participating in large collaborations could consider both a carbon offset plan and an assessment of the carbon footprint associated with travel.
  - *Impact:* Assessment, quantification, and mitigation of environmental impact by the Profession.
  - *Programmatics:* Costs can be included in a facility's planning process.
- **NSF-AST, NASA-APD/SMD, Educational/College/University Institutions**
  - *Method:* The panel suggests redesigning old and funding new initiatives and education programs to focus on climate change.[231]
  - *Impact:* Capitalize on public interest in astronomy to educate large audiences on scientific language and climate change.
  - *Programmatics:* No significant change in funding. Agencies would need to refocus priorities when assessing successful proposals.

N.6.7 Goal 7: Partnering with Indigenous Communities

Align the values of the Profession with those of Indigenous and other local communities impacted by the Profession to cultivate and sustain healthy partnerships for the benefit of both.

The future health of the Profession depends upon developing and maintaining healthy partnerships with Indigenous communities. Optimally sited observatories are a necessary resource for the Profession; access to those sites is critical to their success. Many ground-based observatories[232] are built on lands that have legal, cultural, historical, and/or sacred significance to Indigenous communities. Many large astronomy departments are hosted at academic institutions that have profited from similarly obtained land allotments.[233] Despite the value of these resources, Indigenous stakeholders are the least represented in the Profession,[234] suggesting that the Profession's past and current efforts to engage with Indigenous peoples are ineffective. Growing tensions owing to such land usage are recognized on a global scale, which negatively impacts public and political support for the Profession. It is therefore critical to develop long-term, targeted, functional partnerships with Indigenous communities that explicitly recognize Indigenous sovereignty and personhood.

Building healthy partnerships with Indigenous communities necessitates the following: (1) culturally supported pathways for inclusion in the Profession; (2) equitable access to education, current and emerging technologies, and economic benefits of hosting an astronomical facility; and (3) responsible stewardship in recognition of the use of Indigenous lands by non-Indigenous entities. This last includes partnership with Indigenous communities in order to make reparations and to enter respectful dialogue

[231] Although "any individual actions we take will pale in comparison to corporate and industrial pollution Astronomers have an 'ethical obligation … that must not be ignored' … we should not internalize environmental guilt; instead we must call for systemic change and fight against bad practice." Climate Issue, 2020, *Nature Astronomy*, 4:811, doi: 10.1038/s41550-020-01216-9.

[232] The following is a non-exhaustive list of some of the most prominent U.S. observatory sites listed with the associated Indigenous community: Maunakea Observatories (Kanaka Maoli); Kitt Peak National Observatory (Tohono O'odham); Mt. Graham International Observatory (Apache); Las Campanas Observatory, Cerro Pachón/Gemini South Observatory/Rubin Observatory (Diaguita); Atacama Large Millimeter Array (Likan Antai).

[233] For example, 10.7 million acres of Indigenous lands were allotted to 52 land grant universities through the Morrill Act and similar legislation to aid their economic development and growth. Institutions with astronomy programs that significantly benefit from these lands include Cornell, Penn State, Ohio State, Michigan State, Washington State, University of California, Rutgers, MIT, University of Maryland, University of Massachusetts, University of Wisconsin, University of Arizona, and University of Minnesota.

[234] There are approximately 6.8 million Indigenous people (U.S. Census Bureau, 2020) living in the United States (~2.09 percent total population), but on order of 10 hold Ph.D.s in physics and astronomy, https://worldpopulationreview.com/states/native-american-population/, accessed August 2020.

about the construction of future facilities. The above provides a foundation upon which community values may be realized.

N.6.7.1 Mitigate the Negative Impact of Past Engagement Around the Summit of Maunakea as Part of a Larger Effort to Build a Functional Partnership with Local Indigenous Communities

Lack of an authentic partnership with Kanaka Maoli (the Indigenous people of Hawai'i) impedes the efficacy of the astronomy workforce, significantly risks facilities' investments, negatively impacts Kanaka Maoli, and diminishes public support. It puts into question the integrity upon which scientific discovery is realized. The Profession has not practiced responsible stewardship as described by the equity-advancing values proposed in this report. This is manifested by the lack of guiding principles, to be upheld by the University of Hawai'i (UH), the Thirty Meter Telescope (TMT) International Observatory (TIO), or the Profession as a whole, for the ethical practice of astronomy. Box N.3 gives a brief summary of the Profession's activities on Maunakea in the historical context of engagement with Kanaka Maoli. It highlights the negative impact past modes of engagement have had on both the Profession and Kanaka Maoli, with the intent to learn from past mistakes and frame a pathway for a more equitable and collaborative future together for the benefit of all.

BOX N.3 Contextual History of Engagement of the Profession with Kanaka Maoli

The summit of Maunakea has become home to 13 of the most successful observatories in the world. The anticipated addition of the Thirty Meter Telescope (TMT) is expected to revolutionize ground-based astronomy and was listed as a top priority in the Astro2000 report.[1] However, ongoing demonstrations by kia'i (guardian or protector), led by Kanaka Maoli, bring a serious concern into focus. The construction of TMT, the means by which it is realized, and its impact on Kanaka Maoli have to be recognized within the larger context of Hawaiian history.[2,3,4] Failure to do so[5,6,7] has led to several iterations of major delays,[8,9] arrests,[10,11,12] rulings,[13,14,15] and governor-issued directives[16] since the groundbreaking ceremony was disrupted[17] in 2014.[18] New construction on Maunakea has seen falling public support.[19] As of December 2019, Governor Ige of Hawai'i has withdrawn state law enforcement owing to the $15 million cost surrounding safe access to the summit[20] simultaneously met by halted construction of TMT.[21] Furthermore, continued access to observatories in current operation at the summit is intermittently obstructed.[22] All investments to date are at risk if these issues are not resolved with a long-term plan in place. Instead, the value of these investments and the integrity of the Profession is realized should the Profession work in collaboration with Kanaka Maoli.

The construction of TMT falls during a time of Indigenous cultural reclamation in Hawai'i after over a century of persecution and systemic oppression. The summit of Maunakea[23] is traditionally regarded by many Kanaka Maoli as sacred,[24,25,26,27] as "a place for gods and not for construction of edifices for human use."[28] Ahu (shrines), heiau (temples), pu'u (hills), and burial sites around the summit are a testament to the reverence held by Kanaka Maoli for the Mauna. Cultural practices, like burial of 'iewe (placenta) and gathering of sacred waters, require continued, free access, which is inhibited by current policies around the summit. The Profession's impact on Kanaka Maoli culture is substantial.

A narrative constructed from TMT budgets suggests that the full impact of the project on Maunakea and Kanaka Maoli has been systematically minimized and ignored. Based on documents provided by the TMT to this panel, the preconstruction planning and development phase alone totaled $211.1 million, with clearing and building costs between 2014–2020 totaling $19.3 million. During this same time, a relatively small investment ($13.3 million[29]) was devoted to community engagement efforts. Moving forward, the expected annual cost for operations and maintenance of TMT is $47.0 million plus a sublet cost of $1 million/year to be paid to UH. The lease agreement for the observatory complex on Maunakea

between the state and UH is $1/year ending in 2033, when all lands shall be returned to original conditions within reason.[30] The proposed construction of TMT, just before the lease termination date, sends a message of devaluation to Kanaka Maoli. Every legal effort and counterclaims filed by Kanaka Maoli, including pressures to decommission an observatory before new construction, appeals to reopen construction, and any other disagreements regarding construction on Maunakea, are reported to have "minimal" impact on observatory budgets. Further, no cost estimate has been made for post-lifetime TMT life-support, suggesting that there has been little consideration for the long-term stewardship for Maunakea. When value is equated with dollar signs, the value placed by the Profession on Kanaka Maoli culture, values, voices, and needs is "minimal" except under threat of discontinued operation and construction of observatories on Maunakea.

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[1] NRC (National Research Council), 2001, *Astronomy and Astrophysics in the New Millennium*, Washington, DC: The National Academies Press.

[2] R. Alegado, 2019, Opponents of the Thirty Meter Telescope fight the process, not science, *Nature*, 572, https://www.nature.com/articles/d41586-019-02304-1, accessed 24 August 2020.

[3] A. Witze, How the fight over a Hawaii mega-telescope could change astronomy, *Nature*, 577, https://www.nature.com/articles/d41586-020-00076-7, accessed 24 August 2020.

[4] C. Prescod-Weinstein, et al., 2020, "Reframing Astronomical Research Through an Anticolonial Lens—For TMT and Beyond," Community input from submission, 27 January.

[5] B. Isaki, S. Muneoka, and K.H. Kanahele, 2020, "Kū Kia'i Mauna: Historical and Ongoing Resistance to Industrial Astronomy Development on Mauna Kea, Hawai'i," Community input from submission, 8 January.

[6] K. Kiyuna, 2020, "Ka Piko Kaulana o ka ʻĀina: Additional Context for Understanding the Cultural Significance of Mauna Kea," Community input from submission, 8 January.

[7] S. Kahanamoku, R.A. Alegado, K.L. Kamelamela, B. Kamai, L.M. Walkowicz, C. Prescod-Weinstein, M.A. de los Reyes, and H. Neilson, 2020, "A Native Hawaiian-Led Summary of the Current Impact of Constructing the Thirty Meter Telescope on Maunakea," Community input from submission, 9 January. 64f0d1cc4f85beae7842d196a156c767_Native_Hawaiian_Impacts_Astro2020_final.pdf, accessed 24 August 2020.

[8] TMT construction delayed—11 Apr 2015, *khon2*, http://khon2.com/2015/04/11/thirty-meter-telescope-construction-delayed/, accessed 24 August 2020.

[9] TMT construction delayed—19 Dec 2019, Hawai'i Public Radio, https://www.hawaiipublicradio.org/post/tmt-wont-begin-construction-time-protesters-told-clear-mauna-kea#stream/0, accessed 24 Aug 2020.

[10] C. Jones, Associated Press, 2015, "Clash in Hawaii Between Science and Sacred Land," 3 April, in *US News*, https://www.usnews.com/news/science/news/articles/2015/04/03/clash-over-telescope-at-sacred-hawaiian-site-intensifies, accessed 24 August 2020.

[11] "Police, TMT Issue Statements on Mass Arrests on Mauna Kea," *Big Island Video News*, 2 April 2015, http://www.bigislandvideonews.com/2015/04/02/police-tmt-issue-statements-on-mass-arrests-on-mauna-kea/, accessed 24 August 2020.

[12] "Department of Land and Natural Resources Releases Names of Those Arrested on Maunakea," *Hawaii Tribune Herald*, 24 July 2019, https://www.hawaiitribune-herald.com/2019/07/24/hawaii-news/dlnr-releases-names-of-those-arrested-on-maunakea/, accessed 24 August 2020.

[13] See Hawai'i Board of Land and Natural Resources Case BLNR-CC-16-002.

[14] Hawai'i Supreme Court case SCAP-14-0000873, https://www.courts.state.hi.us/docs/opin_ord/sct/2015/December/SCAP-14-0000873.pdf, accessed 25 August 2020.

[15] Hawai'i Supreme Court case SCOT-17-0000777, https://law.justia.com/cases/hawaii/supreme-court/2018/scot-17-0000777.html, accessed 25 August 2020.

[16] Governor Y. Ige of the State of Hawai'i, State of the State Address, "News Release: Governor David Ige Announces Major Changes in the Stewardship of Mauna Kea," https://governor.hawaii.gov/newsroom/news-release-governor-david-ige-announces-major-changes-in-the-stewardship-of-mauna-kea/, accessed 24 August 2020.

[17] "TMT Groundbreaking Disrupted," *Hawaii Tribune Herald*, 8 October 2014, https://www.hawaiitribune-herald.com/2014/10/08/hawaii-news/tmt-groundbreaking-disrupted/, accessed 24 August 2020.

[18] References listed here on the history of negotiations on the construction of TMT on Maunakea are not exhaustive.

[19] K. Dayton, "Public Support for TMT Drops Sharply, According to New Honolulu Star-Advertiser Poll," *Star Advertiser*, 25 September 2019, https://www.staradvertiser.com/2019/09/25/hawaii-news/public-support-for-tmt-

drops-sharply-according-to-a-new-honolulu-star-advertiser-poll/?HSA=78e87324d7c8c9011961208b9ed13d2797888c07.

[20] Associated Press, "Governor Says Hawaii Spent $15M to Ensure Mauna Kea Access," *Hawai'i Public Radio*, 18 December 2019, https://www.hawaiipublicradio.org/post/governor-says-hawaii-spent-15m-ensure-mauna-kea-access#stream/0, accessed 25 August 2020.

[21] C. Harlow and K. Hiraishi, "TMT Won't Begin Construction at This Time, Protestors Told to Clear Mauna Kea," *Hawaii Public Radio*, 19 December 2019, https://www.hawaiipublicradio.org/post/tmt-wont-begin-construction-time-protesters-told-clear-mauna-kea#stream/0, accessed 25 August 2020.

[22] *Nature* 577, 457–458, 2020.

[23] These lands were deemed "public" following the coup overthrow of the Hawaiian sovereign nation in 1893 and reassigned as "Ceded Lands" when Hawai'i became a U.S. territory in 1959.

[24] B. Isaki, S. Muneoka, and K.H. Kanahele, 2020, "Kū Kia'i Mauna: Historical and Ongoing Resistance to Industrial Astronomy Development on Mauna Kea, Hawai'i," Community input from submission, 8 January 2020. .

[25] K. Kiyuna, "Ka Piko Kaulana o ka 'Āina: Additional Context for Understanding the Cultural Significance of Mauna Kea," Community input from submission, 8 January 2020

[26] T.K.H. Kanahele and D. McGregor, "Impacts of Astronomy on Indigenous Customary and Traditional Practices as Evident at Mauna Kea," 6 January 2020, https://doi.org/10.6084/m9.figshare.11522289.v1, accessed 26 August 2020.

[27] S. Kahanamoku, R.A. Alegado, K.L. Kamelamela, B. Kamai, L.M. Walkowicz, C. Prescod-Weinstein, M.A. de los Reyes, and H. Neilson, 2020, "A Native Hawaiian-Led Summary of the Current Impact of Constructing the Thirty Meter Telescope on Maunakea," Community input from submission, 9 January..

[28] This relationship has been documented as early as 1826 by missionary Joseph Goodrich. B. Isaki, S. Muneoka, and K.H. Kanahele, 2020, "Kū Kia'i Mauna: Historical and Ongoing Resistance to Industrial Astronomy Development on Mauna Kea, Hawai'i," Community input from submission, 8 January 2020..

[29] $5.5 million went toward the Community Benefits Package and $7.8 million went toward education and public engagement.

[30] State of Hawai'i General Lease No. S-1491.

The misalignment between the Profession's actions and Indigenous values has led to the current impasse. The situation on Maunakea in Hawai'i jeopardizes the following: (1) *Economic prosperity* through the potential loss of all investment in future observatories and access to current observatories. (2) *Health and well-being* of Indigenous astronomers who are forced to choose from a false dichotomy between cultural and professional values, thus creating both an unnecessary conflict within Indigenous communities and a narrative that counters any efforts toward inclusion of Indigenous people,[235,236] the least represented group within the Profession. Members of the Profession are forced to align for or against construction of TMT, which can be divisive within the scientific community when moral principles are not in alignment with science driven goals. (3) *Broadening participation and continued innovation* because both the academic pursuit of excellent science and Indigenous practices are lost or impeded by ongoing conflict around access[237] to the lands on and around Maunakea's summit.

The following methods suggest a path forward that begins and ends with Indigenous stakeholders and protectors of the land. It relies upon the inherent integrity of the Profession to pause all construction, listen to Indigenous communities, and engage in ethical practices that build trust and fundamentally acknowledge Indigenous personhood. These methods are meant to serve as a foundation upon which

[235] H. Kaluna, M. Neal, M. Silva, and T. Trent, 2020 "A Collective Insight into the Cultural and Academic Journeys of Native Hawaiians While Pursuing Careers in Physics and Astronomy," Community input form submission,6 March.

[236] A. Venkatesan, D. Begay, A. Burgasser, I. Hawkins, K. Kimura, N. Maryboy, L. Peticolas et al., "Collaboration with Integrity: Indigenous Knowledge in 21st Century Astronomy," white paper submitted to the Astro2020 Decadal Survey, https://baas.aas.org/pub/2020n7i020/release/1.

[237] Cultural practices that require access to the summit and its surrounding lands can be unplanned and personal in nature, requiring unfettered and timely access.

future and current facilities, institutions, observatories, and observatory sites can assess investments in partnership with Indigenous stakeholders.

Goal 7, Suggestion 1: The panel suggests that funding agencies hold ground-based observatories accountable to a high ethical standard, particularly around the construction of TMT on Maunakea. A true partnership as defined above would redirect effort to identify stakeholders and assess their needs, values, and activities, especially in relation to the Kanaka Maoli.[238]

Method, impact, and programmatics and cost to achieve this suggestion:

- **State of Hawai'i and TMT Institutions, Held Accountable by Funding Agencies**
  - *Method:* The panel strongly suggests that *any* new or continued construction on the summit of Maunakea be contingent upon having proactively established a pathway forward using a community-based approach that is based on consent and *mutual* agreement.[239] To ensure said pathway, the panel suggests, in addition to following guidelines developed in Goal 1, Suggestion 2, and Goal 6, Suggestion 1, the three methods outlined below. The panel further suggests that funding agencies not invest in future projects on Maunakea unless this and the following three methods are realized.
  - *Impact:* Allow time for respectful dialogue, which cannot occur under duress.[240]
  - *Programmatics:* No change in cost.[241]
- **TMT International Observatory LLC (TIO), University of Hawai'i (UH), and other Facility Lease Holders on Maunakea's Summit, Held Accountable by Funding Agencies**
  - *Method:* Allocate funding in facilities budget for proactive, ecologically sound maintenance of current facilities and complete cleanup of decommissioned observatory sites.[242] The panel suggests that funding agencies mandate annual reports on maintenance, cleanup, and other terms of land lease/occupation, as a requirement of any federal investment in TMT and in compliance with Goal 6, Suggestion 3.
  - *Impact:* Demonstrate that Indigenous voices have been heard on this matter and are respected, and thus intentional reparations are enacted.
  - *Programmatics:* Federal agencies can ensure compliance. Cost is $1 million/year for maintenance, $23.5 million/observatory for decommissioning and cleanup.[243] These costs will need to be verified and updated using independent estimates and in collaboration with the local community.

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[238] The NSF statement on August 13 (https://www.nsf.gov/news/news_summ.jsp?cntn_id=301034) is an encouraging motion in the proposed direction with the hope that these efforts will be used to effectively engage with local Indigenous stakeholders and define a mutually beneficial pathway forward. Should a formal federal environmental review process begin, inclusion of local Indigenous stakeholder perspectives is critical for assessing outcomes and process.

[239] There have been proposals, such as those of Governor Ige in 2015 (see Box N.3), in reaction to demonstrations. The panel's overarching suggestion is that the profession position itself to proactively approach the coming decade, rather than continue down a trajectory that is increasingly reactive in nature.

[240] See Box N.3 for a brief historical accounting, and references therein that were provided by Kanaka Maoli to this panel, as evidence of Indigenous perspectives and experiences.

[241] TMT declined to report delay costs in the report they provided to the panel. It is here assumed that these will not exceed current costs.

[242] A. Witze, 2015, Hawaii prunes Mauna Kea telescope hub, *Nature*, 522:15–16, https://www.nature.com/news/hawaii-prunes-mauna-kea-telescope-hub-1.17688, accessed 26 August 2020.

[243] One to three of the 13 current observatories on the summit are projected to be decommissioned in the next few years, whereas the current lease mandates all 13 to be completely cleaned up by 2033. This cost is based on the estimate provided by TIO for a single observatory. The expected cost investments for maintenance, decommissioning, and cleanup were provided by TMT and are in 2019 dollars.

- **TIO,** Held Accountable by **Funding Agencies**
  - *Method:* Fund initiative(s) for stakeholders who have an interest in Maunakea, including Kanaka Maoli cultural knowledge holders, to open a respectful and continuous dialogue around informed consent, where Kanaka Maoli are included in the TMT/TIO leadership. Informed consent[244] means an iterative process of proposal and review that addresses ethics and impacts on Indigenous persons and communities. Funding agencies can hold TIO accountable by making any federal funding for TMT contingent upon the ethical practices for partnership.
  - *Impact:* Provide a roadmap for the respectful development of future facilities that upholds the integrity of Indigenous people and the Profession.
  - *Programmatics:* Cost: $10 million initial efforts, 10 percent annual operating and maintenance costs—in addition to "Community Benefits Package" and "Education and Public Outreach."
- **Funding Agencies and Institutions**
  - *Method:* Systematically determine whether there are Indigenous stakeholders and what their needs, values, and activities are prior to and during development of any new facility. Hold facility development to the same ethical standards as any partnership in the Profession.[245] Within this framework, local stakeholders (especially Indigenous) would be included in planning, construction, maintenance, and decommissioning of facilities, as well as in defining benchmarks for accountability.
  - *Impact:* Funding Institutions and land holders would create an ethics review board, in accordance with Goal 6, Suggestion 1, tasked with review and approval of facilities development, working in partnership with local stakeholders. Funding agencies can provide federally mandated and professionally established ethical standards, protections, and guidelines for individual human, cultural, artifact, and environmental impacts from facilities development.
  - *Programmatics:* Included in construction and maintenance cost.
- **The Profession and Funding Agencies**
  - *Method:* Require proposals using observational facilities that have Indigenous stakeholders consider the societal impacts of the observatory and its use on those communities. The panel suggests that a mandatory educational module be included in the time application, where this module would be developed in collaboration with Kanaka Maoli and focus on societal impacts and the equity-advancing values outlined in the section "A Values Statement for the Profession of Astronomy and Astrophysics," earlier.
  - *Impact:* Self-education of PIs on the process and impact of observatory construction on Indigenous lands.
  - *Programmatics:* Low-cost. Could be implemented immediately.

N.6.7.2 Build Functional Partnerships with Indigenous Communities and Culturally Supported Pathways for the Inclusion for Indigenous Members of the Profession

The panel believes that there is a critical need to build long-term, functional partnerships with Indigenous communities. Lack of resources, often related to the limited availability of culturally relevant

[244] Defined in the Department for Health and Human Services Common Rule Federal Policy for the Protection of Human Subjects.

[245] Examples are literature surveys, stakeholder surveys, focus groups, cultural impact surveys like those required by the National Historic Preservation Act, and an evaluating committee that includes historians, environmental protection representatives, local community representatives, and sociologists.

education systems, as well as poverty[246] are major contributing factors to the broad education gap in Indigenous communities starting in early childhood.[247] Tribal Colleges and Universities (TCU) and Indigenous education centers are increasingly able to provide education through culturally relevant systems of study, but these same institutions are often severely underresourced. For example, such institutions may not have basic Internet access, technological infrastructure, or support for adequate computational literacy education and training. Students from underresourced institutions suffer the consequences of inequitable access from the earliest career stages. The combination of underresourced educational institutions and cultural marginalization within the Profession ultimately counters the inclusivity efforts of Indigenous scientists within the Profession. The addition of the optics of world-class facilities, occupied by non-Indigenous people, on Indigenous lands, can deepen distrust for the Profession in some Indigenous communities. Initiatives that aim to build mutually respectful and culturally relevant partnerships with Indigenous communities are shown[248] to significantly increase support for the Profession from local Indigenous stakeholders—and more broadly STEM—and to open culturally supported pathways for Indigenous youth to enter the Profession.

> **Goal 7, Suggestion 2:** The Profession is accountable for promoting equitable, culturally supported participation. This requires a change in the Profession's culture so that Indigenous contributions are appropriately credited and Indigenous people and their cultures and values are granted respect. The panel suggests that funding agencies increase the scope of engagement and funding for existing partnerships with Indigenous communities and new partnership initiatives. Indigenous participation can be supported using targeted funding for (1) fellowships that support astronomy students from Indigenous communities, (2) Indigenous-led research, and (3) partnerships and support networks between Indigenous educational centers and larger research institutions and collaborations.
>
> *Method, impact, and programmatics and cost to achieve this suggestion:*
>
> - **The Profession, AAS Journals**
>   - *Method:* Self-educate about Indigenous methods of producing, curating, and sharing Indigenous Traditional Knowledge (TK), which include oral histories and protocols, in order to develop, in partnership with Indigenous communities,[249] standards for respectfully crediting and using TK (e.g., in journal articles and talks).[250] The panel suggests that the Profession change language that reinforces adversarial or dismissive attitudes toward Indigenous communities and perspectives.

[246] Indigenous communities experience more than twice the national poverty rate. United States Census Bureau, https://data.census.gov/cedsci/table?q=B17&d=ACS%201-Year%20Estimates%20Detailed%20Tables&tid=ACSDT1Y2018.B17001C&vintage=2018, accessed 24 August 2020.

[247] UN Department of Economic and Social Affairs, Indigenous Peoples, Education Report, https://www.un.org/development/desa/indigenouspeoples/mandated-areas1/education.html, accessed 24 August 2020.

[248] Lee et al., 2020, "Building a Framework for Indigenous Astronomy Collaboration: Native Skywatchers, Indigenous Scientific Knowledge Systems, and The Bell Museum," International Planetarium Society Conference Proceedings. [[SRO: PLEASE PROVIDE FULL CITATION]]

[249] For example, use Traditional Knowledge Labels, https://localcontexts.org/tk-labels/, accessed 24 August 2020.

[250] Standards and protocols set forth by the Global Indigenous Data Alliance through the FAIR and CARE principles are an emerging avenue for such endeavors, https://www.gida-global.org, accessed 24 August 2020.

- — *Impact:* Lay groundwork to meaningfully and respectfully credit culturally significant Indigenous contributions.[251]
- — *Programmatics:* No cost. Can be implemented immediately.

- **NSF and NASA**
  - — *Method:* Fund PIs located at TCUs, from Indigenous communities, or at institutions that predominantly serve Indigenous populations in partnership with Indigenous communities in order to develop culturally supported, Indigenous-led research and extended (5 year) research engagement through faculty and student training and mentorship,[252] administrative support, and up-to-date technological tools and support. Optimally, these would include funding for efforts to build strong, long-term research partnerships with large institutions/big data centers/collaborations with the aim of developing culturally supported pathways for full participation of Indigenous people in science careers.
  - — *Impact:* Provide equitable access and increase multimodal expertise.
  - — *Programmatics:* $200,000/year to support two initiatives at $100,000/year per agency and implemented in 2–3 years.
- **NSF, NASA, and DOE**
  - — *Method:* Fund Indigenous education centers in partnership with Indigenous communities. This could include building and maintaining a computational infrastructure to enable remote participation in education opportunities, conferences, collaboration, and training from within Indigenous communities.[253] This includes computational facilities, AV equipment, and training, with Internet standards of an R1 institution.
  - — *Impact:* Provide equitable access and amplify Indigenous voices and approaches within the Profession.
  - — *Programmatics:* Cost: $1 million/year per agency, implemented in 1–2 years.[254]
- **NSF, NASA, and DOE, Private Foundations**
  - — *Method:* The panel suggests that private foundations create long-term, $50,000/year fellowships, from undergraduate to Ph.D., for students belonging to Indigenous communities. The panel further suggests that federal agencies create bridge fellowships for students from TCU and Tribal Community Centers.
  - — *Impact:* Provide equitable access to and amplify Indigenous voices and approaches within the Profession.
  - — *Programmatics:* $100,000/year per agency and $500,000/year from private foundations, implemented in 1–2 years.[255]

[251] A. Venkatesan, D. Begay, A. Burgasser, I. Hawkins, K. Kimura, N. Maryboy, L. Peticolas. et al., ., "Collaboration with Integrity: Indigenous Knowledge in 21st Century Astronomy," white paper submitted to the Astro2020 Decadal Survey, https://baas.aas.org/pub/2020n7i020/release/1.

[252] A. Venkatesan, D. Begay, A. Burgasser, I. Hawkins, K. Kimura, N. Maryboy, L. Peticolas et al., "Collaboration with Integrity: Indigenous Knowledge in 21st Century Astronomy," white paper submitted to the Astro2020 Decadal Survey, https://baas.aas.org/pub/2020n7i020/release/1..

[253] Many Indigenous cultures value physical presence within their home community. In these cases, equitable access can only be attained when this cultural value is supported via remote participation.

[254] Grants would provide financial support for infrastructure and maintenance. This program is designed to equip and support all TCUs over a decade, with institutional needs widely varying. Costs have been calculated on the basis of 37 institutions, each of them being provided a total of about $500,000 over a decade.

[255] Grants would provide financial support for 18 students per year in physics and astronomy.