

*Main threats or potential threats to the site:* The enforcement of the lighting ordinance needs to be maintained with vigilance. Over one million tourists annually pass through Tekapo en route to other destinations, and many stay overnight. As tourism develops, the careful protection of the environment in the village is essential. Fortunately, the Mackenzie District Council is committed to sustainable development that protects the environment, including the night sky.

The Mount John site is a mixed site for scientific research, educational tourism and recreation. So far this has been a successful venture, but it needs to be carefully controlled and monitored.

*Management:* The environment in the Mackenzie Basin is mainly crown lease land, the remainder being privately owned.

The Mackenzie District Council is the branch of local government with jurisdiction over the Mackenzie Basin and Aoraki/Mount Cook. The Council's District Plan is part of the Resource Management Act 1991 and includes a lighting ordinance, first enacted in 1981—see <http://www.mackenzie.govt.nz/Site/Internal/Environmental/Districtplan.aspx>.

The Aoraki/Mount Cook National Park (<http://www.doc.govt.nz/parks-and-recreation/national-parks/aoraki-mount-cook/>) is controlled and managed by the New Zealand Department of Conservation under the authority of the National Parks Act 1980 (<http://www.legislation.govt.nz/act/public/1980/0066/latest/DLM36963.html>).

The University of Canterbury leases the 3 ha. summit of Mount John from the crown (New Zealand government). Earth and Sky Ltd (<http://www.newzealandsky.com/>) have an agreement with the University of Canterbury to run educational astro-tourism at Mount John. This activity is a required condition of the Mount John lease.

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## Case Study 16.2: Eastern Alpine Starlight Reserve and Großmugl Starlight Oasis, Austria

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*Günther Wuchterl*

### Presentation and analysis of the site

*Geographical position:* East Alpine Starlight Reserve: numerous communities, provinces of Lower Austria, Upper Austria, Styria and Carinthia, Austria. Großmugl Starlight Oasis: community of Großmugl, province of Lower Austria, Austria.

*Location:* East Alpine Starlight Reserve: Latitude 46° 52' to 47° 58' N, longitude 13° 35' to 14° 55' E. Elevation generally between c. 1000m and 1500m above mean sea level. Großmugl Starlight Oasis (core zone): Latitude 48° 29' 20" N, longitude 16° 13' 20" E. Elevation 250m above mean sea level.

*General description:* Within the Eastern Alps WSW of Vienna is an elliptical area, about 200 × 100km in size, where the high surrounding mountains provide sufficient shielding from light pollution that the dark night skies are of near perfect natural quality. A separate, much smaller area to the north of Vienna provides a dark-sky 'oasis' that is easily accessible of millions of city dwellers.



**Fig. 16.2.1.** The constellation Orion is almost overwhelmed by the light from the countless stars in the pristine skies above the Gesäuse National Park in the East Alpine Starlight Reserve. Photograph © M. Reithofer.

*Inventory of the remains:* The East Alpine Starlight Reserve is an area of about 20,000 km<sup>2</sup>, located about 150km to the west of Vienna where the Alps reach a height of 3000m. At the heart of this area, the dark night sky is of an exceptional quality. This is because low lighting in the surrounding communities together with the mountain topography provide an 80km-wide shield against central European light-pollution and city-light ‘domes’. The high elevation also reduces light scattering and extinction of starlight.

The Großmugl Starlight Oasis is a small area of 1.3 km<sup>2</sup> within the lower hills at the very eastern end of the Alps, about 30km north of Vienna. While the skies here are not pristine they are dark enough to provide a clear view of the Milky Way and thousands of individual stars (with a dependable visual limiting magnitude of 6). This is because the hills cover the sky-glow from nearby Vienna. Within the Oasis, a viewing spot near the largest bronze-age tumulus in central Europe offers a 360° unobstructed horizon, 250m above sea level. Taken together with the nature reserve *Leiser Berge*, the Starlight Oasis covers 300 km<sup>2</sup>.

*Cultural and symbolic dimension:* It is extraordinary that an area with a near-natural dark night sky should exist within the heart of Europe, a continent that is so brightly lit. Furthermore, the proximity of the East Alpine Starlight Reserve to population centres, including the cities of Vienna, Salzburg, Linz and Graz, as well as to a major north-south route across the continent, provides millions of people with easy access to an area where they can view a near pristine dark night sky. This is an almost unique natural resource.

The Großmugl Starlight Oasis provides a smaller but still exceptional dark-sky resource that is even closer to the City of Vienna—it is only 33km from St Stephen’s Cathedral in the city centre—and hence within easy reach of 70% of the Austrian population.



**Fig. 16.2.2.** The view north-eastwards at midnight towards the south-western end of the Gesäuse National Park in the East Alpine Starlight Reserve. The setting moon illuminates the Admonter Kalbling, 2196m, in the background. Photograph © Thomas Posch.

## Present site management

*Present use:* The night skies in the East Alpine Starlight Reserve area are already well embedded in National Park programs including night hiking and observation of nocturnal species, many of them endemic and reliant upon the natural nighttime environment. The area also includes the world's largest monastic library, at Admont, and the Eisenerz Iron Road world heritage initiative.

The Großmugl Starlight Oasis is used by local schools and universities in their courses, as well as for recreational and amateur astronomy. The Starlight Oasis provides optimal conditions for viewing the dark night sky, with moderate temperatures and sufficient oxygen (being at a low enough elevation) that visual perception is not impaired.

*Protection:* The bronze-age tumulus in Großmugl is protected by federal law as a historic monument. It is surrounded by a circular no-building zone, 0.65km in radius, regulated by the community. A 10km buffer zone has been proposed, which would include an existing nature protection area, the *Leiser Berge*.

The Starlight Oasis is fully supported by the community of 300 households in Großmugl itself, where there are fewer than 100 streetlights. By-laws to protect the night sky have been passed by the city council, making reference to the Starlight Reserve.

*Context and environment:* The naked-eye sky quality in the East Alpine Starlight Reserve area is indistinguishable from the best sites in the world. Measurements at elevations of 800m to 1800m give a sky brightness of 21.6 (for the Milky Way) to 21.8 mag/arcsec<sup>2</sup> (for the Galactic pole). Light-levels of near 1mlx are indistinguishable from the world's best astronomical sites. With the mountains shielding most of the natural airglow, valley light levels drop below 100  $\mu$ lx, producing pure starlight. Atmospheric inversion frequently provides viewing conditions above cloud-covered valleys that are similar to these obtained in western-continental deserts and trade-wind volcanic islands.

*Management:* The East Alpine Starlight Reserve area contains the *Kalkalpen* and *Gesäuse* National Parks (both IUCN category II), the *Dürrenstein* wilderness area (IUCN Ib) and more than 10 nature reserves. The Conservation areas and National Parks are managed by the respective administrative bodies.

The bronze-age tumulus area is protected by the federal agency for historic monuments (Bundesdenkmalamt) and managed by the town and community of Großmugl.

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## Case Study 16.3: AURA Observatory, Chile

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**Malcolm Smith**

### Presentation and analysis of the site

*Geographical position:* Approximately 80km east of La Serena, Coquimbo Region, Chile.

*Location:* Cerro Tololo: Latitude 30° 10.2′ S, longitude 70° 48.4′ W. Elevation 2240m above mean sea level. Cerro Pachón: Latitude 30° 14.4′ S, longitude 70° 44.1′ W. Elevation 2700m above mean sea level.

*General description:* The AURA (Association of Universities for Research in Astronomy) Observatory in Chile comprises two mountain-top groups of telescopes: Cerro Tololo and Cerro Pachón. Cerro Tololo is the site of the first of the various major, international observatories that are now operating in Chile. Following this lead, and attracted by the pristine night skies, the world's astronomers have made northern Chile the primary centre for major astronomy research observatories in the southern hemisphere. The wide-field, 4m, Blanco telescope was the largest optical telescope in the southern hemisphere during the period 1975–1997. Clear, dark skies over the Blanco telescope were crucial to its selection by the two groups who used it to make the initial discovery of the acceleration of the Universe.

*Inventory:* Main telescopes: 4m Blanco; 8m Gemini South; 4.2m SOAR; and 8.2m Large Synoptic Survey Telescope (LSST) under development. There are also other, smaller telescopes. This site was recently selected for the LSST after an international, competitive survey. This telescope will provide deep images of the whole sky every 3–4 nights.

*History of the site:* The observatory has been in operation on this site for nearly 50 years.

*Cultural and symbolic dimension:* The AURA Observatory in Chile forms a part, located in the southern hemisphere, of a single set of sites in the world with exceptional conditions for observing the Universe. These sites, including their natural and cultural components, are exceptional 'windows of science and knowledge'.

### Present site management

*Present use:* The observatory is the site of the telescopes listed above.

Regarding interpretation and outreach, the observatory has formed a 200+ schools network and support organization in collaboration with the Municipality of La Serena and the local University. The Coquimbo Region has an extensive astro-tourism development initiative.