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Research and Development Portfolio of the Sustainability Science Team National Sustainable Operations USDA Forest Service

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Abstract

The Sustainability Science Team (SST) of the U.S. Department of Agriculture (USDA) Forest Service Sustainable Operations Initiative is a 18-member virtual research and development team, located across five regions and four research stations of the USDA Forest Service. The team provides research, publication, systems analysis, and decision support to the Sustainable Operations program of USDA Forest Service Business Operations. This report examines the role of the SST in supporting ongoing agency developments in the emerging field of sustainability science. We provide an overview of current areas of research, including the broad themes of resource consumption, energy efficiency, and organizational change to promote sustainability. We review the mandates and structure of current programs and identify future opportunities. Six environmental footprint areas have been identified to guide activities of the SST: energy, water, waste, transportation, purchasing, and leadership. These six areas have been incorporated into the team's research on life-cycle analysis, footprinting, cost-benefit analysis, return-on-investment analysis, assessment protocols, systems analysis, knowledge management strategies, and behavior-change impact analysis.

Keywords: Sustainable Operations, USDA Forest Service, greenhouse gas emissions, biomimicry, energy efficiency.

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Introduction

Why Sustainability Matters

Sustainable development is the overriding challenge of the 21st century, according to a United Nations report calling upon nations, private businesses, nongovernmental organizations, universities and research centers, and all other stakeholders to address extreme poverty, economic instability, social inequality, and environmental degradation (Jeremić and Sachs 2013). In a related action, President Obama issued Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," which broadly defined sustainability as "conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations." Executive Order 13514 will have far-reaching implications; for example, it specifies stringent ramifications for buildings starting in 2020.

In a similar initiative, Executive Order 13423 requires energy consumption reductions in federal facilities of 30 percent from a baseline year of 2003 by the year 2015, and sets requirements for renewable energy use. This order instructs federal agencies to

> …conduct their environmental, transportation, and energy-related activities under the law in support of their respective missions in an environmentally, economically and fiscally sound, integrated, continuously improving, efficient, and sustainable manner.

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This is significant because the federal government is one of the main consumers of resources in the Nation, and its purchasing power has potential to induce far-reaching changes in government and other sectors.

Sustainability in the Federal Government

The federal government is the largest consumer of energy products and services in the United States, and its actions and policies can directly influence these markets. The Federal Energy Management Program was established in the U.S. Department of Energy in 1973 to encourage effective energy management through several measures including energy efficiency investments, technical assistance, and energy audits. Thus, sustainable operations in the U.S. Department of Agriculture (USDA) Forest Service draws upon a long history of policies to guide energy efficiency purchasing decisions.

Federal government initiatives in sustainability are showing encouraging results over periods of decades. For example, the energy intensity of government buildings has decreased by 23 percent between fiscal years 1985 and 2001 (Gillingham et

al. 2006). However, it is estimated that federal agencies still could save more than $200 million per year through additional use of energy-efficient products (US DOE 2008), while reducing carbon emissions by up to 8.6 million metric tons per year (Gillingham et al. 2006). Federal agencies are required to purchase either ENERGY STAR products, or if ENERGY STAR® labels do not apply, to purchase products in the upper 25 percent energy efficiency range. This is significant in that federal agencies collectively purchase more than 10 percent of all energy-using products in the United States.

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The USDA is tracking its greenhouse gasses (GHGs) under a Strategic Sustainability Performance Plan that requires annual reporting. Three scopes of GHG emissions are being tracked through 2020. Since 2008, GHG emissions have been reduced between 5.5 and 17.9 percent (USDA 2013). This report also states that of the agency's total electrical use, 7.3 percent came from renewable sources.

Sustainability in the USDA Forest Service

The USDA Forest Service has a desire to proactively mitigate climate change impacts, and created several initiatives developed in the Office of the Climate Change Advisor. Included among these initiatives are the Climate Change Strategic Framework (USDA Forest Service 2008) and the Climate Change Performance Scorecard (USDA Forest Service 2010). Using the scorecard approach, national forests are working toward attainment measures in 10 elements within four broader themes. Performance areas include integrating climate change into program work, assessing vulnerability of key resources, performing a baseline assessment of carbon stocks and flows, and progressing toward targeted reductions in resource use. The performance scorecard will be a useful planning document to gauge energy efficiency improvements and will dovetail with the mission of the Forest Service Sustainable Operations program.

Also within the Forest Service, the Sustainable Operations Collective Executive Board is a chartered organization representing 12 Deputy Regional Foresters and Assistant Station Directors. Their actions and reporting requirements are responsive to Executive orders, the Environmental Management System, and the Office of Management and Budget.

The Forest Service Sustainability Operations Collective has focused on three "critical flows" (energy, water, and solid waste) among three activities known to generate GHGs (transportation, purchasing, and buildings). Leadership is another central theme, given the importance of ensuring the science findings are ultimately translated into organizational change. One of the strong motivations behind this effort concerns efficiency—ways for the agency to "do more with

less." The approach relies heavily upon collaboration across regions, stations, and disciplines. The Forest Service Research Executive Team (FSRET), which consists of the Deputy Chief, Station Directors, and Washington Office Program Directors, formally adopted the Sustainability Operations Charter in 2013. This action is expected to strengthen the link between local and national efforts.

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Introducing the Sustainability Science Team

The Sustainability Science Team (SST) is a virtual, national team of researchers (currently numbering 18 members; see box p. 5) distributed across Forest Service regions and research stations throughout the Nation. The team works to share learning within the Forest Service both regionally and nationally, as well as with other federal agencies, host communities, nonprofit cooperators, and the private sector. Their charter has identified three primary objectives:

- Contribute to quantitative and analytical methods needed for the Forest Service to accurately report sustainability accomplishments, which in turn lead to improved operations.
- Build learning networks within the Sustainable Operations community by conducting research studies and case study syntheses.
- Ensure that research findings are translated into policy, planning, and decisions.

Quantification and analysis provided by the SST plays an important role in agency accomplishment reporting, cost savings, and decision support. The SST supports Sustainable Operations efforts including return on investment from agency operations, synthesizing, comparing, and publishing results. Integration of research findings are often incorporated into a wide range of outlets, including regional scientific assessments, planning documents, and employee policies and initiatives.

The SST engages in a portfolio of research and technology transfer projects to help reduce the environmental impacts of the USDA Forest Service. The team relies on the comparative advantages and research strengths of its members to address relevant issues that can be directly used by Forest Service managers. Research themes include energy efficiency, water footprinting, biomimicry, and community energy management (described in more detail in the next section).

Table 1—USDA Forest Service fiscal year 2010 total emissions (metric tons of carbon dioxide equivalent) by category

Category	Metric tons of carbon dioxide equivalent per year	Percent of total
Purchased electricity	99,000	34
Transmission and distribution losses	6,500	2
Federal employee business air travel	4,000	2
Federal employee business ground travel	2,600	1
Federal employee commuting	11,100	4
Contracted wastewater treatment	200	0
Building energy consumption	35,300	12
Mobile emissions: vehicles and equipment	11,900	4
Mobile emissions: FAST	119,900	41
Fugitive fluorinated gases and other fugitive emissions	100	0
Onsite wastewater treatment	500	0

The Sustainability Science Team (SST):

- Initiates, coordinates, and publishes Forest Service research on the environmental impacts of agency operations
- Coordinates reliable data and accounting methods to facilitate operating efficiency
- Hosts webinars and summits featuring studies and scientists, emerging technologies, and decision support tools
- Contributes to quantitative and analytical rigor of Sustainable Operations reporting
- Increases studies and networked Sustainable Operations research
- Increases the uptake of findings in policy, planning, and decision support
- Synthesizes publications on current knowledge and future research needs
- Engages a national scientist network to help managers access the science and decision support
- Monitors best available science for planning documents

Sustainability Science Team Emphasis Areas

In the 4 years since its founding, the SST has developed an ambitious research portfolio covering wide-ranging topics. Although our research topics and the overall nature of our work have evolved over the past 4 years, much of our research has been "applied" in nature so that it can quickly be adapted by Forest Service managers. The following summaries describe key areas of our work and research topics under those areas.

AREA I—Applied Research

Water footprinting analysis—
The potential for water demand to outstrip supply is likely to increase in certain parts of the country under projected climate change and population growth scenarios. Addressing these shortages holistically requires balancing the water deficits from the supply side against the demands of industry, agriculture, and other uses. However, most hydrological analysis in the Forest Service ends at the forest borders, and few quantitative efforts characterize this ecosystem service in terms of supply and demand.

Using a geographic water footprint analysis, which delineates demand drivers and outlines water supply and demand together, we address the water footprint of public land under Forest Service management on the Helena National Forest. This is one of the first case studies to consider the demand for ecosystem services such as water supply. The objective is to use quantified indices to support water management strategies that incorporate both water sources and sinks within national forest boundaries, as well as downstream regions. Results showed "hydrological overshoot" (blue-water footprints exceeded blue-water availability[2]) occurred in 4 out of 12 months annually. Over time, hydrological overshoot can reduce the health, diversity, and resilience of watersheds, which in turn affects other ecosystem services. Land managers can lead water conservation efforts within forest boundaries, and cooperate with municipalities and water management boards downstream to better manage hydrological overshoot. Research activities by SST scientists support a more cohesive understanding of water-related ecosystem services and increased participation of forest hydrologists, land managers, state and local authorities, and other federal agencies.

Addressing Energy Efficiency Barriers Within the Forest Service—
This publication reviews energy efficiency measures in facilities across the USDA Forest Service to examine opportunities and obstacles, as well as identify success factors (Meyer et al. 2013).

[2] "Blue" water is water withdrawn for irrigation from rivers, lakes, and aquifers, while "green" water is precipitation (Rost et al. 2008).

Adoption of energy efficiency measures at Forest Service sites was found to have the greatest chances of success when decision control was local to the site, when budget timing and structures were familiar to decisionmakers, and when measures were planned for in advance. For example, projects already implemented on national forests include the use of hand-crank flashlights, energy-efficient office improvements, use of rechargeable lithium batteries, "waterwise" landscaping projects, and small-scale solar energy upgrades (Meyer et al. 2013). These research findings and others can help other Forest Service units and other governmental agencies reach the ambitious energy reduction goals stated in Executive Orders 13423 and 13514.

Although many of the efforts summarized in this paper address smaller purchasing decisions and energy-saving equipment, future developments include larger scale projects including new construction of Leadership in Energy and Environmental Design (LEED)-certified buildings and renewable energy facilities. Solutions that join technical innovation with pragmatic budget planning (such as breaking a larger project down into preapproved, easier to fund steps) can support more ambitious planning. Within-government zero-interest loans to fund infrastructure projects (repaid via cost savings) are anticipated to have a long-run public benefit if the correct structures and incentives are established.

Environmental footprint of the Tongass National Forest, Alaska—
The Tongass National Forest (TNF) is a pioneer in the Sustainable Operations arena. In 2013, the second environmental footprint report was completed, detailing measures to reduce environmental impact from each footprint area (including energy, water, fleet, waste reduction, and green purchasing). The TNF is one of the four pilot forests to report GHGs at the national level and is part of the Environmental Protection Agency (EPA) Climate Leader Project. The General Services Administration carbon footprint tool documents GHG emission from fiscal years 2008 through 2011, generating a rich data set and providing the foundation for sustainable science principles to enter into forest management planning. This report describes TNF green team case studies, reviews literature related to TNF projects, and summarizes interview responses from key Forest Service staff.

Biomimicry within the Forest Service—
Biomimicry, or imitation of nature, can be defined as, "copying or adaptation or derivation from biology" (Vincent et al. 2006). Biomimicry provides solutions for sustainability by emulating principles found in nature. The SST researchers have provided an overview of biomimicry approaches to problemsolving for 12 Forest Service applications and case studies. Workshops led by EPA professionals have helped guide participants in using their knowledge of local organisms and culture to

solve management problems. Examples ranged from solving the problem of excessive plastic drink bottle waste to managing eroding shorelines. Inspired by nature, the workshop team made recommendations to update public information, revise locations of drinking water stations, improve recycling containers and signage, and offer reusable aluminum drinking bottles for sale.

Use of biomimicry by federal agencies can inspire innovation while reducing the pollution associated with well-known products. For example, the potential harmful impacts of toxic chemicals used in thermal and carbonless paper can be reduced by identifying natural pigments. Areas such as packaging, transportation, engineering, energy, and agriculture also have the potential to benefit from biomimicry. We provide current information and examples of how we have solved problems in many areas by emulating and taking inspiration from nature, and how this information in turn reinforces culture and efficiency in sustainability efforts within federal agencies (fig. 1).

Figure 1—The Bullitt Center, Seattle, Washington. Some of the features of this building include net zero energy, net zero water, net zero carbon, composting toilets, toxic-free materials, and enhanced day lighting using high-performance windows. Even the shape of the roof appears to imitate a tree canopy.

Community Energy Management in Sitka, Alaska—
This paper summarizes practical energy management strategies that could help communities in southeast Alaska move closer to energy independence, while utilizing local resources more effectively (Nicholls and Patterson 2013). Our analysis focuses primarily on Sitka, Alaska, yet could be relevant to other communities having similar energy structures that rely primarily on hydroelectric power. We consider how locally abundant resources can help communities build their capacities to generate renewable energy while moving towards greater energy independence. Our recommendations focus on energy conservation, appropriate-scaled renewable energy project development, and adoption of new technologies, including electric vehicles. We also identify key stakeholder elements that could be important for successful collaborative projects in southeast Alaska. Lastly, we consider broader implications for southeast Alaska, including communities having energy resources different from those of Sitka.

Sustainable operations planning documents—
Planning documents are essential tools in helping operations become more sustainable. We review the need for standard language in National Environmental Policy Act documents regarding sustainable operations, defined as being related to energy or water conservation, fleet and transportation, waste prevention and recycling, and green purchasing. We accomplish this via a synthesis of interviews with Forest Service Pacific Northwest Region (Region 6) environmental coordinators. Results focus on the current use or need for standardized language or mechanisms to transfer language from one plan to another, as well as specific areas of planning that integrate well within sustainable operations.

AREA II: Technology Transfer

Findings of the SST are communicated to end users through multiple technology transfer outlets. Team members have presented research findings on a variety of topics at regional and national conferences (Meyer et al. 2013; Nicholls and Patterson 2012a, 2012b). Within the Forest Service, technology transfer efforts are facilitated through "green teams," often based in a ranger district or research lab. Green team members act as liaisons to coordinate environmental actions at the facility (i.e., local) level. The SST adopts sustainable practices for its own operation as well. Most meetings are conducted using webinars or conference calls so that travel is minimized. Virtual summits have been conducted in Atlanta (2010) and in Sacramento (2012), providing venues for professionals to interact nationally without the need to travel to the conference site.

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A primary technology transfer goal is to provide key findings of the SST to Forest Service managers in a practical and timely manner, some of which are described in the following activities:

GreenGov forum in Washington, DC: establishing the Research and Development science tracks—
This annual government forum often focuses on products and purchasing. It has high visibility across all government agencies and is therefore a valuable tool to facilitate knowledge transfer and research impact across agencies. This effort will promote a science forum as part of the GreenGov conference, offering significant opportunities for technology transfer. Sustainability science team members will take the lead in outlining sessions, inviting counterparts to present findings, and following policy developments and research agendas. Other federal agencies will be invited to contribute and share their scientific findings and to coordinate initiatives for shared learning and reporting across agencies.

The big "rethink": action planning for renewable energy—
Progress toward sustainable operations can require rethinking basic operating principles, while successful models of organizational change often require retaining familiar organizational structures and modes of business. Our team has examined several of these ideas such as "Net Zero" energy, carbon-neutral operations, among others. This activity explores broad conceptual rethinking and a framework to support the shift of federal operations to nearly 100 percent renewable energy. The approach uses a framework that is familiar to that used by wildland fire managers, specifically the National Incident Management System (NIMS), which allows priorities to be assigned based on expected impacts, including loss of life, property damage, or mission disruption. The overall objective of this effort is to outline the necessary characteristics of a hypothetical "Voluntary Sustainability Directive," which dovetails with Homeland Security Presidential Directive 5 and NIMS. This presentation may also be of interest to municipalities or adopted by local business units.

Science delivery—
This deliverable creates a platform for publishing SST findings. This task develops and implements a publication process that will make science findings available outside of the scope of conventional journal articles. These on-line articles draw upon case studies and other analyses to help quantify the impact of particular initiatives in terms of cost savings and environmental benefits (e.g., Meyer et al. 2013, Nicholls and Patterson 2013). This deliverable creates an outlet for participating scientists to analyze and share outcomes from sustainability initiatives.

AREA III-Return-On-Investment Studies

These studies quantify and describe sustainable operations impact on the agency, using the accomplishment report and overlaying the financial data of the current and historical budgets. We have focused our efforts in the following areas:

Energy bill cleanup—
As more energy mandates are developed and budgets become tighter, the USDA Forest Service Sustainable Operations program is mindful of the need to use energy funds wisely. This activity describes a systems approach to agency cost savings through more efficient payment of energy bills. The "energy-bill clean up" initiative is one of the most successful agency cost-reduction efforts in history, and creates a model for tackling similar change in other agencies and cost areas.

In the energy-bill cleanup model, costs were reduced by using experts trained in diagnosing and addressing waste in utilities, accounts, and billing. Bills are processed, paid, analyzed, and tracked; savings opportunities are targeted and implemented. Monitoring systems create awareness of anomalies, such as an unexplained increase in an individual bill, or a water line break in a remote facility. The return-on-investment analysis reports on achievements and savings from units using the cleanup process, and characterizes potential for other forests and regions to realize similar savings. Despite the highly positive outcome, ad hoc interviews suggest widespread use remains a challenge—energy bills are typically paid out of cost pool dollars, and any savings is not directly seen on the ground. This suggests a need to create positive feedback loops to incentivize and reward savings by individual units.

Sustainable operations: initiative investments, growth, and sustained finance—
Sustainable operations can be both tactical and strategic in nature. A critical step in strategic investments is cultivating opportunities for evaluating past success, as well as including feedback mechanisms to address and correct weaknesses. The budget allocation for sustainable operations began informally in 2006, and formally with the charter in 2009, yet the impact of savings and workforce involvement is often obscured because of in-kind contributions from units, forests, and regions. These actions increase integrated benefits and cost savings but detract from the ability to report on specific line items or support budget stability over time.

Returns-on-investment and the micro grant program—
When evaluating return on investments of sustainability measures, a combined approach that considers both top-down support and bottom-up change is often needed. To this end, Sustainable Operations created a micro grant program to assist and promote sustainable improvements to projects and facilities in each

Forest Service region. Employees nominate actions to receive micro grant funding, capitalizing on the creativity and "hidden talents" of the workforce. As a bottom-up initiative, solutions are tailored to local energy, climatic, and operational needs. A primary goal of the micro grant program is to demonstrate outcomes, learning, and benefits, often through simple return-on-investment methods, encouraging more widespread use of the program. Information on the micro grant program is available by Forest Service region (Sustainable Operations 2014), including micro grants in the southwest region, and other success stories.

Future Directions for Sustainable Operations Research

Guiding Principles for Future Work

Identifying agents of change—

A recent report by the National Academy of Sciences suggests that federal agencies should nurture "change agents" at various levels by revising performance plans, rewards, and training, and enable cross-agency management and funding of sustainability activities (Committee on Sustainability Linkages in the Federal Government 2013). These recommendations were consistent with findings from a "Greening from the Ground Up" report, which emphasized distributing responsibility for sustainable operations throughout field-level agency as a means of facilitating local actions (Jones-Crabtree et al. 2008). In particular, it cited the success of "green teams" in sharing success stories, maintaining a forum to discuss important issues, and experimenting with new consumption behaviors. It also noted the importance of rewarding successes in reporting and changing consumption patterns. However, the report also noted several weaknesses in the current Sustainable Operations program, including the lack of consensus that sustainable operations is integral to delivering the agency mission at all levels, and the limited integration of research and development into sustainable operations efforts by managers.

Assessing and responding to research needs—

Scientists have recognized the need to integrate decisionmaking and transparency of scientific information into decisionmaking that promotes sustainable and equitable use of resources (Kasemir et al. 2003). Measurements of sustainability have relied on survey methods that can become quickly outdated. However, the rise of real-time data sources based upon remote sensing, crowdsourcing, and smart devices will revolutionize efforts to promote sustainability across many fields (Aman et al. 2013, Boulos et al. 2011, Havlik et al. 2011). The adoption of such methods can serve to expand public participation in sustainability by helping people collect data and observe their contributions to larger efforts. Research to evaluate the effects of these methods will require scientists with skills using these rapidly evolving sources of data.

Practical Aspects of Future Work

The SST successfully addresses a wide range of issues throughout all geographic regions of the Forest Service. The diversity of our staff and our broad set of interests and technical skills allows us to successfully address problems on a national scale. Energy efficiency and renewable energy project development are expected to remain key national issues, and the Sustainable Operations team has an important role to play in this effort.

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Although significant strides have been made, the potential for energy efficiency savings throughout the Forest Service is still substantial, and the resulting environmental and economic benefits great. However, further improvements will require ongoing monitoring, documentation, and analysis as well as effective use of feedback and lessons learned. In addition to energy efficiency improvements, future work could include more detailed evaluations of renewable energy projects, including small-scale solar, wind, and biomass. For example several wood energy facilities have recently come on-line at Forest Service buildings (Anon. 2013, Groom and Elder 2009) and are making positive contributions toward energy savings. Future work will include detailed evaluations of operating conditions, project economics, and life-cycle analysis. Thus, the combined effect of energy efficiency projects and renewable energy generation will help substantiate the Forest Service's commitment to reducing GHG emissions, helping the agency to comply with Executive orders and other statutory mandates.

A key part of monitoring efforts will be for consistent measurement and analysis procedures to be established across Forest Service regions. Topics as diverse as energy use modeling, GHG emissions analysis, economic analysis, life-cycle inventory and assessment, and others will be addressed by the Sustainable Operations team. Because new technologies and monitoring methods are quickly emerging, it will be important for Sustainable Operations members to stay abreast of these developments.

Green building will likely play an important role in future Forest Service efforts. New construction and renovation will take advantage of green building practices to increase energy efficiency and reduce carbon footprints. Examples include a newly renovated Forest Service building in downtown Portland, Oregon (Malone 2013), a net-zero office building on the National Renewable Energy Lab campus in Golden, Colorado (Dillow 2010), and others. In other arenas, new wood-based building techniques are utilizing cross-laminated timber to enter construction markets yet unrealized by bio-based materials—e.g., high buildings built entirely from wood. As more and more LEED-certified Forest Service buildings are constructed, research could also play a role in shaping these decisions. Life-cycle

analysis is expected to become an integral part of the team's future research efforts. It will be critical to look at energy savings and environmental burdens and footprints from a "cradle-to-grave" perspective to accurately characterize all environmental burdens and benefits.

Lastly, the Sustainable Operations science team will continue to identify the most important "knowledge gaps" and transmit information to the Forest Service managers who can benefit most. As Forest Service facilities adopt new energy technologies and implement new practices, it will be essential that these be communicated and demonstrated within the agency, to reach managers and planners who may be considering similar measures. This technology transfer role will be a vital part of our team's success as well as help meet agency mandates. An overarching goal of our science and technology transfer efforts will be to reduce the carbon footprint, and increase energy efficiency and sustainability in all areas of Forest Service operations.

Conclusions

For more than a century, the USDA Forest Service has had a strong conservation and stewardship ethic, and this is translating into actions to make the agency more sustainable. The focus of sustainable operations in organizations has typically been on evaluating organizational efficiency and is often evaluated on purely financial terms, including payback periods and returns on investment. However, in the larger framework of sustainability science, the focus is ultimately on societal benefits. The SST has used these guiding principles to initiate a broad-based research and technology transfer program engineered to be of practical value to Forest Service managers. During its first 5 years, the SST has made significant strides in the areas of energy efficiency, water footprinting, biomimicry, community energy management, and carbon footprinting. This research is expected to guide decisionmaking in the USDA Forest Service by providing managers with practical information, allowing them to pursue economically feasible avenues for increasing their sustainability. The Forest Service and the USDA can lead by example, to the benefit of other government agencies.

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