

Artificial Intelligence Strategy for the U.S. Geological Survey



Circular 1562

Cover. Photograph showing the Hovenweep supercomputer (named after the national monument spanning the Utah-Colorado border), which supports U.S. Geological Survey (USGS) research initiatives leveraging artificial intelligence. Photograph by USGS, November 30, 2023.

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By Janice M. Gordon, Alison P. Appling, Alfredo Artxabaleta, John F. Bechtell, Thomas E. Burley, Janet M. Carter, Peter C. Esselman, Jason C. Fisher, Graham W. Lederer, James M. Mitchell, Neal J. Pastick, Jake Weltzin, and Tim Woods

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Abbreviations

AI	artificial intelligence
AUV	autonomous underwater vehicle
GeoAI	geospatial AI
GPU	graphics processing unit
HPC	high-performance computing
IT	information technology
NPU	neural processing unit
USGS	U.S. Geological Survey
XAI	explainable artificial intelligence

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Abstract

Artificial intelligence (AI) can offer opportunities to enhance the science, science delivery, and business operations of the U.S. Geological Survey (USGS). Although USGS staff have proactively adopted AI into our workflows for many years, a comprehensive USGS strategy for AI has not previously been developed. The strategy described here is motivated by the acceleration of AI technological development, the benefits of increased AI adoption to USGS mission delivery as anticipated by USGS staff, rising public concern about the implications and trustworthiness of AI, and emerging Federal directives and guidance about AI. The USGS vision is to continue integrating AI to deliver valuable science for the public good while maintaining high ethical standards, scientific quality and integrity, and compliance with Federal and U.S. Department of the Interior requirements. To realize this vision, the USGS can take steps to (1) develop a strong AI workforce, (2) adapt our organizational approaches to include AI governance and communication, (3) ensure responsible and trustworthy use of AI, (4) modernize our computing and data infrastructure to support AI, and (5) accelerate AI adoption and innovation in the Bureau.

Introduction

The strategic adoption and development of artificial intelligence (AI) technology has the potential to transform and accelerate the science and effectiveness of the U.S. Geological Survey (USGS). AI is broadly defined as “a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions” (from 15 U.S.C. 9401(3), in U.S. Congress, 2020). USGS researchers have long been adopters of AI starting in the late 1990s and early 2000s (Lemeshewsky, 1997; Singer and Kouda, 1997; Guinand and others, 2002; Waddle and others, 2009; Huang and others, 2010) to help scientific understanding of Earth system processes and better equip the USGS to serve the Nation. Additionally, emerging generative AI capabilities

have begun shifting the paradigm of work, automating or accelerating previously time-consuming tasks, such that USGS staff can increasingly focus on the elements of their work that require human judgment and ingenuity.

To date (2025), many USGS successes with AI have focused on the use of AI to analyze Earth observation data in support of our 21st-Century Science Strategy (U.S. Geological Survey, 2021). USGS researchers have used AI to assess human-environment relationships between traffic and caribou movement (Severson and others, 2023), extreme wetland methane emissions (Feron and others, 2023), prescribed burns and grassland fire fuels (Wells and others, 2021), and much more. The USGS uses AI to process large volumes of imagery and sensor data to extract terrain features from topographic data (Usery and others, 2021), characterize coastal landforms (Buscombe and others, 2023), track condor behaviors (Sur and others, 2023), and monitor for earthquakes (Yeck and others, 2021). The USGS also uses AI to inform environmental resource decision making, such as for forecasting river temperatures downstream of reservoirs (Zwart and others, 2023), identifying climate-resistant vernal pools (Cartwright and others, 2022), and predicting the locations of mineral deposits (Lawley and others, 2022). The USGS not only uses AI for Earth science but also leads cutting-edge research in the field of geospatial AI (GeoAI), combining geospatial science with AI to leverage insights from spatiotemporal data (Li and others, 2024). The USGS is ready to build on these and many other AI research successes as new AI methods and opportunities emerge.

The USGS can build on a foundation of organizational practices that ensure the quality and richness of its information products. For example, sound data management and high-quality data are the bedrock of successful AI applications, and the USGS has a strong data-centric culture and vision as outlined in the USGS Data Strategy (Hutchison and others, 2024). Additionally, overall science quality at the USGS is assured by the Office of Science Quality and Integrity through its Fundamental Science Practices policies (Fundamental Science Practices Advisory Council, 2023), which will help guide USGS research through the responsible adoption of new AI technologies.

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As AI tools become increasingly powerful and versatile, USGS AI applications are also diversifying. AI is already enabling efficiency gains, such as in the extraction of information from old geological maps (Lederer and others, 2022). The advent of generative AI models trained on massive datasets promises productivity gains for writing, reading, data visualization, and coding, while simultaneously raising challenges in learning to apply and govern such uses effectively (Dell'Acqua and others, 2023; National Institute of Standards and Technology [NIST], 2023). Generative AI approaches also offer new opportunities such as the potential development of Earth system (Wang and others, 2024) and geospatial (IBM and NASA, 2023) **foundation models** that can ingest and predict varied information, adding efficiencies and robustness to the USGS's science modeling. As the field of AI continues to progress, a potential challenge will be to provide user support, advanced data and computing infrastructure, incentives, and guard rails to ensure that the USGS can adopt emerging AI tools while maintaining the quality and integrity of our science products.

Deeper integration of AI into USGS science and business practices is supported by Federal policies and guidelines. Executive Order 14179, "Removing Barriers to American Leadership in Artificial Intelligence," motivates U.S. global leadership in AI "to promote human flourishing, economic competitiveness, and national security" (White House, 2025a), positioning the USGS to take leadership in AI for Earth and geospatial sciences to better provide unbiased scientific information to our stakeholders, decision makers, and the American public. Memorandum M-25-21, "Accelerating Federal Use of AI through Innovation, Governance, and Public Trust" (Office of Management and Budget [OMB], 2025b), encourages agencies to accelerate responsible AI adoption, increase transparency, and govern for safe innovation while protecting the privacy, civil liberties, and civil rights of Americans through risk management practices. The USGS strategy recommendations in this report can help our organization align with Federal and Department of the Interior AI objectives by building on existing organizational structures, policies, and practices.

In the following sections we describe five goals and corresponding objectives to support the development of efficient and robust approaches to incorporate AI into USGS research and operations. The five goals are:

1. Develop a strong AI workforce
2. Optimize USGS's organizational approach
3. Ensure responsible and trustworthy AI
4. Modernize technical infrastructure
5. Accelerate AI adoption and innovation

If implemented, some of the recommendations herein may necessitate shifts in resource allocation, responsibilities, and infrastructure. Some reallocations may emerge naturally, such as where AI is the obvious best solution to a near-term problem. For other recommendations, up-front investment could realize long-term benefits. Ultimately, given the potential of AI to help transform USGS research and operations in the coming decades, strategic investments in AI could enable more accurate, timely, and relevant science products than ever before in service of our mission.

Goal 1—Develop a Strong AI Workforce

A skilled, AI-ready USGS workforce with AI knowledge and experience can effectively adopt, discover, and innovate on AI tools to advance Earth science research, upgrade business processes, and improve science delivery for the benefit of the American people.

Objective 1.1—Attract and Hire New Talent

In a competitive hiring space, the USGS could distinguish itself through its unique mission and workplace culture to attract applicants who are skilled in AI tools and techniques. The USGS can leverage hiring incentives and special pay rates to recruit top candidates (U.S. Office of Personnel Management, 2024). The USGS can also proactively engage students through outreach programs, internships, fellowships, and collaborative work with top local universities, including Tribal colleges and universities, and professional organizations. Actively recruiting candidates with a variety of skills and talents could improve our AI products and science by expanding our internal ability to proactively identify risks and opportunities with AI.

Objective 1.2—Train the Workforce

AI is a rapidly changing field that demands constant learning to keep up with new developments. The entire USGS workforce could benefit from access to training in the responsible and effective use of **generative AI** tools (fig. 1). Broad introductory training would introduce managers and potential AI users to the opportunities and pitfalls in adopting or building new AI tools and applications. AI practitioners can benefit from networking and knowledge sharing in active communities of practice (such as the USGS Community for Data Integration [Hsu and others, 2022] and the General Services Administration AI community of practice [General Services Administration, 2025]) and through the provision of AI-specific continuing education opportunities across skill levels and use cases.

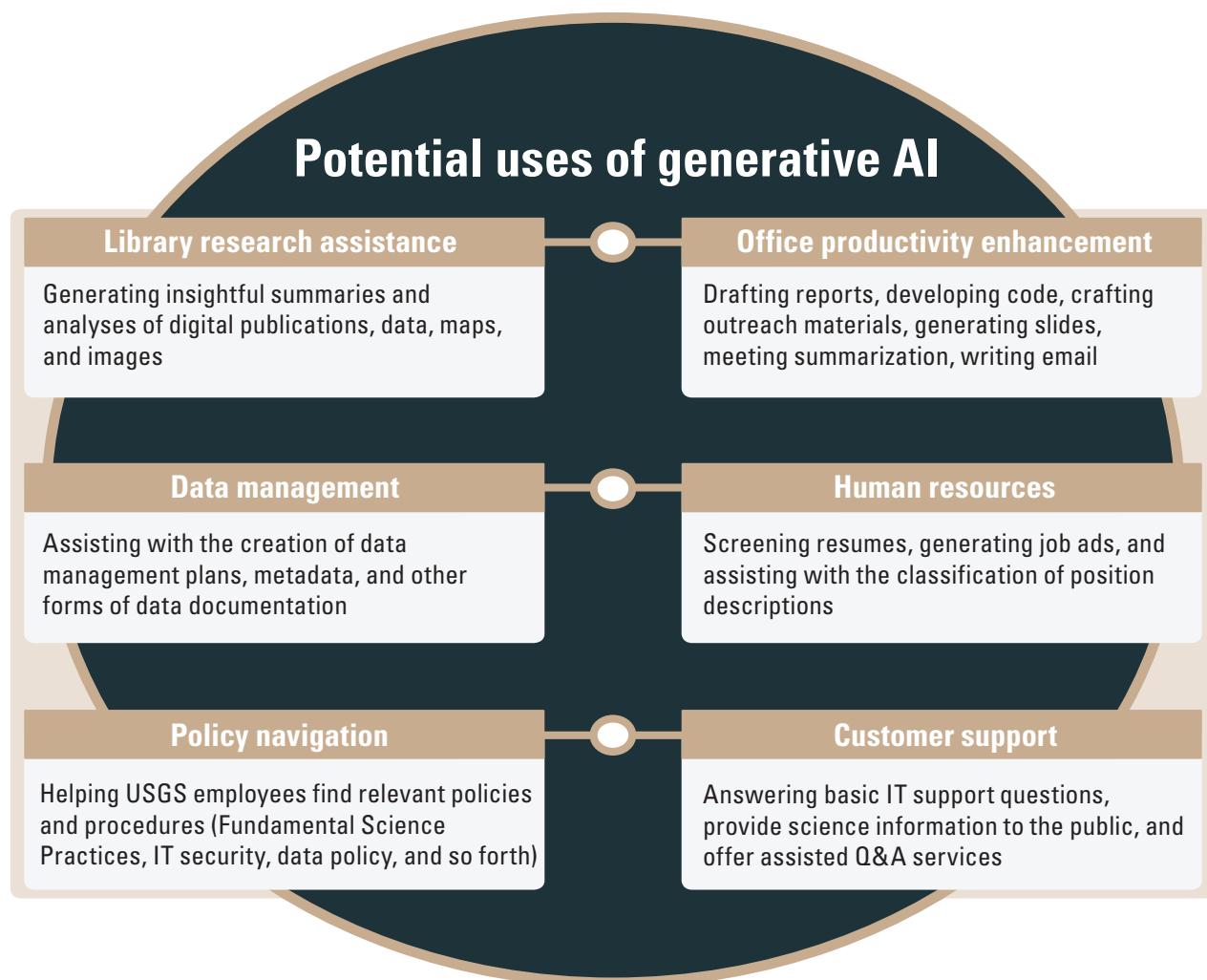


Figure 1. Examples of opportunities to use emerging generative artificial intelligence (AI) capabilities, such as **large-language models**, to enhance business processes at the U.S. Geological Survey. (IT, information technology)

In addition to the business-oriented examples given in [figure 1](#), generative AI can be applied to modeling, data visualization, and other science activities. If used effectively, these opportunities could improve the USGS work experience and the quality, efficiency, fairness, and timeliness of our internal and external products. Such uses of AI are not yet widespread in USGS but are increasingly permeating organizations and businesses worldwide (Al-kfairy, 2025; Stanford Institute for Human-Centered Artificial Intelligence, 2025), such that the USGS will need to anticipate—and possibly benefit from—the fundamental shift that AI is driving in how work gets done.

Objective 1.3—Retain Talent

The retention of an AI-proficient workforce can be improved by supporting the career advancement and development of AI professionals and by continuing to foster a workplace where all employees have an opportunity to

thrive through a culture of learning. Policies and practices that support the retention of AI talent could include the establishment of career advancement pathways for AI specialists and continued opportunities for mentorship, training, growth, and collaboration within and beyond the USGS.

Goal 2—Optimize Our Organizational Approach

Existing organizational structures at the USGS provide a strong start for governance and management of AI. By adapting our policies and procedures within those structures to address AI-specific needs and coordinating AI-related activities across those structures, the USGS can more efficiently meet Federal and departmental AI directives and support the set of goals outlined in this strategy ([fig. 2](#)).

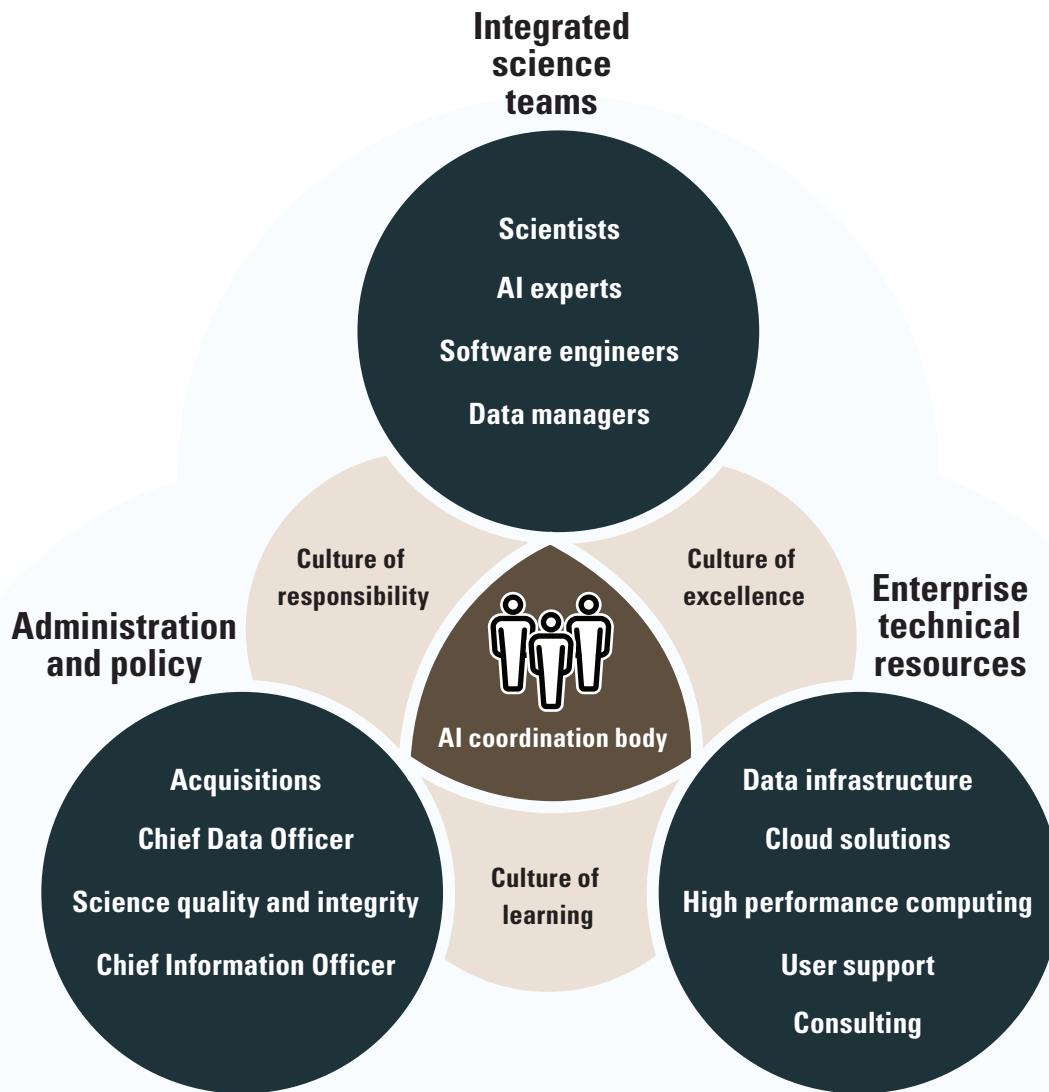


Figure 2. Diagram on how to structure an organization to embrace artificial intelligence (AI). Adapted from General Services Administration (undated).

The USGS already has many of the components recommended in figure 2 in place. For example, (1) AI talent is embedded in our integrated science teams; (2) we have enterprise technical resources, including cloud-based services and high-performance computing; and (3) we have experts to offer guidance on legal, ethical, information technology security, data, acquisitions, human resources, and science quality and integrity. The USGS can change and adapt the policies and procedures guiding these structures to fully support AI adoption.

Objective 2.1—Adapt Policies and Procedures

Bureau-level policies and procedures (for example, those described by the Fundamental Science Practices Advisory Council, 2023) are fundamental to ensuring the scientific quality and integrity of AI development and use (refer to goal 3), information security for AI applications, and the information technology (IT) that supports AI (refer to goal 4). Many existing policies and procedures followed by the USGS are already broadly inclusive of AI-based science and technology, but adaptations may be needed as AI evolves, for example to address emerging questions such as intellectual property and quality assurance for AI-generated content, to build checklists for IT acquisitions experts and peer reviewers to assure the safety and quality of a new AI technology, or to remove unnecessary hurdles to AI adoption (refer also to goals 3 and 4). Coordination of these adaptations—for example, at the intersection of policies and IT tools for protecting private data or ensuring transparency of our AI applications—could help ensure that USGS staff can effectively use AI in the public's best interests.

Objective 2.2—Communicate and Coordinate

Thorough and clear communication about USGS AI policies, resources, and activities can maximize the value of USGS AI investments to our mission delivery. A central coordination group could ensure robust communication and consistency across any new policies and technologies.

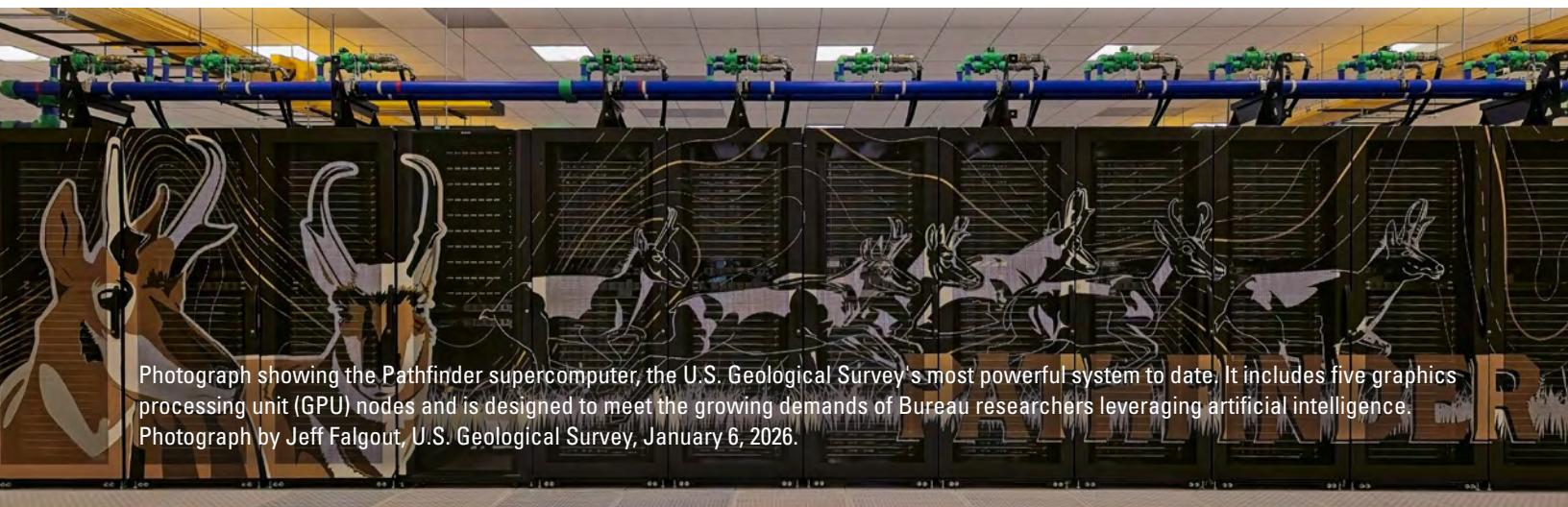
An internal AI communication plan could give USGS staff anytime access to the information needed to use AI efficiently, responsibly, and collaboratively. An external AI communication plan could ensure that USGS AI activities are broadly visible and well represented in Federal AI data calls, interagency working groups, and innovative partnerships, and to the American public. Additionally, USGS leaders serving on departmental and Federal AI working groups could expand Bureau awareness of broader AI activities and opportunities.

Objective 2.3—Govern Effectively

Effective, coordinated governance of AI potentially will encourage innovation while providing guardrails to ensure robust, accurate, and useful AI applications. AI governance will likely also need to be flexible to accommodate diverse uses, emerging tools, and evolving best practices for AI. Governance of information technology coupled with appropriate data management and quality assurance can protect against inadvertent data leaks or other cybersecurity issues associated with AI applications and tools. The USGS's rigorous and thorough Fundamental Science Practices (Fundamental Science Practices Advisory Council, 2023) can enforce policies and best practices while encouraging cutting-edge techniques in AI development, use, and interpretation. Bottom-up governance can include training programs to equip researchers with techniques to use AI responsibly (refer to objective 1.2) and manage staff to foster a culture of personal accountability and proactive adoption of best practices for AI.

Goal 3—Ensure Responsible and Trustworthy AI

A comprehensive but balanced approach to the management of risks posed by the adoption of AI across the USGS can help maintain our gold standards of science quality and integrity while limiting barriers to innovation.



Objective 3.1—Manage Risk Comprehensively

AI has strong potential to enhance the quality and efficiency of USGS products and operations, but the use of AI also brings risks—some familiar, some unprecedented. A first step is to identify high-priority risks such as the production or promulgation of flawed data, incorrect interpretations of model outcomes, leaks of sensitive data, or adverse effects on civil rights, civil liberties, or privacy. Risks can be mitigated with ethical and technical guidelines encompassing data collection and management, algorithm design, model training and evaluation, publication, operational production, and communication practices for AI applications. Those guidelines can then be enforced through top-down and bottom-up governance (refer to objective 2.3) to a degree commensurate with the degree of risk and the USGS's risk tolerance in each use of AI. AI risk management and governance frameworks (for example, NIST, 2023; AI Verify Foundation and Infocomm Media Development Authority, 2024; World Economic Forum [WEF], 2024) can be used to determine a balanced approach to risk, risk tolerance, and potential benefits of AI for the USGS.

Objective 3.2—Protect Scientific Integrity

AI, and especially generative AI, is transforming the way people do tasks, including writing code and reports, producing images and videos, and evaluating written materials. These applications raise new questions about intellectual property and scholarly integrity (Eke, 2023; Chesterman, 2025), and they introduce risks such that traditional quality assurance and quality control practices potentially will be insufficient for generative AI outputs (Freeman and others, 2025; Joshi, 2025). The USGS can reap the productivity benefits of AI while maintaining its gold standards of scientific integrity (Fundamental Science Practices Advisory Council, 2023; White House, 2025b,) by fostering a strong culture of human responsibility for all AI outputs (Blau and others, 2024), by attending to Federal and industry guidance on AI acquisition and management (for example, OMB, 2025c), and by adopting tools and best practices to proactively monitor for errors in

Photograph showing Cape Greig, Alaska, an area frequently used by walrus herds and supports active fisheries managed by the State of Alaska. When sea ice is absent, walruses rest on shore, making them more vulnerable to disturbances that can trigger stampedes and lead to mass mortality. To address this, the U.S. Geological Survey is developing automated artificial-intelligence workflows that analyze photographs to rapidly detect walruses remotely, improving management decision timeliness while reducing staff workload (Fischbach, 2023). Photograph by Anthony Fischbach, May 9, 2023.

AI output (NIST, 2023) and anticipate potential violations of intellectual property standards (Congressional Research Service, 2023).

Objective 3.3—Ensure Transparency through Stakeholder Engagement

Like conventional techniques and approaches, AI has the potential to produce erroneous or even biased science predictions. Unlike conventional methods, the logic of AI tools can be difficult to explain and correct. The nontransparency of AI models thus raises new challenges for the USGS in earning the trust of stakeholders for our AI applications, despite our existing policies for publishing model code and outputs (Fundamental Science Practices Advisory Council, 2023). Engagement with stakeholders, partners, and the public may help the USGS avoid or mitigate potential flaws in AI applications that could affect the trust in, and thus utility of, our models and scientific products. To complement USGS's existing peer review processes that are applied to all science products (Fundamental Science Practices Advisory Council, 2023), the proactive evaluation of AI models and tools to screen for flaws, along with **explainable artificial intelligence** (XAI) efforts to better understand and communicate our AI applications, models, and model outputs, may also strengthen the USGS's mission delivery.

Goal 4—Modernize Technical Infrastructure

By expanding and modernizing our data and computing infrastructure to meet the common and emergent needs of AI projects, the USGS can help its staff to effectively and efficiently apply AI to deliver accurate and timely science products.



Custom **machine-learning** algorithms (forms of AI) have been trained to identify important lakebed-feature invasive species such as zebra and quagga mussels (*Dreissena* spp.; fig. 3). Big data pipelines have been engineered to use the USGS's high-performance computing systems (Falgout and others, 2025) to summarize ecosystem patterns for more than 3,000 kilometers of AUV transects completed to date, comprising more than 2 million images. The results can be used to inform decisions about predator stocking and invasive species control.

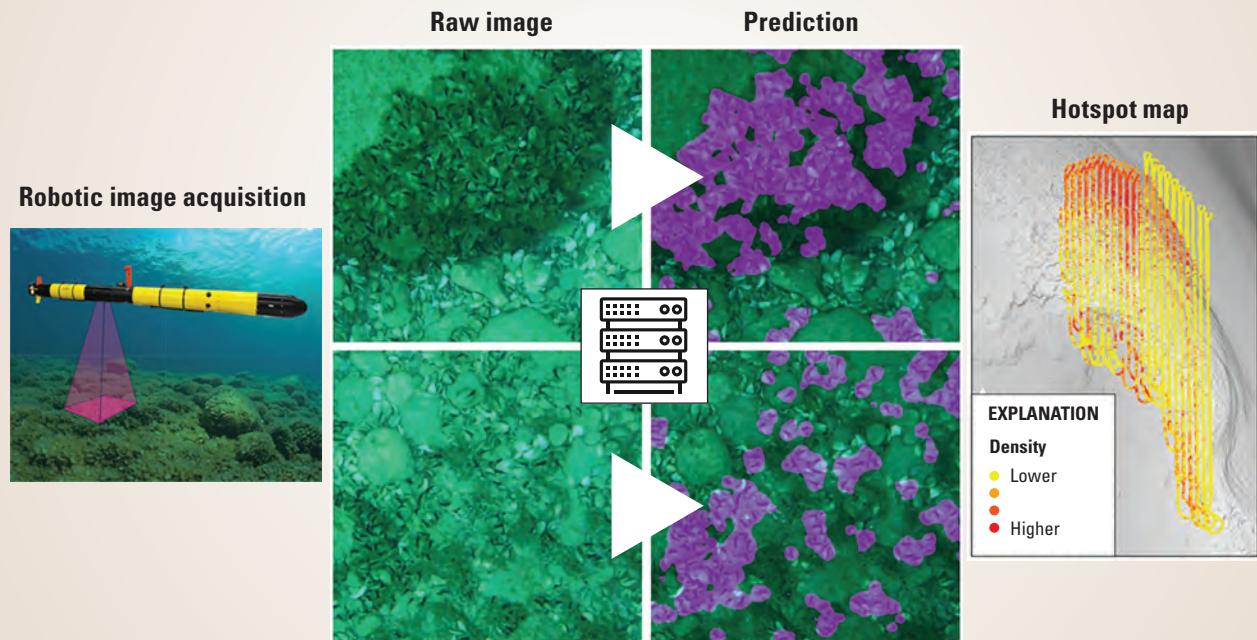


Figure 3. The U.S. Geological Survey (USGS) is using autonomous underwater vehicles (AUVs) and artificial intelligence to survey invasive species in the Laurentian Great Lakes. (Figure from Peter Esselman, USGS, written commun., 2025.)

Objective 4.1—Upgrade Foundational Infrastructure

Accessible, high-quality data, advanced computing, cloud services, and high-speed research networks are essential for AI model development, training, and use. Training AI models requires access to large volumes of data on **high-performance computing (HPC) systems** with graphics processing units (GPUs) or neural processing units (NPUs) for massive **parallelism** (fig. 3). The successful adoption of some AI methods also potentially requires high-speed networks and data transfer tools to quickly potentially and securely share large datasets among USGS facilities, cloud and on-premises computing environments, and partner research organizations. Stable and efficient provisioning of these resources, and the timely inclusion of new AI infrastructure as technologies advance, support the USGS in continuing our exploration, innovation, and effective development of AI methods.

Objective 4.2—Facilitate Exploration and Discovery

Creating environments in which the USGS can test new technologies, including third-party tools, supports our emerging science and operational activities. These technologies range from basic AI-ready programming languages to fully trained AI models with user-friendly software. The proactive, rapid review and approval of emerging third-party AI tools and services—and in-house tools built on these technologies—can help USGS staff understand the strengths, weaknesses, and risks of these new systems and may help expand creative thinking related to science products, end-user applications, and Bureau operations.

Objective 4.3—Share High-Quality Data and AI Advances

Recent Federal guidance (OMB, 2025b) directs agencies to “actively engag[e] in quality data governance and management and the reuse of data and AI assets” to ensure efficient use of resources. Consistent with this directive, the USGS Data Strategy emphasizes the importance of providing unbiased, accessible, high-quality, and interoperable data to better serve societal needs (Hutchison and others, 2024). Such well-managed data can ensure the development of trustworthy AI-enabled science products. Once developed, USGS data and AI products can be most effectively reused if dissemination follows the principles of “findable, accessible, interoperable, and reusable (FAIR),” which also improve transparency and reuse across the scientific community and public through their alignment with open science (National Academies of Sciences, Engineering, and Medicine, 2018), and “open, public, electronic, and necessary (OPEN)” government data (OMB, 2025a). Further, the use and development of enterprise tools for efficiently sharing AI models, model metadata, training data, code, and publications could allow the USGS to better leverage and contribute to AI expertise and capabilities within the broader science community, and could reduce the duplication of effort and support knowledge sharing across the Bureau.

Goal 5—Accelerate AI Adoption and Innovation

By vigorously promoting AI adoption and innovation where AI has potential to be the best tool for the job, the USGS can maintain and strengthen its leadership in the provision of high-quality Earth system monitoring, analysis, prediction, and delivery of actionable intelligence for societal needs.

Objective 5.1—Prioritize and Incentivize AI Adoption

To encourage AI adoption, AI-based approaches can be prioritized relative to comparable alternatives during the planning and selection of new projects. Recognition programs can highlight and incentivize innovative AI advancements. Innovation can also be spurred by initiating and supporting participation in public AI competitions, granting seed funding for high-potential pilot projects, sponsoring AI-focused interns and fellows, and providing AI innovators across the USGS with subsidized access to computing resources and third-party AI tools (refer to objectives 4.1 and 4.2).



The robotic transporter arm inside the Grizzly storage system, which is designed to store up to 185 petabytes of compressed research data. Photograph by Jeff Falgout, U.S. Geological Survey, January 6, 2026.

Objective 5.2—Support AI Research and Development

An AI user support and consulting capability composed of cross-functional teams of AI specialists, data scientists, software engineers, high-performance computing experts, and information technology (IT) specialists working with domain experts can facilitate the development of AI solutions that are creative, robust, and scalable. Providing comprehensive technical support can spur the adoption and use of AI, broaden the understanding of available resources and emergent needs, and enhance proficiency in AI and AI-driven research across the USGS. A holistic support approach can also facilitate the effective transition of AI research into operational capabilities that support the USGS mission (for an example, refer to [fig. 4](#)).

Objective 5.3—Collaborate with the AI Community

Synergistic collaborations and partnerships can accelerate innovation and enhance scientific advancements. The USGS can continue to actively engage and build strategic alliances with academia, industry, national laboratories, other agencies, international organizations, and AI communities of practice. By leveraging external AI expertise and sharing unique USGS contributions, a reciprocal exchange of knowledge can be fostered to build partnerships. This may strengthen USGS AI innovation and leadership, especially in key domains such as geospatial and Earth sciences, ultimately increasing the effectiveness of USGS mission delivery.

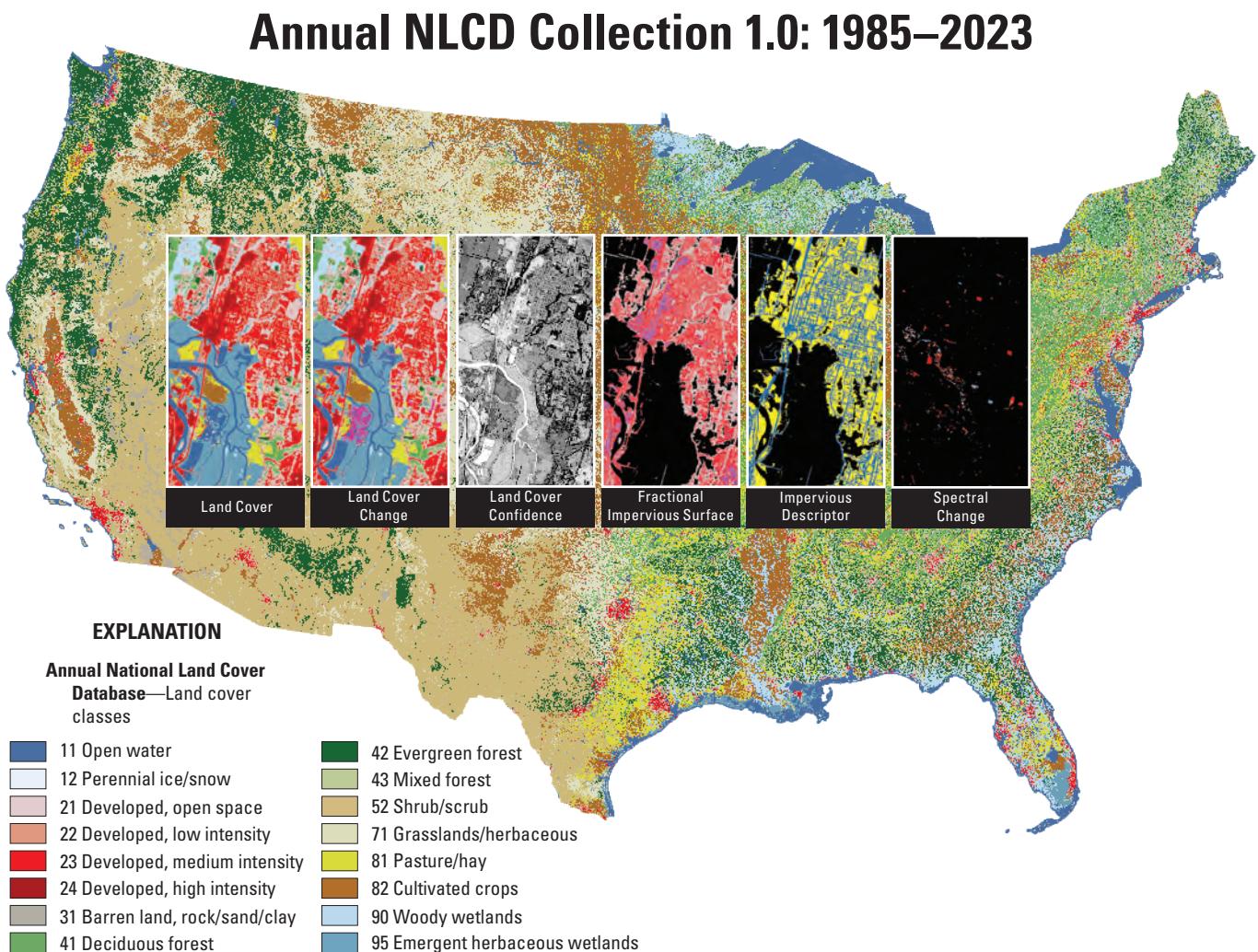


Figure 4. Example of U.S. Geological Survey operational data production using artificial intelligence. Annual National Land Cover Database (NLCD) products are created using deep-learning algorithms (U.S. Geological Survey, 2024).

Summary

The strategic plan described in this report calls for a multipronged approach to enable effective, responsible, and innovative integration of artificial intelligence (AI) into U.S. Geological Survey (USGS) science and business practices. Although AI is only one set of tools among many that the USGS can use to support its mission—and one that brings new risks and challenges to manage—AI could improve the quality, timeliness, and breadth of our science products. The five goals outlined in this report reflect the expectation that the USGS's capability to responsibly develop and leverage AI will be synergistically enhanced by attention to the Bureau's staff, technology, organizational culture, structures, policies, and procedures. An implementation plan can identify measurable objectives specific to each mission area and region

to achieve this strategic vision. As the field of AI grows and changes, this strategy and the details of its implementation can be updated to meet emergent challenges and opportunities in AI. Above all, an agile and proactive approach can help ensure that AI can be leveraged safely, securely, responsibly, and innovatively to enhance the USGS's service to the American public.

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More than 1,500 walruses resting on shore at Cape Grieg in southeastern Bristol Bay, Alaska. Photograph by U.S. Geological Survey, April 4, 2016.

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Glossary

explainable artificial intelligence (XAI) Explainable artificial intelligence refers to the area of research and practice that aims to provide transparency to AI models and their outputs through explanations that are understandable at an acceptable level to human users (Miller, 2019; Ali and others, 2023).

foundation model An AI model trained on a vast amount of data so that the model can easily be adapted for a wide range of general tasks, including to generate text or other outputs (refer to the Glossary entry for “generative AI”).

generative AI The class of AI models that emulate the structure and characteristics of input data in order to generate derived synthetic content. This can include images, videos, audio, text, and other digital content.

high-performance computing (HPC) Refers to the use of powerful computing systems—often called supercomputers—to solve large, complex problems that require substantial computational resources. These systems aggregate computing power through parallel processing (refer to Glossary entry for “parallelism”), where many calculations are performed simultaneously across multiple processors. HPC systems are supported by specialized hardware and high-speed interconnection networks, enabling them to process massive datasets and perform sophisticated simulations or analyses far beyond the capabilities of standard computers.

large-language model (LLM) A generative AI model trained on massive corpuses of text, images, and (or) videos.

machine learning (ML) A set of techniques that can be used to train AI algorithms to improve performance of a task based on data (U.S. Congress, 2020).

parallelism Also known as parallel processing or parallel computing, parallelism is a computational approach where large problems are divided into smaller tasks that are executed simultaneously across multiple processors. This technique is widely used in AI model training using specialized chips designed for parallel execution.

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