Chapter 6

Biological Dimensions of Forest Planning

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INVENTORY AND MONITORING IN A STRATEGIC PLAN

Strategic planning requires systematic monitoring of resources to assess trends and manage according to public desires. An inventory of resources is necessary to provide baseline data on what exists on the forests. Monitoring leads to a continuous record of information on the quality and quantity of resources and permits an evaluation of trends. Monitoring activities can be adjusted to respond to trends, changing interests, and emerging issues.

The Forest and Rangeland Renewable Resources Planning Act of 1976 (RPA) and the National Forest Management Act of 1976 (NFMA) call for an integrated approach to resource management:

> In the development and maintenance of land management plans . , . the Secretary shall use a systematic interdisciplinary approach to achieve integrated consideration of physical, biological, economic, and other sciences (section 6(b)).

The integrated approach was to minimize duplication of data gathering and to facilitate considering interactions among resources in developing forest plans (174). Some researchers consider inventories aimed at collecting data on one resource, such as a timber survey, to be multiresource inventories, because some of the collected information might be useful to an analysis of other resources, such as wildlife habitat. Lund (156), however, limits multiresource inventories to those with planned integration. He defines an integrated inventory system with six characteristics: 1) adaptable to a wide range of ecological conditions; 2) easy to use at different levels of management; 3) replicable and suitable for statistical analyses; 4) flexible enough to fulfill different information needs; 5) adaptable to a monitoring program; and 6) suitable for use with automated data processing. An integrated resource inventory also includes a multiresource component that emphasizes interactions among variables (174).

Because planning under NFMA calls for an integrated approach to resource management, the Forest Service must structure inventory and monitoring programs around integrated multiresource characteristics. This is not an easy task. An inventory and monitoring system that exhibits integrated multiresource characteristics will result, by its very design, in compromises in the gathering and analysis of data (174). For example, rangelands are defined by several physical features (topography and soil conditions) as well as a suitability factor for grazing by domestic livestock or wildlife. To inventory and monitor adequately the range-forage resource, the Forest Service must make specific decisions regarding which elements or combination of elements (interactions) to address, including specific methods of inventory, data analysis, and model development (174). The many decisions required to define the resource characteristics and ensure an integrated design make it extremely difficult to strive for an integrated multiresource inventory and monitoring program.

RESOURCE INVENTORY AND MONITORING IN THE FOREST PLANS[1]

Inventory and monitoring require the collection of information. When data collection is planned efficiently, inventory information can also be used in monitoring, and monitoring can be used to update and improve inventories (137). The primary difference between the two activities is that inventories are used to guide plan development, while monitoring is used to measure plan implementation and effects. An inventory might include collecting data on sizes and types of trees, or number of eagle nests with young. Monitoring would then include maintaining the records of tree size and type, or number of eggs hatched over time, to permit a determination of trends-in annual growth rates or hatching success. Both resource inventory and monitoring are essential to the evaluation of resource conditions on

[1] OTA did not try to review all Plain for national forests. In addition to the traditional published information and discussions and interviews, however, OTA did contract for background papers that reviewed plans for 11 national forests in depth and several others in less detail. Eight of the indepth plans were chosen randomly to represent each of the eight Forest Service regions (137). Three additional case studies were conducted, one each in the eastern (238), southwestern (166) and northern (42) regions. The selection of these forests was not to point to particularly good or bad plans, but to illustrate problems that are inherent in many of the plans.

the national forests and to the proper implementation of management activities.

Since NFMA was enacted and the regulations have been in effect, several problems have surfaced in relation to inventory and monitoring activities conducted by the Forest Service. Problems common to both inventory and monitoring are discussed below. Problems unique to data gathering or to monitoring programs are then addressed in separate sections.

Forest inventory and monitoring have been criticized for failing to produce an integrated, multiresource program. The scientific community, which has participated in long-term discussions on what constitutes appropriate inventory and monitoring, is as much to blame for this failure as the Forest Service (174). Although there is general agreement on the need for rigorous application of proper sampling design and statistical analyses, ''few clear guides exist in the scientific literature on how specific resources should be inventoried and monitored" (174). Advanced academic training and extensive research experience are required to design inventories, analyze inventory data, and establish monitoring programs that will achieve an appropriate standard. The scientific community, however, has not agreed on the makeup of a "rigorous and proper' sampling design. And, the Forest Service has not been quick to institute an integrated multiresource program, because specific designs and analytical techniques have not been established, and because the agency has not had enough experts to design such programs.

Slowness in developing an integrated multiresource inventory and monitoring system also can be blamed on the Forest Service's historical emphasis on inventory of the timber resource. Before passage of RPA and NFMA, inventorying by the agency concentrated primarily on ways to maximize timber production (162, 174). Inventory and monitoring programs used by the Forest Service today attempt to include integrated, multiresource inventories but are designed largely by retrofitting timber-oriented programs (174).

> Even in 1986, in the absence of final Forest Plans, functional timber management plans were still prepared and were still the basis of most day-to-day management activities (122).

Retrofitting a timber-focused program to include integrated, multiresource inventories has persisted in forest planning for three reasons. First, agency personnel have training and experience in specific techniques and are slow to change (174). Second, substantial changes in sampling design may impede the use of previously collected data. Finally, the original version of FORPLAN, the primary forest planning model, was not designed to address forest multiresource interactions. (See also ch. 7.)

Another shortcoming of forest inventory and monitoring programs has been the failure to address ecosystem processes, and the lack of attention to appropriate spatial and temporal scales for examining ecosystems. The enormous complexities of nature-soil formation, plant growth and succession, decomposition by fungi and bacteria, modifications by invertebrates and vertebrates, and natural catastrophes, especially forest frees-should be accounted for in an inventory and monitoring program (174). In the past, many ongoing resource inventories were designed to furnish information about the condition of a single resource for a small land area, such as a timber sale or a report on range or watershed improvement needs (166). In contrast, inventory data for a forest plan must provide information on a forestwide basis, often a million acres or more, for decisions that need to be made in the planning process. An inventory of timber stands does not address ecosystem elements. Aggregation of timber stands into larger units will also not address interactions that go beyond the stand boundaries, such as water flows and wildlife movements. In addition, appropriate temporal scale must be adopted for evaluating ecological systems. For example, sampling wildlife in only one season (e.g., summer only or winter only) will bias data collection to breeding or wintering requirements. Data for a forest plan must, therefore, be collected at the appropriate scale (in time and space) and be more organized-by resource as well as by site, date of information, and possible interrelated effects-than data collected under a nonintegrated approach for small areas (166).

Data collection and monitoring by the Forest Service has also been criticized for not being sensitive to statistical requirements for effective data analysis. Critics have pointed to several key components for statistical evaluation of data: clear identification of variables to be evaluated; accuracy and precision of variable estimates; and adequacy of sample sizes (174). The weaknesses in statistical validity of Forest Service inventories and monitoring have been attributed to the lack of biometricians on the planning teams.[2] This lack of expertise has resulted in the inability to improve data collection and analysis for accurate reporting of resource conditions and trends (174).

Problems with inventory and monitoring activities of the Forest Service are made worse by the lack of adequate funding (166). Monitoring is expensive and funding has not been provided for the systematic completion of forestwide inventories for most resources. For example, range managers on a national forest may use a variety of range inventories. Analysis of some allotments may have been completed recently and include field measurement of forage use. Other allotments may have been inventoried many years ago, using different inventory techniques. Some allotments may never have been inventoried (166).

Verner (304) provided a worst case scenario in response to the question, ''Can we afford reliable monitoring systems?" He used the pileated woodpecker ***(Dryocopus pileatus)*** to illustrate that the cost of monitoring annual changes in abundance on a particular forest for this species could exceed $1 million per year. The potentially high costs of monitoring activities, and the lack of adequate funding, require managers to analyze costs carefully as the monitoring plans are being developed.

RESOURCE INVENTORY

Inventory Requirements in NFMA and the Regulations

NFMA directs the Forest Service to obtain ''inventory data on the various renewable resources, and soil and water' (section 6(g)(2)(B)) and to base the forest plans on those inventories (section 6(f)(3)). NFMA contains several planning requirements that imply the need for resource inventories. For example, plans are required to provide 'sustained yield of products and services" (section 6(e)(l)) by generally limiting timber harvests to ''a quantity which can be removed . . . annually in perpetuity' (section 13(a)). To meet this requirement, a national forest must have inventory information on the stocks and growth rates of its trees.

Other planning requirements that depend on data from resource inventories are associated with land capabilities. Plans are required to ensure that timber is harvested only under certain conditions: lands that are suited for timber production considering physical, economic, and other pertinent factors (section 6(k)); lands where adequate reforestation can be assured within 5 years after harvest (section 6(g)(3)(E)(ii)); and lands where soil, slope, or other watershed conditions will not be irreversibly damaged (section 6(g)(3)(E)(i)). In developing the timber program, the forest must provide for the protection of water bodies ''where harvests are likely to seriously and adversely affect water conditions or fish habitat" (section 6(g)(3) (E)(iii)). Plans must also provide for the diversity of plant and animal communities based on the suitability and capability of the specific land area (section 6(g)(3)(B)). NFMA also requires the plans to be revised when conditions have significantly changed. Again, developing and maintaining resource inventories can facilitate fulfilling these requirements.

NFMA's requirements for resource inventories are reiterated and expanded in the regulations governing forest planning issued by the Forest Service in 1979 and revised in 1982:

> Each Forest Supervisor shall obtain and keep current inventory data appropriate for planning and managing the resources under his or her administrative jurisdiction. The Supervisor will assure that the interdisciplinary team has access to the best available data. This may require that special inventories or studies be prepared. The interdisciplinary team shall collect, assemble, and use data, maps, graphic material, and explanatory aids, of a kind, character, and quality, and to the detail appropriate for the management decisions to be made. Data and information needs may vary as planning problems develop from identification of public issues, management concerns, and resources use and development opportunities. Data shall be stored for ready retrieval and comparison and periodically shall be evaluated for accuracy and effectiveness (36 CFR 219.12 (d)).

The regulations require: specific inventories of roadless areas (36 CFR 219.17); fish and wildlife

[2] J. Verner, U.S. Department of Agriculture, Forest Service, Forestry Sciences Laboratory, Fresno, CA, personal communication, October 1990.

[3] Based largely on Krahl et al. 1990 (137).

populations (36 CFR 219.19); forage production and range conditions (36 CFR 219.20(a)); recreation opportunities (36 CFR 219.21 (a)(l-3)); visual resources (36 CFR 219.21(f)); water and watershed conditions (36 CFR 219.23 (a),(b), (c),and (e)); cultural and historic resources (36 CFR 219.24(a) (l-6)); unique biological and geologic areas (36 CFR 219.25); and diversity of plant and animal communities (36 CFR 219.26). Like NFMA, the regulations contain several planning requirements that imply the need for resource inventories: determination of maximum physical and biological production potentials (36 CFR 219.12 (em)); land suitability and assurance of reforestation for timber production (36 CFR 219.14 (a)(l-4)); culmination of mean annual increment of growth of timber species (36 CFR 219.16 (a)(2) (iii)); and sustained yield of timber harvests (36 CFR 219.16(a)(2)(iv)).

Problems With Inventory Data

Although NFMA and the implementing regulations require national forests to base initial and subsequent planning efforts on resource inventories, direction is not provided on how ongoing inventories should be used in planning (137, 238). Some plans refer to inventories in their goals and objectives and monitoring plans, or even include inventory activities as a subcategory in each resource section of their standards and guidelines. Other plans may contain little or no reference to resource inventories, or may list only new inventories that would be required for plan implementation.

A report by the Committee of Scientists reviewing proposed NFMA regulations considered adequate inventory data essential to sound forest plans:

> No plan is better than the resource inventory data that support it. Each forest plan should be based on sound, detailed inventories of soils, vegetation, water resources, wildlife, and the other resources to be managed (48).

Despite the critical role of good inventory data, the committee found that data for most resources in the plans were insufficient for making management decisions.

Nonetheless, the Forest Service has made progress in developing inventories in the 15 years since NFMA was enacted. A current agency handbook provides guidance on resource inventories, and identifies five objectives for Forest Service inventories: 1) determine the condition, production, potential, and amounts of key ecosystem components or processes; 2) identify a benchmark for describing the current physical and biological situation and for forecasting projected changes; 3) provide ecological information as a basis for protection and management decisions about land and resource uses, proposed plans, or actions; 4) consider conditions and trends that either change the demand for resources or that are affected by resource decisions; and 5) refer all inventory information to specific units of land (284).

These general objectives, however, have not ensured that forest planning will address past problems with inventories, such as gaps in information on plants and nongame and invertebrate animals (174, 238, 321). For example, of eight forests examined, only the Eldorado National Forest identified inventories used in initial plan development (137). (See table 6-l.) Even in this case, the data and methods used to conduct the inventories were not identified. Major problems with inventories on the national forests are discussed below in relation to quantity, quality, and timeliness of inventory data, and compliance with NFMA requirements.

Table 6-1--National Forest Plans Sampled for Inventory and Monitoring Reviews

Forest	Region	State	Draft plan	Final plan
Bitterroot	1	Montana	1985	1987
San Juan	2	Colorado	1982	1983
Coconino	3	New Mexico	1985	1987
Dixie	4	Utah	1985	1986
Eldorado	5	California	1986	1989
Siskiyou	6	Oregon	1987	1989
Nantahala and Pisgah	8	North Carolina	1984	1987
Nicolet	9	Wisconsin	1984	1986

SOURCE: L. Krahl, H. Severtson, and H.H. Carey, *The Impacts of NFMA on Resource /inventories and Monitoring on the National Forests*, OTA background paper, Oct. 31, 1990.

Quantity and Quality of Inventory Data

Absence of inventory data is a problem on many forests. Some timber inventories have been based primarily on air photo interpretation. Critics claim they contain little information on growth rates and location of stands, little field reconnaissance, errors in classification of plots, and questionable acreage figures (42). For example, the Cibola National Forest defined and mapped areas based on soil characteristics, potential natural vegetation (PNV), and slope (166). Field data were used for 20 percent of the forest, while the remaining 80 percent was delineated using aerial photos, limited site examination, and extrapolation from existing inventories. Thus, field measurements required for accurate and replicable location of unit boundaries were available for only a small number of areas. Accuracy and replicability could have been improved if more time and funding had been available. Improvements in the next planning cycle are likely because of more extensive survey work being completed on this forest (166).

In other cases, timber data may be inadequate because timber plots from early inventories may not be remeasured to verify growth rates (42). Growth rates for timber stands may simply be predicted by computer programs without field verification (42). Forests also may be classified by site productivity classes rather than present vegetation—a misleading classification system for designating timber stand suitability (42).

As with other resources, inventories on soils and rangeland resources vary in quality and quantity. Some national forests have designed their soil inventories to provide information over large land areas quickly and have relied on air photo interpretation with limited field reconnaissance. Inventories designed in this way require supplemental information for use in high intensity or small area planning projects (42). For example, the Idaho Panhandle National Forests grouped all soils information into four categories (sensitive or nonsensitive soils with slopes over or under 40 percent). The environmental impact statement noted that a greater number of ''specific land types would provide more accurate response units, ' but that FORPLAN was incapable of handling more types.

Variations in range resource inventories are explained by lack of funding as well as amount of rangeland present on the forest, and thus the priority in forest inventory tasks (166). For example, only a small portion of the Idaho Panhandle forests—about 7500 acres—is managed for domestic grazing (42). The range inventory for these forests, as described in the forest plan, is designed to provide useful information about the range resources. However, the descriptions of range allotments were labeled as "vague and subjective' (42).

Likewise, the Forest Service has described data on range condition on the Cibola National Forest as ''available but inadequate' and has criticized past data collection strategies for being based on reports that ''went back several decades and are not consistent with present methodologies" (166, 270).

Data quality in the Cibola forest plan generally has been poor (166). The Cibola forest planners stated that it is not Forest Service policy to do resource inventories specifically for land management planning. Rather, the forest relies on compiling a database for the plans by extrapolating and disaggregating data collected for other management purposes. The forest is, however, now developing two data sets based on field inventories. One, for timber, examines all commercial timber stands. The second is a terrestrial ecosystem survey examining soil characteristics, potential natural vegetation, and slope. The forest is also working on implementing a geographic information system in anticipation of markedly improved data.

Timeliness of Inventory Data

Delays in forest plan completion may lead to as much as a 10- to 15-year gap between the date the data were collected and publication of the plan (137). Six of the forests in table 6-1 used timber inventories that were at least 5 years old when the draft plans were released. The timber inventory was up to 8 years old in the draft plan for the Siskiyou and 15 years old in the draft plan for the San Juan.

Additional problems exist with respect to timeliness of data collection. Forest Service planning rules adopted in 1979 stated that". . . existing data will be used in planning unless such data is [sic] inadequate" (36 CFR 219.5). Forest Service Manual provisions issued in March 1980 added to this rule:

> Where additional data and information collection is necessary, it must be limited to that which is essential for analysis and decisionmaking in the planning process *(267).*

Under direction of the Chief of the Forest Service to rely substantially on existing data, some forests postponed new inventories, and used existing data that were not comprehensive enough to aid planning and management decisions (42). Although the 1982 revision of the forest planning rules eliminated the statement that "existing data will be used," by that time, some forests were committed to using existing data in preparing their plans (42).

Compliance With Inventory Requirements

Several plans from forests in table 6-1 failed to comply with inventory requirements in NFMA. One of the critical requirements is the inventory of roadless areas. Only one (the Bitterroot) provided for an annual inventory of roadless areas and changes in wilderness characteristics. Staff on the other forests stated that, although they did not have systematic inventories of wilderness characteristics in roadless areas, they did include assessments of these characteristics in the National Environmental Policy Act (NEPA) documentation for proposed projects in the wilderness areas (137). The forest staff stated that the inventory conducted under the second roadless area review and evaluation (RARE II) was sufficient, and that project-specific assessments were adequate to maintain the inventory (137).

The sufficiency of the RARE II inventories has been questioned, however. In ***California v. Block (690*** F. **2d 753, 9th Cir. 1982), the court held that RARE II failed to meet the** NEPA requirements for site-specific evaluation of the consequences of recommending that areas be available for nonwilderness management. This ruling required forest planners to reevaluate RARE II roadless areas for wilderness. For the Idaho Panhandle National Forests, the Forest Service stated that the analysis of roadless areas had a substantial effect on the outcome of the plan (282). However, one critic claimed that the analysis had little effect on the forest plan because many distinguishing attributes of the forests' roadless areas were not identified in FORPLAN (42).

Only two of the plans from the eight forests in table 6-1 (Siskiyou and Coconino) prescribed inventories for threatened fish habitats, and none identified inventories of waters threatened by timber harvests (137). Interviews with forest staff suggested that, although the inventories were not prescribed in the plans, conditions of aquatic re**sources are inventoried, especially within project areas.**

Summary and Conclusion

The poor quality of national forest resource inventories, the lack of coordination among various resource-specific inventories, and the inappropriate use of information in decisionmaking contributed to the enactment of NFMA (137). The situation on the forests since NFMA was enacted has not changed substantially. Absence of data along with poor data quality, limited collection of new data, out-of-date information, and failure to comply with the law are inherent in many of the resource inventories of the forest plans. These problems are magnified by data that are poorly documented and inaccessible. Some forests have not set up a well-organized, easy-to-access data system that the public could use to obtain background information on resource inventory or even to know what inventories are maintained. Few forests summarize their resource inventories in a document that is appropriate for reading by the general public (238).

A critical first step in the planning process is to identify key resource management decisions and define data needs. The Forest Service, in trying to make management decisions based on limited data, must examine available knowledge, combine it with expert opinion, and make predictions about the consequences of alternative management actions (247). While the national forests rarely have all the information that might be desirable to make a management decision, and certainly are in need of more and better data to assist in management decisions, it is important that the existing data are accessible and applied to appropriate management situations. Major roadblocks-an emphasis on timber inventory as well as little funding-have limited the scope of resource inventories. Priorities can be set by identifying significant gaps in resource data. New inventories can be designed to provide missing information, with special and unusual data needs met with additional surveys and inventories. Inventory data that do exist must provide baseline information for identifying and examining impacts of activities conducted on the forests. The inventory data must be organized and presented in a meaningful, usable form that can be aggregated for a broader picture of the Nation's resources.

RESOURCE MONITORING

Monitoring Requirements in NFMA and the Regulations[4]

In contrast to its inventory requirements, NFMA contains no general provision requiring monitoring. The word ''monitoring' appears only once, in reference to research and evaluation of the effects of management systems (section 6(g)(3)(C)). The need for monitoring is inferred in requirements for reforestation (section 3(d)(l)), herbicide and pesticide use (section 3(e)), revegetation of temporary roads (section IO(b)), and implementation of even-aged harvest (section 6(g)(3)(f)(v)).

Unlike the law, the regulations highlight monitoring as a critical component of forest planning. The regulations require monitoring plans as part of the land and resource management plan for each national forest. Implementation of these monitoring plans must be reviewed periodically to determine if the prescribed monitoring is occurring as well as if the resources are being managed sustainably.

> At intervals established in the plan, implementation shall be evaluated on a sample basis to determine how well objectives have been met and how closely management standards and guidelines have been applied. Based upon this evaluation, the interdisciplinary team shall recommend to the Forest Supervisor such changes in management direction, revisions, or amendments to the forest plan as are deemed necessary (36 CFR 219.12(k)).

Additionally, the regulations imply that monitoring must be conducted to assess the impact of timber harvests on soil, water, fish, wildlife, recreation, and aesthetic resources (36 CFR 2 19.27(c)(6)). Monitoring to preserve and enhance the diversity of plant and animal communities is also implied in regulatory requirements for diversity ''at least as great as that which would be expected in a natural forest" (36 CFR 219.27(g)). The regulations require that monitoring include: quantitative outputs and services and costs of management prescriptions (36 CFR 219.12 (k)(l)and(3)); documentation of measured prescriptions and effects, including significant changes in productivity of the land (36 CFR 219.12(k)(2)); and a description of actions, effects, or resources measured, the frequency of measurements, the expected precision and reliability of the monitoring process, **and the** time when evaluation will be reported (36 CFR 219.12 (k)(4) (i-iii)).

The monitoring requirements in NFMA and the regulations reinforced some existing Forest Service activities. Measuring and reporting outputs and monitoring project implementation had been conducted on the national forests for many years. NFMA and the regulations augmented these procedures by requiring the forests to: 1) specify standards and guidelines for monitoring project implementation; and 2) monitor environmental impacts, a practice that had not been common, especially for noncommodity resources. NFMA also requires that forest plans be revised when conditions have changed significantly, but at least every 15 years (section 6(f)(5)(A)). This implicitly requires that forest plan implementation and forest conditions be monitored, to determine when significant changes have occurred. The regulations further require forest supervisors to "review the conditions on the land covered by the plan at least every 5 years to determine whether conditions or demands of the public have changed significantly" (36 CFR 219.10(g)). If the supervisor finds significant changes, the plan must be revised.

Problems With Monitoring Activities

Compliance With Monitoring Requirements

Monitoring measures the results of resource management activities to ensure that prescribed activities are undertaken and that they have the expected effects. The regulatory requirements for reports on monitoring are not always fulfilled. Although five of the forests in table 6-1 (Bitterroot, Coconino, Nantahala/Pisgah, Nicolet and San Juan) have issued monitoring reports, only the Bitterroot has issued annual monitoring reports according to the schedule in its plan (137). The Dixie completed its plan in 1986 and the Eldorado and Siskiyou completed their plans in 1989. These forests may release monitoring reports by the end of 1991.

Although all of the plans in table 6-1 prescribed monitoring activities to measure product and service outputs, they were less consistent in prescribing monitoring to assess noncommodity resources (137). Only two plans (Dixie and Siskiyou) prescribed monitoring to meet all of the noncommodity goals and objectives in their forest plans. Three plans

[4]Based largely on Krahl et al. 1990 (137).

(Bitterroot, Coconino, and the Nantahala/Pisgah) prescribed monitoring for at least 75 percent of their noncommodity goals and objectives, while the remaining three plans (Eldorado, Nicolet and San Juan) prescribed monitoring for less than 65 percent of their noncommodity goals and objectives (137). In addition, despite the requirement to submit an annual report on the amounts, types, uses, and beneficial or adverse effects of herbicides and pesticides, none of the eight plans in table 6-1 included this information. Even though this information was not in the plans, staff from these forests stated that they report herbicide and pesticide use, in compliance with regional or State requirements (137).

Levels of Monitoring

The Forest Service defines monitoring at three different levels: 1) implementation monitoring, or an evaluation of whether management activities are carried out according to the forest plan; 2) effectiveness monitoring, or an evaluation of whether the management activities meet the plan objectives; and 3) validation monitoring, or an evaluation of whether the initial plan assumptions are correct (267). (See box 6-A.) To date, complaints with implementation monitoring have been the most common, but problems with all three levels of monitoring have led to criticism of the management plans.

Implementation monitoring poses the question: "Did the Forest Service do what they said they would do?' Many monitoring programs have been criticized for promising too much (42, 248). For example, personnel needs in the Chequamegon National Forest's monitoring plan for the next 6 years (1990 to 1996) call for an increase of 95 percent in the number of work days over that of 1989—an unlikely scenario (238). As implied in the plan, however, the proposed increase would considerably enlarge the scope of the monitoring program and provide the forest with greater knowledge of the condition of its resources.[5]

The Idaho Panhandle monitoring plan has been criticized for uneven monitoring-items that are easy to quantify, like the size of timber cutting units, were successfully monitored, while items less easily quantified, e.g., wildlife and fish population trends, were less successfully monitored. Some items were not monitored at all (e.g., the status of certain wildlife species and effects of management on insects and disease) (42).

Box 6-A—Example of Levels of Monitoring on a National Forest[1]

Forest Plan Goal: To maintain stream temperature by keeping 10 percent of Moose Creek in shade and thereby maintain trout populations in Moose Creek.

Forest Plan Standard and Guideline: Do not remove any trees within 15 feet of a stream.

Implementation Monitoring: Did the forest do what they said they would do? Did the forest remove any trees within 15 feet of the stream?

Effectiveness Monitoring: **Did the Forest Service accomplish what they set out to do, and did they do it in the most efficient way? Can the trout populations in Moose Creek be maintained by not removing any trees within 15 feet of the stream?**

Validation Monitoring: Are the Forest Service goals and objectives appropriate? Does maintaining 10 percent of Moose Creek in the shade keep temperatures from rising above the limit for maintaining trout populations?

[1]Information adapted from Handout 11.13, Unit 11, **Monitoring and Evaluation of the Forest Plan Implementation Course 1900-01.**

Effectiveness monitoring poses the question: "Did the Forest Service accomplish what they set out to do, and did they do it in the most efficient way?" The forest plans have been criticized for inaccurate reporting of resource conditions. An audit by the Idaho State Department of Lands found that some timber sales on the Idaho Panhandle had unacceptable implementation of best management practices (BMPs). In 1989, the forest began a program to determine if the BMPs were successful in meeting State water quality requirements. At least four of the planned watershed monitoring programs were not completed due to lack of funding and personnel (42).

Validation monitoring poses the question: "Are the Forest Service goals and objectives appropriate?" Regardless of specific monitoring programs developed by the Forest Service, the programs must

[5]The forest has been increasing spending related to forest plan monitoring, going from $0 specifically allocated to forest plan monitoring in fiscal year 1988 to over $50,000 in fiscal year 1991 (letter from Forest Service to OTA, Aug. 20, 1991).

be defendable in terms of rigorous study design and analysis (174). If, as is often the case, the forests have not carried out the proposed monitoring activities it is difficult to evaluate this question. Thus, investigations of Forest Service monitoring cannot evaluate the appropriateness of Forest Service goals and objectives because there are few data to analyze and defend.

Summary and Conclusion

Monitoring on the national forests involves the repeated inventory of managed resources to determine conditions and trends. Because the Forest Service is directed to maintain a comprehensive survey and analysis of conditions of renewable resources under its jurisdiction (section 3(b)), the focus of this section of the law is really monitoring rather than point-in-time inventory (174). It is still early to determine whether the Forest Service has successfully met its monitoring requirements—some of the forests have not yet issued monitoring reports. The monitoring the Forest Service has scheduled, however, often has not been implemented. The forests have typically promised more than they have been able to deliver.

One way of reducing measures of ecosystem health to a manageable level is to review the relevance of the chosen measures to human concerns (127). Important characteristics to include in an inventory and monitoring program relate directly or indirectly to something that people are concerned about. Identifying these characteristics may require an explanation of why the measure is relevant.

Newly proposed regulations (287) may strengthen the role of monitoring in the planning process. The agency may place renewed emphasis on integrated, multiresource programs and an ecosystems approach. Given the lack of money for detailed monitoring, however, the forests need to reevaluate their monitoring plans. The plans must reflect more accurately what is possible and what is most important to accomplish under staff and budget constraints and according to public interest.

SPECIAL ISSUES

Biological Modeling

Environmental planning requirements of NFMA are varied and extensive. In fact, the data required from the Forest Service by law ‘are far beyond those ever compiled by the Forest Service or anyone else . . . “ (51) Historically, most forests have lacked data useful to forest planning, including reliable data on tree growth and yield (particularly for regenerated stands in plantations) and up-to-date vegetation maps (64). Forestry research also had not provided much support in the way of practical biological models for forest planning (64). After NFMA, the overwhelming task facing forest planners was to come up with reliable, desirable plans for large, complex, million-acre areas-a task requiring a lot of data, time, money, and a skilled workforce. Not enough of any of this was provided to the agency to accomplish the tasks required in NFMA (64).

As abstractions and simplifications of reality, biological models depict relationships among environmental factors (174). Models represent a theoretical framework for understanding the environment. Simplification is necessary in model development, to describe complex systems in comprehensible ways. The extent and form of the simplification are critical, because if the simplification is not appropriate, management decisions based on the model will be faulty (174). Inappropriate simplification of models has resulted from poor quality data, data that emphasize the timber resource, and failure to recognize the importance of scale in study design.

Data Problems

Despite RPA/NFMA requirements for integrated, multiresource inventories, Forest Service inventory and monitoring have failed to support models depicting resource interplay within a complex environment (174). The historic emphasis on timber in Forest Service management has led to inventory data that fit into models for timber production forecasting. Forest models developed for FORPLAN emphasize the growth, manipulation, and harvest of trees (64). (See also ch. 7.) FORPLAN’s emphasis on timber management reflects both the design of FORPLAN and the lack of reliable theory and data to quantify nontree outputs. Except for timber assessments, “Land managers have had to rely on intuitive judgment rather than the evaluation of systematically organized data sets and processes’ (135). FORPLAN directly or indirectly links outputs such as forage, water, sediment, recreation, fish, visual quality, and wildlife habitat to forest management through land allocations and restrictions on timber production (64). For example, FORPLAN rarely contains a reliable, well-documented, quantitative yield table to represent nontimber outputs and how they respond to use and development. In many cases, the existing inventories emphasizing timber are now driving model development, rather than the models driving data collection by generating hypotheses that determine critical variables and appropriate sampling designs (174).

Wildlife managers are especially challenged to provide sufficient and reliable data on nongame species, which are essentially new to the inventory (304). Models have been developed to estimate effects of forestry activities on these species and to forecast trends in abundance. However, many wildlife population models have been developed on assumptions about habitat suitability that may not be valid (304). For example, one common assumption is that species abundance can be used as an index to habitat suitability. Challenges to this assumption suggest that indices based on demographic parameters (e.g., clutch size or growth rate) may prove to be more reliable than indices based on abundance (96, 302). Another common assumption in wildlife population models is that populations change in proportion to the availability of suitable habitat (304). However, animal numbers may beheld below carrying capacity by other factors, including predation, parasitism, competition, weather extremes, and unpredictable events.

Even if wildlife population models are correct in assuming that abundance may be a good measure of habitat suitability, critics claim that the available data are still insufficient to draw conclusions for guiding management activities (304):

> Existing inventory techniques are generally too expensive and they require more skilled personnel than are available . . . To date, no comprehensive system for monitoring wildlife resources on a major land-management unit has been developed and tested . . .

Questions have also been raised regarding logistical procedures for updating files that are used to build biological models. Verner (304) claimed that efforts to update inventories on national forests "have been marginally successful because of cost and lack of suitable computerized data files."

Scale Problems

Use of appropriate scale is also a problem in the modeling of biological systems for the national forests. The characteristics of ecological systems differ at different scales. For example, small plots surveyed for bird species may show that two species are found in different habitats, perhaps in forests of different age classes. When surveying at a broader scale, the two species may be associated together rather than with other species that occur in more distinct habitats, such as cattail marshes or sedge meadows. Thus, inventory results would vary depending on the scale of survey.

> [I]f we study a system at an inappropriate scale, we may not detect its actual dynamics and patterns but may instead identify patterns that are artifacts of scale (319).

Each forest is unique at the continental scale, since major environmental factors such as geologic features, temperature, and precipitation vary throughout the country (172). Each forest is also unique, however, at the local level, where topography, geology, and history influence conditions. It is important that management decisions recognize the appropriate scale of influence and impact of management activities. Section 6(b) of NFMA requires that a systematic interdisciplinary approach, including economic and environmental considerations, be used to evaluate management alternatives. This implies that the plans will show interactions among the managed resources. Shugart and Gilbert (234) conclude that:

> One might argue that the Forest Service should not be trying to do such comprehensive planning forest-wide, and yet the National Forest Management Act states that a single plan must be produced.

One approach to improve the usefulness of biological models in forest planning is to treat models as tools rather than goals:

> The goal is to apply research findings usefully to predict management effects. . . The model is but one tool to reach the goal (36),

Management is, in many respects, an experiment in applying models to the real world. Results are monitored to evaluate and improve the models (146). Development of multiple-resource models with linkages to a geographic information system are described as particularly promising for integrated analysis at various scales (146). GIS can provide information on resources with site specificity in an accessible format and assist in the evaluation of results from the models and in the estimations of environmental effects (278).

Biological Diversity

Legal Requirements

Biological diversity refers to the variety and relative frequency of living organisms (174). Ecosystem interactions are integral components of biological diversity, and biological diversity, in turn, determines ecosystem interactions. Morrison (174) offered the following analogy for understanding the relationship between biodiversity (biological components of the ecosystem) and ecosystem functioning:

> You can count all the parts of a vehicle and assess their condition individually without being assured that the assembled vehicle will start, or how well it will run over the long term. The fewer parts you inventory and monitor, the less likely you will be to predict whether the finished product is complete and how it will function.

NFMA directly refers to maintaining biological diversity in the land and resource management plans. Section 6(g)(3)(B) states that the regulations for developing the plans are to:

> . . . provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives . . .

The Committee of Scientists interpreted this as clear congressional intent for considering diversity throughout the planning process and for maintaining or increasing the diversity of plant and animal species and of biological communities (48).

The Forest Service regulations repeat and expand on NFMA's guidance to provide for diversity of plant and animal communities in the forest plans:

> Forest planning shall provide for diversity of plant and animal communities and tree species consistent with the overall multiple-use objectives of the planning area. Such diversity shall be considered throughout the planning process. Inventories shall include quantitative data making possible the evaluation of diversity in terms of its prior and present condition. For each planning alternative, the interdisciplinary team shall consider how diversity will be affected by various mixes of resource outputs and uses, including proposed management practices (36 CFR 219.26).

The regulations also limit the loss of diversity to be tolerated under prescribed management practices (36 CFR 219.27(g)) and recognize that national forests are ecosystems and that their management requires awareness of the interrelationships among resources (36 CFR 219.1(b)(3)). The regulations specify biological diversity as a criterion for evaluating lands as potential wilderness areas (36 CFR 219.17(a)(2)(v)).

In addition to the requirement to inventory and monitor the diversity of plant and animal communities, Forest Service regulations require the forests to maintain viable populations of species:

> Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area (36 CFR 219.90).

A viable population is defined as 'one which has the estimated numbers and distribution of reproductive individuals to insure its continued existence is well distributed in the planning area" (36 CFR 219.9). A Department of Agriculture regulating extends the requirement beyond vertebrates, to maintain at least viable populations of "all existing native and desired non-native plants, fish, and wildlife species" (321). Population viability is one part of biodiversity, since diversity clearly declines when species go extinct (174). Thus, inventory and monitoring for diversity must estimate the numbers of organisms as well as assess the relationship between the numbers and population viability (174).

Wilcove (321) argued that forest plans have failed to address the issue of conservation of biological diversity adequately. The current approach tends to increase populations of widespread species at the expense of rarer species, because each national forest can assure viable populations for common species but not for uncommon species. In contrast, a regional approach considering all landowners could better fulfill the intent of preserving biological diversity in all natural ecosystems (321).

The inadequate treatment of biological diversity has been blamed, at least in part, on the failure to identify measurable attributes of diversity for inventory and monitoring programs (184). Ness (184) outlined a characterization of biodiversity that identified three biological components--composi-

[6] U.S. Department of Agriculture, Departmental Regulation 9500-4, Fish and Wildlife Policy, Aug. 22, 1983.

tion, structure, and function--for four levels of diversity-regional, community, population, and genetic. Others have also called for conservation of biological diversity using a more comprehensive, landscape-level approach (107, 318).

Diversity in NFMA Planning

Although NFMA requires the national forests to inventory diversity, neither the law nor the regulations specify the kinds of data needed to create such inventories. Forest plans, therefore, vary in the data they consider in their evaluation of diversity (238).

A review of 20 national forest plans showed that most of the forests specified the level of diversity, stated the diversity level in terms of overall multiple-use objectives, discussed the consequences of the diversity level provided, and justified the reductions in existing diversity in terms of multiple-use objectives (167). Management prescriptions to provide for diversity of the natural forest, however, were not identified by any of the forests and only one compared diversity of past and present conditions. Also missing were quantitative measures of the distribution and abundance of plant and animal species. Most forests (60 percent) used the percent of total forest acreage in different age classes as a surrogate measure of animal diversity. Seven forests (35 percent) measured diversity as the percent change in forestwide habitat capability for management indicator species. Specific measures of plant diversity were not included, under the assumption that animal (habitat) diversity reflects vegetative diversity (167). (See also the following discussion of indicator species.) The study concluded that although the 20 forests generally conformed with NFMA requirements to provide for diversity and show effects of outputs on diversity, the measures of diversity were general values for tree age classes or animal numbers, rather than specific measures for plant and animal communities and species distribution and abundance. These measures were also insensitive to effects of different management options on diversity (167).

Timber and range vegetation types are the most common measures of diversity in these plans of forests listed in table 6-1. The Bitterroot, Eldorado, and San Juan Forests included old-growth forest, but surprisingly, the Siskiyou did not--even though old-growth forest protection has been an issue in that region. Six of the forests (Coconino, Eldorado, San Juan, Siskiyou, Nantahala/Pisgah, and Nicolet) included wildlife habitat measures in their inventories of diversity. All of these measures of diversity, however, fail to adequately evaluate spatial, temporal, and structural characteristics of biological diversity (137). Three of the forests have developed special inventories to address these shortfalls. The Eldorado National Forest greatly expanded its plant inventories; the Siskiyou participated in a regional inventory of vegetative communities that will include measures of fragmentation and biological corridors; and the Nantahala/Pisgah, in response to a successful administrative appeal based on the inadequacy of the diversity section of the forest plan, is evaluating alternative inventory methods to determine status and trend of diversity (137).

To compile information on diversity, the Chequamegon National Forest staff used data from the Wisconsin Department of Natural Resources on vertebrate species, selected sensitive and game vertebrate species, rare vascular plants, and potential research natural areas. The forest also used general vegetation information from its Vegetation Management Information System (238). These data, like the biological diversity data collected on other forests, are incomplete in that no species list was available for invertebrate animals and no information was available for nonvascular plants, lichens, and fungi. The Chequamegon Forest has taken steps to resolve some of these problems by enlarging the scope of diversity information and by focusing monitoring efforts on species and processes of greatest public concern or those most affected by forest management. Examples of programs to be added include monitoring the reproduction of white cedar and the use of various plant foods by mammals (238).

Several plans have been criticized for promoting management practices that do not protect the biological resources of the National Forest System: forests are being converted to monoculture, genetic diversity is not being enhanced, and animal habitats are being fragmented (321). Plans from national forests in Florida, for example, promote management practices that will convert longleaf pine forests into stands of species that would not occur there naturally. The final plan for the Ouachita National Forest, in Arkansas and Oklahoma, was criticized for managing almost solely for pine forests and for decreasing genetic diversity by artificially regenerating clearcut stands with pine. Restrictions on clearcutting and pine plantations were considered for this area in the Winding Stair Mountain National

Recreation and Wilderness Area Act.[7] However, only an annual timber management report and an advisory coremittee were finally specified in the act. The plans for the Arapaho/Roosevelt and Shoshone National Forests (in Colorado and Wyoming, respectively) were criticized because they would allow a high level of forest fragmentation. Biological diversity would not be protected (321).

Indicators

General Indicator Concept

An indicator has been defined as:

> A characteristic of the environment that, when measured, quantifies the magnitude of stress, habitat characteristics, degree of exposure to the stressor, or degree of ecological response to the exposure.[8]

Indicators have been used as an index of conditions that are too difficult, inconvenient, or expensive to measure directly (140). Indicators can streamline investigations of environmental conditions by minimizing the number of characteristics that need to be measured. Indicators may be of several kinds. Some may be ecological in that they provide information on the biological condition of a resource. Others may be stressor indicators, providing information on environmental hazards, or management indicators, providing information on management activities.

While saving time and money, the indicator concept has been criticized for presenting an oversimplified view of environmental conditions. Indicator species, in particular--in contrast to the broader indicator concept that can include characteristics such as climatic fluctuations or levels of nutrients in tree foliage in addition to individual species—have been described as misleading:

> Indicator species often have told us little about overall environmental trends, and may even have deluded us into thinking that all is well with an environment simply because an indicator is thriving (184).

A poor selection process for indicator species could lead to poor assumptions about the effects of an environmental hazard, such as a chemical pollutant. For example, **assuming that a** chosen indicator species will decline if the chemical pollutant is harmful **to its** food source may not be effective if the chosen indicator does not depend solely on that food source. Declines in other species that do rely solely on the affected food source might go unnoticed because these species were not monitored.

Recommendations to make the use of indicators more rigorous include: a clear statement of goals; thorough biological knowledge of the indicator; and peer review of assessment design, methods of data collection, statistical analysis, interpretations, and recommendations (140). The most useful indicators will be sensitive to stress, responding to it rapidly in a predictable way; be easy and economical to measure; and be relevant to the goals of the investigation (127). A set of carefully selected indicators, rather than a single indicator species, is more likely to exhibit all of the characteristics recommended as selection criteria (184).

Forest Service Use of Management Indicator Species

Forest Service regulations require the forests to select and monitor a set of management indicator species (MIS) (36 CFR 219.9). The Forest Service regulations list five categories to be represented when selecting MIS: 1) endangered or threatened species identified at the State or Federal level; 2) species sensitive to planned management activities; 3) game and commercial species; 4) nongame species of special interest; and 5) ecological indicator species that are used to monitor the effects of management practices on other species. Following the general indicator concept, the MIS chosen to represent these categories act as surrogates for measuring environmental conditions of the forest communities. Management indicator species differ from other types of indicators in that: 1) they are species (in contrast to characteristics); 2) they indicate the effects of management activities (in contrast to effects of other events such as natural disasters or changes in rainfall); and 3) they indicate the effects of management activities on forest resources (not solely on other species). The use of MIS assumes that some relationship exists between a prescribed management activity and the presence or abundance of the MIS (174, 189).

As with the indicator concept itself, several major problems confront the use of MIS: guidelines have

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[7] Act of Oct. 18, 1989, Public Law 100-499 (102 Stat. 2491).

[8] U.S. Environmental Protection Agency, "Environmental Monitoring and Assessment Program, Ecological Indicators," Office of Research and Development Washington DC, September 1990.

not been set for the selection of species; training and expertise to select, monitor, and analyze MIS have been lacking; and some species are ignored in the inventory process (174, 189). With no guidelines for the selection of MIS, selection processes vary among forests. Some are criticized for choosing an insufficient number of indicators, others for choosing indicators that are not related to ecosystem conditions. The following examples illustrate specific problems some forests have had with the use of MIS.

The Idaho Panhandle National Forests and the Cibola National Forest fell short in their selection of an adequate number of indicators and their collection of data on chosen indicators (42, 166). On the Idaho Panhandle, no indicator species existed for mature lodgepole pine which covers a major part of these forests. Also on the Idaho Panhandle, no data were available on populations or population trends for most of the nongame indicator species (marten, pileated woodpecker, and goshawks) (42). On the Cibola, inventory data were also nonexistent for population size and distribution of nongame indicator species (166).

The Chequamegon National Forest plan recognized 25 ecological community types, but only identified 15 indicator species to evaluate conditions in these communities. Deciduous trees dominate at least half of this forest, but the stands were lumped into two classes: young/mature hardwoods with ruffed grouse as an indicator, and old-growth hardwoods with the pileated woodpecker as an indicator. Under this classification, several communities (a young, even-aged stand of red oak and red maple, an uneven-aged pure stand of sugar maple, and a mixed stand of basswood and yellow birch) would all be lumped into one category. Tracking populations of ruffed grouse and pileated woodpeckers would poorly represent changes in these communities or in their other constituent species (238).

Also in the Chequamegon plan, two species were selected as aquatic indicators, but were dropped from the list because ‘‘little management of aquatic habitats is planned for this decade” (238). Thus the potential effects of such management activities as timber harvesting or road construction on aquatic ecosystems are ignored. In addition, one of the chosen indicator species did not depend on natural conditions for reproduction in the forest. The muskellunge, a game fish stocked in the lakes and streams in the Chequamegon National Forest by the Wisconsin Department of Natural Resources, was chosen as the sole “ecological” indicator for warm water habitats in the forest. But because of artificial stocking, muskie population numbers are inaccurate indicators of the effects of national forest management (238).

A review of 104 draft and final plans for 118 national forests showed that the majority failed to choose a wide spectrum of indicator species and overlooked the advantages of selecting plants and some invertebrates:

> Ninety-three plans did not have any plants on their MIS lists, other than species already listed as threatened or endangered by the federal government. Eighty-seven did not include any unlisted invertebrate animals, despite the fact that invertebrate animals constitute the vast majority of living species. Of the 1,439 MIS in these plans (excluding federal threatened and endangered species), 50 percent were birds, 27 percent were mammals, 17 percent were fishes, two percent were reptiles and amphibians, less than one percent were invertebrates, two percent were plants, and two percent were multi-species assemblages of birds, plants, fishes, or invertebrates (321).

Thus, while birds and mammals can serve as good ecological indicators for other species with smaller area requirements, an MIS list composed only of vertebrate animals will be inadequate for protecting all rare plants or invertebrate animals in a given area (321).

Indicator Species and a Monitoring Program

The selection of appropriate management indicator species must be combined with an adequate monitoring program. The Forest Service regulations state that:

> Population trends of the management indicator species will be monitored and relationships to habitat changes determined (36 CFR 219.19(a)(6)).

The goal of monitoring MIS on the national forests is to verify assumptions in the forest plans about effects of management activities on ecosystem health. Monitoring MIS can lead to needed changes in management activities. Three important components of a successful monitoring program include: 1) a scientifically sound method for assessing populations of the MIS in question; 2) a reasonable frequency of measurement; and 3) a standard for population levels or degrees of change in population size, density, or distribution that triggers a reanalysis of management activities.

Monitoring programs in many forest plans do not meet these standards (32 1). Some plans propose only to monitor habitats rather than populations, while others call for only infrequent monitoring of the MIS—populations may be counted only once every 5 or sometimes 10 years. This infrequent monitoring will only detect the most drastic population changes and will not alert the forest in time to avert or alter destructive management activities.

Summary and Conclusions

Forest planning under NFMA requires a tremendous database accompanied by time, money, and trained staff. Emphasis on timber management and the lack of data on nontree outputs has hindered the development of thorough and accurate biological models to assist forest planning. Questions have been raised on the validity of assumptions, the adequacy of updating and maintaining data files, and the use of appropriate scale. Future models to aid planners in forest resource management must take advantage of new technologies in data collection, storage, and updating and must pay closer attention to scale of analysis as well as to more comprehensive, integrated analysis of renewable resources.

NFMA and the forest planning regulations make repeated reference to maintainingg biological diversity in the national forests. Treatment of this issue in the plans, however, has not received favorable reviews. The Forest Service lacks adequate inventory data to address diversity questions, and critics assert that the agency has a short-term, myopic view of conservation of biological diversity rather than a long-term, comprehensive approach.

Problems with the use of management indicator species make this requirement subject to varied interpretations and criticisms. It is not economically feasible to study all species on a forest; the MIS concept offers a less costly alternative to tracking environmental trends. Application of the MIS concept to the national forests, however, has been described as neither efficient nor effective. Continued use of indicators on the forests should involve an effort to improve the selection process as well as a more comprehensive approach to evaluating the forest ecosystem. This comprehensive approach should include analysis of management indicators as well as indicators of habitat conditions and ecological processes. The national forests may have numerous chances to revise and expand the characteristics chosen as indicators, but interest in collecting information for determiningg long-term trends discourages this from happening often. It is important that the forests select an adequate number of indicators that will provide the maximum amount of information with reasonable monitoring ease.

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