Can Ecosystem-process Studies Contribute to New Management Strategies in Coastal Pacific Northwest and Alaska?

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Pages 77-83 *in* J.A. Trofymow and A. MacKinnon, editors. Proceedings of a workshop on Structure, Process, and Diversity in Successional Forests of Coastal British Columbia, February 17-19, 1998, Victoria, British Columbia. Northwest Science, Vol. 72 (special issue No. 2).

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Abstract

The question of whether ecosystem process studies can be made relevant to new, emerging management strategies to achieve ecosystem sustainability on U.S. Federal lands is addressed by examining a small sample of studies underway in the Pacific Northwest and Alaska. Processes being studied by many researchers—other than those directly associated with habitat creation—appear largely unrelated to policy statements such as the Northwest Forest Plan (ROD 1994). Yet these processes appear to underpin the broader goals of ecosystem sustainability and, fundamentally, the Plan itself. Studies of successional, windthrow, podzolization, and productivity processes in southeast Alaska forests, and studies on the role of early-successional species in changing mineral-soil organic matter in Pacific Northwest forests, are briefly described. Examples are given of how to use information from these studies in management strategies, some of which are being implemented by managers. We conclude that management studies—designed with help from ecosystem-process researchers—are a viable method to link process research with management for ecosystem sustainability.

Introduction

Ecosystem process is defined here as any change inside a defined ecosystem boundary—it is normally limited to biophysical processes, but also includes social processes such as learning. Failure to anticipate change is a common reason for failing to meet management goals. Better understanding of the causes and nature of change, we argue, is necessary to achieve management goals.

In concept, **ecosystem management,** mandated for U.S. Federal lands, has often been defined as applying ecosystem-ecology concepts to managing forests, fully recognizing the complex interactions between biotic and abiotic components, and ecosystem processes and resulting patterns. In the 1970s, the decreasing proportion of old-growth stands was the initial factor driving a rather slow change in management approach from plantation forestry toward ecosystem management. Not until the 1990s did policy for Federal lands in the Pacific Northwest and Alaska focus on maintaining historical proportions of seral stages and their associated species by distributing stages across the landscape through fixed land allocation to reserved and managed areas. The first regional interpretation and application of ecosystem management concepts was the Northwest Forest Plan (ROD 1994). In this plan, four ecosystem processes are clearly expressed as a focus of management policy:

- **Restoring late-seral habitat,** mainly by managing plantations in late-successional reserves;
- **Restoring riparian and stream habitat,** mainly by converting hardwoods to conifers along streams and adding in-stream structures;
- **Harvesting trees,** by converting standing volume into log-truck loads, mostly in the so-called ‘matrix’ allocation; and
- **Natural development**, mainly by setting aside large areas to develop on their own, allowing them to be disturbed (except perhaps by fire), and without the influence of people (usually ignoring issues like global change, pollution, and recreation effects).

These lists, however, are quite different from typical lists of ecosystem-process studies, which include primary and secondary production, climate change, carbon sequestration, water movement, erosion, mass movement, fire, windthrow, predator-prey interactions, host-pathogen interactions, nutrient cycling, weathering of primary minerals, soil development, plant succession, and stand development. Reasons for this disconnect are beyond the scope of this paper. Rather, we focus on a small subset of process studies in the Pacific Northwest and Alaska and their potential contribution to newly evolving management strategies. The purpose of the paper is to explore new pathways where ecosystem-process knowledge may become more relevant to ecosystem-management goals.

Examples of Process Studies and Management Strategies that Could Use Them

Succession, Windthrow, Podzolization, and Productivity in Southeast Alaska

In the past, management has been influenced mostly by a very simplified view of succession—especially the idea that after catastrophic disturbance, all forests develop into old growth and remain in old growth for a long time until the next disturbance. In this model of natural succession, processes other than competition, self thinning, natural catastrophic disturbances, and timber harvest are largely ignored, and only processes related directly to species viability—such as cavity formation and changes in habitat for prey species—appear relevant to management.

A study of long-term forest succession in southeast Alaska suggests that the simple successional sequence ending in late-seral forest may be more an exception than a rule (Kramer 1997). On largely unmanaged Kuiu Island, chronic catastrophic windstorm damage results in a variety of successional pathways on the forested landscape. As much as 30% of the forests may never reach late-seral stage because of the frequent, catastrophic wind storms. Even in topographically protected areas (about 35% of the forested landscape), evidence of a wide range of disturbance intensities and frequencies was found, although they tended to create what looked like a late-seral forest. The remaining 35% of forests may develop, after small-scale and partial or complete stand-replacement disturbances, into mid- to late-seral stages. Catastrophic storm disturbance is an important process controlling the structure and development of these forests.

Catastrophic windthrow may also be important in maintaining forest productivity by mixing soil when rootwads are upturned. Dense podzols develop in only 200 years in southeast Alaska, immobilizing much of the site nutrient capital in organic and Bh horizons (Figure 1). Roots tend to become limited to thick organic horizons and become segregated from increasingly acidic mineral soil (Figure 2). If soil disturbance from windthrow happens before roots become confined to the organic horizons, podzolization is reversed by speeding decomposition, freeing nutrients that can be used by remaining trees, and promoting

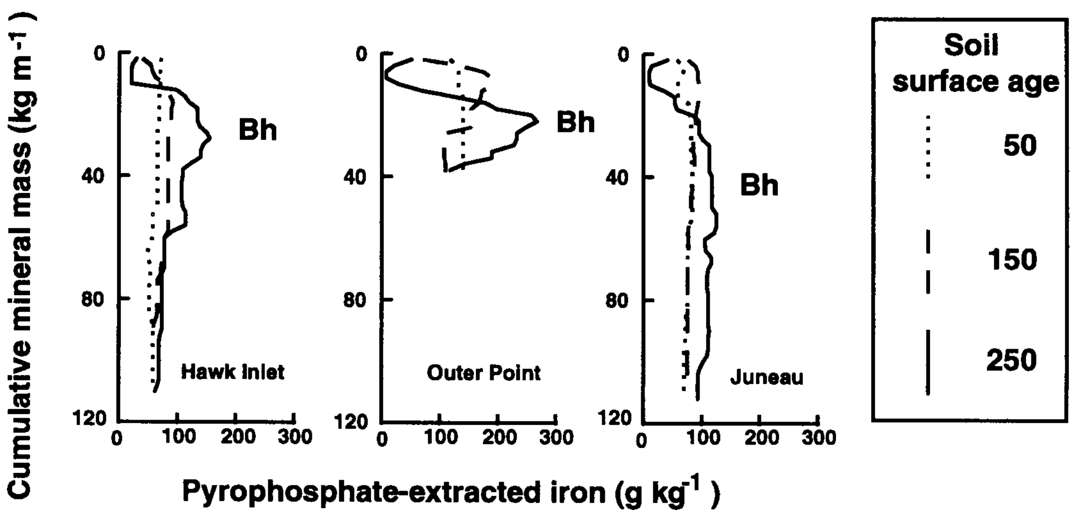

Figure 1. The downward migration of iron (cumulative mineral mass approximates soil depth) over time into Bh horizons, in the process known as podzolization (Bormann et al. 1995). The depth to which the Bh forms is strongly related to the parent material.

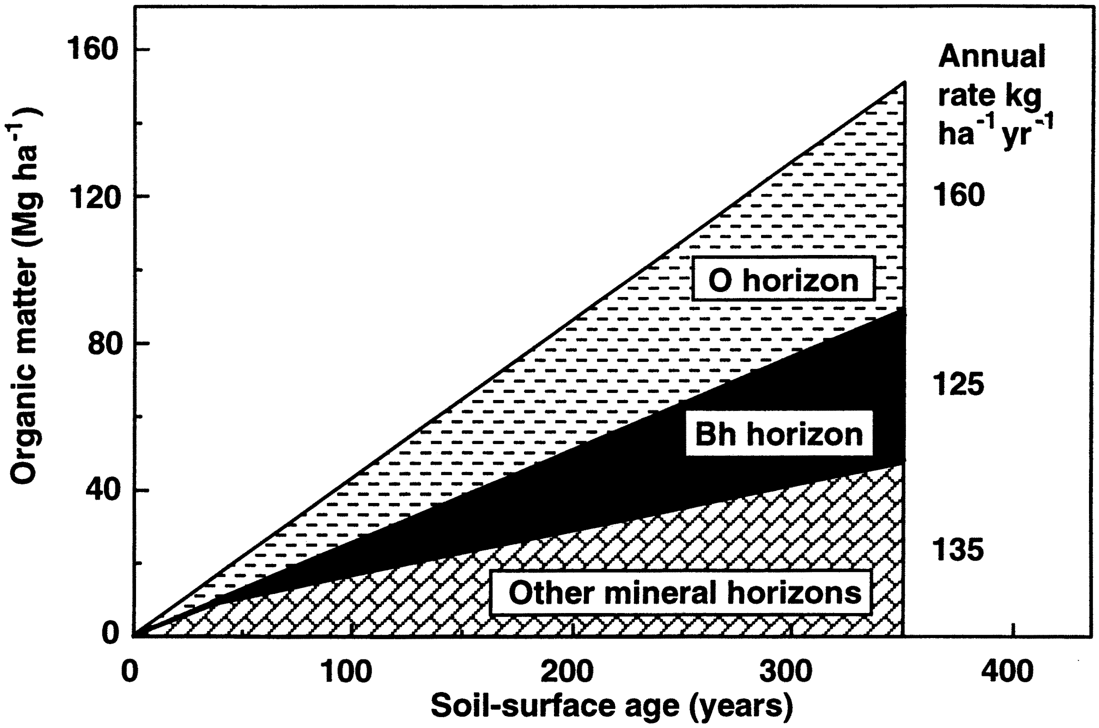

Figure 2. Rate of organic matter accumulation in podzols in southeast Alaska. Nutrients become immobilized, especially in the Bh horizon, and are freed only by soil disturbance, which is frequently provided by windthrow.

deeper rooting and early successional plants. If roots become confined to organic horizons, soils are hypothesized to become increasingly organic and infertile because trees can no longer mix mineral and organic horizons when windthrown. Harvesting trees before they can be windthrown and minimizing soil mixing during yarding almost eliminate soil mixing, which historically was a common natural disturbance. Concerns arising from the exclusion of soil disturbance from these sites include: loss of soil fertility—which is perhaps irreversible without drastic measures; loss of area in productive forest; and reduced viability of associated species (such as bears and badgers that den in rootwads). Maintaining the soil-mixing process appears to reverse nutrient immobilization, maintain or increase rooting depth, and increase weathering to supply base-element nutrients. A recent study has noted a marked 6-year growth response in seedlings planted on artificial mounds relative to unmounded areas, in coastal northern British Columbia (A. Banner, B.C. Ministry of Forests, Smithers, pers. comm.).

Management Strategies Based on Knowledge of Windthrow and Podzolization

On Kuiu island, a management strategy is being proposed to better maintain natural disturbance processes in the harvest units (Crane and Rowan Mountain timber sales, draft EIS 1997, on file, Petersburg Ranger District, Petersburg, Alaska). A diameter-limit (41 to 97 cm dbh) and small gap harvest (Figure 3) is proposed to create a frequency distribution of gap sizes that more closely approximates natural disturbance patterns (Figure 4). Perhaps more important, some standing trees will uproot and not be salvaged; thus the possibilities of some root throw and downed logs are maintained. Because this strategy is new, an intensive monitoring program will assess, for example, the effect of wind exposure and sheltering on root throw and snap off of remaining trees and changes in gaps, regeneration, and productivity over time. In wind-sheltered areas, most of the trees left after harvest may remain standing. In forests directly

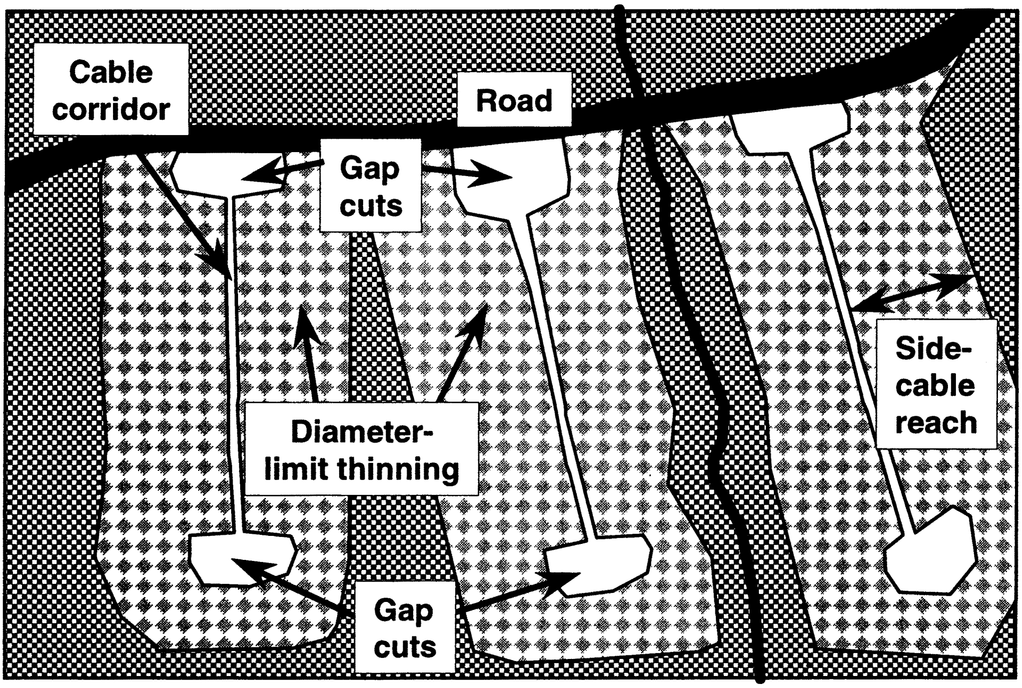

Figure 3. The Kuiu prescription. A cable system is applied along existing roads to harvest trees 41 to 97 cm dbh, and in small gaps.

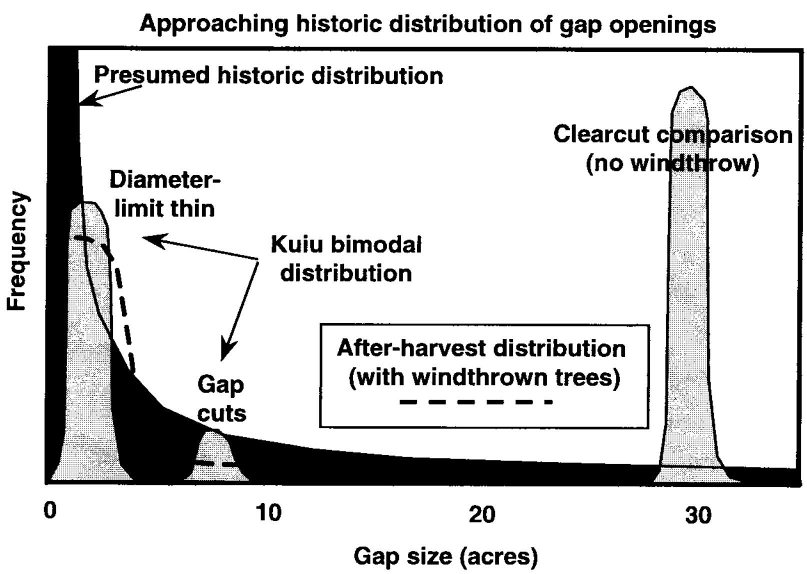

Figure 4. The distribution of gap sizes resulting from the Kuiu prescription more closely resembles the presumed historical distribution of gaps, and—by alllowing leave trees to blow down over time—the root-throw process is partly maintained (compared to complete elimination, as in clearcut units).

exposed to chronic windthrow, over time, the greater than 97-cm trees may blow over or snap off as they decay. The stands may tend to remain two-aged, with remnant trees providing habitat structures for animals and shade for light-sensitive understory plants (Nowacki and Kramer 1998). Over time, these stands may trend toward uneven-aged conditions (TLMP 1997) and maintain much of the original old-growth-like structure (Pojar and MacKinnon 1994).

More active management to maintain the soil-mixing process might be considered in forests with soils thought to be on a threshold of becoming highly organic. For example, windthrown trees could be salvaged (rootwads must be propped up or they often fall back into place), small gaps could be placed to encourage windthrow and subsequent harvest, and physical mixing of podzols during yarding and site preparation might be tried in appropriate areas.

Changes in Mineral-Soil Organic Matter as Affected by Early-Successional Species

Federal policymakers have assumed that the large acreages of young plantations now being created, mostly on non-Federal lands, means that shortage of early-successional species and processes is not a concern. Plantation management, however, has made great strides in shortening the time that shrubs and hardwood trees occupy the site. Our process research seeks to find out whether early-seral species (especially deciduous shrubs and hardwoods with associated microbes) affect long-term productivity through effects on soil organic matter, water-holding capacity, nitrogen fixation, and weathering. As an example, if dense stands of deciduous shrubs and trees have the same net primary production as dense young conifer stands, then—because conifers are more efficient in converting net production into woody tissue—less organic matter will build up in the soil. If early-seral species increase soil organic matter that offsets later declines under pure-conifer stands, then excluding early-seral species may cause loss of associated processes and species and may reduce growth and development of late-seral species and structures. Retrospective analysis of old-growth trees in the Oregon Coast Range suggests that almost all of these stands had very wide conifer spacing during the first 100 years or so (Tappeinier et al. 1997) and, presumably, dense shrub cover.

Controlled experiments have demonstrated large differences in the effects of conifer and hardwood trees on mineral-soil organic matter. In one five-year study using common, homogenized soil, mineral-soil organic matter declined 20% under two pine species, and increased 5% under alder (Bormann et al. 1993). Weeding experiments in coastal Oregon have demonstrated the potential importance of deciduous shrubs on mineral-soil organic matter. Small plots with planted Douglas-fir (*Pseudotsuga menziesii*) and dense salmonberry (*Rubus spectabilis*) had 45% more soil C in the top 15 cm of mineral soil than did fully weeded plots after five years. Salmonberry plots also had 34% more soil C than did plots with shrubs removed, leaving Douglas-fir with competition only from the herbs, mostly foxglove (*Digitalis purpurea*) (Kermit Cromack Jr., pers. comm.). The effect of these changes on subsequent stands has not been widely tested. The Long-Term Ecosystem Productivity project (http://www.cof.orst.edu/research/ltep), a series of replicated management-scale experiments in Oregon and Washington, focuses partly on testing differences in processes in young plantations compared to 'natural' early-successional assemblages, as well as effects of soil changes on subsequent production (Figure 5; Bormann et al. 1994).

Management Strategies Based on Knowledge of Soil Organic-Matter Changes

In appropriate areas, changes in vegetation management might include letting shrubs and hardwoods occupy sites longer, planting conifers at very wide spacing, thinning, encouraging deciduous shrubs and hardwoods, planting mixed stands, and creating gaps large enough for shade-intolerant species. A management experiment at Mt. Hebo in the Oregon Coast Range is presented as an example of a research-management partnership, partly designed to evaluate the importance of early-successional species (Figure 6). The Mt. Hebo experiment—starting with an 80-year-old Douglas-fir plantation—compares four prescriptions for growing old growth and producing some timber: a no-cut control (a), a light gap thinning (b), a heavy thinning around the 30 largest trees per acre followed by planting either red alder (*Alnus rubra*) (c) or western hemlock (*Tsuga heterophylla*) (d), where the underplanted trees are grown in

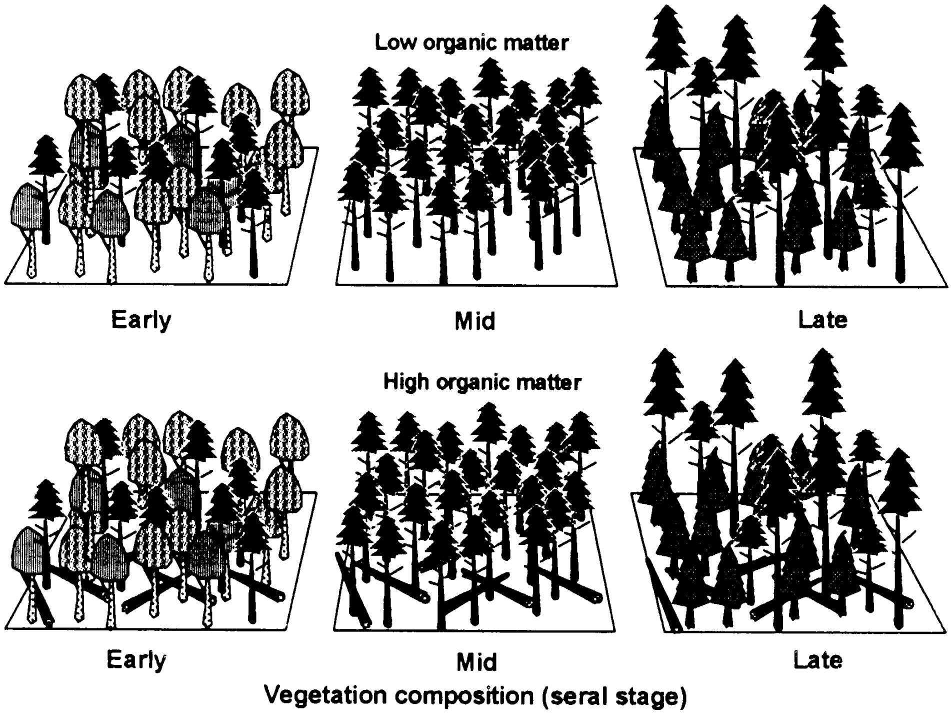

Figure 5. The long-term ecosystem produtivity experiment design installed on four sites in western Oregon and Washington.

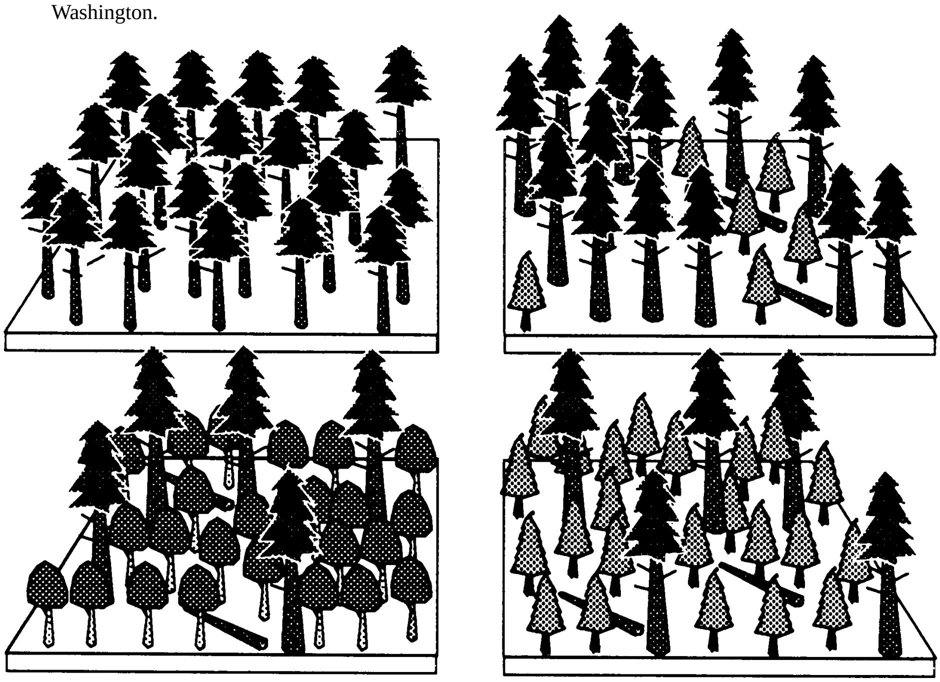

Figure 6. The Mt. Hebo restoration project. Four prescriptions—compared as part of a timber sale to speed development of old growth and produce some timber—were replicated three times on 15-acre plots assigned randomly to an 80-year-old plantation.

short rotations without reducing the Douglas-fir leave trees to less than 10 trees/acre. The alder underplanting and other hardwoods are hypothesized to increase mineral soil organic matter, nitrogen, and base-element nutrients to speed, and later maintain, growth of residual large conifers to meet old-growth standards. The 15-acre management units were established in initially similar areas, and the four treatments were assigned at random with three replications. An additional purpose for this action is learning how to grow old-growth habitat from existing plantations.

Conclusions

A broad definition of the goal of management for Federal lands is to achieve **sustainable ecosystems**, defined as meeting the simultaneous condition of providing what people want for themselves and future generations and what is ecologically possible in the long run (Bormann et al. 1993). The goal of sustainable ecosystems clearly requires a fuller understanding of ecosystem processes—like wind disturbance, soil mixing, and incorporation of organic matter in mineral soils.

Linking research on ecosystem processes with management has proved difficult in the past. Developing new policies that encourage management strategies to maintain, or that approximate, the historical processes thought to be important in reaching management goals, is a good start. Strong links are built when managers decide to include ecosystem-process concepts in large-scale management studies to supplement, and help test, research findings in managed areas. Failure to explore these links is likely to increase the probability of failure in meeting management goals.

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