problem of light pollution, therefore we underline the possibility that laws on the matter evidence the importance of developing initiatives towards giving information and sensitize the population about the astronomical, biological and ecological consequences of the phenomenon and the needs for energy conservation.
REFERENCES


http://www.cielobuio.org/index.php?option=com_content&view=article&id=1075&Itemid=40

CieloBuio, 2008 (aggiornato 2009). Facciamo chiarezza sui LED. ControLuce, Osservatorio del libero pensiero illuminotecnico, di scienza e cultura. 


