Assessing the Impacts of the Proposed Cielo Centro Observatory

Prepared for The University of New Mexico-Taos (UNM-Taos)

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FEBRUARY 2026

Acknowledgments

We would like to thank all of the individuals at The University of New Mexico-Taos (UNM-Taos) who have contributed to the advancement of this report. In particular, we would like to thank Chancellor Mary Gutierrez, Dr. Colin Nicholls (Director of the Cielo Centro), and George Rankin (Observatory Liaison) for their expertise, guidance, and input. Their depth of knowledge and passion have been extremely valuable to the development of this report. We also owe a debt of gratitude to Dr. Alejandra Villalobos Meléndez (Director of Strategic Initiatives & Research), who, alongside George, facilitated meetings and made cross-department communication easy and effective. Further appreciation is extended to Wayne Bewley (Director of Business Operations) for providing the construction estimates.

BBER would also like to recognize the assistance and cooperation of the following organizations, listed alphabetically, who addressed any technical or programming-related questions:

- Capulin Volcano National Monument
- Carlsbad Caverns National Park
- Chaco Culture National Historical Park
- Clayton Lake State Park and Dinosaur Trackways
- Cosmic Campground
- Fort Union National Monument
- Las Cruces Astronomical Society
- New Mexico Museum of Natural History and Science
- Pajarito Environmental Education Center
- UNM Campus Observatory
- Valle de Oro National Wildlife Refuge
- Valles Caldera National Preserve
- Valley Vista Getaway

At UNM BBER, we would like to thank Rose Rohrer (Senior Research Scientist) for providing valuable feedback and to Director Dr. Michael O'Donnell, JD, for his oversight and support.

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Executive Summary

In October 2025, The University of New Mexico-Taos (UNM-Taos) commissioned UNM's Bureau of Business & Economic Research to evaluate the social, financial, and environmental impacts of the proposed Cielo Centro Observatory. The observatory – which will house the powerful 36-inch diameter, 12-foot, 6-inch tall Dobsonian telescope gifted by the King and Oglesbee Families – will provide students, community members, and visitors the unique opportunity to form a personal connection with the universe by allowing individuals to observe celestial objects millions of light years away.

As part of the broader Cielo Centro (Sky Center) project, the observatory will support workforce development and fuel community prosperity by preparing students for meaningful careers through internships, partnerships, and hands-on research. The observatory will also allow UNM-Taos to capitalize on the fast-growing and emerging industry of astrotourism.

Altogether, the construction of a dedicated roll-off roof observatory can position UNM-Taos to expand educational programming, diversify the local economy, and promote environmental stewardship through dark sky preservation.

Limitations of the Study

The research and analysis presented in this report provides a structured assessment of the Cielo Centro Observatory's social, financial, and environmental impacts. However, three limitations influence the scope of the findings, as outlined below:

- Given the project's timeline and budget parameters, the analysis relies solely on secondary data. These data were gathered from reputable, trusted sources, including the Arts & Economic Prosperity 6 (AEP6) survey, the National Park Service Social Science Program, New Mexico Tourism Department, the NOAA NCEI Local Climatological Data Version 2 (LCDv2), the UNM Office of Institutional Analytics, among others.
- Because Taos – and the broader Taos County region – is already a well-established tourist destination known for its outdoor recreation and art galleries, distinguishing new visitor spending from existing visitor spending can be challenging. For this reason, an economic contribution analysis – which examines the observatory's role "as is" within the tourism industry – may be a more useful approach for future analyses once it begins operation.
- Estimating the observatory's economic impacts from construction and visitor spending requires balancing multiple moving pieces. Because the observatory is not yet functional, this analysis uses 2024 visitation data from four nearby national parks and Taos County spending patterns as benchmarks.

Key Findings

The key findings of this report are listed on the following pages and are organized by topic:

History and Background of the 36-Inch Dobsonian Telescope:

- In April 2023, UNM-Taos received a 36-inch, 12-foot, 6-inch tall Dobsonian telescope from the King and Oglesbee Families.
    - The telescope was gifted with the intent of supporting astronomy in Taos and surrounding communities.
- Since acquiring the telescope, UNM-Taos has embarked on a journey to build an observatory that would:
    1. House, protect, and allow UNM-Taos students, local K-12 students, and the public to use the telescope.
    2. Help preserve the natural wonder of the dark sky from the ongoing threat of light pollution.
    3. Become a significant asset for the region, attracting tourists and astronomy enthusiasts.
- UNM-Taos has contracted an engineering firm to restructure the primary components and to make it accessible to any and all individuals. Upcoming improvements include:
    - Developing a Periscope: Due to the telescope's size, using the eyepiece requires a ladder, which presents accessibility issues. To overcome this obstacle, a periscope will be developed that allows users to observe from ground level while seated, eliminating the need to reposition the ladder each time the telescope is moved.
    - A Plate Solving Camera: A camera, which is linked to a computer, will be mounted on the secondary part of the telescope. The camera will capture images of the sky being viewed and transfer the data to the computer, allowing the system to determine exactly where the telescope is pointed. The computer can then adjust the telescope's position to precisely image the selected target.

Model of the 36-Inch Dobsonian Telescope in Action

- Because of its size, the 36-inch telescope is currently stored in parts approximately one mile from UNM-Taos.
    - As a result, the telescope cannot be used since the storage facility is neither designed to provide a full, unobstructed view of the night sky nor large enough to accommodate the fully assembled telescope for storage, operation, or maintenance.
- UNM-Taos has concluded that a roll-off roof observatory would be the best design for an observatory.
    - Unlike a standard observatory that only has one viewing slot, a roll-off roof design offers 360-degree access to the night sky, directly supporting the facility's mission of connecting people to the sky.
    - This design also makes it possible for two telescopes to observe different objects simultaneously and allows astronomers or technicians to point out and explain the objects being viewed while visitors wait to look through the telescope.

UNM-Taos Educational Profile:

- When comparing the per-credit hour tuition rate between UNM-Taos and the Albuquerque campus, tuition is 71.4% cheaper for residents and 80.3% lower for non-residents at UNM-Taos.
    - Students at the Albuquerque campus are subject to various fees, whereas UNM-Taos students incur a singular, flat-rate support service fee.
- UNM-Taos serves nearly 1,300 students every term from "cradle to career" in the northern New Mexico region.
    - Many of these students are adult learners who are enrolled part-time and juggle multiple responsibilities.
- Over the past four academic years, approximately two-thirds of UNM-Taos students have been local 'home' students, while the remaining one-third have been 'visiting' students – students from other UNM campuses who enroll in one or more courses at UNM-Taos during a given term.
- At UNM-Taos, females have consistently made up the majority of the population, averaging 64.0%.
    - This trend is also reflected among pre-science majors. Relative to the overall student population, 12.1% of female students and 9.2% of male students are enrolled in the pre-science program.
- Hispanic students continue to represent the majority of the student population at 54.9%, followed by White (non-Hispanic) students at 31.6%. These statistics also hold true for pre-science majors.
- While the pre-science major represents a natural academic nexus for the Cielo Centro Observatory, the facility is equally positioned to serve as a high-impact experiential learning site for students across disciplines.
    - The Cielo Centro Observatory, through the Film & Digital Media Arts (FDMA) and Fine Arts Programs, can provide a dynamic setting for students to produce documentary films, short features, astrophotography, promotional media, livestreamed observing sessions, immersive visual storytelling projects, exhibition materials, and public art components.

UNM-Taos Environmental and Atmospheric Conditions:

- Taos' elevation of 6,967 feet in the mountainous, high desert region of New Mexico near the 1000-year-old Taos Pueblo makes Taos an optimal location for stargazing, as the natural formation of mountains block light pollution from near and far.
- A study by Falchi et al. in 2016 found that light pollution is increasing by 10 percent every year, more than 80 percent of the world's population lives under light-polluted skies, and some populations cannot even see the Milky Way Galaxy.
    - This is because artificial lights raise night sky luminance, creating the most visible effect of light pollution: skyglow.
    - Not only does skyglow affect urban clusters, but it can also disperse light pollution to remote areas, thereby compromising darkness and dark night skies.
    - Studies have also shown that light pollution hinders astronomical research, disrupts biodiversity, increases carbon dioxide which contributes to climate change, and impacts human health.
- Light pollution levels in Taos and Taos County did not exceed any thresholds that are considered threatening, despite being in and in close proximity to urban areas.
    - This yields favorable outcomes for the potential success of the Cielo Centro Observatory, as UNM-Taos can take a leading role in promoting the value of the night sky while positioning the state to secure its position as a pioneer in astrotourism and dark sky conservation.
- From 2018 to 2024, Taos had excellent air quality. "Good" AQI conditions were recorded for 90% of the year, and air quality overall remained within satisfactory thresholds for all population groups year-round.
- Taos has had an average of 80.5% clear or mostly clear skies over the past seven years.
    - This level of clarity is considered excellent, especially for a high-elevation, mountainous region where comparable areas like Flagstaff, Arizona (an International Dark Sky City) frequently experience cloud formation and changing weather.
    - With the presence of clear skies, stars can appear brighter and atmospheric distortion can be minimized, thereby making Taos an ideal location for an advanced telescope and observatory.
- Whenever wind interacts with the earth's surface, disruptions in airflow occur due to the different levels of energy and temperature that meet.
    - 96.6% of wind speeds in Taos from 2018 to 2024 were below 8 miles per hour (mph), with the majority (76.5%) between 0 and 3 mph.
- Taos has experienced "dry and comfortable" dew point temperatures from 2018 to 2024, with both the average and maximum values well below the "sticky" threshold.
    - These conditions suggest that observer comfort and the performance of equipment will not be impaired.

Astrotourism in New Mexico:

- Astrotourism, a form of noctourism, has been identified as one of the next biggest trends, and the New Mexico Tourism Department has been enthusiastically championing the state's dark skies through its New Mexico True campaign.

- Organizations across New Mexico coordinate events ranging from traditional stargazing and telescope viewing to sensory experiences, astrophotography, and educational programming.
- Expanding the boundaries of astrotourism not only benefits local communities but also protects cultural traditions by fostering a deeper connection between people and the natural world.
- Astrotourism can also find success when establishments integrate night-sky experiences into existing tourism offerings.
    - Astrotourism depends on collaboration between communities and organizations, as evidenced by partnerships between astronomy groups and parks.

International Dark Sky Places:

- The International Dark Sky Places (IDSP) program certifies public and private spaces and facilities that preserve and protect night skies.
- As of November 26, 2025, the U.S. is home to 156 designated Dark Sky Places. This total includes 93 Dark Sky Parks, 41 Dark Sky Communities, 11 Dark Sky Sanctuaries, 9 Dark Sky Places, and 2 Dark Sky Reserves.
    - Nine of these Dark Sky Places are located in New Mexico.
    - New Mexico currently has no designated Dark Sky Community.
- The most recent site in New Mexico to achieve Dark Sky status was Valles Caldera National Preserve in 2021.
- Another site currently preparing an application for Dark Sky certification is the Rio Grande del Norte National Monument.
    - The unique setting of the monument serves as a gateway to northern New Mexico's dark skies, and its 3.5-mile location west of Cielo Centro prompted BLM to collaborate with UNM-Taos and El Valle Astronomers in their pursuit of Dark Sky certification.
- Following the construction of the observatory, UNM-Taos would like to pursue and secure an IDSP certification.

Social Impacts:

- Hands-On Learning and Technical Skills:
    - In astronomy, the universe is the lab, and the telescope is the equipment.
    - The Cielo Centro Observatory can preserve a sense of wonder and transform student learning by activating students' sensibilities, enabling them to experience the connection between theory and reality.
    - It can provide an avenue for hands-on approaches through the maintenance of observatory facilities and grounds.
    - The Cielo Centro Observatory can also position UNM-Taos to serve as a regional educational anchor by providing PreK-12 students with access to a high-quality astronomical facility that is hard to find in rural communities.

        - The UNM-Taos area of responsibility includes the communities of Taos, Questa, and Cimarron.[1] Within Taos, Questa, and Cimarron, there are 23 PreK-12 schools across eight districts serving approximately 3,453 students.[2]
        - These schools represent a geographically dispersed, largely rural population where access to advanced scientific instrumentation and immersive STEM experiences is often limited by distance, funding constraints, and infrastructure gaps.
- Career Development, Mentorship, and Opportunities:
    - The Cielo Centro Observatory has the ability to support the state's endeavors by creating unique STEM experiences that combine classroom instruction with real-world educational applications.
    - The housing of the telescope in the observatory can enhance a student's understanding of instrumentation, data acquisition, and analysis – skills that are pertinent for career readiness and workforce development.
    - The observatory can allow students to network with STEM professionals through mentored research experiences and allow UNM-Taos to share resources and services with other institutions.
        - An example of this is the potential formation of the Southwest Regional Space-STEM Consortium.
            - The mission of this consortium is to provide underserved and underrepresented students with the opportunity to work in the space economy at a professional or technical level, and to connect employers with a highly qualified pool of local workers by sharing instructional resources and students.
    - The observatory can create multiple entry points for learning across grade levels.
        - Younger learners can engage through guided sky tours and interactive demonstrations, while middle and high school students can participate in more advanced observational projects, data collection activities, and mentorship opportunities with UNM-Taos faculty and students.
    - Such skills and experiences that are developed by working with the telescope can also pave the way for more advanced degrees that are research-based and require independent thinking, which complement UNM-Taos' goal of "Advancing New Mexico: Trusted Provider of Education and Workforce Development."
- Community Engagement as a Pathway to Literacy:
    - When an individual is able to form a personal connection with their surroundings, it can enhance their understanding and appreciation of the vast and intricate cosmos.
    - A case in point is the Cielo Centro Observatory, which will offer tangible experiences by allowing students and visitors to observe celestial bodies through telescopes.
    - By offering dynamic programming that resonates with diverse audiences, the observatory can positively shape the perception of science by integrating economic, cultural, and environmental sustainability through cross-domain collaboration.

[1] Click this link to see a map of the Geographic Areas of Responsibility by county.
[2] See Appendix C for a breakdown of enrollment and the types of PreK-12 schools in the UNM-Taos service area.

        - Providing targeted programs that blend night-sky experiences with familiar contexts can reduce inequities among underrepresented populations by expanding the boundaries of astronomy and inspiring curiosity in those who may not have had an interest in science.
    - By investing in today's youth, the observatory can help cultivate future generations of scientists and engineers who will continue to advance scientific discovery and contribute to the state's knowledge economy.
    - For first-generation and historically underserved students in northern New Mexico, such exposure is particularly significant, as it reduces structural barriers tied to geography and access.
- The observatory's social impacts directly support three of UNM-Taos' goals: (1) Student Experience and Educational Innovation: Inclusive and Empowering Learning Experiences, (2) Inclusive Excellence: Cultural Respect and Community Engagement, and (3) Sustainability: Sustainable Community Development, Stewardship, and Wellness.

Financial Impacts:

- Economic Impacts of Construction and Visitor Spending:
    - To estimate the economic impact of the observatory, BBER utilized IMPLAN, which is an Input-Output (I-O) model used to gauge and estimate the direct, indirect, and induced impacts.
        - An I-O analysis suggests independence exists between sectors and consumers in an economy through buy-sell relationships, meaning one transaction or economic activity will support successive economic activity.
    - Construction:
        - On July 23, 2024, UNM-Taos generated a project cost summary for the observatory, observation deck, and access.
        - Hard costs, which included construction and contingencies, were estimated to be $5,722,984 (75.30% of the total project cost).
        - This estimate was used in our analysis and inflated to 2027 dollars to reflect the year of construction.
        - The construction of a 2,022-square-foot observatory would be responsible for creating 46 temporary construction-related jobs, almost $2.6 million in labor income, nearly $3.9 million in value added, and about $8.5 million in total output.

Impact	Employment	Labor Income	Value Added	Output
Direct	34	$2,048,687.34	$2,684,217.34	$6,089,844.00
Indirect and Induced	12	$550,003.04	$1,170,139.59	$2,392,995.26
Total	**46**	**$2,598,690.38**	**$3,854,356.93**	**$8,482,839.26**

- Visitor Spending:
  - When guests visit the Cielo Centro Observatory, they will likely spend money at local businesses purchasing trip-related goods and services.
  - According to a 2019 study by Mitchell and Gallway, non-local tourists who value the dark sky are expected to spend $5.8 billion over ten years in the Colorado Plateau, a region of the United States that includes parts of Utah, Colorado, Arizona, and New Mexico.
  - Assuming the observatory opens in 2028, 3,942 visitors are estimated to spend $555,461.34 in Taos County while visiting the Cielo Centro Observatory. These expenditures are expected to support a total of 6 jobs, almost $214 thousand in labor income, nearly $441 thousand in value added, and $786 thousand in economic output.

Impact	Employment	Labor Income	Value Added	Output
Direct	4	$156,278.17	$322,850.86	$551,461.34
Indirect and Induced	2	$57,275.61	$118,065.27	$234,813.25
Total	**6**	**$213,553.78**	**$440,916.13**	**$786,274.59**

  - Note that the magnitude of the impact will depend on how the geographic area is defined, as only non-local residents bring in outside dollars.

- Fiscal Impacts:
  - The Cielo Centro Observatory can help the local economy grow by collecting tax revenue from tourists who spend money on goods and services at local businesses.
  - As long as new revenue exceeds new costs, the fiscal impact is said to be positive.
    - This is critical because such revenues help finance governmental programs, including public education, infrastructure, healthcare, and public safety.
- Increase in Net Tuition and Fee Revenue:
  - UNM-Taos can leverage the observatory to attract more students and diversify its revenue streams.
  - Rather than bolstering revenue streams by leveraging tuition dollars, UNM-Taos can expand enrollment by encouraging greater participation in STEM classes and programs.
- Increase in New Sources of Revenue:
  - Charging for programming events at the Cielo Centro – including observing time through the telescope – could serve as a significant source of income.
  - Telescope time and related resources could also be exchanged with other colleges to access services that UNM-Taos does not currently offer.
  - Beyond income and resource sharing, the observatory can also open doors for UNM-Taos to pursue sponsorship and research funding opportunities.

Environmental Impacts:

- In 1999, the New Mexico Legislature enacted the Night Sky Protection Act (NMSA 1978, Chapter 74, Article 12) to regulate outdoor lighting fixtures and preserve the state's dark sky heritage.
- Taos County and Taos voted to adopt more rigorous ordinances in 2006 and 2007 to protect the night sky.
    - Despite these progressive measures, the increased use of LED lighting – combined with limited code enforcement – has compelled community members and dark sky advocates to call for stronger, more effective measures.
- With the possible construction of the Cielo Centro Observatory, the Taos Dark Sky Initiative has intensified its campaign to protect natural nighttime darkness – not only as a cultural and scientific resource, but as a defining element of Taos' identity.
- Night Sky Protection:
    - Artificial Light at Night (ALAN) alters circadian rhythms, the internal sleep-wake body clock that differentiates night from day. Given that many species rely on natural cycles of daylight and darkness to trigger spatial patterns like hunting, foraging, mating, migrating, and more, ALAN needs to be limited.
    - The Cielo Centro Observatory, however, can work with surrounding communities and nearby jurisdictions to limit ALAN by advocating for new legislative measures that require shielding regulations and adaptive lighting controls.
    - Protecting the dark skies is not only a scientific priority but also a cultural responsibility, reinforcing the observatory's role in advocating for light pollution policies that preserve ancient traditions.
- Pursuing an International Dark Sky Place (IDSP) Designation:
    - New Mexico currently has no designated International Dark Sky Community.
    - Pursuing and securing this accreditation represents a significant opportunity for UNM-Taos to strengthen its role in dark sky tourism in northern New Mexico and surrounding regions.
    - Beyond serving as an economic engine, the certificate can also inspire community members to gain knowledge about the night sky, raise awareness of the harmful effects of light pollution, and support land management agencies in achieving long-term conservation goals while connecting people to the universe.

Introduction

1.1. Study Background

In 2023, UNM-Taos was presented with a unique opportunity to expand its educational and tourism offerings, thanks to a one-of-a-kind donation by the King and Oglesbee Families: a 36-inch diameter, 12-foot, 6-inch tall Dobsonian telescope. This addition, which will claim the title for being the largest operable public telescope in the state, will open new doors for public engagement, astronomical study, and the preservation of Taos' exceptional night sky.

UNM-Taos currently has the telescope disassembled and stored in a warehouse about one mile from campus; however, the facility is not suitable for astronomical viewing. Moreover, although the telescope structure is currently being enhanced to support routine public use, a dedicated observatory will still be necessary for regular observations, training, and public viewing.

The Cielo Centro Observatory will also serve as part of a larger outdoor learning area – which will include an amphitheater and nature trail – designed to inspire and train students, attract visitors, and celebrate Taos' unique dark sky resource. To support this initiative, UNM-Taos contracted UNM's Bureau of Business & Economic Research (BBER) to assess and communicate the anticipated social, financial, and environmental impacts of the observatory.

This report summarizes the results of the study.

1.2. Purpose of Study

UNM-Taos requested technical assistance to assess the social, financial, and environmental impacts of the Cielo Centro Observatory. This report focuses on the short-term and long-term impacts of the proposed main observatory structure.

The observatory, which will house the 36-inch Dobsonian telescope, will enable students, community members, and visitors to view celestial objects millions of light years away. Cielo Centro will act as a regional consortium that will train students to work in the space economy, prepare students for internships, and strengthen academic connections across institutions, laboratories, and commercial partners. In addition, the observatory will allow UNM-Taos to capitalize on the emerging and fast-growing industry of astrotourism – a form of tourism in which individuals travel to experience astronomy-related events like stargazing, eclipses, and other astronomical phenomena.[3]

With a world-class telescope and ideal environmental and geographic conditions, UNM-Taos can transform educational programming, diversify the economy, and engage in environmental stewardship, all while helping the region become a leader in astrotourism. However, to fully realize the anticipated benefits of the 36-inch telescope, UNM-Taos must construct a roll-off roof observatory to house it.

[3] https://travelnoire.com/astro-tourism-travel-trend

The remainder of this report is dedicated to discussing and addressing the scope of work and is organized as follows:

Chapter 2 – Background: Chapter 2 sets the background for this report by providing a high-level overview of UNM-Taos; the history, specifications, and storage conditions of the 36-inch telescope; and future plans for the telescope, including the need for a roll-off roof observatory to ensure its protection and long-term success.

Chapter 3 – UNM-Taos Demographic Profile: This chapter assesses the composition of the UNM-Taos student population over the last four academic years using data from UNM's Office of Institutional Analytics (OIA) and UNM-Taos Institutional Research.

Chapter 4 – Environmental and Atmospheric Conditions: Chapter 4 examines UNM-Taos' capacity to support a specialized observatory that will house a technologically advanced telescope. Key topographic, environmental, and atmospheric conditions are analyzed, since favorable values are essential for optimal seeing conditions.

Chapter 5 – Astrotourism in New Mexico: This chapter evaluates the market for astrotourism in New Mexico by looking at how organizations and establishments engage with astrotourism through their equipment, offerings, and outreach activities. Special emphasis is placed on International Dark Sky Places, which adhere to strict criteria to maintain their designation.

Chapter 6 – Case Studies: Chapter 6 looks at how the location and logistics of comparable observatories in New Mexico and neighboring states have influenced their development, purpose, use, and accessibility.

Chapter 7 – Social, Financial, and Environmental Impacts of the Cielo Centro Observatory: Chapter 7 evaluates the anticipated social, financial, and environmental impacts of the observatory by quantifying and describing its monetary and non-monetary benefits. The chapter also discusses how the Cielo Centro Observatory can support UNM-Taos' strategic plan and mission.

Background

2.1. The Intersection of UNM-Taos and the 36-Inch Dobsonian Telescope

2.1.1. A Brief History of UNM-Taos

The University of New Mexico-Taos (UNM-Taos), formerly known as "Taos Branch Community College," is one of four branch campuses of the state's flagship institution: The University of New Mexico. Established on July 1, 2003, under the Branch Community Colleges Act (NMSA 1978, Chapter 21, Article 14, Section 1), UNM-Taos was created to "serve the citizens of New Mexico more fully and to provide the highest quality of education throughout the state for students [...] pursuing postsecondary education."[4] With programs that include certificates, associate degrees, transfer pathways to four-year universities, and workforce development support, UNM-Taos allows students in northern New Mexico to pursue high-quality, post-secondary education that is affordable and close to home.[5]

The UNM-Taos campus is divided between two locations – Klauer Campus and Civic Plaza Campus:

- **Klauer Campus:** Klauer Campus is located atop a ridge near NM State Road 68 and County Road 110 in Ranchos de Taos, about six miles outside of Taos. It houses administration, student support services (library, bookstore, advisement, tutoring), classrooms, and ancillary services. Buildings include Pathways, Fred Peralta Hall, Pueblo Hall, Padre Martinez Hall, Rio Grande Hall, STEM-H Center, and the Kids Campus.[6]
- **Civic Plaza Campus:** The Civic Plaza Campus is located in downtown Taos on Civic Plaza Drive. Rio Grande Hall (Health Sciences Center, Bataan Hall) is located at this campus.

2.1.2. The Gifting of the Telescope

On April 15, 2023, UNM-Taos received a 36-inch Dobsonian telescope from the late Melinda King. The telescope was gifted with the intent of supporting the study of astronomy in Taos and surrounding communities, as the late Melinda King's son was familiar with UNM-Taos' astronomy program through El Valle Astronomy Club.

Since acquiring the telescope, UNM-Taos has embarked on a journey to "build an observatory [that would] house, protect, and allow UNM-Taos students, local K-12 students, and the public to use [the telescope]." This initiative has since expanded into a construction project known as Cielo Centro (Sky Center). Once operational, Cielo Centro is expected to:[7]

- Serve as an educational hub, offering hands-on learning experiences for K-12 students, college students, and the general public.
- Preserve the natural wonder of the dark skies from the ongoing threat of light pollution.

[4] https://handbook.unm.edu/f10/
[5] UNM-Taos also offers a bachelor's degree in nursing.
[6] https://taos.unm.edu/about/campus-maps/
[7] https://taos.unm.edu/community/cielo-centro/

- Become a significant economic asset for the region, attracting tourists and astronomy enthusiasts.

Cielo Centro will be located on the west side of Klauer Campus above the high ridge, adjacent to future parking, and in proximity to existing facilities and planned developments.[8]

2.1.3. Components of the Cielo Centro

Although this report focuses solely on the observatory, the Cielo Centro is also expected to have the following components:[9]

- Education Center: Serves and supports UNM-Taos students, K-12 outreach, and visitor education.
- Outdoor Amphitheater: Hosts open-air astronomy sky tours and other presentations.
- Combined Nature/Solar System and Art Walk Trail

The rest of this chapter is devoted to the telescope and observatory.

2.2. Technical Specifications and Future Plans for the 36-Inch Telescope

2.2.1. Technical Specifications

The 36-inch telescope consists of two mirrors: a primary mirror and a secondary mirror.

- Primary Mirror: The primary mirror is 36 inches in diameter and features a sandwich design. That is, the mirror consists of two glass sheets separated by over 80 one-inch glass cubes. This construction makes the mirror stiff, lightweight, and allows for rapid cooling.[10] Its focal ratio is f/4, meaning its focal length is four times its aperture or diameter (36*4 = 144 inches = 12 feet).[11] This wide-angle design lets observers see a wider slice of the sky.
- Secondary Mirror: The secondary mirror is a 7-inch Cer-Vit mirror, a low expansion glass commonly used in high-end observatory mirrors that stabilizes the image across a range of viewing temperatures. Located at the top of the telescope, the mirror is elliptical, with a minor axis of seven inches and a major axis just under ten inches.

2.2.2. Future Plans for the 36-Inch Telescope

When UNM-Taos first received the telescope, the optical performance of the telescope was not complete in that:

- The mirror was uncoated.
- The mirror cell (the structure that supports the mirror in the telescope) was still in development.
- The primary mechanical structure was made of plywood and particle board, which, while adequate for an amateur astronomer, is not robust or precise enough to be used in an observatory.
- The control and movement electronics were incomplete.

[8] This site was chosen to account for wind patterns, drainage, and utility locations.
[9] As of January 2026, construction of the amphitheater and groundwork for the telescope viewing area are expected to be completed in Summer 2026.
[10] Mirrors made of a single disk of glass are heavier and take longer to cool after use.
[11] https://www.popastro.com/focal-ratio/#:~:text=The%20focal%20length%20divided%20by,to%20as%20the%20f%2Dnumber.

Since taking ownership of the telescope, UNM-Taos has either been making or will make significant technological improvements to prepare the telescope for use in an observatory. UNM-Taos has contracted a local engineering firm to optimize the telescope and to restructure the primary mechanical components by using El Valle Astronomers' 30-inch, f/5 Dobsonian club telescope as a prototype. Upcoming improvements include:

1. Developing a Periscope: Due to the telescope's size, using the eyepiece requires a ladder, which presents accessibility issues. To overcome this obstacle, a periscope will be developed that allows users to observe from ground level while seated, eliminating the need to reposition the ladder each time the telescope is moved. This design can be seen in Figure 1.
2. A Plate Solving Camera: A camera, which is linked to a computer, will be mounted on the secondary part of the telescope. The camera will capture images of the sky being viewed and transfer the data to the computer, allowing the system to determine exactly where the telescope is pointed. The computer can then adjust the telescope's position to precisely image the selected target.

Figure 1: Model of the 36-Inch Dobsonian Telescope in Action

Source: UNM-Taos

2.3. Current and Future Storage Conditions

Because of its size, the 36-inch telescope is currently stored in parts approximately one mile from Klauer Campus. As a result, the telescope cannot be used since the storage facility is neither designed to provide a full, unobstructed view of the sky nor large enough to accommodate the fully assembled telescope for storage, operation, or maintenance.

Figure 2: Stacked Parts of the 36-Inch Dobsonian Telescope

Source: UNM-Taos

This limitation necessitates that UNM-Taos' current facilities address the following space requirements:

- Infrastructure to support a large-aperture telescope and equipment with tracking capability, including:
  - Routine operation of the telescope,
  - Maintenance operations,
  - Storage conditions to protect the telescope when not in use.

After comparing various observatory dome designs, including drop-down and clamshell domes, UNM-Taos personnel determined that a roll-off roof observatory is the most suitable option. Unlike a standard observatory

that only has one viewing slot, a roll-off roof design offers 360-degree access to the night sky, directly supporting the facility's mission of connecting people to the sky. This design also makes it possible for two telescopes to observe different objects simultaneously and allows astronomers or technicians to point out and explain the objects being viewed while visitors wait to look through the telescope.[12]

2.4. Conclusion

As this chapter has showcased, the pending technological improvements are expected to transform the 36-inch telescope into an accessible and technologically advanced telescope that can help New Mexico strengthen its knowledge economy, increase public and student educational offerings, and provide greater visibility and recognition of UNM-Taos through increased visitation. Building on this momentum, UNM-Taos seeks to advance its curated mission by expanding the Cielo Centro footprint to include a roll-off roof observatory to house the telescope.

Accordingly, the remainder of this report is dedicated to identifying, quantifying, and describing the observatory's anticipated social, financial, and environmental impacts. However, before diving into this venture, the contextual details and foundational knowledge need to be expanded.

[12] https://www.vaticanobservatory.org/sacred-space-astronomy/observatory-thomas-college/

UNM-Taos Demographic Profile

Universities within the education sector, much like establishments in other sectors, are confronted with the ongoing challenge of assessing existing market trends and characteristics while also developing new strategies to maintain long-term competitiveness. Since the higher education landscape is rapidly evolving, the profile of a typical student is also changing, thereby making it more challenging for universities to address the different needs of their diverse student population. College students used to be defined as "young, full-time learners who enrolled at a college campus immediately after high school."[13] Today, however, the student body also includes a growing number of adult learners, many of whom are part-time and juggle multiple responsibilities. This is especially true for community colleges like UNM-Taos, which serves nearly 1,300 students each term from "cradle to career" in the northern New Mexico region."[14]

Over the past four academic years, approximately two-thirds of UNM-Taos students have been local 'home' students, while the remaining one-third have been 'visiting' students – students from other UNM campuses who enroll in one or more courses at UNM-Taos during a given term.[15] This section analyzes the composition of the UNM-Taos home student population using data from UNM's Office of Institutional Analytics (OIA) and UNM-Taos Institutional Research by examining key demographic variables in relation to institutional metrics.

Although particular attention is given to the pre-science major – which includes recommended focus areas like biology, chemistry, earth and planetary science, mathematics, and physics/astrophysics – this chapter also considers interdisciplinary programs like digital and media arts and fine arts to understand how the Cielo Centro Observatory can support and improve student outcomes for all learners.[16]

Table 1: UNM-Taos Undergraduate Enrollment by Demographics and Status (F2021–S2025)

	Fall 2021	Spring 2022	Fall 2022	Spring 2023	Fall 2023	Spring 2024	Fall 2024	Spring 2025	Average (F2021–S2025)
Headcount									
Total Headcount	1,284	1,115	1,282	1,287	1,290	1,239	1,292	1,337	1,266
Home Student Headcount	732	539	787	802	857	812	897	881	788
Gender									
Male	257	186	282	291	315	291	329	320	284
Male (Pre-Science)	26	26	26	27	27	32	22	25	26
Female	475	353	505	511	542	521	566	559	504
Female (Pre-Science)	56	46	47	54	61	57	78	86	61
Not Reported	0	0	0	0	0	0	2	2	2
Ethnicity									
American Indian/Alaska Native	37	25	35	50	38	54	51	60	44

[13] https://www.bhdp.com/insights/college-campus-design-crafting-spaces-diverse-student-population
[14] https://extendingnmhn.unm.edu/cnmunm-branch-campus-information.html
[15] Total enrollment includes all students who are enrolled at UNM-Taos in a given semester. However, a share of the enrollment includes students from other UNM campuses (these are called 'visiting' students). Home students are those for which their primary/home campus is UNM-Taos (students in degree-seeking programs, dual credit students, and non-degree students).
[16] https://taos.unm.edu/academic-programs/degrees-and-certificates/

American Indian/Alaska Native (Pre-Science)	7	4	8	7	4	6	5	6	6
Asian	5	3	6	4	6	3	7	11	6
Asian (Pre-Science)	1	1	0	1	1	1	1	1	1
Black or African American	5	4	4	5	8	6	4	4	5
Black or African American (Pre-Science)	1	1	0	0	2	2	1	1	1
Hispanic	416	267	446	421	475	447	511	486	434
Hispanic (Pre-Science)	45	33	39	42	53	51	72	77	52
International	3	2	3	2	0	0	1	1	2
International (Pre-Science)	0	0	0	0	0	0	0	1	0
Native Hawaiian	1	1	2	1	1	0	0	0	1
Native Hawaiian (Pre-Science)	0	0	0	0	0	0	0	0	0
2+ Races	17	16	18	18	10	10	8	10	13
2+ Races (Pre-Science)	2	2	2	3	1	0	0	0	1
Unknown	26	20	35	35	43	36	44	40	35
Unknown (Pre-Science)	4	5	6	5	5	5	5	3	5
White Non-Hispanic	222	201	238	266	276	256	271	269	250
White Non-Hispanic (Pre-Science)	22	26	18	23	22	24	16	22	22
Student by Population									
Concurrent/Dual Credit	347	239	390	373	378	364	421	409	365
Concurrent/Dual Credit (Pre-Science)	0	0	0	0	0	0	0	0	0
Continuing	205	227	191	272	254	334	261	327	259
Continuing (Pre-Science)	52	60	42	62	49	71	52	90	60
First-Time/Beginning Freshman	73	20	69	45	83	29	111	42	59
First-Time/Beginning Freshman (Pre-Science)	16	6	16	6	19	5	34	7	14
New Transfer from NM, In-State	11	3	8	18	13	8	11	9	10
New Transfer from NM, In-State (Pre-Science)	2	0	1	1	2	4	5	2	2
New Transfer from Out of State	20	13	38	40	46	16	30	32	29
New Transfer from Out of State (Pre-Science)	2	1	3	4	5	2	2	4	3
Readmit	73	36	89	53	81	60	60	62	64
Readmit (Pre-Science)	10	5	11	8	13	7	6	8	9
Other	3	1	2	1	2	1	3	0	2
Other (Pre-Science)	0	0	0	0	0	0	1	0	0

3.1. Gender

At UNM-Taos, females have consistently made up the majority of the population, averaging 64.0% over the last eight semesters, compared to 36.0% for males. This trend is also reflected among pre-science majors, with more females than males declaring this major. Relative to the overall student population, 12.1% of female students and 9.2% of male students are enrolled in the pre-science program.

Table 2: UNM-Taos Undergraduate Enrollment by Gender (Pre-Science vs. All Majors, F2021–S2025)

	Fall 2021	Spring 2022	Fall 2022	Spring 2023	Fall 2023	Spring 2024	Fall 2024	Spring 2025	Average (F2021–S2025)
% Males Enrolled in Pre-Science Relative to All Majors	10.1%	14.0%	9.2%	9.3%	8.6%	11.0%	6.7%	7.8%	9.2%
% Females Enrolled in Pre-Science Relative to All Majors	11.8%	13.0%	9.3%	10.6%	11.3%	10.9%	13.8%	15.4%	12.1%

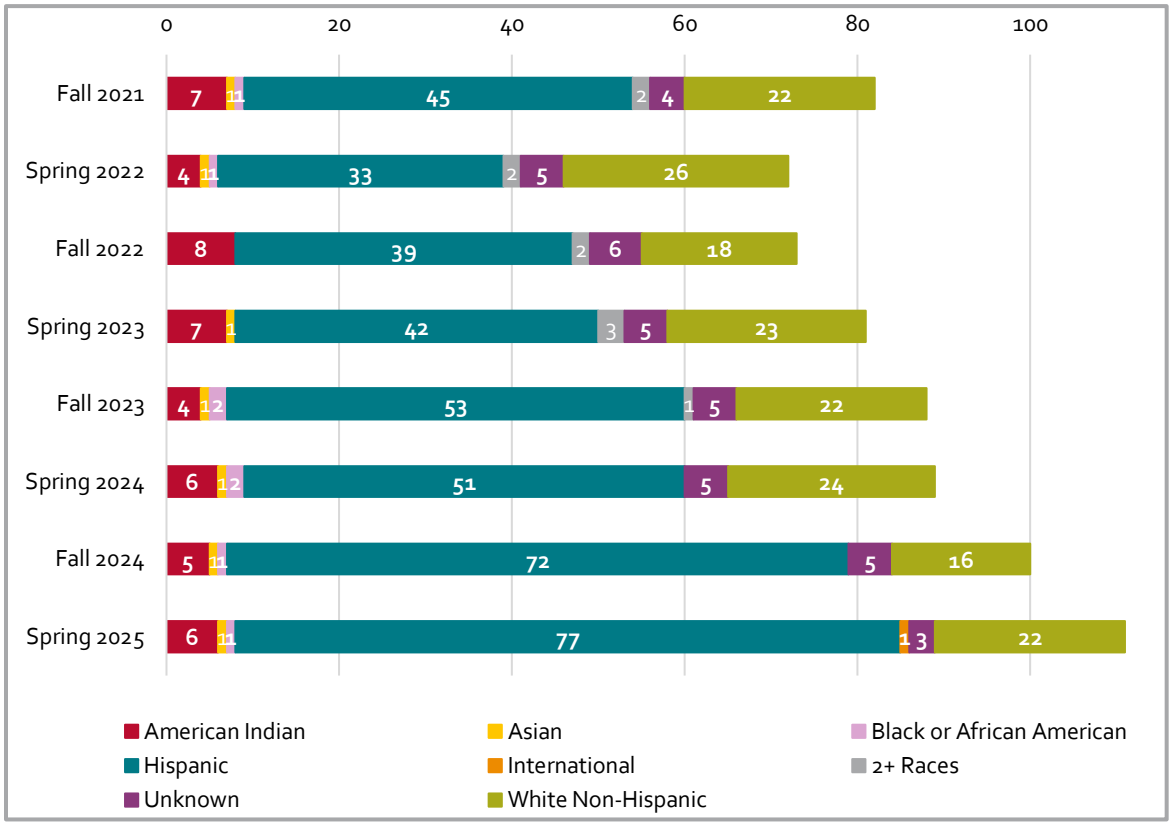
3.2. Ethnicity

The ethnic composition of undergraduate students has remained stagnant over the past four years, with only modest shifts among major groups. Hispanic students continue to represent the majority of the student population at 54.9%, followed by White (non-Hispanic) students at 31.6%.[17]

Unsurprisingly, these statistics also hold true for pre-science majors, as shown in Figure 3 below. While enrollment among most ethnic groups has remained relatively stable over the last few years, the number of Hispanic students declaring pre-science as their major has increased.

[17] Because UNM is a Hispanic-serving institution, anyone who self-identifies as Hispanic and some other race/ethnicity is categorized as Hispanic.

Figure 3: UNM-Taos Undergraduate Enrollment by Ethnicity for the Pre-Science Major (F2021–S2025)



3.3. Student Status and Residency

Flagship institutions like The University of New Mexico cover large geographical areas with diverse markets and student needs. Branch campuses help meet these needs by supporting all types of learners seeking flexible, local access to education.[18] And this is no exception for UNM-Taos, where most students are part-time, in-state residents.

Not only do branch campuses allow students to begin their education close to home (often up to an associate's degree) – but they also tend to have lower tuition and fees. When comparing the per-credit hour tuition rate between UNM-Taos and the Albuquerque campus, tuition is 71.4% cheaper for residents and 80.3% lower for non-residents at UNM-Taos.[19] Students at the Albuquerque campus are also subject to various fees, including course fees, premiums for upper-division courses, athletic fees, student government fees, counseling and technology fees, and academic program fees. UNM-Taos students, on the other hand, incur a singular, flat-rate support service fee.

[18] Fraser (2016), pp.9, 13

[19] Note that 300- and 400-level courses are subject to main campus tuition and fees. Moreover, tuition rates for bachelor and graduate programs are the same as those on main campus. See the link for more details: https://taos.unm.edu/students/admissions-and-enrollment/tuition-costs.html

Tuition Rates	UNM-Taos (Per Credit Hour)[20]	Albuquerque Campus (Per Credit Hour)[21]
Resident	$81.00	$283.46
Non-Resident	$206.00	$1,047.44

Branch campuses also provide educational access to high school students who are enrolled in dual credit programs by providing them with the opportunity to earn college credit through academic or technical courses.[22] While first-time college students have made up the majority of enrollment in the early semesters, their numbers have fluctuated significantly, with dual credit enrollment increasing significantly over the same period (Fall 2021 – Spring 2025).

3.4. Transfer Admissions

From 2017 to 2024, 1,263 students from UNM's four branch campuses – Gallup, Los Alamos, Taos, and Valencia – transferred to the Albuquerque campus. Of these students, 26 held associate degrees prior to transferring, and 362 went on to graduate with a bachelor's degree from UNM. UNM-Taos accounted for 178 of those transfer students, including one who already earned an associate degree prior to transferring. Transfer student data have also been disaggregated by gender and academic year, as seen in Table 3 below.

Table 3: Transfers from UNM-Taos to UNM Main Campus by Gender (AY2017–AY2024)

Academic Year	Male	Female
2017–18	18	26
2018–19	2	19
2019–20	11	19
2020–21	4	24
2021–22	2	17
2022–23	7	14
2023–24	6	9
Total	**50**	**128**

Among pre-science majors, only two male students transferred to UNM – one in the 2019–20 academic year and the other in the 2022–23 academic year. While this may initially appear alarming, this statistic most likely reflects the small size of the program and shifting student interests. Moreover, since pre-science is not offered as a major at the Albuquerque campus, it is possible that students declared a science-related major (e.g., earth and planetary science, physics, chemistry, etc.) when enrolling instead of transferring under the pre-science designation.

3.5. Expanding Interdisciplinary Access

While the pre-science major represents a natural academic nexus for the Cielo Centro Observatory, the facility is equally positioned to serve as a high-impact experiential learning site for students across disciplines. In

[20] This is based on the Fall 2024 Undergraduate Tuition Rate for 1 to 14 hours (per hour).
[21] This is based on the most recent undergraduate tuition rates (per hour).
[22] https://taos.unm.edu/academic-programs/dual-enrollment/

particular, the Film and Digital Media Arts (FDMA) and Fine Arts programs at UNM-Taos are equally aligned to leverage the observatory as a creative production and storytelling laboratory.

The FDMA program has developed a strong regional reputation for producing high-quality digital content centered on outdoor landscapes, tourism, environmental narratives, and cultural storytelling. Students regularly engage in location-based production work that integrates technical filmmaking skills with community engagement and regional identity. As such, the Cielo Centro Observatory can provide a dynamic setting for students to produce documentary films, short features, astrophotography, promotional media, livestreamed observing sessions, and immersive visual storytelling projects. Similarly, Fine Arts students can participate in the design and creation of interpretive installations, public art components along the natural/solar system trail, exhibition materials, and interdisciplinary art-science collaborations. These experiences would allow students to build professional portfolios while contributing directly to the observatory's outreach, marketing, and educational programming.

By positioning the observatory as both a scientific and creative space, UNM-Taos can foster cross-disciplinary collaboration that reflects contemporary workforce trends by intersecting digital media, science, communication, and experiential design. This model can also strengthen student learning outcomes while simultaneously enhancing the observatory's visibility and long-term sustainability.

3.6. Conclusion

The undergraduate student profile at UNM-Taos is not a one-size-fits-all: first-generation, underserved, and non-traditional students often face distinct challenges in navigating the systems and social structures embedded within the education-to-employment environment.[23] The Cielo Centro Observatory, however, has the potential to bridge this gap by offering programs, mentorship, and research opportunities that more effectively support existing and incoming students. Through targeted outreach efforts, pre-science and non-pre-science majors alike can engage in research and hands-on learning experiences at the observatory, while also exploring avenues for strategic alliances through which students, faculty, instruction, and job training are shared among colleges, universities, laboratories, and corporations.

The observatory can also strengthen UNM-Taos' institutional capacity to serve a diverse student population by functioning as a collaborative hub where technical, artistic, and cultural competencies converge. As discussed in Section 3.5, the observatory's impact is not just limited to STEM pathways. By serving as an experiential learning site for programs such as Film and Digital Media Arts and Fine Arts, Cielo Centro expands access to applied, place-based learning across disciplines. The integration of art and astronomy – through photography, projection art, sculpture, sound design, and multimedia installations – can deepen public engagement and broaden the accessibility of scientific content.

The next chapter evaluates the quality of the night sky's seeing and transparency in Taos by analyzing topographic, environmental, and atmospheric conditions, including elevation, air quality, light pollution, cloud coverage, wind speed, and dew point.

[23] These obstacles may stem from financial constraints, learning styles, limited access to industry connections, and a long-standing reputation that STEM fields are both challenging and competitive.

Environmental and Atmospheric Conditions

New Mexico is a geographic mosaic – a land of striking, diverse ecosystems encompassed by variations in climate, vegetation, and wildlife that influence the region's climate and topography.[24] And this finding can also be extended to describe the topography of Taos. Bordered by the Sangre de Cristo Mountains (the southernmost subrange of the Rocky Mountains) to the east and the Picuris Mountains to the south, its elevation of 6,967 feet in the mountainous, high desert region of northern New Mexico near the 1000-year-old Taos Pueblo make Taos an optimal location for stargazing.[25] Not only does the natural formation of mountains block light pollution from near and far, but its higher elevation also offers the opportunity to be "above the dense air at low altitudes that contains haze, fog, and smoke that mask [the] view of the stars."[26]

In conjunction with topography, environmental and atmospheric factors such as air quality, light pollution, cloud coverage, wind speed, and dew point can also affect seeing conditions. The rest of this chapter is dedicated to exploring these factors for Taos and other comparable geographies in New Mexico, where applicable.[27]

4.1. Air Quality

Research has shown that air quality plays a major role in how the night sky appears. High concentrations of particulate matter raise the air quality index (AQI), which causes the night sky to look brighter, hazier, and less transparent.[28]

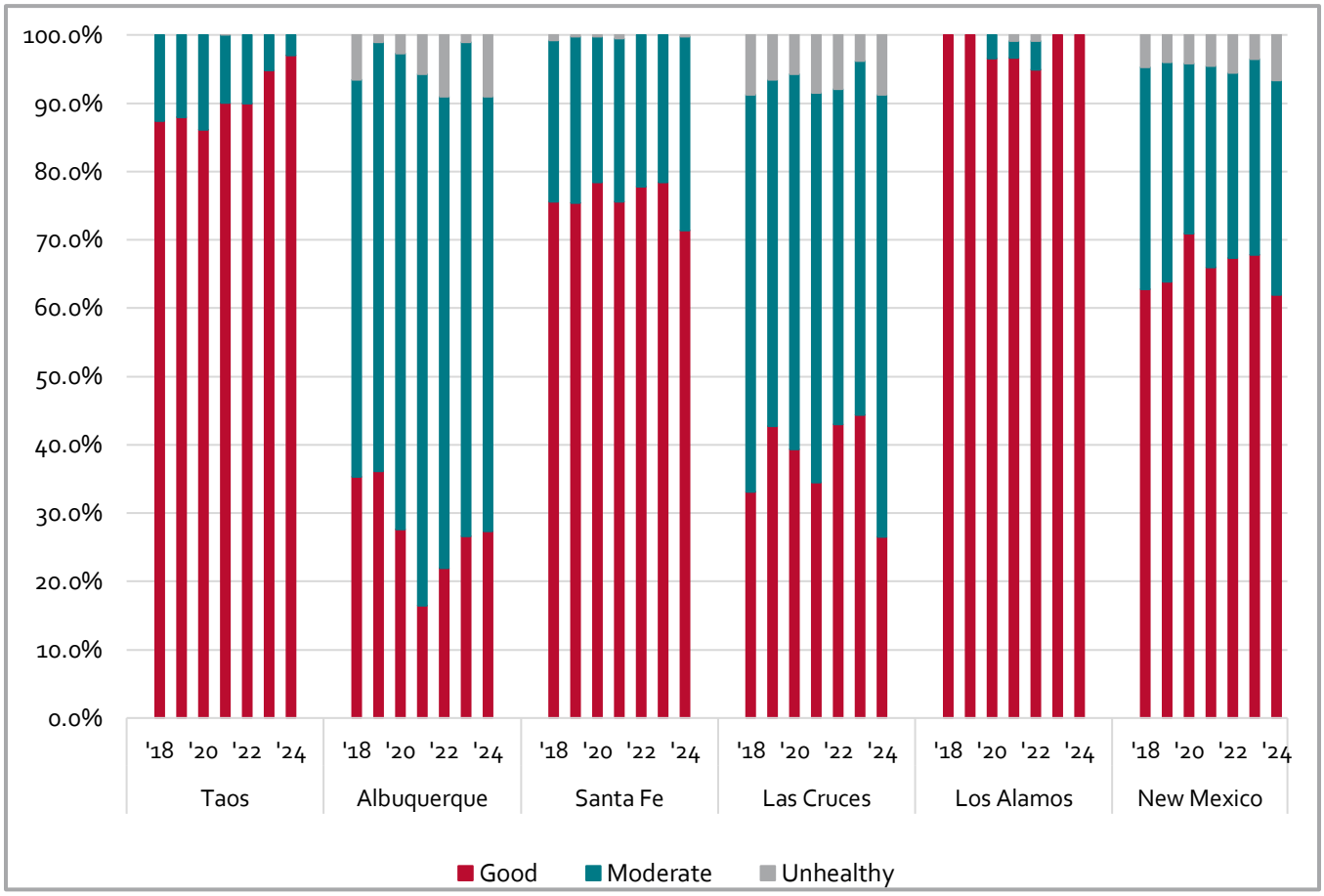
The United States Environmental Protection Agency (EPA) monitors air quality by recording concentrations of major pollutants regulated by the Clean Air Act. The raw measurements are then converted into a separate air quality index (AQI) value for each pollutant (ground-level ozone, particle pollution, carbon monoxide, and sulfur dioxide) using standard formulas developed by the EPA. The highest of these AQI values is reported as the AQI value for that day and categorized using the following scale:

- Good Days (AQI: 0–50)
- Moderate Days (AQI: 51–100)
- Unhealthy Days (AQI: 101–200)
- Very Unhealthy Days (AQI: 201–300)
- Hazardous Days (AQI: 301+)

Figure 4 below visually displays the number of days within each AQI category for Taos and other comparable geographies.

[24] New Mexico is home to mountains, forests, grasslands, and deserts.
[25] https://geoinfo.nmt.edu/geoscience/projects/astronauts/geologic-setting.html
[26] https://science.nasa.gov/solar-system/how-to-find-good-places-to-stargaze/#:~:text=Getting%20farther%20way%20from%20population,can%20make%20for%20clearer%20skies.
[27] For instances where data for Taos were not available, data for Taos County were used instead.
[28] https://www.nps.gov/subjects/nightskies/lightpollution.htm

Figure 4: Air Quality Index - Taos County vs. Select Counties and the State (2018–2024)



As the chart above displays, Taos had excellent air quality from 2018 to 2024, with air pollution posing little to no risk. "Good" AQI conditions were recorded for 90% of the year, and air quality overall remained within satisfactory thresholds for all population groups year-round (with only one unhealthy day reported in 2020). While it may seem as though Los Alamos reported slightly better air quality values than Taos, it is also important to note that Los Alamos only recorded AQI values for about one-third of the year (~120 days). Consequently, Los Alamos' true annual air quality index may have been either lower, higher, or similar to what the available data suggest. Thus, taken together, Taos has had better air quality than other comparable geographies (including the state as a whole), a finding that may be attributed to the higher elevation, arid climate, and minimal industrial activity – more of which will be discussed in the subsequent subsections.

4.2. Light Pollution

The shift from dark skies filled with celestial wonders to bright skies scattered by artificial light did not occur until the late nineteenth century when the emergence and intensification of electrification catalyzed industrial development and redesigned the way the world and society function.[29] The creation and production of artificial

[29] https://newsroom.ucla.edu/releases/new-report-global-light-pollution-consequences-solutions#:~:text=The%20growing%20use%20of%20outdoor%20lights&text=The%20conference%20included%20astronomers%2C%20conservation,vision%2C%20which%20lowers%20overall%20awareness.

light – ranging from incandescent light bulbs to LED lights – has resulted in a round-the-clock operation in which inhabited areas lack exposure to complete darkness. Despite the early recognition of this issue by astronomers in the 1970s, significant measures to address the impacts of light pollution only emerged recently. This delay can be attributed, in part, to two reasons:

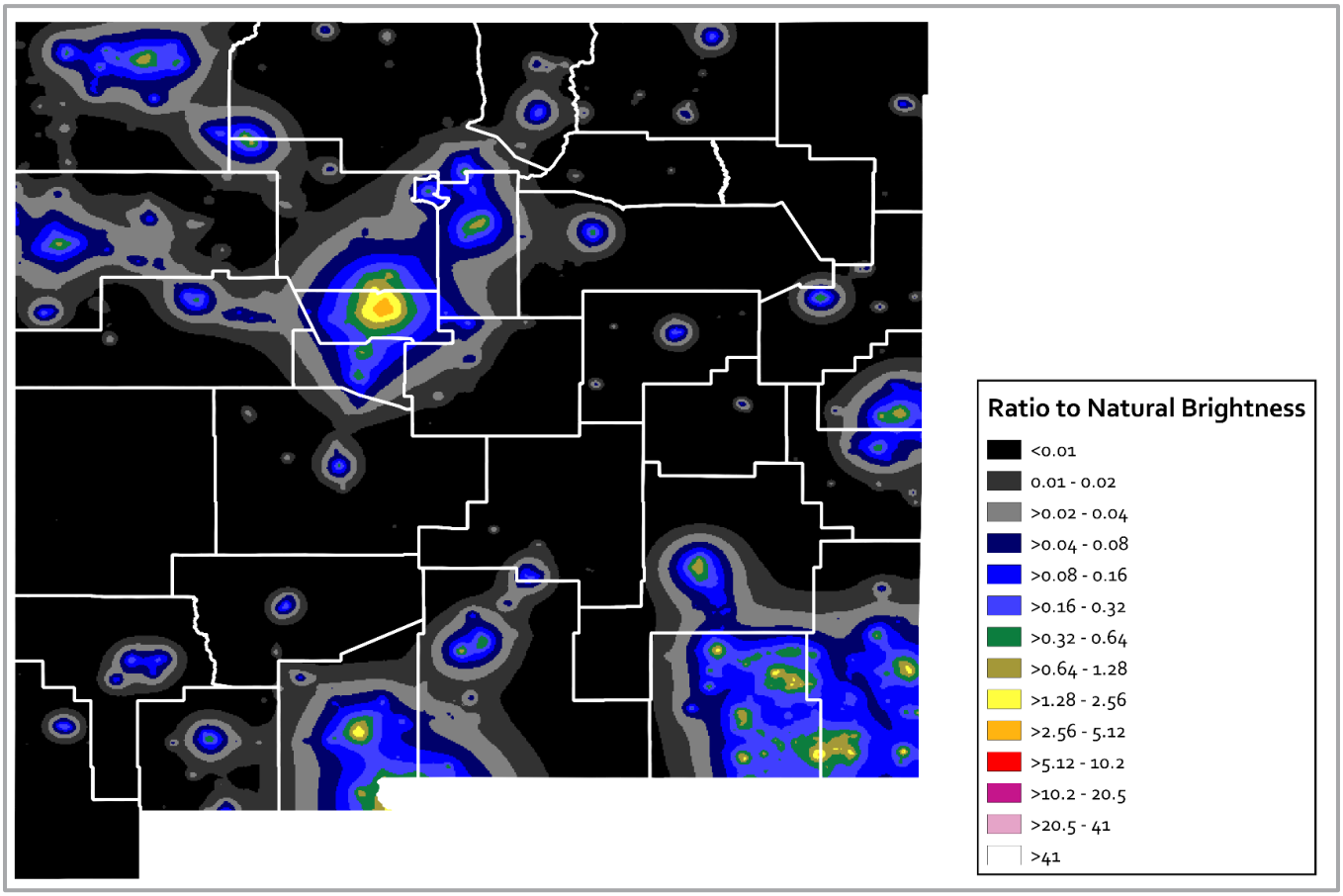
1. Light pollution is a relatively modern phenomenon, and its harmful effects were still novel.[30]
2. Early measurements of light pollution were conducted through the classified United States government Defense Meteorological Satellite Program (DMSP), thereby limiting public access to data and images.[31]

It was not until the declassification of the DMSP in the early 1990s that civilian researchers were able to launch satellites and share images of the Earth at night. In 2001, a group of researchers led by Pierantonio Cinzano released the *First World Atlas of the Artificial Night Sky Brightness*.[32] In 2016, Fabio Falchi and Cinzano – who also worked on the 2001 atlas – refined the methodology and instrumentation by using "new high-resolution satellite data and new precision sky brightness measurements" to quantify the impact of light pollution. Titled *The New World Atlas of Artificial Night Sky Brightness*, this study found that light pollution is increasing by 10 percent every year, more than 80 percent of the world's population lives under light-polluted skies, and some populations cannot even see the Milky Way Galaxy.[33] This is because artificial lights raise night sky luminance, creating the most visible effect of light pollution: skyglow. Not only does skyglow affect urban clusters, but it can also disperse light pollution to remote areas, thereby compromising the night sky. Studies have also shown that light pollution hinders astronomical research, disrupts biodiversity, increases carbon dioxide which contributes to climate change, and impacts human health – effects that will be discussed in greater detail in Section 7.3.1.[34]

Using supplemental data released by Falchi et al., maps were created to visualize the effects of light pollution in the continental United States relative to conditions in New Mexico. The same color scale presented in the study was used to represent the degree to which the night sky deviates from a "pristine" state. Black indicates the most pristine skies, with artificial brightness at no more than 1% of the natural background (<0.01). Dark gray, representing 1-2% (0.01–0.02), signals the need to protect these areas from future increases in light pollution. Blue (0.08–0.16) suggests that the sky may be polluted from an astronomical standpoint. Yellow (1.28–2.56) indicates that the Milky Way cannot be seen in the winter months, whereas orange (2.56–5.12) indicates that the Milky Way cannot be seen neither in the winter nor in the summer. In areas that appear red, "people never experience conditions resembling a true night because it is masked by an artificial twilight."[35]

[30] https://education.nationalgeographic.org/resource/light-pollution/
[31] https://darksky.org/news/new-research-strengthens-ability-to-monitor-light-pollution-from-orbit/
[32] See Cinzano et al. (2001)
[33] Falchi et al. (2016), Abstract
[34] See Dunn and Edensor (2023), Silver and Hickey (2020), Alva et al. (2023)
[35] Falchi et al. (2016), pp. 2-3

Figure 5: Light Pollution - Artificial Night Sky Brightness in New Mexico (2016)



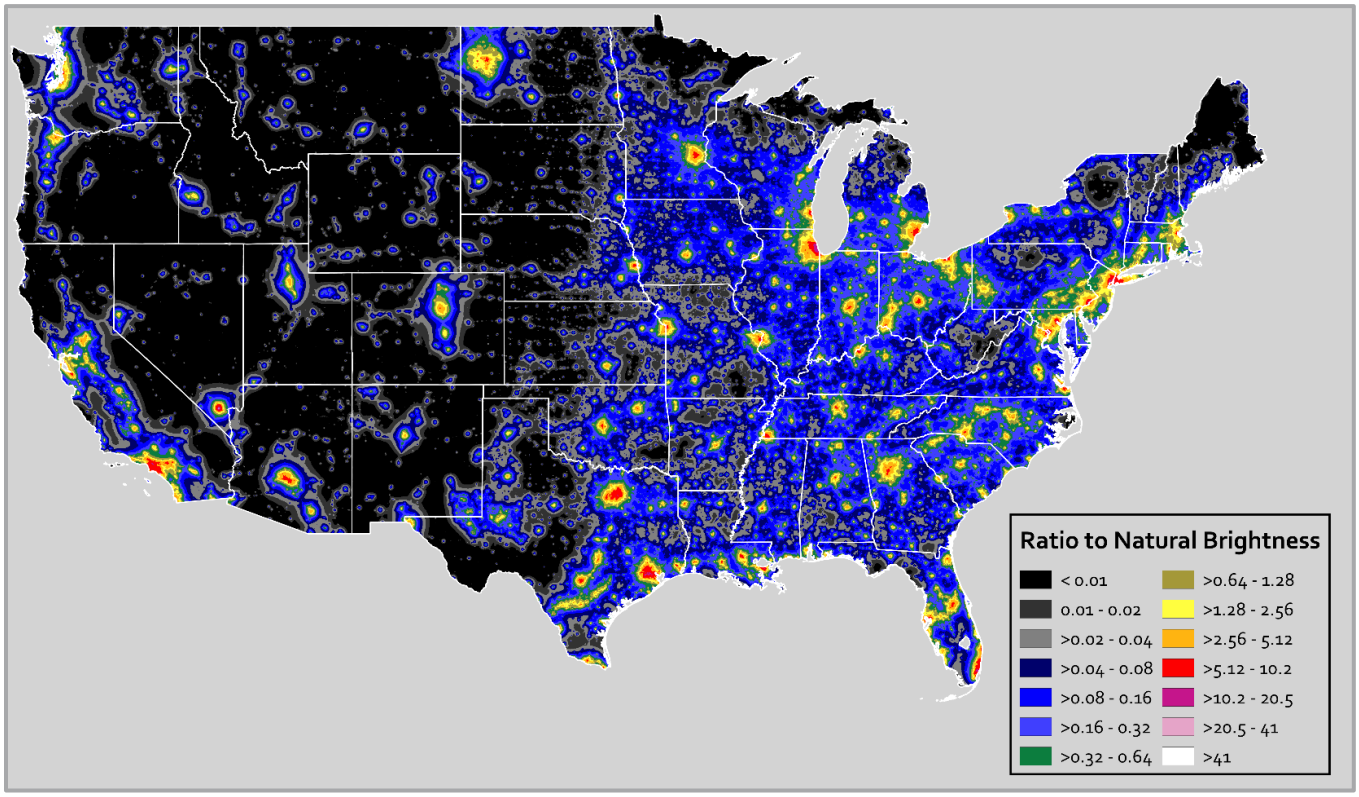
Source: The New World Atlas of Artificial Night Sky Brightness. Cartographer: Alexis P. Amodio-Cardwell

Fortunately, in 2016, New Mexico contained no regions classified as red, magenta, light pink, or white. Nevertheless, it is to be expected that larger and more developed areas generate higher levels of light pollution. A granular analysis reveals that urban clusters like Albuquerque, Santa Fe, Las Cruces, Farmington, Gallup, Clovis, and Roswell – as well as the oil- and gas-producing Lea and Eddy Counties in southeastern New Mexico – emitted modest quantities of light pollution. This is because many outdoor lights are not shielded, thereby allowing excess light to escape into the atmosphere.

Findings for Taos and Taos County, however, followed a different arc: light pollution did not exceed any thresholds that are considered threatening (despite being in and in close proximity to population centers). This yields favorable outcomes for the potential success of the Cielo Centro Observatory, as UNM-Taos can take a leading role in promoting the value of the night skies while positioning the state to secure its position as a pioneer in astrotourism and dark sky conservation. UNM-Taos can also benefit from its geographic proximity to Taos, an established domestic and international destination that is well suited to include astrotourism into its offerings.

Without sustained mitigation, however, light pollution conditions in New Mexico could worsen in ways already seen across the central and eastern United States. See Figure 6 for a visual overview.

Figure 6: Light Pollution in 2016 in the Continental U.S.



Source: The New World Atlas of Artificial Night Sky Brightness. Cartographer: Alexis P. Amodio-Cardwell

4.3. Cloud Coverage, Wind Speed, and Dew Point

According to information published by the National Park Service (NPS) and other relevant space agencies, it is best to view the night sky "at least 1.5 hours after sunset or 1.5 hours before sunrise" to avoid the sun lightening the sky.[36] Thus, for our purposes, we have only analyzed sky conditions (cloud coverage), wind speed, and dew point during post-sunset and pre-sunrise hours to determine seeing conditions.

Data from the Local Climatological Data Version 2 (LCDv2) provided by the NOAA National Centers for Environmental Information (NCEI) were used, and hourly observations collected at the "Taos Municipal Airport" fixed weather station were analyzed. For more information on how the data were processed and calculated, refer to Appendix A: Data and Methodology.

4.3.1. Cloud Coverage

Given that clouds are composed of individual water droplets that scatter sunlight in different directions, light is reflected downward to the ground, thereby causing the night sky to appear significantly brighter than it would under clear conditions. When combined with light pollution from cities and towns, research has shown that

[36] https://www.nps.gov/grsa/planyourvisit/experiencethenight.htm

"clouds can extend the reach of sky glow into remote areas not affected by light pollution on clear nights."[37] For this reason, clear skies are especially important for good visibility and seeing conditions.

As shown in Table 4 below, Taos has had an average of 80.5% clear or mostly clear skies over the past seven years. This level of clarity is considered excellent, especially for a high-elevation, mountainous region where comparable areas like Flagstaff, Arizona, frequently experience cloud formation and changing weather.[38,39]

With the presence of clear skies, stars can appear brighter and atmospheric distortion can be minimized, thereby making Taos an ideal location for a state-of-the-art telescope and observatory.

Table 4: Types of Cloud Coverage in Taos, New Mexico (2018–2024)[40]

	2018	2019	2020	2021	2022	2023	2024	Average
Clear	76.7%	73.6%	78.8%	77.2%	76.2%	73.7%	70.5%	75.2%
Mostly Clear/Mostly Sunny	3.9%	5.2%	3.5%	3.9%	4.6%	5.0%	10.4%	5.2%
Partly Cloudy	3.6%	2.8%	3.3%	3.1%	3.0%	3.2%	2.9%	3.1%
Mostly Cloudy	5.4%	5.7%	4.7%	5.1%	5.5%	6.3%	5.3%	5.4%
Cloudy	10.4%	12.7%	9.6%	10.6%	10.7%	11.8%	10.9%	11.0%
Favorable Conditions (Clear + Mostly Clear)	**80.6%**	**78.8%**	**82.4%**	**81.1%**	**80.8%**	**78.7%**	**80.9%**	**80.5%**

4.3.2. Wind Speed

Any time the wind changes speed, direction, or moves around obstacles (particularly buildings), disruptions in airflow occur. Known as eddies, these turbulent swirls move air vertically, causing cold air from higher altitudes to move down and warm air near the ground to travel up.[41] Because of these irregularities in the atmosphere – which are caused by clashes in energy and temperature – stars appear to twinkle, an indicator that the seeing conditions are poor.[42]

Table 5 indicates that approximately 96.6% of wind speeds were below 8 miles per hour (mph), with the majority (76.5%) ranging between 0 and 3 mph. Even though air typically becomes less dense and more fluid at higher altitudes (often resulting in stronger winds near mountains), Taos does not experience this phenomenon. As a result, this protection from high wind gusts further supports the claim that Taos (and more

[37] Ściężor (2020), p. 3
[38] https://www.flagstaff.com/weather
[39] Flagstaff, Arizona, was recognized as the world's first International Dark Sky City in 2001.
[40] Sample Sizes for Each Year: 2018 = 2797, 2019 = 2395, 2020 = 2989, 2021 = 2895, 2022 = 2772, 2023 = 2729, 2024 = 2426
[41] https://www.weather.gov/source/zhu/ZHU_Training_Page/winds/nighttime_influences/Nighttime_Influences.htm#:~:text=The%20Wind%20Also%20Stirs%20Things,have%20on%20surface%20air%20temperatures?
[42] https://www.assa.org.au/resources/sky-watching/seeing/

specifically, UNM-Taos) will be able to safely and effectively operate a high-performance telescope within the proposed observatory.

Table 5: Wind Speed in Taos, New Mexico (2018–2024)[43]

Description (Beaufort Number)	Speed	2018	2019	2020	2021	2022	2023	2024	Average
Calm (0)	Calm	14.5%	12.6%	13.7%	12.2%	13.4%	12.6%	13.1%	13.2%
Light Air (1)	1 to 3 mph	63.3%	65.7%	62.8%	61.3%	62.0%	64.7%	63.4%	63.3%
Light Breeze (2)	4 to 7 mph	18.6%	18.9%	19.4%	22.3%	21.0%	20.1%	20.2%	20.1%
Gentle Breeze (3)	8 to 12 mph	3.3%	2.8%	3.9%	4.0%	3.3%	2.6%	3.3%	3.3%
Moderate Breeze (4)	13 to 18 mph	0.3%	0.1%	0.2%	0.2%)	0.3%	0.1%	0.2%	0.2%
Fresh Breeze (5) – Hurricane Force (12)	19 to 75+ mph	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

4.3.3. Dew Point

Similar to cloud composition, the individual water droplets that scatter the sky and form liquid water can cause seeing problems.[44] While humidity can be used to assess the conditions of the night sky, dew point can be a better measure. Dew point is the temperature needed for relative humidity (RH) to equal 100%. For example, if the dew point is zero degrees, then the temperature must be zero degrees for the RH to be 100%. There is a direct relationship between dew point and moisture: the higher the dew point, the more moisture there is and vice versa.[45]

[43] Sample Sizes for Each Year: 2018 = 3464, 2019 = 3435, 2020 = 3299, 2021 = 3304, 2022 = 3535, 2023 = 3642, 2024 = 3185
[44] https://www.discovermagazine.com/sky-lights-68-15662
[45] https://www.weather.gov/arx/why_dewpoint_vs_humidity

Table 6: Dew Point Temperature in Taos, New Mexico (2018–2024)[46]

Dew Point Temperature (°F)	Description	2018	2019	2020	2021	2022	2023	2024	Average
Less Than or Equal to 55	Dry and Comfortable	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Between 55 and 65	Becoming "Sticky" with Muggy Evenings	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Greater Than or Equal to 65	Lots of Moisture in the Air, Becoming Oppressive	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average Dew Point Temperature (°F)	-	**-4.9**	**-4.0**	**-4.8**	**-4.3**	**-3.7**	**-4.0**	**-3.4**	**-4.2**
Max Dew Point Temperature (°F)	-	**14.0**	**14.4**	**15.0**	**14.4**	**15.0**	**15.0**	**16.0**	**14.8**

High levels of moisture resulting from relative humidity can cause the telescope's "optical system and electrical wires to oxidate or leach if it is not protected."[47] As Table 6 displays, Taos has experienced "dry and comfortable" dew point temperatures from 2018 to 2024, with both the average and maximum values well below the "sticky" threshold (the second tier). These conditions, again, suggest that observer comfort and the performance of equipment will not be impaired, further supporting the conclusion that UNM-Taos is well-suited for the construction of the Cielo Centro Observatory and the housing of the 36-inch telescope.

4.4. Conclusion

In summary, Taos' high elevation and mountainous terrain in northern New Mexico naturally dissipate light pollution triggered from nearby urban areas. Combined with favorable environmental and atmospheric conditions – including good air quality, 80.5% favorable cloud conditions, 96.6% calm-to-light wind patterns, and a 100% dry and comfortable dew point – these factors support stable, high-quality observing conditions. Together, they reinforce the claim that UNM-Taos is an ideal site for the Cielo Centro Observatory – designed to deepen local science education and innovation and promote astrotourism.

The next chapter discusses astrotourism in New Mexico with a special emphasis on International Dark Sky Places.

[46] Sample Sizes for Each Year: 2018 = 3519, 2019 = 3580, 2020 = 3665, 2021 = 3475, 2022 = 3658, 2023 = 3693, 2024 = 3709
[47] See Haslebacher et al. (2022), p. 3 and Bradley et al. (2006), p. 176

Astrotourism in New Mexico

Astronomy tourism, commonly known by the portmanteau "astrotourism," has recently emerged as an interdisciplinary, multifaceted form of tourism designed to expose individuals to the night sky by promoting science engagement and education, eco-friendly development, cultural immersion, and environmental conservation.[48] Although astrotourism was initially centered on scientific exploration and astronomical instruments, it has since expanded its focus by converging different sectors to form a shared, community-centric approach.

New Mexico True, the official tourism campaign for the state, promotes programs by highlighting unique experiences that align with current travel trends. Astrotourism, a form of noctourism, has been identified as one of the "next biggest trends," and New Mexico True has been enthusiastically championing the state's dark skies.[49] This commitment is exemplified by the creation of a curated guide called the "New Mexico True Space & Technology Trail." Featuring 30 locations ranging from science and technology museums to space and astronomy sites, this journey celebrates and commemorates the state's rich scientific heritage while reinforcing its commitment to remain relevant in the field.[50]

The first half of this chapter provides a detailed examination of some of the places featured on the Space & Technology Trail, focusing on how local organizations have created experiences that promote astrotourism. The second half is dedicated to the International Dark Sky Places program and New Mexico's nine certified Dark Sky Places.

5.1. Identifying Different Forms of Astrotourism in New Mexico

Organizations across New Mexico coordinate events ranging from traditional stargazing and telescope viewing to sensory experiences, astrophotography, and educational programming. Table 7 below synthesizes some of these offerings using publicly available data and organizational materials.

Table 7: Astrotourism Events in New Mexico by Organization and Type. All information is publicly available.

Event	Number of Times Offered	Description
The Albuquerque Astronomical Society (2025)		
GNTO Observing	~24	Member-only viewing near 3rd Quarter or New Moon at TAAS' General Nathan Twinning Observatory (GNTO).
Public Outreach + Telescope Viewing	~29	Private and public events featuring TAAS telescopes for guided observing.
Public Talks	~11	Astronomy basics, social hour, spotlight talks, and updates.

[48] https://darksky.org/news/darksky-internationals-principles-of-responsible-astrotourism/
[49] https://www.seattletimes.com/nation-world/what-will-be-the-biggest-travel-trends-in-2026/
[50] https://www.newmexico.org/space/science-and-technology-trail/

Telescope Viewing with Other Organizations	~11	Collaborations with Chaco Culture NHP, Valle de Oro NWR, the Rio Rancho Astronomical Society, and UNM.
Telescope Help	~23	Expert telescope assistance at Manzano Mesa Multigenerational Center.
Angel Fire Resort (2024)		
Stargazing & S'mores	~5	Learn about the night sky through a telescope with an astronomer. S'mores included.
Carlsbad Caverns National Park (2025)		
Night Hikes	~10	Guided 1.5-mile hike with night sky viewing.
Night Sky/Star Viewing	~12	Explore the night sky through a powerful telescope.
El Valle Astronomers (2025)		
Star Parties	~11	Public and private star parties for educational outreach. Viewing with large telescopes and binoculars.
The Astronomical Society of Las Cruces (2025)		
New Mexico State University Open House	~8	Guided telescope observing at Tombaugh Campus Observatory on Friday closest to 1st Quarter Moon.
Moon Gaze Viewing with Telescope	~12	ASLC members set up telescopes at Plaza de Las Cruces on Saturday closest to 1st Quarter Moon.
Public Outreach + Telescope Viewing	~26	Private and public events featuring ASLC telescopes for guided observing.
State Park Public Observing	~33	Laser presentation and telescope viewing at nearby state parks.
New Mexico Museum of Natural History & Science (2025)[51]		
Fractal Shows	First Friday evening of each month	Planetarium show featuring fractals in nature and 3D fractal zooms. Showings hourly from 6pm-9pm.
James Hood's Mesmerica 360	Select Friday evenings	Planetarium visual music journey that engages the mind, senses, and feelings.
Public Talks	~4 times per year	Discussions on trending science topics, held in conjunction with Family Day.
Regularly Scheduled Planetarium Shows	Sunday–Saturday, except Tuesday	Science movies and interactive astronomy program. Showings: 11 a.m., 12 p.m., 2 p.m., 3 p.m.
Sensory Relaxed Nights	~3 times per year	Sensory-friendly programs in the museum and planetarium.
New Mexico Museum of Space History (2025)		
Astronomy League Meeting/Star Party	~4	Public observing, off-site adventures, and star shows.
Special Event	~4	Theater opening celebration, exhibit premiere, and special tours.
Public Outreach	~4	Educational camps for elementary and middle school students.

[51] The Planetarium is powered by META. A 16" observatory telescope is also used occasionally.

Public Talk/Theater Showing	~13	Public talks, lectures, star shows, and astronomy films in the planetarium and theater.
Pajarito Environmental Education Center (2025)		
Astrophotography	~3	Astrophotography workshops and exhibits.
Chaco Canyon Planetarium Experience	~2	Explore the connection between Chaco Canyon architecture and astronomy at the PEEC planetarium.
Fractal/Night Sky Planetarium Shows	~16	Planetarium night-sky tour or fractal show.
Night Hikes	~3	Moon hike.
Planetarium Movies	~61	Science movie showing in the planetarium.
Public Talks	~10	Discussion on current topics led by scientists and experts.
Rio Rancho Astronomical Society (2025)		
New Moon Observing	~9	All-night observing on Saturday closest to New Moon at White Ridge Parking Lot (San Ysidro, NM).
Public Star Party	~12	Public star party at Rainbow Park Observatory (Rio Rancho, NM).
White Sands National Monument (2024)		
Full Moon Nights	~5	Extended park hours for full moon viewing.
Moonlight Hikes	~8	Hike the dunes under the moon.
Solar Viewings	~1	View the sun in collaboration with the NM Museum of Space History.

Collectively, these offerings demonstrate how expanding the boundaries of astrotourism can "not only benefit local communities but also preserve invaluable cultural heritage and foster a deeper connection between people and the natural world."[52] For example, the Pajarito Environmental Education Center (PEEC) in Los Alamos hosts an event titled "Getting Oriented with Chaco Canyon." A collaboration between PEEC and Chaco Culture National Historical Park, this event bridges astronomy and local cultural heritage by showing visitors how the horizon cycles of the Sun and Moon are reflected in Chaco Canyon's architecture.[53]

Astrotourism can also find success when establishments integrate night-sky experiences into existing tourism offerings.[54] For example, Carlsbad Caverns National Park in southeastern New Mexico offers star viewing events through a telescope following the park's bat flight program.[55] In this scenario, Carlsbad Caverns capitalizes on existing offerings that already make the park a highly sought-after place (exploring the cave and watching the bats). Similarly, Angel Fire Resort in northern New Mexico uses astronomy as a backdrop at the "S'mores & Stargazing" event. At this event, an astronomer operates a telescope while the public enjoys s'mores.

According to an article published by Penn State University, some farms have been offering stargazing opportunities on farm stay platforms. This concept is similar to what another organization is doing in Animas, New Mexico.[56] Valley Vista Gateway, whose owner is a technician at Dark Sky New Mexico (DSNM), hosts a tiny

[52] Mdhluli (2025), p. 3
[53] Chaco Culture National Historical Park is an UNESCO World Heritage Site and International Dark Sky Park.
[54] Mdhluli (2025), p.4
[55] In this program, Brazilian free-tailed bats emerge from the cave to migrate or search for food.
[56] https://extension.psu.edu/agritourism-trend-watch-astrotourism

home cabin and RV site where guests can either bring their own telescope or use those provided to observe the night sky and/or solar prominences.[57] Guests also perform astrophotography and tour DSNM.[58]

Astrotourism also depends on collaboration between communities and organizations, as evidenced by the number of partnerships between local astronomy groups and parks.[59] Even though some organizations operate their own observatory, they continue to participate in public outreach by visiting and engaging with local communities. For example, the Las Cruces Astronomical Society hosts telescope viewing events and laser-viewing shows at Rockhound State Park, Leasburg Dam State Park, and City of Rocks State Park; the Albuquerque Astronomical Society provides telescopes to Valle de Oro National Wildlife Refuge for star parties; and the Rio Rancho Astronomical Society offers stargazing experiences at White Ridge Bike Trails, a Bureau of Land Management (BLM) site.

5.2. International Dark Sky Places

The International Dark Sky Places (IDSP) program certifies public and private spaces and facilities that preserve and protect dark skies. The program was founded in 2001 by Dark Sky International when Flagstaff, Arizona, became the world's first International Dark Sky Place. Since then, Dark Sky International has formed a certification process that recognizes areas with dark sky conservation. Qualification is based on factors like management, location, nighttime public access, resources, and night sky quality, after which interested applicants seek nominations and collaborate with Dark Sky staff to verify that they have met the requirements for one of five certification programs:[60]

- International Dark Sky Parks: Publicly or privately owned conservation areas that implement good outdoor lighting and provide dark sky programs.
- International Dark Sky Sanctuaries: The most remote (and often darkest) places in the world, whose conservation state is most fragile.
- International Dark Sky Reserves: Dark "core" zones surrounded by a populated periphery where policy controls protect the darkness of the core.
- Urban Night Sky Place: Urban sites that promote an authentic nighttime experience despite being in the midst of significant artificial light.
- International Dark Sky Communities: Cities and towns with quality outdoor lighting ordinances that educate residents about the importance of dark skies.

As of November 26, 2025, the U.S. is home to 156 designated Dark Sky Places. This total includes 93 Dark Sky Parks, 41 Dark Sky Communities, 11 Dark Sky Sanctuaries, 9 Dark Sky Places, and 2 Dark Sky Reserves. Nine of these Dark Sky Places are located in New Mexico.

Table 8 below lists the nine Dark Sky Places in New Mexico. A map is also provided to show the geographical locations of these sites in relation to UNM-Taos (marked by the red star).

[57] The owner has a 12" Schmidt Cassegrain Telescope (SCT) and a Lunt hydrogen alpha solar scope.
[58] DSNM hosts remotely operated, sophisticated telescopes.
[59] Mdhluli (2025), p. 6
[60] This infographic provides an overview of the application process.

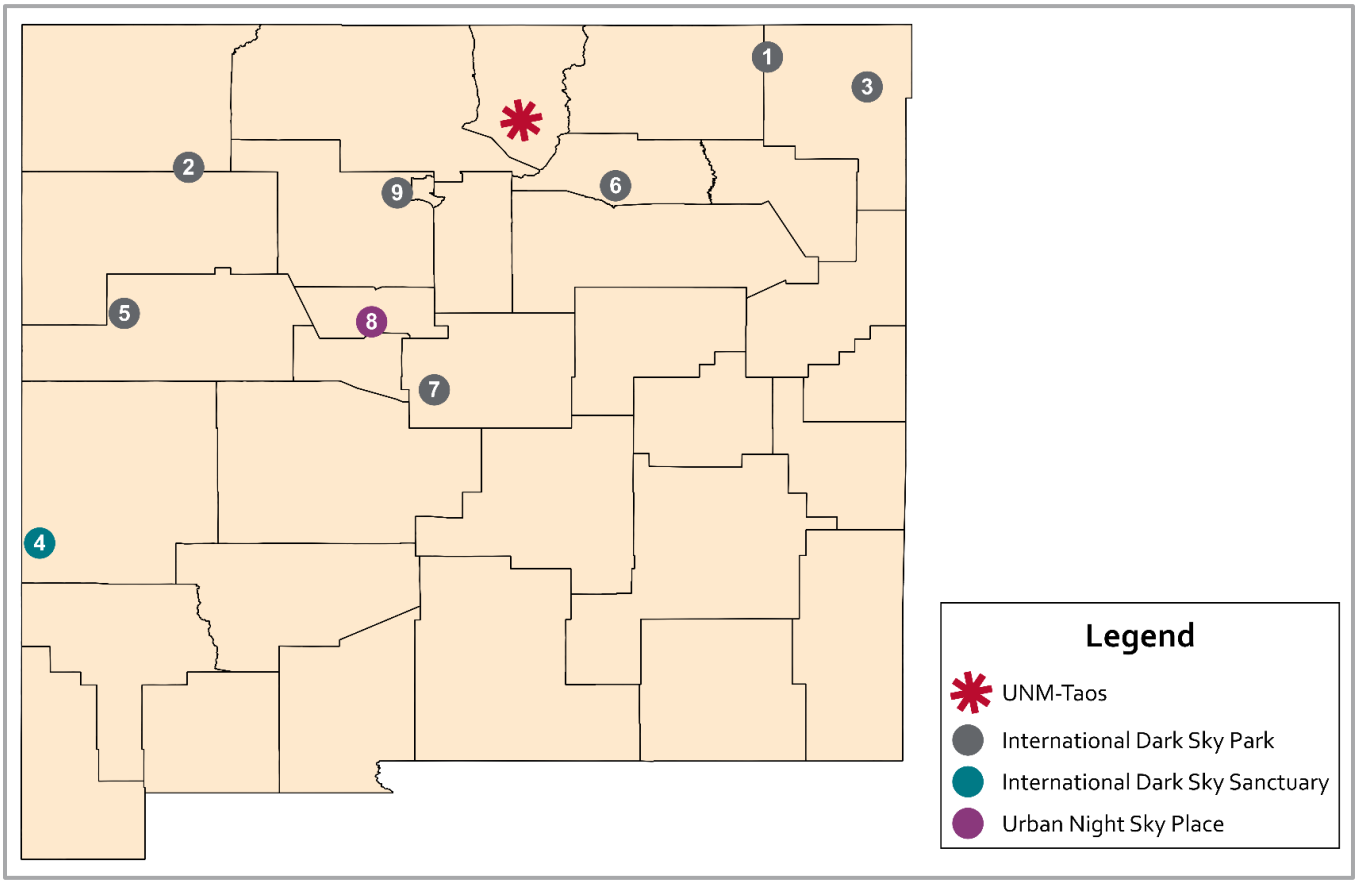
Table 8: International Dark Sky Places in New Mexico. All information is publicly available.

ID	Name	Miles from UNM-Taos	Address	Int'l Dark Sky Place Type	Designation	Admission Fee to Park (2024)	Equipment
1	Capulin Volcano National Monument	129	46 Volcano Highway Capulin, NM, 88414	Int'l Dark Sky Park	2016	$10–$20	•One 14" Meade SCT[61] •Two 8" Celestron SCTs •One 11" Celestron SCT •One Orion 14" Dobsonian
2	Chaco Culture National Historical Park	181	1808 County Road 7950 Nageezi, NM, 87037	Int'l Dark Sky Park	2013	$15–$25	•One 24" Dobsonian. •Two smaller telescopes.
3	Clayton Lake State Park	180	141 Clayton Lake Road Clayton, NM, 88415	Int'l Dark Sky Park	2010	$5–$10	•One 12" Meade inside Star Point Observatory (retractable roof)
4	Cosmic Campground	357	33°28'46.71"N 108°55'22.66"W, elevation 5360 feet Catron County, New Mexico, 88039 United States	Int'l Dark Sky Sanctuary	2016	Free	•No telescopes.
5	El Morro National Monument	245	89 Monument Drive Ramah, NM, 87321	Int'l Dark Sky Park	2019	Free	-
6	Fort Union National Monument	86	3115 SR 161 Watrous, NM 87753	Int'l Dark Sky Park	2019	Free	•Two 11" SCTs (one Meade, one Celestron) in alt-azimuth configuration. •One 11" Celestron SCT on equatorial mount. •One 14" Celestron SCT on equatorial mount.
7	Salinas Pueblo Missions	157	105 South Ripley Avenue	Int'l Dark Sky Park	2016	Free	-

[61] SCT = Schmidt Cassegrain Telescope

	National Monument		Mountainair, NM, 87036				
8	Valle de Oro National Wildlife Refuge	137	7851 2nd St SW Albuquerque, NM 87105	Urban Night Sky Place	2019	Free	•The Albuquerque Astronomical Society (TAAS) provides telescopes.
9	Valles Caldera National Preserve	78	39201 NM-4 Jemez Springs, NM 87025	Int'l Dark Sky Park	2021	$15–$25	•Three Celestron SkyMaster 8x56 Binoculars •Two SeeStar •One Celestron NexStar 8SE Computerized Telescope •One Lunt Solar Systems LS80THa •Three Hexum 80/600 Telescopes •One Celestron 11" CPC Deluxe 1100

Figure 7: Map of International Dark Sky Places in New Mexico



Source: International Dark Sky Places. Cartographer: Alexis P. Amodio-Cardwell

As shown in Table 8 above, the most recent site in New Mexico to achieve Dark Sky status was Valles Caldera National Preserve in 2021. Another site currently preparing an application for Dark Sky certification is the Rio Grande del Norte National Monument. Established on March 25, 2013, by presidential proclamation, the monument spans approximately 242,555 acres of canyons, volcanic cones, native grasslands, and wildlife.[62] It is one of 906 units managed by the Bureau of Land Management's (BLM) National Conservation Lands program. This program is designed to respect the ties that native and traditional communities have to public lands by protecting natural and cultural resources and offering opportunities for "hunting, solitude, wildlife viewing, history exploration, and scientific research."[63] The monument's unique setting also serves as a gateway to northern New Mexico's dark skies, and its 3.5-mile location west of Cielo Centro has prompted BLM to collaborate with UNM-Taos and El Valle Astronomers in their pursuit of Dark Sky certification.

Moreover, when looking at Table 8 and Figure 7 above, New Mexico currently has no designated International Dark Sky Community. Thus, pursuing and securing this accreditation can provide a major opportunity for UNM-Taos to strengthen its role in dark sky tourism in northern New Mexico and surrounding regions. This opportunity is supported by prior research, which has shown how astronomy programs have attracted visitors

[62] https://www.blm.gov/sites/blm.gov/files/Rio%20Grande%20del%20Norte%20Proclamation.pdf
[63] https://www.blm.gov/programs/national-conservation-lands

from near and far and that the inclusion of an International Dark Sky Place designation has "increased interest in many parks in rural areas that would otherwise not see high visitor presence."[64]

Astrotourism is an experiential phenomenon; it allows individuals to feel connected to the universe through the alignment of the mind, heart, and soul.

[64] Alva et al. (2023), p. 16

Case Studies

Since well before its admission to the Union in 1912, New Mexico has been encouraging space exploration, astronomical research, and astrotourism. This endeavor can be attributed to the state's geographic and environmental conditions, particularly in Taos and northwestern New Mexico. Situated within the Colorado Plateau – which stretches across the Four Corners region of Utah, Colorado, New Mexico, and Arizona – this area is characterized by high elevation, an arid climate, excellent air quality, and mostly cloudless nights.[65] Together, these conditions have supported numerous national parks, observatories, and dark sky places, presenting a rare opportunity to experience and conduct research on an extraordinary and diminishing resource: the dark night sky.

With this in mind, this section aims to inform UNM-Taos of the types of comparable observatories within New Mexico and in neighboring states by assessing the physical and operational characteristics. These observatories were selected based on a combination of the following criteria that align with the vision of the Cielo Centro Observatory:

- Physical proximity
- Similar educational mission and function
- Public accessibility
- Other programming and managerial characteristics

For each of the case studies, geographic and institutional factors are compared to understand the observatory's purpose, development, and function.

6.1. Case Study: The University of New Mexico Campus Observatory

Name: UNM Campus Observatory

Address: 800 Yale Blvd NE Albuquerque, New Mexico 87106

Distance from UNM-Taos: 129 miles

Open to the Public: Yes

Admission ($): No

Figure 8: UNM Campus Observatory. Photo Courtesy: UNM Campus Observatory

Overview: The UNM Campus Observatory was built in 1954 by the Institute of Meteoritics to house a 15-inch reflector used for research, astronomy lab classes, and public open houses.[66] Today, the observatory uses their 14-inch Celestron Edge HD telescope acquired in 2018 to provide opportunities for UNM students, school groups, and the public.

[65] https://www.npca.org/articles/341-destination-darkness
[66] https://physics.unm.edu/about/history/index.html

Observatory Use: During the week, the facility is used for academic purposes. On Friday nights, however, it is open for public viewing sessions where telescope operators will describe visible objects and answer questions.

Equipment: Received in 2018, the UNM Campus Observatory has a 14" Celestron Edge HD telescope. The telescope is located on a raised platform inside the observatory, which is only accessible via stairs.

Additional Information: During the academic year, the UNM Campus Observatory collaborates with The Albuquerque Astronomical Society to host Friday night public viewing sessions at the observatory. These events, which draw an average of 20 to 50 visitors per session, begin shortly after sunset and last two hours (weather permitting). Moreover, UNM is planning to build a new campus observatory, as evidenced by an active fund with the UNM Foundation.[67]

6.2. Case Study: The University of Texas McDonald Observatory

Name: The University of Texas McDonald Observatory

Address: 3640 Dark Sky Dr, Fort Davis, Texas 79734

Distance from UNM-Taos: 587 miles

Open to the Public: Yes

Overview: Located atop Mount Locke and Mount Fowlkes in the Davis Mountains of West Texas, the McDonald Observatory received a generous endowment from a local banker to construct an observatory "for the study and promotion of the study of Astronomical Science."[68] Since its dedication on May 5, 1939, the observatory has been expanding its presence by conducting astronomical research, teaching, and engaging in public education and outreach.

Figure 9: Aerial View of The University of Texas McDonald Observatory. Photo Courtesy: McDonald Observatory

Observatory Use: McDonald Observatory hosts ten distinct daytime and nighttime activities, with information on each event shown below.

[67] https://www.unmfund.org/s/1959/lg22/form.aspx?sid=1959&gid=2&pgid=478&cid=1147&dids=3136&bledit=1
[68] https://mcdonaldobservatory.org/about/milestones

Event Name	Time	Admission ($)	Number of Events (2025)	Description
Visitor Center General Admission	12 p.m.–4:30 p.m.	$3	Tuesday through Saturday	Access the Visitor Center, outdoor telescope park, and take self-guided tours of the summits.
Solar Viewing	Normally at 1pm	$5	Tuesday through Saturday	Explore the Sun in the Visitor Center Theater.
Guided Tour	Normally at 2 p.m.	$5–$10	Tuesday through Saturday	90-minute guided tour of the 107-inch Harlan J. Smith Telescope and the Hobby-Eberly Telescope (HET).
Star Party	After Sunset	$5–$25	~165	Experience the night sky through telescope viewing.
Special Guided Otto Struve Telescope Tour	Normally at 12:30 p.m.	$5–$10	~30	75-minute guided tour of the 82-inch Otto Struve telescope, the observatory's first telescope.
36" Special Viewing Night	After Sunset	$100	~15	Observe the night sky through the powerful and sophisticated 0.9-m (36-inch) telescope.
82" Special Viewing Night	After Sunset	$150	~21	Observe the night sky through the powerful and sophisticated 2.1-m (82-inch) Otto Struve Telescope.
Telescopes 101	After Sunset	N/A	~5	Workshop on telescope basics (types of telescopes and mounts, finding objects in the sky, and other important accessories).
Astrophotography Workshop	Normally at 2 p.m.	N/A	~6	Workshop designed to teach individuals how to take photos of the night sky.
Dark Skies Festival	04/22/2025–04/26/2025	Free	~5	In honor of International Dark Sky Week, this festival features special talks, tours, star parties, regularly scheduled programming, and more.

Equipment: McDonald Observatory operates six research facilities, most of which are located in Fort Davis, Texas. Some of these telescopes are hybrid, meaning they can be operated locally (in the dome), remotely (via a network), and/or autonomously. In addition, several telescopes are joint projects with other institutions, whereas others are host sites for other universities. The types of telescopes available are:

- 10-m Hobby-Eberly Telescope (HET): Optimized for spectroscopy, this optical telescope is designed to search for planets around stars.
- 2.7-m Harlan J. Smith Telescope (HJST): Used to study the compositions of stars and motions of galaxies.
- 2.1-m (82-inch) Otto Struve Telescope: Constructed during the period 1933–1939, this was the observatory's first telescope.
- 0.8-m Telescope: Given its optimal field of view, this telescope is ideal for large search and survey projects.
- Other Telescopes: The McDonald Observatory also hosts other telescopes for research and educational purposes at its facility in West Texas, including a 0.9-m telescope, a McDonald Geodetic Observatory, a Las Cumbres Observatory Global Telescope, a 1.2-m MONET telescope, and a 20-inch telescope.

- Giant Magellan Telescope: The Giant Magellan Telescope (GMT), which is currently being built in Chile, will consist of seven mirrors spanning across 25 meters. It will be a new generation of "extremely large telescopes."

Additional Information: Observing time (for research purposes) is allocated through a peer-reviewed proposal process and is only available on select telescopes.

6.3. Case Study: Lowell Observatory

Name: Lowell Observatory

Address: 1400 West Mars Hill Rd, Flagstaff, Arizona 86001

Distance from UNM-Taos: 449 miles

Open to the Public: Yes

Admission ($): Yes

Figure 10: Lowell Observatory. Photo Courtesy: Lowell Observatory

Overview: The Lowell Observatory was initially established by Percival Lowell on May 28, 1894, to study Mars and to explore the possibility of life on the planet. Although it first gained momentum in 1930 when Clyde Tombaugh discovered Pluto at the observatory, it has since expanded into a state-of-the-art observatory and research hub, having acquired numerous telescopes and participating in groundbreaking discoveries that continue to shape astronomical research and education.

Observatory Use: Except for Tuesday, the observatory is open to the public every day from 12pm to 10pm. There are two types of admission packages: General Admission and General Admission Plus. General Admission includes access to select activities at the Astronomy Discovery Center, the Giovale Open Deck Observatory, historical tours and exhibits, the Putnam Collection Center, the Rotunda Museum, the Pluto Discovery Dome, and the famous Clark Telescope.[69] General Admission Plus includes everything that is in General Admission but also includes admission to the Dark Sky Planetarium laser-guided stargazing show (weather permitting) and the Cosmic Highways tour.

Event Name	Time	Admission ($)	Location	Number of Events (2025)	Description
Astronomy Discovery Center	12 p.m.–10 p.m.	Included with GA	Lowell Observatory	Daily except Tuesday	Access to Meet the Planets, Strange New Worlds, Cosmic Highways – A Centennial Tour, Orbits Curiosity Zone, Origins of Lowell, Celestial Visions, Stardust Lab Astronomy Gallery,

[69] https://lowell.edu/experiences/general-admission/

					Welcome to Lowell, Origins Gallery.
Giovale Open Deck Observatory	12 p.m.–10 p.m.	Included with GA	Lowell Observatory	Daily except Tuesday	Access to six state-of-the-art telescopes.
Historical Clark Telescope (24" Refractor)	•M, W, Th: 3 p.m.–Dusk. •F, Sat, Sun: 1 p.m.–Dusk	Included with GA	Lowell Observatory	Daily except Tuesday	Access the historic telescope that inspired Lowell to search for Mars and gave Apollo astronauts early views of the moon.
24" Dyer Telescope	Varies	Private	Lowell Observatory	Varies	Premium access event.
13" Pluto Discovery Telescope	3 p.m.–6:30 p.m.	Included with GA	Lowell Observatory	Daily except Tuesday	Access the telescope that Clyde Tombaugh used to discover Pluto.
Putnam Collection Center	5 p.m.–7:30 p.m.	Included with GA	Lowell Observatory	Daily except Tuesday	Access historical exhibits.
The Rotunda Museum	Varies	Included with GA	Lowell Observatory	Varies	Access the historic library.
Meet an Astronomer/Planetary Scientist	7 p.m.	Included with GA	Lowell Observatory	~23	Learn about various science topics and look at real-time images with astronomers and planetary scientists.
Speaker Series	Either at 5 p.m. or 7 p.m.	Included with GA	Lowell Observatory	~25	Staff and experts share topics that bridge the gap between science, art, and exploration.
Special Oral Presentation	After Sunset	Included with GA Plus	Lowell Observatory	~7	Premier science talks and storytelling experiences at the outdoor, Dark Sky Rooftop Planetarium.
Special Event	Varies	Varies	Varies	~11	Outreach events, collaborations, celebrations.
I Heart Pluto Festival	02/14/2025–02/17/2025	Included with GA, Additional Events between $18 and $29	Varies by Event	~7	Given the observatory's rich scientific history to northern Arizona, there is an annual week-long celebration of Pluto.
Astronomy on Tap	Normally at 6:30 p.m.	Free	Mother Road Brewery	~7	Talk about space and drink beer.

Equipment: The Giovale Open Deck Observatory, which is open to the public for observation, consists of six telescopes:[70]

- 5.5" APO Refractor: Wide-field views of rich star fields.
- 8" Refractor: Views of celestial objects under high power.
- 32" Dobsonian: Makes deep sky objects appear bright and allows for the viewing of finer details.
- 16" Meade ACF: Corrects errors at the edge of the field of view to prevent stars from looking blurry.
- 17" PlaneWave CDK: Well-suited for astrophotography and instrumented observation due to its detailed images.
- 14" PlaneWave CDK: Well-suited for astrophotography and instrumented observation due to its detailed images.

In addition to the telescopes at the Giovale Open Deck Observatory, Lowell Observatory also has three other telescopes. Note, however, that only the 24" Clark Refractor and the 13" Lowell Telescope are open to the public:[71]

- 24" Dyer Telescope: Newest telescope at Lowell.
- 24" Clark Refractor: Historic telescope that inspired Lowell to search for Mars and gave Apollo astronauts early views of the moon.
- 13" Lawrence Lowell (Pluto Discovery) Telescope: Telescope that Clyde Tombaugh used to discover Pluto.

Additional Information: There are astronomers, planetary scientists, scholars, and researchers who actively conduct space research in areas such as exoplanetary systems, planetary defense, the solar system, stellar physics, galactic and extragalactic astronomy, and instrumentation research and development.[72] The observatory has also formed partnerships with several academic institutions.

6.4. Case Study: The University of Arizona Steward Observatory

Name: The University of Arizona Steward Observatory

Address: 933 North Cherry Avenue, Tucson, Arizona 85719

Distance from UNM-Taos: 575 miles

Open to the Public: Yes

Admission ($): Yes

Overview: Established in 1918 and dedicated in 1923, the Steward Observatory at the University of Arizona is a leading astronomical research center that designs,

Figure 11: UArizona ARO Submillimeter Telescope. Photo Courtesy: The University of Arizona Astronomy & Steward Observatory

[70] https://lowell.edu/discover/telescopes-exhibits/godo/
[71] https://lowell.edu/discover/telescopes-exhibits/
[72] https://lowell.edu/research/at-lowell/

builds, and operates telescopes and instruments for ground-based and space-based missions; conducts pioneering research; trains future astronomers through undergraduate, graduate, and postdoctoral programs; and promotes community engagement through its public-access facilities and programs.

Observatory Use: Steward Observatory, which is the research unit for the University of Arizona Department of Astronomy, either manages or is a joint partner in several optical, infrared, and radio telescopes located across the world. This includes various mountain peaks around southern Arizona (Mt. Graham, Mt. Hopkins, Kitt Peak, Mt. Bigelow, Mt. Lemmon), as well as locations in Hawaii, Mexico, Chile, Spain, and Antarctica. Steward Observatory has also assisted in space missions, having built instruments for NASA's Hubble Space Telescope and Spitzer Space Telescope.[73]

Equipment: The Steward Observatory operates numerous telescopes and facilities, which are grouped into the following categories. Note that optical and infrared telescope time is allocated through a competitive observing proposal process.

- Optical and Infrared:
  - Giant Magellan Telescope (partner facility)
  - Large Binocular Telescope (partner facility)
  - Magellan Telescopes (partner facility)
  - MMT 6.5-m Telescope (partner facility)
  - Vatican Advanced Technology Telescope (partner facility)
  - Bok 2.3-m (90") Telescope
  - Kuiper 61"
  - Spacewatch Telescopes on Kitt Peak (0.9-m, 1.8-m)
  - Catalina Sky Survey
  - Raymond E. White, Jr. 21" Telescope (open to the public)
- Radio:
  - University of Arizona ARO 12-meter Telescope
  - University of Arizona Submillimeter Telescope
  - Event Horizon Telescope (partner facility)
  - High Elevation Antarctic Terahertz Telescope
- Facilities and Labs:
  - Richard F. Caris Mirror Lab
  - Imaging Technology Lab
  - Steward Observatory Radio Astronomy Lab
  - Center for Astronomical Adaptive Optics
- Open to the Public:
  - Mt. Lemmon SkyCenter

Additional Information: Steward Observatory uses Mt. Lemmon SkyCenter and the Raymond E. White, Jr. 21" Telescope to engage in community outreach, more of which will be discussed below.

[73] The observatory is currently preparing for an independent space mission that will study galaxy evolution through ultraviolet observations. Click the link for more details.

- Mt. Lemmon SkyCenter: Part of Steward Observatory and located about 43 miles northeast of Tucson, Mt. Lemmon SkyCenter seeks to "strengthen interest in science and astronomy through premium educational and public outreach experiences" that appeal to different audiences.[74]

Event Name	Time	Admission ($)	Number of Events	Description
SkyNights StarGazing Program[75]	2 hours before sunset	$60–$85	Varies	5-hour adventure that includes an astronomy presentation, sunset from a mountain overlook, guided exploration of the night sky using binoculars, and observing through the Schulman 32-inch and Phillips 24-inch telescopes.
DayTours[76]	Varies	$5–$10	Varies	90-minute guided tour of the observatory grounds and select facilities, history and current research conducted at the Center, and up-close views of telescopes including the Schulman 32-inch and Phillips 24-inch.
Astronomer Nights	Varies	$1500 per night for up to 4 people	Varies	For 1 to 2 evenings, visitors lodge in the on-campus astronomer dormitories and observe as professional astronomers using the 0.8-m Schulman telescope.
SummerSky[77]	Varies	$5–$10	Varies	Discussions on current research, projector presentations, and live Q&A sessions with astronomers. No telescope viewing.

- Raymond E. White, Jr. 21" Telescope: This 21-inch telescope is used in general education courses and for the on-campus public viewing events. The on-campus public viewing events occur after the astronomy talks at 8:30pm, and the telescope is operated by astronomy undergraduate students.

[74] https://skycenter.arizona.edu/content/about-us
[75] https://skycenter.arizona.edu/plan-your-visit/programs/skynights
[76] https://skycenter.arizona.edu/plan-your-visit/programs/daytours
[77] https://skycenter.arizona.edu/summersky

6.5. Case Study: Apache Point Observatory

Name: Apache Point Observatory

Address: 2001 Apache Point Road, Sunspot, New Mexico 88349

Distance from UNM-Taos: 314 miles

Open to the Public: No

Admission ($): N/A

Figure 12: Aerial View of Apache Point Observatory. Photo Courtesy: Apache Point Observatory

Overview: Apache Point Observatory is a private observatory located in the Sacramento Mountains of the Lincoln National Forest in south-central New Mexico, approximately 106 miles northeast of Las Cruces. It is owned by the Astrophysical Research Consortium (ARC) – a nonprofit educational and research corporation composed of nine institutions, including APO's operator New Mexico State University (NMSU).[78] Observatory staff includes a site manager, technical specialists, and observing specialists who manage the observing modes.[79] There is also an ARC board, which appoints representatives from partner institutions to oversee and approve budgets for operations at APO.

Observatory Use: One of the observatory's largest ongoing endeavors is the Sloan Digital Sky Survey (SDSS). The SDSS is a spectroscopic survey that observes supermassive black holes, the Milky Way galaxy, and interstellar gas in the Milky Way and nearby galaxies to provide a 3-D map and databank of the universe.[80] The observatory has also been working on lunar laser ranging, which uses lunar retroreflectors to measure the distance between surfaces of the Earth and the Moon.[81]

Equipment: APO has four telescopes:[82]

- Astrophysical Research Consortium (ARC) 3.5-m Telescope: General purpose research telescope offering a mix of imaging and spectroscopic capabilities.
- 2.5-m Sloan Foundation Telescope, home of the Sloan Digital Sky Survey (SDSS): Wide-field survey telescope with robotic fiber optic positioners.
- NMSU 1.0-m Telescope: Telescope within the Stellar Oscillations Network Group (SONG) network that has a fiber-fed spectrograph.
- The 0.5-m Astrophysical Research Consortium Small Aperture Telescope (ARCSAT): Training platform and research aid for bright objects.

[78] ARC was founded in 1984 by five institutions to construct and operate a 3.5-m telescope at APO, which is still in use today.
[79] Holtzman et al. (2009), p. 2
[80] https://sloan.org/programs/research/sloan-digital-sky-survey#:~:text=The%20Sloan%20Digital%20Sky%20Survey%20(SDSS)%20is,to%20the%20public%20under%20open%20use%20principles.
[81] https://mainapo.apo.nmsu.edu/mainpage/apollo/apolloguide/
[82] https://mainapo.apo.nmsu.edu/

In addition to telescopes, APO also has retroreflectors, spectrographs, spectrometers, and other instruments.

Additional Information: While non-affiliated individuals can walk the APO campus during daylight hours (7am – 5pm), access to the facilities and telescopes is only permitted to authorized personnel. Nevertheless, individuals can visit the Sunspot Solar Observatory to learn more about APO, more of which is discussed below.

- The Sunspot Solar Observatory – which is located on Sacramento Peak in Sunspot, New Mexico – gives guests the opportunity to visit the museum and participate in a guided tour of the Dunn Solar Telescope, a 0.5-mile loop around the property.[83] The Dunn Solar Telescope, which has been active since 1969, is designed to observe extremely small features in the sun's photosphere (surface) and chromosphere (lower atmosphere).[84] Tours are available on the following days (weather permitting):
  - Weekdays: Monday, Tuesday, Thursday, and Friday from 12pm to 2pm.
  - Weekends: First weekend of every month (Saturday and Sunday) from 12pm to 2pm.
- The museum, which is open daily from 9am to 5pm, features exhibits on the Sun, planets, general astronomy, APO, and the Lincoln National Forest. [85,86]

6.6. Case Study: Magdalena Ridge Observatory

Name: Magdalena Ridge Observatory

Address: 101 East Road, Socorro, New Mexico 87801[87]

Distance from UNM-Taos: 202 miles

Open to the Public: Yes

Admission ($): N/A

Figure 13: Aerial View of the Magdalena Ridge Observatory at Sunset. Photo Courtesy: Magdalena Ridge Observatory

Overview: Magdalena Ridge Observatory (MRO) is located in the Magdalena Mountains of the Cibola National Forest in Socorro County, New Mexico – about 20 miles west of Socorro. After having received its first telescope in 2006, MRO has since become a multi-use research and educational observatory. Built and operated by the New Mexico Institute of Mining and Technology (NMT), MRO continues to support astronomy, space situational awareness, and education and outreach.

Observatory Use: The observatory is currently being used to operate a 2.4-meter fast-tracking telescope and to lay the groundwork for the Magdalena Ridge Observatory Interferometer (MROI). The MROI project will

[83] The Observatory also has solar imaging instruments and spectropolarimeters; however, these are not available to the public.
[84] https://sunspot.nmsu.edu/about/dunn-solar/index.html
[85] Hours may vary during the off-peak season.
[86] https://sunspot.nmsu.edu/visit/education.html#15
[87] This is the address to the Magdalena Ridge Observatory New Mexico Tech (MRO NMT) Research Office Building.

attempt to demonstrate high-resolution "imaging capabilities on geosynchronous objects" by observing optical light under a collection of ten 1.4-meter diameter movable telescopes.[88]

Equipment: The MRO consists of two major facilities:

- Operating 2.4-meter fast-tracking telescope: This telescope is primarily used to observe, track, and characterize targets-of-opportunity like solar system astronomical targets, artificial Earth satellites, space vehicles, and missile tracking.[89]
- Magdalena Ridge Observatory Interferometer (MROI): The MROI is expected to be one of the largest Earth-based optical telescopes, made up of an array of ten 1.4-meter telescopes that will work together to produce images with resolutions equal to a single telescope. NMT anticipates the facility "will be available to public tours, K-12 school programs, and will promote collaboration with other state, regional, national, and international universities."[90] Although the MROI is currently undergoing construction, some of the instruments and telescopes are already being built.

Additional Information: Magdalena Ridge Observatory conducts public outreach events at Etscorn Campus Observatory. Public star parties are usually hosted by MRO and the New Mexico Tech Astronomy Club on the first Saturday of every month.[91] In addition to public engagement events, Etscorn has three telescopes that are used for research: two Celestron C-14 and one 20-inch Dobsonian. These computer-controlled telescopes and CCD cameras are currently being used to determine the light curves of asteroids.[92]

6.7. Conclusion

Collectively, this chapter's comparative assessment of observatories in New Mexico and bordering states highlights how the interconnectedness of geography, education, and equipment plays a pivotal role in the operation of an observatory. These case studies provide valuable insights for UNM-Taos and reinforce the idea that fostering research excellence, educational advancement, and an appreciation of the dark skies can help bolster and grow the space economy in Taos and surrounding areas. Moreover, when considering the full scope of the Cielo Centro's offerings – including the observatory, amphitheater, education center, and combined nature/solar system & art walk trail – no other establishment in the state offers such an experience, and few two-year colleges nationwide feature such an integrated and versatile site.

The next chapter discusses the anticipated social, financial, and environmental aspects of the Cielo Centro Observatory.

[88] Creech-Eakman et al. (2024), Abstract
[89] https://www.mro.nmt.edu/about-mro/
[90] https://www.afrl.af.mil/News/Article/2850598/afrl-collaborates-with-magdalena-ridge-observatory-to-further-space-exploration/
[91] https://www.mro.nmt.edu/education-outreach/star-parties/
[92] https://www.mro.nmt.edu/education-outreach/etscorn-campus-observatory/research/

Social, Financial, and Environmental Impacts of the Cielo Centro Observatory

Besides construction costs and other operational expenses, it can be challenging to quantify the social and environmental impacts of the Cielo Centro Observatory, for many of its benefits – such as hands-on learning opportunities and night-sky protection – do not have direct monetary values. Nevertheless, examining each impact category remains important to understand how UNM-Taos' involvement in the Cielo Centro Observatory can enhance workforce development and contribute to long-term environmental stewardship. Accordingly, this chapter highlights the positive social, financial, and environmental impacts associated with the observatory.

7.1. Social Impacts of the Cielo Centro Observatory

In September 2024, UNM-Taos developed a five-year strategic plan (2025 – 2030) centered on an actionable roadmap that can provide comprehensive, high-quality education. This section outlines the potential social impacts of the Cielo Centro Observatory and how the observatory can support these goals.

7.1.1. Hands-On Learning and Technical Skills

Many classes rely primarily on traditional classroom teaching where students listen to an instructor explain the material either in-person or remotely. Science classes, in contrast, apply the principle of "training in observation" by supplementing lectures with inquiry-based labs that require hands-on learning. For example, biology classes use microscopes, chemistry classes work with Bunsen burners, and physics classes incorporate live demonstrations. These approaches reflect a hybrid learning environment that has been shown to increase retention and improve success rates through active learning. Multimodal instruction is especially useful for nontraditional students who have "been away from formal education for years [and] may struggle with traditional lecture-based teaching methods."[93]

In astronomy, the universe is the lab, and the telescope is the equipment. Traditionally, community college and undergraduate students have had limited access to telescopes "capable of collecting data for learning purposes," as these instruments are primarily reserved for graduate students, post-doctoral researchers, and faculty. The construction of the Cielo Centro Observatory, however, can remove this obstacle.[94]

The Cielo Centro Observatory can preserve a sense of wonder and transform student learning by activating students' sensibilities, enabling them to experience the connection between theory and reality. It can provide an avenue for hands-on application of skills through the maintenance of observatory facilities and grounds. For example, fundamental observational techniques – which include target selection, photometry and/or spectroscopy methods, astrometry, and error analysis – can be taught and applied to improve data collection. Equally important, the observatory can inspire students, which can come "in the form of the thrill of an

[93] https://www.bhdp.com/insights/college-campus-design-crafting-spaces-diverse-student-population
[94] https://aas.org/posts/news/2022/12/bringing-telescopes-wonder-and-inquiry-our-science-classrooms

instrumental challenge, the insight from a scientific observation, or even the simple impact of seeing a large telescope for the first time."[95]

The Cielo Centro Observatory can also position UNM-Taos to serve as a regional educational anchor by providing PreK-12 students with access to a high-quality astronomical facility that is hard to find in rural communities. The New Mexico Higher Education Department designates Geographic Areas of Responsibility. The UNM-Taos area of responsibility includes the communities of Taos, Questa, and Cimarron.[96] Within Taos, Questa, and Cimarron, there are 23 PreK-12 schools across eight districts serving approximately 3,453 students.[97] These schools represent a geographically dispersed, largely rural population where access to advanced scientific instrumentation and immersive STEM experiences is often limited by distance, funding constraints, and infrastructure gaps. By contrast, Cielo Centro can offer a place-based, locally accessible resource where school-age children can experience astronomy through direct observation and exploration as opposed to abstract theory – opportunities that are often limited to urban centers or research universities.

All of these outcomes directly support one of UNM-Taos' goals: Student Experience and Educational Innovation – Inclusive and Empowering Learning Experiences.

7.1.2. Career Development, Mentorship, and Partnerships

The global space industry has been taking off at supersonic speeds, driven by decades of public investment and the private sector's role in both independent and government-contracted projects. New Mexico has already planted its foot in this industry by hosting national laboratories; attracting companies like SpaceX, Blue Origin, and Virgin Galactic; and supporting public and private research entities. Nonetheless, the space science industry still remains a primary economic focus for the state, and New Mexico would like to seize this opportunity by advancing its national standing and strengthening its local workforce.

Specifically, the state would like to increase private-sector employment in science and technology and establish new contracts with national labs by (1) showcasing technologies to encourage better understanding, (2) matching talent and training resources to the new economy, and (3) creating new STEM education programs and training workers in STEM fields.[98] These initiatives are most likely informed by the low levels of current employment in STEM occupations, coupled with an even smaller opportunity for employment, especially in northern New Mexico, where workforce development data are often unreported or deemed confidential.[99]

The Cielo Centro Observatory, however, has the ability to support the state's endeavors by creating unique STEM experiences that combine classroom instruction with real-world educational applications. As discussed in the previous section, the housing of the telescope in the observatory can enhance a student's understanding of instrumentation, data acquisition, and analysis – skills that are pertinent for career readiness and workforce development. It can also allow students to network with STEM professionals through mentored research experiences and enable UNM-Taos to share resources and services with other institutions. An example of this is the potential formation of the Southwest Regional Space-STEM Consortium, which is being guided by key

[95] Privon et al. (2009), p.4
[96] Click this link to see a map of the Geographic Areas of Responsibility by county.
[97] See Appendix C for a breakdown of enrollment and the types of PreK-12 schools in the UNM-Taos service area.
[98] https://www.mrcog-nm.gov/370/Science-Technology
[99] This is based on 2024 Occupation Data from the New Mexico Occupational Employment and Wage Statistics (OEWS) program. Visit this link for more details.

personnel who are also behind the Cielo Centro Observatory. The mission of this consortium is to provide underserved and underrepresented students with the opportunity to work in the space economy at a professional or technical level, and to connect employers with a highly qualified pool of local workers. Like many other two-year colleges in small towns, UNM-Taos cannot offer all of the courses needed to prepare students for education or employment, especially in a specialized program like space science. As such, this regional consortium can share instructional resources and students, all while allowing students to get telescope time on the 36-inch telescope housed at the Cielo Centro Observatory.

The observatory can also create multiple entry points for learning across grade levels. Younger learners can engage through guided sky tours and interactive demonstrations, while middle and high school students can participate in more advanced observational projects, data collection activities, and mentorship opportunities with UNM-Taos faculty and students. This tiered approach reinforces a cradle-to-career educational curriculum within the region.

Ultimately, these opportunities can allow students of all ages to bridge the gap between education and employment by opening doors through networking and reducing barriers. Such skills and experiences that are developed by working with the telescope can also pave the way for more advanced degrees that are research-based and require independent thinking, which complement UNM-Taos' goal of "Advancing New Mexico: Trusted Provider of Education and Workforce Development."

The transition to a knowledge economy not only retains local talent but also attracts outside talent, resulting in increased discretionary income that can be used to stimulate the economy.

7.1.3. Community Engagement as a Pathway to Literacy

The power of astronomy is rooted in its capacity to provide novel experiences that stimulate the senses and fill people with a sense of awe. When an individual is able to form a personal connection with their surroundings, it can enhance their understanding and appreciation of the vast and intricate cosmos. A case in point is the Cielo Centro Observatory, which will offer tangible experiences by allowing students and visitors to observe celestial bodies through telescopes.

By offering dynamic programming that resonates with diverse audiences, the observatory can positively shape the perception of science by integrating economic, cultural, and environmental sustainability through cross-domain collaboration. For example, providing targeted programs that blend night-sky experiences with familiar contexts can reduce inequities among underrepresented populations by expanding the boundaries of astronomy and inspiring curiosity in those who may not have had an interest in science. In doing so, the observatory "not only provides the general public with information about the activities of the observatory, but more importantly, motivates children and teenagers to acquire an interest in science and technology."[100] By investing in today's youth, the observatory can help cultivate future generations of scientists and engineers who will continue to advance scientific discovery and contribute to the state's knowledge economy. For first-

[100] Allekotte and Calvo (2025), p. 6

generation and historically underserved students in northern New Mexico, such exposure is particularly significant, as it reduces structural barriers tied to geography and access.

These results directly support two of UNM-Taos' goals:

1. Inclusive Excellence: Cultural Respect and Community Engagement.
2. Sustainability: Sustainable Community Development, Stewardship, and Wellness

7.2. Financial Impacts of the Cielo Centro Observatory

7.2.1. Economic Impacts of Construction

To estimate the economic impact of the observatory under consideration, BBER utilized IMPLAN v25.7. IMPLAN is an Input-Output (I-O) model used to gauge and estimate the direct, indirect, and induced impacts. An I-O analysis suggests that interdependence exists between sectors and consumers in an economy through buy-sell relationships, meaning one transaction or economic activity will support successive economic activity. For example, the direct effects are the spending and employment that would occur because of the construction and operation of the observatory. The indirect effects are obtained when purchases are made in the local economy during construction and operation that create and support jobs and economic activity in the local economy. The induced effects are incurred when those employed (both directly and indirectly) because of the project spend their wages and income in the local economy.

This report uses construction results to measure the direct, indirect, and induced effects on employment. Although the full methodology is found in Appendix A, two points should be noted here:

1. The economic impact of construction is a one-time impact since temporary jobs will only be supported while the observatory is being built.[101]
2. Inputs for construction only include hard costs; furniture, fixtures, and equipment that are added to the structures to make them fully operational are not modeled through the construction industry.[102]

7.2.1.1. Cielo Centro Observatory

On July 23, 2024, UNM-Taos generated a project cost summary for the observatory, observation deck, and access. Hard costs – which included construction and contingencies – were estimated to be $5,722,984 (75.30% of the total project cost). This estimate was used in our analysis and inflated to 2027 dollars to reflect the year of construction.

In total, the construction of a 2,022-square-foot observatory would be responsible for creating 46 temporary construction-related jobs, almost $2.6 million in labor income, nearly $3.9 million in value added, and about $8.5 million in total output. Combining indirect and induced effects, we see the ripple effects that result from construction with the creation of 12 jobs, $550 thousand in labor income, and almost $2.4 million in total output. See Table 9 below for more details.

[101] Architects, engineers, construction workers, and other related personnel are considered contractors.
[102] https://support.implan.com/hc/en-us/articles/360043873053-Analyzing-Capital-Investments#:~:text=Only%20the%20cost%20of%20a,not%20captured%20in%20construction%20spending

Table 9: Construction Output for a 2,002 Sq. Ft. Observatory (in 2027 dollars)

Impact	Employment	Labor Income	Value Added	Output
Direct	34	$2,048,687.34	$2,684,217.34	$6,089,844.00
Indirect and Induced	12	$550,003.04	$1,170,139.59	$2,392,995.26
Total	**46**	**$2,598,690.38**	**$3,854,356.93**	**$8,482,839.26**

7.2.2. Economic Impact of Operations

When guests visit the Cielo Centro Observatory, they will likely spend money at local businesses purchasing trip-related goods and services. As such, visitor spending expenditures are categorized as follows: (1) Lodging, (2) Food and Beverage, (3) Retail Spending on Goods and Services, including groceries and gasoline, (4) Recreation and (5) Local Transportation. These expenditures represent the ways through which visitor spending enters the local economy and generates broader economic activity. Tourism generates sales, production, employment, wages, and taxes, and the underlying reasoning is similar to that for construction. For example, guests who visit the observatory will engage in business transactions, described as the direct effect. To provide these goods and services, businesses must purchase inputs from other industries, creating indirect effects. Finally, employees of these establishments will spend their earnings within the local economy, generating additional induced effects from visitor spending.

7.2.2.1. Cielo Centro Observatory Operations

According to a 2019 study by Mitchell and Gallaway, non-local tourists who value dark skies are expected to spend $5.8 billion over ten years in the Colorado Plateau, a region of the United States that includes parts of Utah, Colorado, Arizona, and New Mexico. These tourist expenditures are projected to generate $2.4 billion in additional wages and create over 10,000 jobs each year in the region.[103] Although the Cielo Centro Observatory's economic impact cannot be determined until its first full year of operation, a conservative estimate of expected visitors and potential revenue can be developed using visitation data from nearby parks.

The basis of this analysis draws on four designated International Dark Sky Places located within the Colorado Plateau and/or in close proximity to UNM-Taos. Visitation data for each site were obtained from the National Park Service, and an average was calculated across the four parks. Next, we estimated the share of visitors who traveled to the parks specifically for night-sky related activities. According to a study conducted by Beeco et al., "two percent of respondents indicated that their primary activity was night sky photography, while five percent reported night sky viewing or astronomy as their primary activity."[104] These percentages were combined to estimate that seven percent of visitors primarily engage in night sky activities, and this proportion was applied to the average visitor count across the four parks as shown in Table 10 below.

[103] Mitchell and Gallaway (2019), Abstract
[104] Beeco et al. (2023), p. 5

Table 10: Comparable National Parks near UNM-Taos

Park	Visitor Count (2024)	Percent Interested in Astronomy	Miles from UNM-Taos	Within the Colorado Plateau?
Capulin Volcano National Monument	96,078	6,725	129	No
Chaco Culture National Historical Park	37,840	2,649	181	Yes
Fort Union National Monument	9,217	645	86	No
Valles Caldera National Preserve	82,111	5,748	78	Near
Average	**56,312**	**3,942**	-	-

Daily spending was proxied using data from the Arts & Economic Prosperity 6 (AEP6) study, which found that non-local attendees spent an average of $128.93 per person per event in Taos County in 2022.[105] Thus, adjusting the AEP6 2022 per-person spending estimate for inflation to 2024 dollars yielded an average of $138.20. Total visitor spending was then calculated by multiplying the estimated number of night sky visitors (3,942) with the inflation-adjusted average spending per person ($138.20).

We then used 2024 data from the New Mexico Tourism Department to determine how visitor expenditures are distributed across industries in Taos County. The New Mexico Tourism Department categorizes visitor spending into five categories: lodging, food & beverage, retail, recreation, and transportation. These spending categories were then mapped to corresponding sectors in IMPLAN to estimate the potential economic impact, with results presented in 2028 dollars to reflect the observatory's first year of operation.

Table 11: 2024 Spending Level Patterns in Taos County

	Taos County
Spending	
Lodging	50.0%
Food & Beverage (Full-Service and Limited-Service Restaurants)	18.2%
Retail (Groceries, Gasoline, and Souvenirs)	15.2%
Recreation	8.4%
Local Transportation (Rental Car + Public Transportation)	8.3%

In 2028, 3,942 visitors are estimated to spend $555,461.34 in Taos County while visiting the Cielo Centro Observatory. These expenditures are expected to support a total of 6 jobs, almost $214 thousand in labor income, almost $441 thousand in value added, and $786 thousand in economic output. See Table 12 for more details.

[105] See Table 9 in the AEP6 Taos County report for the spending breakdown.

Table 12: Economic Impact of the Cielo Centro Observatory (in 2028 dollars)

Impact	Employment	Labor Income	Value Added	Output
Direct	4	$156,278.17	$322,850.86	$551,461.34
Indirect and Induced	2	$57,275.61	$118,065.27	$234,813.25
Total	**6**	**$213,553.78**	**$440,916.13**	**$786,274.59**

Note, however, that the magnitude of the impact will depend on how the geographic area is defined, as only non-local residents bring in outside dollars. For example, a spending impact analysis does not include visitors who live in Taos County if the defined geographic area were Taos County, because the analysis should only capture "new" output to the region. Although Taos County residents may spend money when visiting the Cielo Centro Observatory, their expenditures are not counted because if the observatory did not exist, residents would most likely transfer their money to another business.

7.2.3. Fiscal Impacts

Expanding on the previous section, the Cielo Centro Observatory can help the local economy grow by collecting tax revenue from tourists who spend money on goods and services at local businesses. Assuming that Taos is the defined geographic area, the city collects gross receipts revenues (9.175%) from industries that "perform services" within its limits.[106, 107, 108] These industries include: (1) Hotels and motels, including casino hotels, (2) Full-service restaurants, (3) Retail – miscellaneous store retailers, (4) All other food and drinking establishments, (5) Other amusement and recreation industries and (6) Scenic and sightseeing transportation and support activities from transportation.

As long as new revenue exceeds new costs, the fiscal impact is said to be positive. This is critical because such revenues help finance governmental programs, including public education, infrastructure, healthcare, and public safety.

7.2.4. Increase in Net Tuition and Fee Revenue

State funding for higher education is very volatile, particularly during periods of economic downturn. During recessions, "higher education is highly susceptible to funding shortfalls as states face tighter budgets and competing funding priorities."[109] Given that UNM-Taos functions more like a two-year community college, it is more vulnerable to budget cuts compared to UNM and other four-year universities.

To prepare for potential reductions in state funding, UNM-Taos can leverage the observatory to attract more students and diversify its revenue streams. That is, rather than bolstering revenue streams by leveraging tuition dollars, UNM-Taos can expand enrollment by encouraging greater participation in STEM classes and programs.

[106] This is based on the Gross Receipts and Compensating Tax Rate Schedule for January 1, 2026 – June 30, 2026. Click the link for more details.
[107] The statewide GRT rate for New Mexico is 4.875%. However, Taos has added its own GRT increment or local rate of 4.3%, making the total GRT 9.175%.
[108] Click this link to learn more about gross receipts taxes in New Mexico.
[109] https://bipartisanpolicy.org/explainer/state-funding-and-college-costs-reviewing-the-evidence/

This strategy, in turn, can increase net tuition and fee revenue.[110] However, such growth should occur slowly and with diligence, as "the quality in the form of student support services and the ratio of faculty to students [can be] gradually eroded" when resources are stretched too thin.

7.2.5. Increase in New Sources of Revenue

Charging for programming events at the Cielo Centro – including observing time through the telescope – could serve as a significant source of income. Telescope time and related resources could also be exchanged with other colleges to access services that UNM-Taos does not currently offer. Beyond income and resource sharing, the observatory can also open doors for UNM-Taos to pursue sponsorship and research funding opportunities.

7.3. Environmental Impacts of the Cielo Centro Observatory

In 1999, the New Mexico Legislature enacted the Night Sky Protection Act (NMSA 1978, Chapter 74, Article 12) to regulate outdoor lighting fixtures and preserve the state's dark sky heritage. The act mandates that outdoor lights be shielded so that illumination is pointed downward as opposed to outward or upward to prevent light trespass and/or hazardous glare.[111,112] Given Taos' optimal location in the high desert of northern New Mexico, Taos County and Taos voted to adopt more rigorous ordinances in 2006 and 2007 to protect the night sky. Yet despite these progressive measures, the increased use of LED lighting – combined with limited code enforcement – has compelled community members and dark sky advocates to call for stronger, more effective measures.

With the possible construction of the Cielo Centro Observatory, the Taos Dark Sky Initiative has intensified its campaign to protect natural nighttime darkness – not only as a cultural and scientific resource, but as a defining element of Taos' identity.

7.3.1. Night Sky Protection

Over the last few decades, numerous studies have been conducted to understand the effects of light pollution on the environment. This section synthesizes some of the latest research findings to highlight the negative externalities of artificial light at night (ALAN) and explores how the observatory can help reduce light pollution by advocating for and practicing night sky protection.

As discussed in Section 4.2, the effects of ALAN are amplified when light interacts with the atmosphere. Low air quality caused by particulate matter, combined with high cloud cover and dew points, scatters light everywhere to create skyglow. Skyglow, which can resemble natural lighting or other nighttime illumination, disrupts ecosystems by interfering with natural cycles. Silver and Hockey (2020), Alva et al. (2023), and Dunn and Edensor (2023) have found that ALAN alters the circadian rhythm – the internal sleep-wake body clock that differentiates night from day. Because many species rely on natural cycles of daylight and darkness to hunt, forage, mate, and migrate, disruptions to circadian rhythms can be harmful.

[110] This is especially true for out-of-state and international students who typically pay higher tuition rates than residents.
[111] Light Trespass: an emission of light from a fixture that is not properly shielded, causing the light to extend beyond the property of its origin.
[112] Hazardous Glare: An emission of light from a fixture that creates a brightness that substantially affects or requires a person to look elsewhere.

For example, artificial light can disorient migratory birds that rely on rotating star patterns for navigation. This disorientation can lead to delayed migration, off-course flying, or collisions with brightly lit structures.[113,114] Even though artificial light is not a food source, moths and other nocturnal insects that are attracted to light sources may congregate near artificial lights, thereby making them more vulnerable to predators.[115] Light pollution can also impede plant reproduction by disrupting the plant's natural growth cycles, which in turn reduces food availability for herbivores and omnivores. [116] Together, these disruptions can have cascading effects on ecosystems and can indirectly contribute to broader environmental changes.

The Cielo Centro Observatory, however, can work with surrounding communities and nearby jurisdictions to limit ALAN by advocating for new legislative measures that require shielding regulations and adaptive lighting controls. A study by Noon and de Napoli discovered how "different Indigenous communities have used the star-studded sky to provide a guide for navigation, mark times for hunting, journeying and collecting, and demarcate seasonal ceremonies and rituals." As such, protecting the dark sky is not only a scientific priority but also a cultural responsibility, reinforcing the observatory's role in advocating for light pollution policies that "preserve ancient traditions in the face of advancement of modernization."[117]

> *"Night sky protection enhances wilderness qualities of solitude, naturalness, and untrammeled, undeveloped character that animals depend on for survival, park visitors seek for connections, and many cultural-historical parks require for preservation."*[118]

7.3.2. Pursuing an International Dark Sky Place (IDSP) Designation

This effort to construct the Cielo Centro Observatory and reduce light pollution is also building momentum toward another ambitious goal: positioning Taos to certify as a Dark Sky Community and/or allowing UNM-Taos to pursue the designation of an Urban Night Sky Place – objectives strongly supported by both local dark sky advocates and the Taos Town Council. As discussed in Section 5.2, New Mexico currently has no designated International Dark Sky Community. Pursuing and securing this accreditation therefore represents a significant opportunity for UNM-Taos to strengthen its role in dark sky tourism in northern New Mexico and surrounding regions.

Besides serving as an economic engine, the certificate can also inspire community members to gain knowledge about the night sky, raise awareness of the harmful effects of light pollution, and support land management agencies in achieving long-term conservation goals while connecting people to the universe.

[113] https://www.allaboutbirds.org/news/the-basics-migration-navigation/
[114] https://osr.org/blog/news/birds-navigate-by-the-stars/?srsltid=ARcRdnoRrsPbwnvWT-riFk6VzOMGttwWzoEfvDLZw-2Zg0BoT4VuPQ2q
[115] https://butterfly-conservation.org/news-and-blog/why-is-light-pollution-bad-for-moths
[116] https://www.fws.gov/story/2023-07/dim-lights-pollinators-and-plants-night
[117] https://taospueblo.com/about/
[118] NPS: The Power of Night – Interpretive Handbook, p. 6

7.4. Conclusion

As this chapter has illustrated, UNM-Taos' ecosystem is an interconnected community of diverse individuals interacting with each other and the unique northern New Mexico environment to propel the region forward. By working together, these communities can expand regional opportunities and pool resources. With evidence that creative and innovative efforts generate healthier communities and attract a more stable workforce, UNM-Taos can leverage this finding by using the observatory as a hub that uplifts STEM and creative professions, facilitates connections, shares resources, and protects the region's dark skies.

Realizing these benefits, however, depends on developing the infrastructure that will support this collaborative vision. The area surrounding UNM-Taos already boasts a thriving creative, tourism, and knowledge economy, yet its full potential can only be unlocked through the construction of a roll-off observatory capable of housing the powerful 36-inch Dobsonian telescope.

Appendix A: Data and Methodology

Introduction

The purpose of this section is to describe the data and methods used to obtain the information for the analytical sections of the report. We also discuss the quality and limitations of the data.

Arts & Economic Prosperity 6 (AEP6)

The Arts & Economic Prosperity (AEP) is an economic and social impact study that is administered approximately every five years to 373 communities by *Americans for the Arts.* The study measures "the economic impact of spending by nonprofit arts and culture organizations and the event-related spending by their audiences."[119] Each community receives a customized report that highlights its impact on the community. The national report is a synopsis of all the individual reports.

The 2022 Arts & Economic Prosperity 6 (AEP6) study is a special version of the AEP because Taos County was one of the four study regions in New Mexico. Data from AEP6 were used in Section 7.2.2.

IMPLAN

BBER utilized IMPLAN v25.7 in Section 7.2 to estimate the economic impacts of construction and visitor spending associated with the observatory. [120] IMPLAN is an input-output model used to gauge and estimate the direct, indirect, and induced impacts. An I-O analysis suggests interdependence exists between sectors and consumers in an economy through buy-sell relationships, meaning one transaction or economic activity will support successive economic activity. IMPLAN is widely used in regional economic modeling for estimating economic impacts and multipliers. IMPLAN uses a variety of raw data sources to assess these impacts, including datasets provided by the U.S. Bureau of Economic Analysis (BEA), U.S. Department of Agriculture (USDA), U.S. Bureau of Labor Statistics (BLS), and the U.S. Census Bureau.[121]

The economic impact of construction was accomplished in six main steps. First, the industry of interest was identified, defined, and matched using the North American Industry Classification System (NAICS):

- **NAICS 236220: Commercial and Institutional Building Construction.** This industry comprises establishments primarily responsible for the construction (including new work, additions, alterations, maintenance, and repairs) of commercial and institutional buildings and related structures, including education.

Second, we matched the IMPLAN industry code with the NAICS code using the IMPLAN 528 scheme bridge. This was done to have a standard industry code system. Third, we identified Taos County as our geography of interest. This was done to capture a larger market and because Klauer Campus – which is where the observatory will be built – is located outside of Taos city limits in Ranchos de Taos. Fifth, we inflated the

[119] https://www.americansforthearts.org/by-program/reports-and-data/research-studies-publications/arts-economic-prosperity-6
[120] https://support.implan.com/hc/en-us/articles/33394174147995-Version-25-Release-Notes
[121] https://implan.com/data-sources/#toggle-id-4

outputs to 2027 dollars to reflect when the observatory is assumed to be completed. This is because the original construction estimates were prepared in July 2024. Sixth, we used the impact analysis to estimate the indirect and induced impacts on other sectors of the economy that resulted from the direct effects.

The methodology used to estimate the economic impact of visitor spending was similar to that used for construction, with the following sectors included in the spending analysis:

- Retail:
  - 389: Retail - Food & Beverage Stores (50%)
  - 391: Retail – Gasoline Stores (25%)
  - 395: Retail – Miscellaneous Store Retailers (25%)
- Transportation:
  - 400: Transit and Ground Transportation (25%)
  - 432: Automotive Equipment Rental and Leasing (75%)
- Recreation:
  - 486: Other amusement and recreation industries (100%)
- Lodging:
  - 489: Hotels and motels, including casino hotels (100%)
- Restaurant Food & Drink:
  - 491: Full-Service Restaurants (50%)
  - 492: Limited-Service Restaurants (50%)

Note that these code descriptions are based on IMPLAN's 528 Government Enterprise and Government Employment and Payroll industries, which are mapped and aggregated according to NAICS code descriptions.[122]

NAICS

The North American Industry Classification System (NAICS) is the standard used by federal statistical agencies to classify business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy.

Section 7.2 used NAICS data to identify the industries associated with observatory construction and visitor spending activities.

National Park Service Social Science Program

The National Park Service (NPS) Social Science Program measures, analyzes, and reports visitor use statistics – including visitor counts, spending patterns, and types of visits – across national park units. Using these data, the NPS also produces an annual national park visitor spending effects report that estimates the economic contributions of park visitation.

[122] https://support.implan.com/hc/en-us/articles/30545246649115-U-S-528-Industries-Conversions-Bridges

2024 visitor counts for Capulin Volcano NM, Chaco Culture NHP, Fort Union NM, and Valles Caldera NPRES were used in Section 7.2.2. Spending categories were then matched to IMPLAN sectors using the NPS classification scheme and weights.[123]

New Mexico Tourism Department

The New Mexico Tourism Department is the state agency responsible for promoting New Mexico as a leisure travel destination through its "New Mexico True" brand. The department cultivates and maintains partnerships that highlight the state's culture, geography, history, and cuisine to support economic growth and increase visitation. In collaboration with Tourism Economics, the department also collects, analyzes, and publishes visitor data for New Mexico and its 33 counties.

2024 spending data for Taos County were used in Section 7.2.2.

The New World Atlas of Artificial Night Sky Brightness

On June 10, 2016, a team of researchers led by Fabio Falchi at the Light Pollution Science and Technology Institute (ISTIL) published a GeoTIFF raster file as a supplement to their paper titled: "The New World Atlas of Artificial Night Sky Brightness."[124]

Using the mapping software QGIS, the raster data from this supplement were overlapped with 2024 U.S. Census Bureau TIGER/Line county shapefiles for New Mexico to extract light pollution values within state boundaries. The ratio to natural brightness values were then classified and colorized using a scheme provided by CIRES at CU Boulder to produce maps that visualize artificial light and night sky radiance, which can be seen in the table below.[125]

[123] See "Appendix F: Visitor Spending Effects IMPLAN Sector Bridge" at this link for more details.
[124] Falchi, Fabio; Cinzano, Pierantonio; Duriscoe, Dan; Kyba, Christopher C. M.; Elvidge, Christopher D.; Baugh, Kimberly; Portnov, Boris; Rybnikova, Nataliya A.; Furgoni, Riccardo (2016): Supplement to: The New World Atlas of Artificial Night Sky Brightness. V. 1.1. GFZ Data Services. https://doi.org/10.5880/GFZ.1.4.2016.001
[125] CIRES = Cooperative Institute for Research in Environmental Sciences. See this link for more details.

Ratio to Natural Brightness	Artificial Brightness (µcd/m²)	Approximate Total Brightness (mcd/m²)	Color
<0.01	<1.74	<0.176	
0.01–0.02	1.74–3.48	0.176–0.177	
>0.02–0.04	>3.48–6.96	>0.177–0.181	
>0.04–0.08	>6.96–13.9	>0.181–0.188	
>0.08–0.16	>13.9–27.8	>0.188–0.202	
>0.16–0.32	>27.8–55.7	>0.202–0.230	
>0.32–0.64	>55.7–111	>0.230–0.285	
>0.64–1.28	>111–223	>0.285–0.397	
>1.28–2.56	>223–445	>0.397–0.619	
>2.56–5.12	>445–890	>0.619–1.065	
>5.12–10.2	>890–1780	1.07–1.96	
>10.2–20.5	>1780–3560	>1.96–3.74	
>20.5–41	>3560–7130	>3.74–7.30	
>41	>7130	>7.30	

The data were used to visualize light pollution, as in Figure 5 and Figure 6.

NOAA NCEI LCDv2

Cloud coverage, wind speed, and dew point data were obtained from the National Centers for Environmental Information (NCEI) – a division of the National Oceanic and Atmospheric Administration (NOAA) – using the Local Climatological Data Version 2 (LCDv2).[126] This dataset – which compiles hourly, daily, and monthly weather station observations into annual files – was used in Chapter 4.

For this study, we analyzed hourly data collected at Taos Airport between 2018 and 2024 to identify the best night-seeing conditions. For each observation, sunrise and sunset times were recorded, and the dataset was filtered to only include data collected 1.5 hours after sunset and 1.5 hours before sunrise. Additional data cleaning steps were also required for each variable and are described in the corresponding subsections.

Cloud Coverage

Cloud coverage is measured in "oktas" (eighths of the sky) and is recorded under the variable "HourlySkyConditions." Each observation follows the format ccc-ll-xxx, where ccc is the coverage, ll is the layer amount measured in oktas (ranging from 0 to 8), and xxx is the cloud base height at the lowest point of the layer. This analysis only focused on the first two components: ccc and ll. Observations have also been translated to general forecasting terms for clarity:

[126] Visit this link to view the documentation.

Coverage (ccc)	Definition	Layer Amount/Oktas (ll)	Forecasting Term
CLR	Clear	0	Clear
FEW	Few	1–2	Mostly Clear/Mostly Sunny
SCT	Scattered	3–4	Partly Cloudy
BKN	Broken	5–7	Mostly Cloudy
OVC	Overcast	8	Cloudy

Although up to three cloud layers can be reported for a single observation, only observations with one reported layer were analyzed. That is, an observation was excluded if more than one condition (such as SCT and BKN) was reported during the same hour. Given the 14-mile distance from UNM-Taos to Taos Airport, different sky conditions may be present when multiple layers are reported. In contrast, a single reported condition suggests uniform sky coverage across the area. As a result, data are not available for the following dates:

- **2018:** 06/14–06/17, 06/26–06/30, 07/01–07/04, 07/31, 09/08–09/09
- **2019:** 4/30, 05/18–05/19, 07/16, 07/21–07/22, 07/26–07/31, 08/01–08/21, 09/07–09/09, 09/29, 10/18, 10/22–10/23, 10/25–10/27, 11/21–11/22, 11/24–11/27
- **2021:** 03/11, 04/24
- **2022:** 01/17, 01/19, 04/23, 04/24, 09/30, 10/01–10/06, 10/27
- **2023:** 03/31, 04/02, 08/03–08/28
- **2024:** 01/24, 05/12, 06/21, 06/29, 09/01, 09/29–09/30, 10/01–10/02, 10/06, 10/08, 10/29, 11/23

Wind Speed

Wind speed is recorded under the variable "HourlyWindSpeed." Each hourly observation is assigned a value based on the Beaufort number classification system provided by the National Weather Service (NWS), a division of the National Oceanic and Atmospheric Administration (NOAA).[127]

Beaufort Number	Description	Speed
0	Calm	Calm
1	Light Air	1 to 3 mph
2	Light Breeze	4 to 7 mph
3	Gentle Breeze	8 to 12 mph
4	Moderate Breeze	13 to 18 mph
5	Fresh Breeze	19 to 24 mph
6	Strong Breeze	25 to 31 mph

Beaufort Number	Description	Speed
7	Near Gale	32 to 38 mph
8	Gale	39 to 46 mph
9	Strong Gale	47 to 54 mph
10	Whole Gale	55 to 63 mph
11	Storm Force	64 to 75 mph
12	Hurricane Force	75+ mph
-	-	-

[127] https://www.weather.gov/pqr/wind

Hourly wind speed data are not available for the following dates:

- **2019:** 05/18–05/19, 06/21–06/22, 06/26–06/30, 09/07–09/09, 09/29
- **2021:** 03/11
- **2022:** 01/19, 04/24, 10/27
- **2024:** 09/30

Dew Point Temperature

Dew point temperature is recorded under the variable "HourlyDewPointTemperature." Each hourly observation has been categorized using the following National Weather Service (NWS) definitions:[128]

- Less Than or Equal to 55°F: Dry and comfortable
- Between 55°F and 65°F: Becoming "sticky" with muggy evenings
- Greater Than or Equal To 65°F: Lots of moisture in the air, becoming oppressive.

Hourly dew point temperature data are not available for the following dates:

- **2019:** 05/18–05/19, 06/21–06/22, 06/26–06/30, 09/07–09/09, 09/29
- **2021:** 03/11
- **2022:** 04/24, 10/27

S&P Global Market Intelligence

The original construction estimates were prepared in July 2024. To account for potential overhead inflation due to construction market volatility, costs and the economic impact of construction are presented in 2027 dollars to reflect the expected year of construction for the observatory. Using 2024 as the base year, values were inflated from 2024 to 2027 dollars using the January 2026 S&P Global Market Intelligence's Book of Forecast Tables and Data. For construction, the chained price index for the construction of commercial buildings was selected.

Similar to that for construction, visitor spending values were inflated from 2024 to 2028 dollars using the consumer price index (all-urban) to reflect the observatory's first year of operation.

Inflation rates were calculated using the relative change formula.[129]

U.S. Census Bureau TIGER/Line Shapefiles

U.S. Census Bureau TIGER/Line Shapefiles are extracts of selected geographic and cartographic information from the Census Bureau's Master Address File/Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) System.[130] Shapefiles are digital representations of geographic features used to produce maps.

County shapefiles for the State of New Mexico were used in Figure 5 and Figure 7.

[128] https://www.weather.gov/arx/why_dewpoint_vs_humidity

[129] $Relative\ Change = \frac{Current\ Year\ Index - Previous\ Year\ Index}{Previous\ Year\ Index} \times 100$

[130] To view the technical documentation, please refer to this link.

UNM Office of Institutional Analytics

The University of New Mexico's Office of Institutional Analytics (OIA) is responsible for collecting, aggregating, and publishing institutional data on UNM (including UNM-Taos) students, faculty, staff, courses, degree programs, and other key metrics. These categorical variables have been cross-tabulated (e.g., pre-science major by gender) to uncover dependencies and relationships within the UNM-Taos student population and to understand how the Cielo Centro Observatory can support the diverse UNM-Taos student body.

UNM OIA data were used in Chapter 3.

Appendix B: Types of Events Held at Dark Sky Places in New Mexico in 2024

	Number of Times Offered	Estimated Number of Attendees
Capulin Volcano National Monument		
Dark Sky Festival	2	25
Dark Sky Programs	12	300
Chaco Culture National Historical Park		
Astronomy Festival	1	223
Fall Equinox Sunrise Event	1	68
Spring Equinox Sunrise Event	1	41
Star Party	12	331
Summer Solstice Sunrise Event	1	170
Clayton Lake State Park		
Star Parties	10	400
Cosmic Campground		
Cosmic Campground Cleanup	2	16
Cosmic Campground Dark Sky Party	1	75
Dark Skies in New Mexico	1	15
Night Without Lights	1	6
Perseid Meteor Shower	1	32
Scopes at Cosmic Campground	1	12
El Morro National Monument		
Astronomy Evening Programs	5	71
Informal Staffed Popup Presentations	19	364
Fort Union National Monument		
An International Dark Sky Park	6	49
Salinas Pueblo Missions National Monument		
Dark Sky Program with Dark Sky Photography Workshop/Telescope Viewing/Astronomy Presenters	6	534
Solar Eclipse Event with Mountainair Elementary and Middle School	1	100
Valle de Oro National Wildlife Refuge		
Luminaria Walk & Star Party	1	480
Star Party	2	153
Wild at Night & Star Party	1	176
Valles Caldera National Preserve		
Astrophotography	5	51
Moonlit Walk	6	230
Stargazing	3	54
Stars & Sweets	1	1920

Appendix C: Enrollment and Types of PreK-12 Schools in the UNM-Taos Service Area

Table 13: Enrollment by District for PreK-12 Students in the UNM-Taos Service Area

District Name	District Type	Total Enrollment
Cimarron Public Schools	State District	359
Questa Independent Schools	State District	301
Roots & Wings Community	State Charter	51
Taos Municipal Schools	State District	2,124
Taos Academy	State Charter	192
Taos Integrated School of the Arts	State Charter	207
Taos International School	State Charter	159
Vista Grande High School	State Charter	60
Total Enrollment	–	**3,453**

Table 14: Types of PreK-12 Schools in the UNM-Taos Service Area

School	District	City	Type	Designation
Cimarron Elementary	Cimarron Public Schools	Cimarron	Public School	Traditional
Cimarron Middle	Cimarron Public Schools	Cimarron	Public School	Spotlight
Cimarron High	Cimarron Public Schools	Cimarron	Public School	Spotlight
Eagle Nest Elementary	Cimarron Public Schools	Eagle Nest	Public School	Traditional
Eagle Nest Middle	Cimarron Public Schools	Eagle Nest	Public School	Traditional
Moreno Valley High	Cimarron Public Schools	Angel Fire	District Charter School	Spotlight
Alta Vista Elementary	Questa Independent Schools	Questa	Public School	Traditional
Alta Vista Intermediate	Questa Independent Schools	Questa	Public School	CSI.H
Questa Jr High	Questa Independent Schools	Questa	Public School	Traditional
Questa High	Questa Independent Schools	Questa	Public School	Traditional
Roots & Wings Community	Roots and Wings Community	Questa	State Charter School	Traditional
Anansi Charter School	Taos Municipal Schools	El Prado	District Charter School	Spotlight
Arroyo Del Norte Elementary	Taos Municipal Schools	Arroyo Seco	Public School	Traditional
Ranchos De Taos Elementary	Taos Municipal Schools	Ranchos De Taos	Public School	Traditional
Enos Garcia Elementary	Taos Municipal Schools	Taos	Public School	Traditional
Taos Middle	Taos Municipal Schools	Taos	Public School	Traditional
Taos High	Taos Municipal Schools	Taos	Public School	Traditional
Taos Municipal Charter	Taos Municipal Schools	Taos	District Charter School	Spotlight
Taos Cyber Magnet	Taos Municipal Schools	Taos	Public School	Traditional
Taos Academy	Taos Academy	Taos	State Charter School	Spotlight
Taos Integrated School of the Arts	Taos Integrated School of the Arts	Taos	State Charter School	Spotlight
Taos International School	Taos International School	Taos	State Charter School	Traditional
Vista Grande High	Vista Grande High School	Taos	State Charter School	CSI.Grad

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