

Defining and Measuring Impact in NASA Ecological Conservation Projects

NASA Ecological Conservation activities support the development of products that enhance end users' decision making for conservation planning or action. An end user is any group, organization, body, or person with a specific decision-making need and an authority to act based on the decision(s) made. These products might include maps, models, tools, platforms, or decision support systems. While Application Readiness Levels ([ARLs](#)) track the progress of these products during Ecological Conservation-funded projects, success is measured by the concrete demonstration of 'Impact,' during and after the project, on end users, their decision making, and their practices.

This impact can be observed through various measures. In the spring of 2022, we surveyed NASA internal leadership and identified six definitions of 'Impact' along a continuum of end user engagement with a product. To guide Ecological Conservation PIs, we define and compare these Impact types below.

In general, Ecological Conservation projects progress from Knowledge Gain to Use, then to Action and Benefit, with Sustainability representing long-term continuation of impact. While all six impact types provide useful context for understanding project outcomes, the NASA Ecological Conservation program places greatest emphasis on demonstrating:

- Use — the product is operationally employed by end users,
- Action — the information informs real-world decisions or interventions, and
- Benefit — those actions produce measurable positive outcomes.

Together, these three categories represent the clearest evidence that NASA-supported capabilities are influencing conservation practice and delivering societal or environmental value. In general, higher levels of impact build upon earlier stages; products are typically first developed, then used, then used to inform action, and ultimately generate measurable benefits.

1. Knowledge Gain – Improvement in understanding or ability by the product.

Knowledge Gain is a supporting indicator of impact. Knowledge Gain is a measurable enhancement in decision-making capability, as a consequence of product development, that results in a better understanding of conditions or processes that inform conservation planning or action. Knowledge Gain represents the initial milestone in the product development process. While Knowledge Gain alone is not considered a sufficient project impact, it is essential for all subsequent stages of success. Note that Knowledge Gain is distinct from capacity building and training.

Reporting Guidance - Funded teams will report on Knowledge Gain through ARL progress reports and annual reports.

Examples - Examples include increased spatial or temporal resolution or extent, reduced error rates, or inclusion of additional key variables in a product.

- The Audubon Society, in collaboration with its partners in Colombia, developed this tool, leveraging Landsat 9, GEDI, and other remote sensing technologies to map habitat essential for safe migration of bird species.
- A beta version of this tool was created that brings together Landsat fire severity data, GEDI forest structure, MODIS, aerial lidar, and acoustic measures of avian biodiversity to assess habitat suitability and forest fuel density leading to wildfire.
- The incorporation of satellite data into this tool enabled expanded the geographic area of monitoring to the entire 100,000 sq km project area and provided updates more frequently than by monitoring ground data alone.
- This application now quantifies surface water and mesic vegetation at 10-meter resolution using Sentinel 1 & 2 data, and measures habitat change referencing Landsat data and forecasts future surface water.

2. Use – Extent of product use by the end user or the public.

Use is a core indicator of impact. Use indicates whether the product is being actively employed. Use is often demonstrated through evidence that a tool or capability is operationally employed to support recurring activities, analyses, reporting, or planning. If a team enhances a product's capability (as described in 1. Knowledge Gain) yet it remains unused, the scientific advancements have not been effectively applied and impact through use has not been achieved.

In the context of NASA Ecological Conservation projects, mere publication or product improvement without real world application does not distinguish it from a standard NASA Research and Analysis project. Therefore, we seek examples (during or after a project period of performance) of actual product use by end users.

Reporting Guidance - Funded teams will report on planned Use through initial baseline metrics and actual use through regular project reports or are encouraged to share known examples with their Associate Program Manager after the period of performance.

Examples - Measurements of Use can include end user testimony or usage statistics, such as the frequency of product use (e.g., web statistics, organizational implementation etc.), adoption rate, number of downloads, or similar.

- This tool has been used annually for the Greater Yellowstone Inventory & Monitoring Network and state of the parks reports.
- NOAA Watch uses this tool for daily quality and quantity assurance. NOAA Coastwatch uses the tool for its daily assessment.
- The information produced using this tool is included in our organization's monthly bulletin, which is sent to eighty people.
- This application involves 3,000 data owners working on 6,000 studies, and have collected data from 2.4 billion locations, gathering 3.1 billion measurements. We are currently gaining 3 million new records per day.
- The National Park Service officially adopted a sensory pollution risk web tool, which is now live on the NPS servers.

3. Action – Effect of product use on the decisions made by end users.

Action is a core indicator of impact. Action is the decisions, policies, operations, investments, or on-the-ground interventions informed or changed through use of the product. Action occurs when NASA-supported information influences what an organization or practitioner actually does.

Using a tool, viewing data, including information in a report, or increasing awareness alone are not actions. Action requires evidence that the information informed a consequential decision, activity, or intervention. In Ecological Conservation, the program ultimately prioritizes demonstrated conservation outcomes over publication metrics.

Documenting Action is challenging because many decisions are influenced by factors outside analytical insights, such as politics or resource availability. Additionally, capturing Action requires a deep and ongoing relationship with the end user(s). Teams should understand the decision-making landscape of the end user to best enable product Use and Action. NASA-supported products are often one of many factors influencing decisions and outcomes. Therefore, teams should focus on documenting plausible contribution to decisions or outcomes rather than demonstrating sole causation.

Reporting Guidance - Funded teams should report on planned Action through their baseline metrics and actual Action through regular project reports or directly inform their Associate Program Manager about known examples, even after a project's completion. To aid in tracking both product use and action, an 'End User Annual Report' is now a reporting requirement for all Ecological Conservation projects. Funded teams should additionally note the barriers that might prevent end users from adopting a new behavior or abandoning an established one.

Examples - Examples of Action include deployment of personnel to address an arising issue, revision of policy documents which dictate allowable activities, and the creation of a new conservation asset (e.g., protected area, migration corridor).

- BLM has reported using this tool for legally defensible decision making for renewal of grazing leases, determination of post-mining rehabilitation, and to inform prioritization of invasive species treatment.
- The City of Los Angeles uses this tool to map areas essential for mountain lion movement and from that map, set zoning regulations, plan major transportation investments, and review individual development projects in compliance with.
- This tool is used by the nation of Oman to inform when they deploy booms to protect desalination plants, oil refineries, and fishing areas from harmful algal blooms.

4. Benefit – The positive impacts on end users, stakeholders, or the environment resulting from Use and Action.

Benefit is a core indicator of impact. Benefit is the measurable positive outcome resulting from actions informed by the product, compared to what would have occurred without it. Effectively, how are things better because the tool was used to inform action, compared to the status quo before the data was available. Teams should gather evidence demonstrating the benefits received by end users, stakeholders, or the environment.

Reporting Guidance - Although these benefits may not materialize until after a project is completed, we ask funded teams to discuss the anticipated benefits that their product will bring in baseline metrics and project reports. Teams should critically assess the potential benefits of their work regularly from proposal planning to completion. We ask teams to directly inform their

Associate Program Manager about known examples of benefit, even after a project's completion.

Examples - Examples of Benefit includes tools and products that 1) reduce fieldwork needed, 2) increase the effectiveness of a team's ability to address an ecosystem stressor, or 3) leads to the recovery of a threatened species or ecosystem. NFWF has outlined great examples of what this might look like [here \(on page 25-26\)](#).

- Recent census work has shown tiger numbers have nearly doubled since 2010 (from 3,200 to 5,574). This is driven in part by work of WWF which has leveraged the NASA funded tool to guide securing connected habitat, expanding tiger range, managing conflict, and moving toward coexistence between people and tigers.
- Thanks to conservation efforts informed by satellite imagery, forests essential for Chimpanzee survival have shown dramatic recovery over the 2000s in the Gombe region of Tanzania.

5. Awareness and Perception – Public awareness and perceived value of the product.

Awareness and Perception are supporting indicators of impact. Awareness and Perception refer to how familiar the broader end user community or public is with the relevance of the product to inform conservation action. Essentially, we are asking: If someone from the community were asked about the product, how likely are they to know what it is and express appreciation for its contribution to conservation?

Reporting Guidance - Similar to Benefit, Awareness and Perception may not be measurable until after project's completion. We encourage teams to identify the broader communities they or we may later survey, who are expected to adopt and appreciate the product and implement mechanisms to track awareness and perception. Final reports should note these communities and identify appropriate means to later survey.

Examples - Examples of Awareness and Perception include survey results, web usage statistics, and download analytics.

- A NASA booth was organized at AFWA this year, with visitors asked to respond to a questionnaire. Of those responding, 30% of the people noted awareness of Omniscape, with 5% stating they used the tool for their work.

6. Sustainability

Sustainability is a supporting indicator of impact. Sustainability is the continued long-term Use and Action of the product after the funded project period. Sustainability is closely tied to all other impact types but deserves special attention. As mentioned earlier, end users may base their decisions on factors other than scientific evidence. Similarly, even if a product is used and demonstrates benefits, its adoption by the end user for long-term usage is not guaranteed. Furthermore, sustainability is often challenging to measure until well after a project is completed. The project's plan being implemented near project end for sustained use, including how tools and data will be updated and administered, should be described in the final report. (See below for solicitations supporting relevant post-project Sustainability evaluations).

Reporting Guidance - Sustainability is integral to achieving ARL 9 and is likely first reported through ARL updates. We encourage teams to check in with end users after a project lifetime to determine if they are still in use.

Examples - Examples of sustainability include end user uptake of the product and investment to maintain regular provision of it (whether through PI's system or their own implementation) to inform their decision-making process.

- A decade after development, this tool is still used by NOAA to guide shipping routes along the Atlantic, to minimize whale strikes.
- This tool has been expanded for use from USFS Region 6 to the entire CONUS.

Guidance for NASA Ecological Conservation Teams

We request Ecological Conservation teams to document impacts resulting from their funded activities. We recognize that many of these measures of impact may not be available during the award's duration.

For example, when a project team focuses on achieving lower-level ARLs (ARL 1-4), they may only report on Knowledge Gain. However, teams should be able to discuss the anticipated Use, Action, and Benefit that will occur as the product is further developed.

For certain activities, documenting Use by an end user may be possible once the product has been validated in a relevant environment (ARL 5). Similarly, Action may become possible to document once a product prototype reaches planned operational use (ARL 7).

Understandably, documenting Benefit, Sustainability, or Awareness and Perception is unlikely until after a project achieves ARL 9 and/or after the project period of performance ends. For this reason, the NASA Ecological Conservation program previously released two solicitations ([ROSES23 A.46](#) and [ROSES24 A.45](#)) that provide a year of funding to track impact after the period of performance has ended.

NASA is increasingly cognizant of documenting the long-term societal impact of funded work and wants to report it in this way. Please contact your NASA Program or Associate Program Manager after your period of performance if new examples of impact are documented.