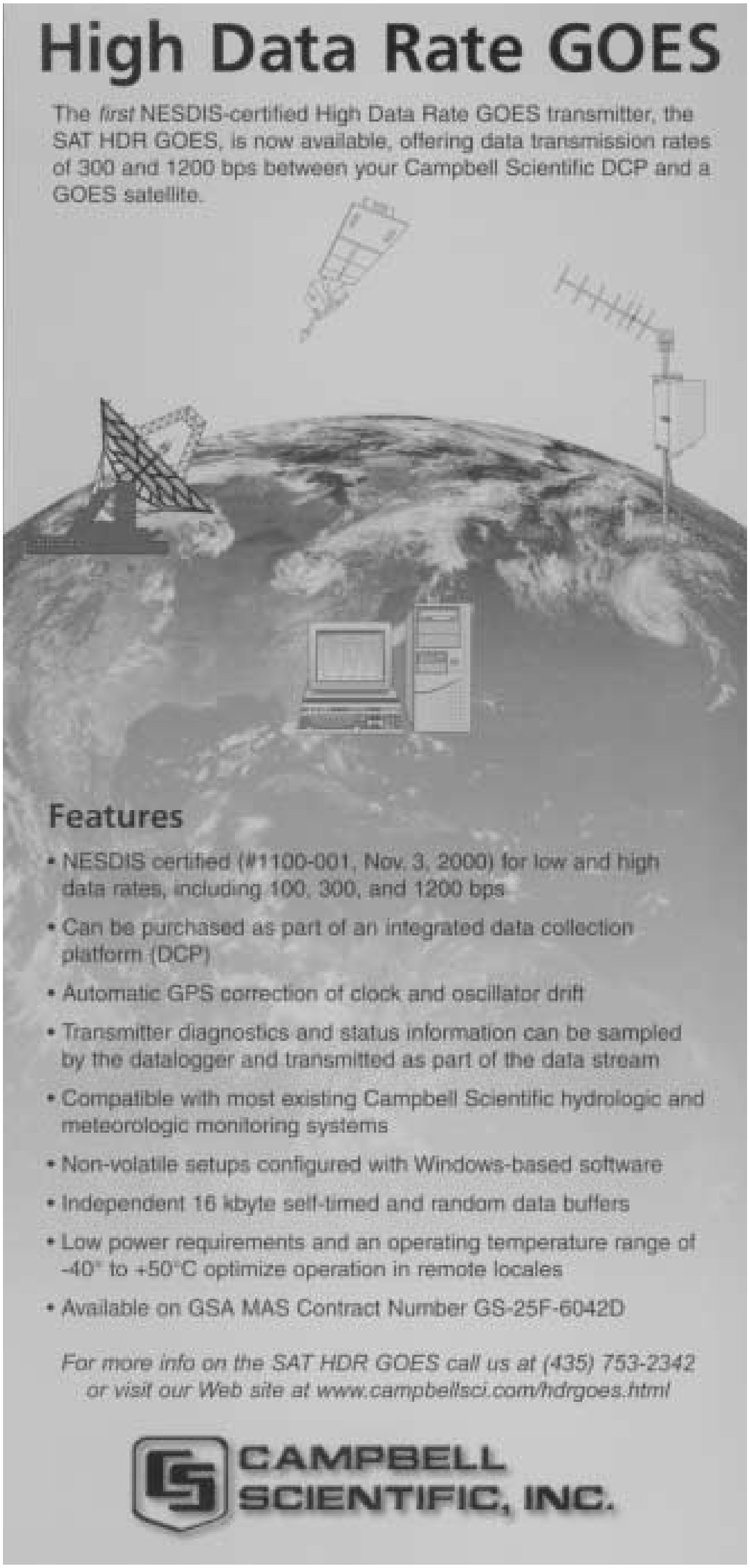

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Forest Roads

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Forest roads are controversial from environmental and economic positions. This issue presents four articles – two address the policy aspects of road use and construction and the last two focus on the scientific elements of road construction and water quality. The authors infer that poor incentives and inadequate rules have lead to poorly designed and constructed roads. Water quality impairment can be improved if managers prioritize actions that affect the forest ecosystem and take care in how to build and close roads in a manner that creates the fewest problems.

FEEDBACK! . . . Let us know what you think. We want to encourage dialogue. Write or e-mail your comments to the Associate Editor of this issue or to me. We appreciate everyone who has sent their comments to us so far and ask that you continue to do so. We would like to get everyone involved in some "conversation" on various topics.

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FOREST ROADS – INTRODUCTION

Jefferson G. Edgens

National forest protection is at the center of today's public debate. Central to the discussion is the concern over road building and the environmental damage caused from poor road construction and maintenance. Last fall President Clinton issued a moratorium calling for a permanent ban on future road construction and instructing the U.S. Forest Service to close certain roads within their jurisdiction.

The U.S. General Accounting Office reports point to numerous problems with road building within National Forests. Problems stem from improperly installed culverts, the lack of best management practices to reduce or minimize runoff, and basic geology and slope. Critics from all stripes blame environmentalists for lobbying to place tighter restrictions on the U.S. Forest Service, while others blame logging companies for negligent timber harvests.

The four articles examine road building within the national forests. The issue is split into two sections – policy and science. Within the policy portion we hear from Randal O'Toole, the author of "Reforming the Forest Service," who provides us with a brief critique on U.S. Forest Service road building and how incentives can improve management of national forests and road construction as well. H. Sterling Burnett gives us his take on roads as vital to wildlife habitat, fire suppression, and good forest management. The authors approach their subject from outside the Agency with the intent of spurring discussion on better ways to improve forest management.

In the science section, Dr. Charles Luce *et al.*, explain the need for prioritization of aquatic habitat before road building takes place. Luce *et al.*, are concerned that without proper information on the aquatic ecosystem before road building takes place, unnecessary environmental damage can occur. Finally, two researchers examine recontouring on a site in eastern Kentucky. Dr. Randy Kolka with the University of Kentucky and Dr. Mathew Smidt of Auburn University performed research on hillsides to study erosion rates on recontouring of logging roads.

We hope you enjoy this issue of *IMPACT* and that it stimulates discussion for future issues.

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INCENTIVES FOR NATIONAL FOREST ROADS

Randal O'Toole

The U.S. Forest Service (USFS) has criss-crossed the 192 million acres of national forests with nearly 400,000 miles of permanent roads – more than one mile of road for every square mile of national forest. Most of these roads were built for timber sales, many of which lost money. Aside from wasting taxpayers' money, the roads also caused major environmental damage, particularly to streams and watersheds. To understand the road issue, it is necessary to understand why the USFS so long persisted in building so many roads.

During the 1980s, the USFS used a computer program called FORPLAN to model forest plans for each of its 120 or so national forests. FORPLAN models typically included the effects of road construction on recreation, wildlife, water, and other resources. In almost every case, the effects were expected to be positive . . . more roads meant more water, more wildlife, and more recreation – even more wilderness recreation.

Yet most research at the time showed that roads were harmful to many resources. Roads might mean more water runoff, but they also mean more silt and other water pollution. Certain abundant species of wildlife benefited from roads as roads fragmented the habitat of species in decline. Roads might give recreationists access to new areas, but the forms of recreation that were shortest in supply were roadless recreation. On top of this, the net income from timber sales from forests reached by the roads was rarely sufficient to pay for the roads.

Why would USFS computer specialists bias their models in favor of more roads? More generally, why would USFS managers continue to build thousands of miles of roads every year when all of the research available to them showed that roads most often did more harm than good?

> *The net result of the USFS's timber sale budgeting process is that forest managers were rewarded for losing money on timber sales and timber-related roads, while they were punished (with smaller budgets) for emphasizing resources other than timber*

The answer can be found by examining the USFS's budget, and in particular the budget related to timber. That process starts with Congressional appropriations, and Congress has a history of funding nearly 100 percent of the USFS's requests for timber sales and roads. In contrast, Congress typically funds only 60 to 80 percent of the agency's requests for recreation, wildlife, and watershed (Alston, 1972).

But appropriations are only the beginning of the story. Timber is one of the few national forest resources that the USFS can legally sell at auction for whatever the market will bear. Under a series of laws passed between 1916 and 1976, forest managers are allowed to keep a virtually unlimited share of timber receipts for their own budgets (O'Toole, 1988). They can spend these receipts on reforestation, timber salvage sales, wildlife habitat, recreation facilities, and watershed restoration.

In short, the funds needed to arrange timber sales are appropriated, while the funds for most follow-up work after the timber sales come directly out of timber receipts. Thus, managers who decided to emphasize timber sales on their forests were doubly rewarded. First, all of their requests for timber sale dollars were fully funded. Second, they were able, on the average, to double these funds by keeping the receipts from timber sales in their own budgets.

Managers who decided to emphasize watershed restoration, wildlife habitat, or recreational facilities on their forests received no similar rewards. Congressional funding of these activities was barely adequate to keep agency doors open; funding for actual on-the-ground management was simply not available. Nor were managers allowed to charge for most of these resources or to keep any fees they could collect. For example, until 1997 most national forest recreation fees went to the U.S. Treasury, not to the forests that generated the fees.

Managers interested in funding watershed restoration, wildlife habitat improvements, or recreation facilities soon learned that the best source of these funds was timber sale receipts. USFS watershed and wildlife specialists soon found themselves endorsing timber sales so they could get funds for their pet projects. Since the funds could be used only in the vicinity of the timber sales that generated them, it is likely that the new roads built to reach the timber often did more damage than the good that came from the watershed and wildlife projects funded by the sales.

USFS rules also directed that a share of timber receipts retained for on-the-ground management be shared with each level of the bureaucracy. Typically, for each timber dollar spent on the ground, the Washington office received 4 cents; the regional office received 10 cents; and the forest supervisor's office received 20 to 50 cents. This gave every level of the bureaucracy an incentive to promote timber sales.

To compensate the U.S. Treasury for the cost of arranging timber sales, USFS rules specified that all sales must return at least 50 cents per thousand board feet sold to the Treasury. This rule was written in the early 1930s, when timber sale preparation cost just 50 cents per thousand. By the mid-1980s, sale preparation and administration costs averaged around $25 per thousand. Managers on many national forests simply subtracted 50 cents per thousand from sale receipts and kept the remainder for reforestation, watershed, and other activities. This guaranteed that timber sales on most national forests would lose money.

Roads added another layer of complexity to the timber sale process. While some roads were built with appropriated dollars, most Congressional road appropriations were spent on road engineering and design. The roads themselves were built by timber purchasers, who were allowed to deduct the cost of the roads from their payments for the timber.

In the eyes of USFS managers, the timber paid for the roads. This gave managers little incentive to control road costs. Instead, national forest engineers almost invariably specified high-cost, high-impact permanent roads even where low-cost, low-impact temporary roads would do just as well. In some cases, timber purchases and environmentalists banded together to beg the USFS to substitute low-impact temporary roads, but the agency refused.

Excepting only foresters, the USFS employed more engineers than any other professional discipline. Most of these engineers spent much of their time designing roads. Substituting temporary low-impact roads for permanent roads would eliminate the need for so many engineers. Agency line officers, many of whom were engineers themselves, did not want to see this happen.

Of course, they told themselves that permanent roads created benefits that outweighed their costs. The USFS often committed the common bureaucratic error of assuming that value of an asset, such as a road, was equal to the amount they made taxpayers spend to produce that asset. If true, then anyone with a swimming pool in their backyard could add $5,000 to the value of their house by spending $5,000 filling their pool with concrete.

Where timber sale values were too low to pay for roads, forest managers cross-subsidized the low-valued timber by including high-valued timber in the same sale. This sometimes led to strange timber sale designs, as high-valued timber in one part of the forest cross-subsidized low-valued timber located several miles away.

The net result of the USFS's timber sale budgeting process is that forest managers were rewarded for losing money on timber sales and timber-related roads, while they were punished (with smaller budgets) for emphasizing resources other than timber. On top of this, managers were rewarded for sales that damaged watersheds and other resources, because more damage allowed managers to keep more money to mitigate the damage.

In the 1980s, a number of young timber sale planners and other professionals began to challenge the sale process on ethical grounds. But none of the older professionals considered themselves unethical. Their ideas of what was good for the forest had been unwittingly shaped by the incentives built into the sale process. Managers who arranged sales that retained lots of receipts were rewarded with larger budgets.

Since their superiors also received a share of those receipts, the rewards went beyond budgets; they extended to promotions and the respect of their peers. Thus, top officials of the USFS often said with sincerity that timber sales were good for watershed restoration, wildlife habitat, and recreational facilities when what they really meant was that timber sales were good for the budgets of watershed restoration, wildlife habitat, and recreational facilities.

Since 1990, national forest timber sales have declined by 70 percent and new road construction has fallen to very low levels. The Clinton Administration tried to restrict new roads in roadless areas and certain other parts of the National Forest System. But the Administration failed to change the incentives that encouraged managers to lose money on environmentally destructive roads and timber sales.

It may be that some national forest timber cutting is good for both forest ecosystems and for local communities. Such timber cutting might need to be accompanied by new roads, and in most cases temporary roads are most likely to be both economically and environmentally the best. But until timber sales incentives are changed, no one can be sure that future USFS plans for more roads and timber cutting are sustainable or if they are simply aimed at promoting agency budgets.

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FOREST ROADS: BENEFITS FOR WILDLIFE MANAGEMENT, FIRE SUPPRESSION, AND WATER QUALITY

H. Sterling Burnett

INTRODUCTION

From their inception as "timber reserves" with the Withdrawal Act of 1891, the United States' National Forests have been controversial. During the last quarter of the 20th century, perhaps no activity in our national forests has come under more sustained criticism than logging and its attendant road building. Environmentalists argue that forests roads harm the environment in various ways. Fiscal conservatives decry the U.S. Forest Service's (USFS) road building and money-losing timber sales. Both sets of criticisms have merit but they only tell part of the story. Forest roads are economically and environmentally costly, but they also provide a myriad of social benefits most of which are not accounted for in typical assessments of the benefits and costs of forest road use. In this article, I examine some of these environmental benefits and argue that properly maintained forest roads may provide a net benefit to society.

BACKGROUND ON THE FOREST ROAD PROBLEM

The USFS is charged with managing the 192 million-acre National Forest System. Under current law, the agency is required to sustainably manage these lands for multiple uses to meet Americans' diverse economic, environmental, and recreational needs. Among the "multiple uses" the USFS is supposed to sustainably manage for are: outdoor recreation, rangeland for grazing, timber production, mineral extraction, watershed and waterflow protection, wilderness protection, and fish and wildlife protection. By "sustainably" is meant the lands must be managed for these purposes, without diminishing the forests' ability to provide these uses for future generations.

Critics of the USFS charge that historically its resources have been unwisely allocated, with too much money and manpower dedicated to logging, and too little devoted to its other programs. The inordinate attention paid to timber production should not be surprising when one considers that logging is the only one of the multiple use activities that directly returns money back to the agency's budget. In addition, to be fair, while the USFS does lose money on its timber programs (which lost $88 million in 1997), the agency's biggest money losing program is recreation (which lost $162 million in 1997) (Burnett 1998).

> *According to USFS figures, fully 60 percent of national forest land is unhealthy and faces an abnormal fire hazard*

Whether or not the USFS has misallocated its resources, the fact is that the agency manages approximately 373,000 miles of road in our national forests – a road system eight times the size of the interstate highway system – with only 7 percent of these roads paved. The forest service has three general classes of roads (Coughlin and Sowa 1998):

- Arterial/Collector roads make up 23 percent of the forest roads system and are maintained for passenger cars.
- Local-Open roads account for approximately 57 percent of forest roads, used for administrative and public needs primarily for high clearance vehicles. Passenger cars are not prohibited from these roads but the road conditions discourage most passenger car drivers.
- Local-Closed roads, approximately 21 percent of the system, are physically closed to motor vehicle use. These roads are opened on a per-use basis for long-term USFS management access.

Though most of these roads were originally built for timber harvesting, recreational users make far more use of the national forest road system than lumber trucks. Indeed, according to the USFS, at 15,000 vehicles per day, timber vehicle traffic is only slightly larger today than the 14,000 vehicles per day it was in 1950. By comparison, at 1.7 million vehicles per day, recreational vehicle traffic has increased more than 10 times as much as it was in 1950 when 137,000 recreational vehicles used forests roads per day. This increase in recreational user traffic has left the USFS with an estimated $8.4 billion maintenance and improvement backlog for roads and associated amenities.

ENVIRONMENTAL HARM

However, forest roads are not only, and perhaps primarily, problematic as a financial drain on the USFS budget. Environmentalists and some USFS managers point out that forest roads contribute to all manner of environmental harms. For instance, forest roads fragment wildlife habitat; contribute to soil erosion and the siltation of forest streams, lakes and ponds; and open up pristine areas to timber companies and to increasing numbers of recreational forest users.

Arguably the most direct type of damage from improperly built and maintained forest roads is the damage to water resources. USFS surveys have counted 11,000 road culverts within the National Forest Transportation System. These culverts interrupt the natural flow of water both above ground and below ground. In addition they cause increasing sedimentation. Sediment, the leading cause of environmental damage in National Forests, is due to erosion around culverts and streams for the most part. The Government Accounting Office surveyed USFS data and documented that federal activities in Arizona, California, Colorado, Oregon, and Utah cause water quality problems – with federal activities in Arizona alone causing 50 percent of water quality impairment in the state. Forest roads also disturb fish and aquatic habitat and contribute to erosion and landslides (Williams 1999).

To solve these problems, environmentalists have suggested ending, or at least dramatically reducing, the amount of logging in national forests, closing and/or removing many forest roads, and prohibiting future road building on all of the roadless areas that remain in the national forests. The Clinton Administration agreed with this prescription, with President Clinton approving a USFS proposal to place 58.5 million acres off-limits to logging in January 2001. Combined with the 35 million acres of roadless areas already designated as wilderness and thus off limits to roads and development, this makes approximately 93 million acres *de facto* wilderness – almost half of the total land in the national forest system.

PROBLEMS WITH ROADLESS POLICIES

If forest roads were nothing more than an environmentally harmful drain on the U.S. Treasury, then the Clinton Administration decision to implement a roadless policy might be a sound solution. However, forest roads serve important national and local purposes, providing benefits – including environmental benefits – that should be considered before finally declaring current roadless areas off limits to road building in the future.

The Society of American Foresters has pointed out that properly constructed and maintained forest roads are necessary for the USFS to carry out its multiple-use mission. Just focusing on the USFS's environmental responsibilities indicates the critical need for roads. For example, for a number of years, a rising share of USFS timber sales have been undertaken for "stewardship" purposes that have an environmentally beneficial purpose – with such sales expected to be 60 percent or more of total timber sales in the future (Nelson 2001). However, few of these stewardship sales will be economically or technically feasible in areas where forest roads are prohibited. Wildlife habitat improvements depend on the kind of active forest management made feasible by forest roads.

The USFS has argued that the Mexican spotted owl may benefit from timber harvest activities that "maintain old-growth pine habitats, and alleviate risk from wildland fire, insects, and disease." Other species that depend on active forest management include red-cockaded woodpeckers, Kirtland's warblers, goshawks, and snowshoe hares (a primary lynx prey species).

In addition, active forest management is generally good for the game species and, when properly done, timber harvests that depend upon forest roads create a mix of habitats and a variety of age classes that are generally beneficial for many species. Thus, the roadless designations would hamper wildlife management activities.

Access to forests for fire management is perhaps the most important environmental benefit which forest roads provide. The USFS's traditional fire suppression policy has created "tinderbox" conditions in our national forests. While historically large ponderosa pines grew in stands of 20-55 trees per acre, they now grow in densities of 300-900 trees per acre. According to USFS figures, fully 60 percent of national forest land is unhealthy and faces an abnormal fire hazard. Among the 90 million acres identified by the USFS as being at high risk from catastrophic fires and thus as having a higher priority for fuel reductions were 14 million acres within the roadless areas designated by the Clinton Administration in the lower 48 states.

The result of the previous Administration's hands-off management policy has been costly in human and economic terms. Forest fires have taken more than 50 lives during the past decade. In addition, since 1990 fire damage to homes and property increased six-fold to $3.2 billion by 1997. These figures exclude the cost from wildfires and mismanaged controlled burns since 1997 and the estimated $1 billion replacement costs of the homes and belongings lost in the 2001 Los Alamos "controlled burn." Indeed, wildfires that destroy 1,000 acres or more have increased from 25 per year in 1984 to more than 80 a year in recent years. Without road access for fire breaks, equipment, and personnel, lack of access will only cause slower fire response and greater ecological and economic damages.

Current forest conditions and lack of access not only contribute to a greater number of forest fires they also alter the nature of the fires. Historically, in most western forests, frequent low intensity fires removed the underbrush and invasive tree species. Suppressing forest fires for decades disrupted this natural process, resulting in an unusually high density of trees, undergrowth, and dead and dying wood from disease and insects. This creates conditions where high intensity "crown" fires are increasingly common.

Crown fires burn at extremely high temperatures, consume entire forest vegetation – including the older and larger trees – and can "sterilize" the soil (later causing rapid runoff and siltation problems downstream). The immediate aftermath of such fires is increased water temperatures and massive amounts of ash clogging streams with the onset of rain. One such crown fire incident in Idaho wiped out a local population of bull trout. Over the longer term vaporized soil hardens into a near concrete-like substance. Natural forest regeneration becomes nearly impossible. As a result, when the rains come, floods and mudslides pour down hardened slopes causing additional watershed, wildlife, and property damage.

CONCLUSION

Other benefits provided by forest roads include: providing access for in-holders to their properties and access across Federal lands to other holdings; allowing access for commercial timber operations and mineral extraction – industries that are especially important to rural towns adjoining national forests; and allowing the general public access to its national forests for recreation. *De facto* wilderness may satisfy the recreational needs of the small percentage of the population that are hard-core hikers or survivalists, but it does not serve the needs of the general public well.

No one can deny the economic costs and environmental harms which stem from poorly maintained forest roads. But one serious fire season resulting from poorly managed national forests – the costs of which too often include the loss of human lives – quickly exceeds the costs of properly maintaining forest roads. The answer is not to close current roads or to prohibit the building of new roads, but rather to build and maintain current and future roads in an environmentally sensitive manner. This may require the USFS be granted increased funding for road upkeep. Perhaps a better policy would be to shift any funds the USFS has budgeted to obtain and manage new properties to its forest roads budget. If the USFS cannot manage the lands it already owns well, then it certainly should not acquire new lands. Another option might be to implement a user fee system. More radically, one could experiment with different management philosophies, allowing selected states or even private companies to manage the national forests under the requirement that they improve both the economic performance of the forests – making them self-sustaining perhaps – and the environmental conditions of the forests. Regardless of the policy chosen to improve forest management, the one policy that should be off the table permanently is decreasing access to national forests by further restricting USFS roadbuilding activities.

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INCORPORATING AQUATIC ECOLOGY INTO DECISIONS ON PRIORITIZATION OF ROAD DECOMMISSIONING

Charles H. Luce, Bruce E. Rieman, Jason B. Dunham, James L. Clayton, John G. King, and Thomas A. Black

INTRODUCTION

Roads provide increased access to lands rich in natural resources and beauty, but they can also damage those lands and the ecological values therein. In particular, much interest has been focused on the hydrologic and geomorphic changes in roaded watersheds and their effects on aquatic ecosystems (Lee *et al.*, 1997; Dunham and Rieman, 1999; also see papers in Luce and Wemple, 2001). As a consequence, most public land management agencies and some private forest land managers are closing and rehabilitating roaded areas to restore forest productivity and improve watershed function.

The decision to decommission or to retain a road is complex and often controversial and involves many issues, including aquatic ecosystem health. While some controversy may be inevitable, managers and specialists given the task of selecting roads to decommission need scientific, ecologically-based criteria to guide their decisions. Existing guidance, however, is limited primarily to descriptions – and occasionally models – of how roads alter stream hydrology, geomorphology, and ecology. Little guidance exists on the effectiveness of road decommissioning and alternative treatments. Coherent strategies for road system management and closure that consider potentially conflicting objectives and opportunities in multiple use and ecological management would be useful (Rieman *et al.*, 2000).

Setting priorities for road closure and decommissioning is not a new practice, and a variety of strategies have been used. While watershed restoration may be a primary motivation, other strategies may emerge where, for example, wildlife or recreation concerns predominate. The most common priority is the 'problem' roads that yield substantial mass wasting or severe surface erosion. Such roads represent a small fraction of most road systems, and many such roads have already been decommissioned. Some proponents of road decommissioning strongly favor prioritizing streamside roads that directly contribute surface erosion, constrain the channel, and reduce shading. Others note that roads in the riparian corridor often have lower gradients than midslope roads and drain to more stable ground so they may represent less of a potential problem. Yet others support a strategy that would reduce road density by decommissioning as much of the road system as financially, practically, and politically feasible. Dead-end ridgetop and short spur roads supporting management of individual stands and recently constructed roads are common targets. In some cases, sediment modeling has been used to support prioritization for road closures and decommissioning. This is often in response to the goal of managing basin-wide sediment yields to be within prescribed limits, such as those prescribed by state's criteria and the Federal Clean Water Act.

> *Surface erosion from forest roads affects the fine sediment budget and may impose a chronic condition of sediment inputs to streams directly affecting the stream substrate and the health of aquatic life*

Despite the obvious rationale for managing and closing roads, there is no common framework for prioritizing management alternatives. Evaluating and prioritizing alternative road management strategies will be difficult, given the diverse nature of watersheds, aquatic ecosystems, and specific effects of roads. However, we believe there are some fundamental principles that can inform a more thoughtful strategy, including the following:

1. Not all ecosystems are of equal importance or value.
2. Not all roads are equal in their physical effects.
3. Not all similar physical effects have equal ecological consequences.
4, Not all road effects can be repaired or mitigated to equal degrees.

In the remainder of this paper, we explore these ideas in more detail.

NOT ALL WATERSHEDS, STREAMS, OR HABITATS ARE OF EQUAL ECOLOGICAL SIGNIFICANCE

Conservation of biological diversity and ecological integrity has become a cornerstone of public land management. A fundamental approach for management has been to prioritize some areas for conservation and restoration because of their disproportionate contribution to biological diversity or ecological process and function.

Biological diversity is an important concept viewed as the representation of the variation in living organisms and the physical and biological complexes in which they occur. The richness of biological elements, such as number of species, is an important component of diversity. There is growing recognition, however, that diversity also includes within-species variation as represented by genes, distinct life histories, life stages, or even behavioral types, as well as the structural and functional characteristics of whole communities and ecosystems (Franklin, 1993).

An important point in this understanding is that the physical environment and the processes that create and maintain habitats for aquatic organisms represent a template for the maintenance and evolution of biological diversity at all scales of organization. Different types of streams and distinct habitats within streams can support different types of species, genetically different populations, and distinct life history forms or life stages within a species or population. To conserve ecological diversity, process, and function, it will be necessary to conserve a mosaic of watersheds, streams, and habitats within streams that represent the range of possibilities. For example, conserving a population of bull trout (*Salvelinus confluentus*) will require the conservation of spawning, rearing, and overwintering habitats and the stream corridors connecting them. All of these elements may be found within a kilometer of stream or scattered across a larger network of streams (Dunham and Rieman, 1999). Conserving populations of all native species may require representation of the higher elevation cold-water habitats required by some, as well as the lower elevation alluvial channels required by others.

Representation of diverse environments is important, but it is also important that some redundancy exists in any particular type (Rieman and Dunham, 2000). Because natural disturbances like fires and floods will alter landscapes and habitats whether humans manage them or not, ultimately, all habitats and populations are vulnerable to change (Benda *et al.*, 1998). If critical types of habitats, streams, and watersheds are replicated in space, the risk of all being degraded or lost in any single event is reduced. If some are particularly productive or large, they may survive most disturbances and serve as important sources for recolonization and gene flow to other areas as they recover (Rieman and Dunham, 2000).

An example may serve to illustrate how redundancy may be useful. Using an erosion model based on the R1-R4 method (Ketcheson *et al.*, 1999), calibrated to the coast range using data from Luce and Black (1999), we estimated the average annual sediment yield from surface erosion off of road segments in a basin and routed it to the stream. The resulting stream map shows that within this basin there is only one stream that has nearly no road sediment over much of its length (Figure 1) although there is quite a bit of variability among streams. The map of roads shows disturbance over most of the watershed, explaining why most of the streams show disturbance from roads. In naturally functioning watersheds, there may be a mosaic of conditions, owing to the patchy nature of natural disturbance and recovery (e.g., Benda *et al.*, 1998). Thus, from the perspective of fish habitat, natural systems are generally not disturbed uniformly in one place or time. In natural systems, some places are suitable for some species at some times, and many species may have evolved to exploit this variability (Rieman and Dunham, 2000). Large-scale homogenization of landscapes through management activities involving roads may explain, in part, the relatively uniform declines of many environmentally sensitive species, such as salmonids (e.g., Lee *et al.*, 1997) over large areas. A major challenge to management is to better understand and mimic natural processes and patterns to support species that depend on a diverse natural environment.

In general, management and roading of most lands has not occurred in a random pattern. Roading and

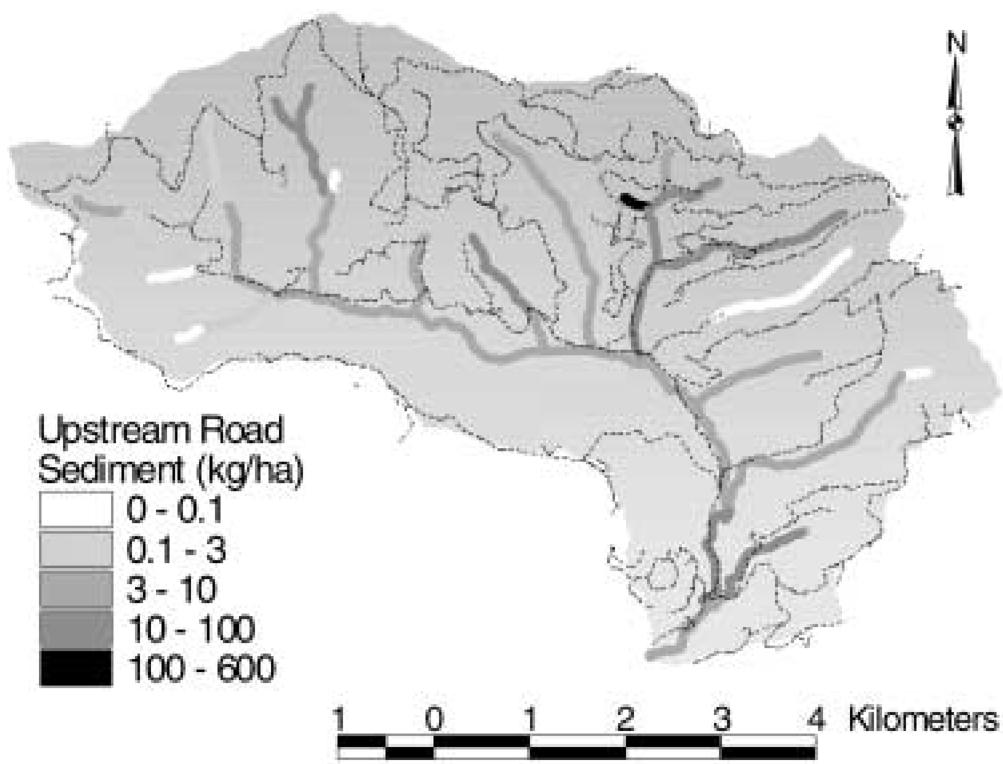

Figure 1. Stream Network of Order 2 and Higher Showing Modeled Sediment Load Derived From Roads Per Unit of Stream Contributing Area. Streams with less contribution from fine sediment are in lighter shades. Fine dashed lines are roads, which are distributed over almost all of the subwatersheds of the basin. Stream colors are generally darker where road densities are higher, and the undisturbed stream segment in the northeast side of the basin is undisturbed because the two ridgetop roads flanking it drain to other areas.

intensive land use, for example, often first occurred in lower elevation, relatively flat areas that were more productive and easier to access. These are also the areas more often held in private ownership. As demand for timber increased in the 1950s and 1960s, steeper, higher elevation lands were entered. In cases where higher elevation lands were entered, effects of disturbance may propagate in a downstream direction to further affect lower elevation streams. As a result, watersheds, streams, and habitats found in higher elevation, steeper, and colder sites are often in better condition than those at lower elevations. Thus, the ecological significance of restoration activities may be much greater in low elevation streams that are not well represented in the distribution of habitat types.

An important goal for managers intent on conserving biological diversity will be to conserve or restore a network of habitats. That network should represent as much of the historic distribution of conditions as possible, should be spatially diverse, and should contain multiple examples of representative habitat with some that are as productive as possible at any point in time. Because strong environmental gradients exist across streams, watersheds, and whole river basins the representation of biological diversity will require the representation of habitats that span those gradients. Some environments may be poorly represented or may be disproportionately important in the scheme of conserving ecological process and biological diversity, so it will be important to prioritize restoration activities that hold the greatest ecological significance.

NOT ALL ROADS ARE EQUAL IN THEIR PHYSICAL EFFECTS

Roads affect watershed function and fish ecology through numerous mechanisms, such as water flow, sediment delivery and transport, stream connectivity, and stream temperature (Jones *et al.*, 2000; Luce and Wemple, 2001). Scientists looking at large scale physical variables relating to fish abundance have noted that increased road density yields lower fish abundance (Lee *et al.*, 1997) or occurrence (Dunham and Rieman, 1999). This evidence supports a strategy of reducing road mileage in heavily roaded basins, and restricting development of new roads in unroaded areas.

A growing body of evidence suggests that all roads are not equal when it comes to increased sediment delivery and erosion. As an example, we applied the same erosion model described earlier and we estimated the average annual sediment yield from surface erosion in 18 small basins (6th code HUC basins between 16 and 26 km^2). The results suggest that road density correlates poorly to sediment yield from surface erosion (Figure 2). The apparent outlier had high sediment yield and delivery from a single poorly constructed road segment. One implication is that a strategy aimed at reducing road miles alone may not reduce sedimentation in streams. This is a general lesson that probably applies to other processes as well.

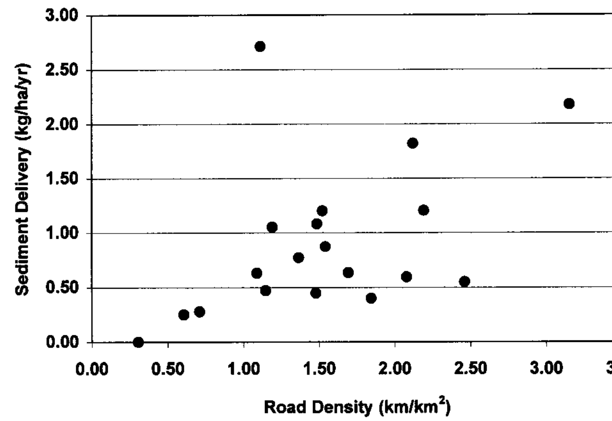

Figure 2. Relationship Between Sediment Delivery Predicted by a Surface Erosion Model and the Road Density in 19 Sixth Code HUC Basins (average about 16 km^2 each) in the Oregon Coast Range.

Surface erosion from forest roads affects the fine sediment budget and may impose a chronic condition of sediment inputs to streams directly affecting the stream substrate and the health of aquatic life. Surface erosion contributions to streams are affected by erosion processes on the road itself and by the fraction delivered. Sediment production is controlled primarily by the road slope, road length, and condition of the surface as expressed by soil texture, road surfacing, or vegetation cover. Traffic and road maintenance have strong effects on the surface condition (Reid and Dunne, 1984; Luce and Black, 1999). Following maintenance or cessation of traffic, reduction of erosion rates can be rapid, potentially reducing erosion rates to very small values (Megahan, 1974; Reid and Dunne, 1984). Factors controlling sediment delivery include distance from the stream, the volume of sediment and water exiting the drainage feature, and sediment texture (Megahan and Ketcheson, 1996). As a consequence, ridgetop roads rarely have substantial surface erosion contribution.

Mass wasting through gullies and landslides can be initiated by road drainage on steep hillslopes. Greater contributing lengths of road and steeper drainage slopes lead to greater probabilities of initiating gullies and landslides (e.g., Montgomery, 1994). Landslides also occur less frequently from a given road over time because there are a limited number of locations where failures can occur, which become exhausted over time, and because road engineers gradually repair problem sites as they become apparent.

Stream crossing culverts are related to a number of difficult problems on roads. Blockages of stream crossing culverts causing diversion over or along the road are risk factors for mass wasting, with undersized, unprotected culverts being at greatest risk (Furniss *et al.*, 1997.). Improperly designed stream crossings can also be barriers to fish migration.

Some evidence exists that roads increase peak flows of more common floods (Jones and Grant, 1996; Thomas and Megahan, 1998). Interception of subsurface flow by forest roads has been suggested as a mechanism for increased peak flows in roaded basins. Subsurface flow interception may also alter the timing of runoff within a season. It is not clear which roads most strongly affect basin wide hydrology. Theoretically, those with the greatest opportunity to intercept flows and those yielding the greatest shortening of flowpaths would pose the greatest risks (Wemple, 1998). Such combinations are most likely to occur on midslope roads.

Where roads are close to streams they affect the stream more directly. Roads in riparian zones prevent growth of dense stands of trees shading streams, and roads that travel long distances along stream channels would be more likely to yield a measurable effect on stream temperature. Roads are sometimes placed partially in an existing stream channel. Riprap is placed to prevent erosion of the road fill, and the channel form is dramatically changed. Access to streams allows fishing and the possible introduction of pathogens and competing species.

NOT ALL SIMILAR PHYSICAL EFFECTS HAVE EQUAL ECOLOGICAL CONSEQUENCE

Clearly the effects of roads may vary with physical and biological conditions and the physical location in question. Our intent is not to provide an analysis of all the possible interactions, but to point out that context is important. Specific biological effects of sediment in streams have been reviewed elsewhere (Waters, 1995). In referring to "context," we refer to the process of considering specific effects of roads in relation to the spatial and temporal dynamics of physical habitats relative to the biological requirements of a species. Biological requirements may be considered at the level of individual fish, populations, collections of populations in a basin, or in relation to life stage (Rieman and Dunham, 2000). For example, important questions related to context might include (1) "How are different life stages affected by the particular physical change?" (2) "Which life stages are most important to population growth?" and (3) "Where are habitats used by sensitive life stages relative to the road under consideration?" These types of considerations separate more thoughtful prioritization strategies from those that seek to reduce one aspect of road impacts across a basin (e.g., reduce overall sediment loading).

The issue of "context" is probably best illustrated with examples. For many fishes, the effects of fine sediment can vary by life stage. Fine sediment can smother embryos and young juveniles rearing in the substrate, and reduce feeding or abrade gills in older juveniles and adults. If survival of young juveniles (including eggs and developing embryos) is believed to be the most important factor limiting population growth, then roads contributing fine sediment to spawning and rearing habitats may constitute a greater ecological risk than roads contributing fine sediment to habitats used for migration.

To carry the above example further, consider the effects of ridgetop roads on a species that spawns in headwater streams. Ridgetop roads are generally more benign, but because they drain to headwater streams, they may directly threaten the integrity of spawning and rearing habitats. Because the effects of roads on sediment may be cumulative, effects of roads in up-slope areas may be especially important for species that spawn downstream of particularly damaging roads but not for those spawning in habitats found predominantly above the influence of the roads. Roads along stream bottoms most directly affect stream segments that may be degraded through other upstream disturbances, so removal of those roads alone, without consideration of the upstream disturbances, may yield less benefit than removing roads from a basin with few other sources of risk or chronic disturbance. In addition, some fish may only use these lower stream segments for migration between higher quality segments. Road crossings that act as barriers to movements low in a watershed might isolate an entire population or eliminate a sizeable area of habitat for a migratory species. Crossings higher in the basin might eliminate a proportionally smaller area of habitat. Roads that access particularly small or vulnerable populations, might significantly increase the threat of local extinction while access associated with healthier populations would not be an issue. These examples highlight the importance of context, in addition to the more conventional views of sediment on stream ecosystems.

NOT ALL ROAD EFFECTS CAN BE REPAIRED OR MITIGATED TO EQUAL DEGREES

Mitigation of road effects ranges in scope from allowing time and nature to take their course to aggressively removing roads and evidence of their existence. Because the success of treatments depends on many factors. including the skill in the design and implementation of some projects, there is little guidance on the effectiveness of some treatments in a general way. We can, however, gain some insight from several investigations.

Surface erosion is a common concern addressed in watershed restoration projects. Techniques to reduce erosion include: application of surfacing or mulch and seed, ripping the road surface, and recontouring the road (pull back fill and place on road to restore original hillslope shape). Vegetation regrowth, and surface armoring can be very effective in reducing surface erosion over just a few years (Megahan, 1974). A small fraction of roads do not recover and produce sediment at sustained high levels over many years. Long, steep, ditchlines and poorly revegetated cutslopes are two characteristics observed to contribute to this behavior. Time, good road surfacing, reduced traffic, and selective ditch maintenance combined with focused effort to revegetate problem cutslopes and shorten long ditchlines can lead to low surface erosion production from open forest roads. Outsloping and frequent drainage can reduce delivery to streams.

Ripping can be partially effective in increasing infiltration into the road tread, reducing runoff and erosion. Conditions improve enough through ripping that runoff generation would be rare, but capacities are not restored to natural conditions (Luce, 1997). After ripping, runoff can occur during high intensity events or during sustained water input that would saturate the ripped layer. Frequent cross drainage would be wise to prevent effects associated with concentration of flows along the ripping furrows. Recompaction and sealing of the ripped surface are two processes leading to reductions in infiltration capacity after ripping. Some ripped roads recompact to densities approaching the original road surface. Substantial improvement may be realized with soil amendments encouraging the development of soil structure. Recontouring suffers from some of same drawbacks as ripping and rills sometimes form in the steep fills.

Risks associated with concentration of flow, like mass wasting, gullies, and increased peak flow can be greatly reduced by ripping or recontouring. The material is still lacking in strength and structure until trees are reestablished, and while there is a reduced risk of uncompacted fill failure it is not completely removed, particularly in lower slope positions (Madej, 2001). If roads are kept open, inventories of road drainage, combined with empirical analysis, can find threshold combinations of segment length and drainage slope yielding gullies and landslides (e.g., Montgomery, 1994) leading to information that can aid in the design of roads with lower risk of initiating erosion. Frequent drainage is once again helpful. Given that there is little control or ability to maintain areas after recontouring or ripping, a well-designed, open, and maintained road may sometimes represent less risk for mass wasting.

For stream encroachment and culvert problems, removal of the road and offending culverts is effective. Culvert replacement and protection from debris combined with increased monitoring and maintenance is a more expensive approach that still retains some risks.

Reestablishing streamside vegetation where there is a streamside road is greatly facilitated by ripping or recontouring the road, as more area is allowed for planting. The problems of recompaction and reduced infiltration in ripped or recontoured roads can lead to poor soil productivity. The nearly complete lack of organic material might be important too. Addressing soil productivity issues for decommissioned roads is important in addressing their effects on stream temperature. Vigorous tall vegetation provides the best shade. If soil productivity is impaired, restoration of vigorous tall vegetation may be delayed or nonexistent. Soil amendments are used in mine reclamation because of the poor tilth and nutrient status of these soils, and amendments may be a promising approach to restoring productivity in decommissioned roads.

TOWARD A MORE THOUGHTFUL STRATEGY

A comprehensive strategy would attempt to generate the greatest ecological benefits with the least fiscal and social cost. So the questions should be: (1) where are the highest priorities ecologically; (2) within those, where are the most damaging roads; and (3) within those, which ones can we effectively decommission or mitigate?

Thus, from an ecological perspective, prioritization of road management alternatives may be viewed as a nested hierarchy of decisions with at least three levels. At the first level, application of this strategy would require a prioritization of available habitats for potential use. This would be a search for which areas would be most critical to the conservation of species, metapopulations, or other critical elements of ecological diversity. Conceptually we want to build a network of high quality diverse habitats with multiple examples of representative habitat. A key for the prioritization process is to rank the available restoration areas, recognizing that social or fiscal constraints may require selection of an alternative.

At the second level of prioritization, we seek out the roads that impose the greatest limitations on habitat quality and connectivity. This requires examining the physical effects of the roads and determining which effects from which roads constitute ecological hazards. This should produce a set of goals for each segment of road within a basin, such as reducing surface erosion, or removing migration blockage. Again, some ranking is needed with the realization that some minimal set of roads may need to be rehabilitated to make any effort in the area worthwhile.

At the third level of prioritization we consider which of the roads can be effectively decommissioned or otherwise mitigated. In this part of the strategy, the physical, financial, and social constraints must be reconciled. If migration blockage is a problem; social constraints prevent culvert removal; and financial constraints do not allow culvert replacement and maintenance, then there may be little we can effectively do for the problem that road represents. If the road is not critical to the overall plan for that area, then prioritization resumes at the second level. If it is critical, a lesser choice of an area to rehabilitate may be a better choice because the restoration may have a greater likelihood of success. Within some region a clear definition of the ecological priorities and possible physical solutions may allow for negotiation or partnership with affected publics to reduce social and fiscal constraints.

This strategy combines the four principles cited at the beginning of the paper with considerations of other factors, like cost and social acceptability. Consideration of a combination of biological and physical processes at site and basin scale, along with an understanding of capabilities in mitigation and decommissioning practices. provides a firm scientific foundation for decisions about forest road decommissioning. When we understand what would be most beneficial to the systems we are managing, it is easier to turn to our publics and show them the choices and tradeoffs.

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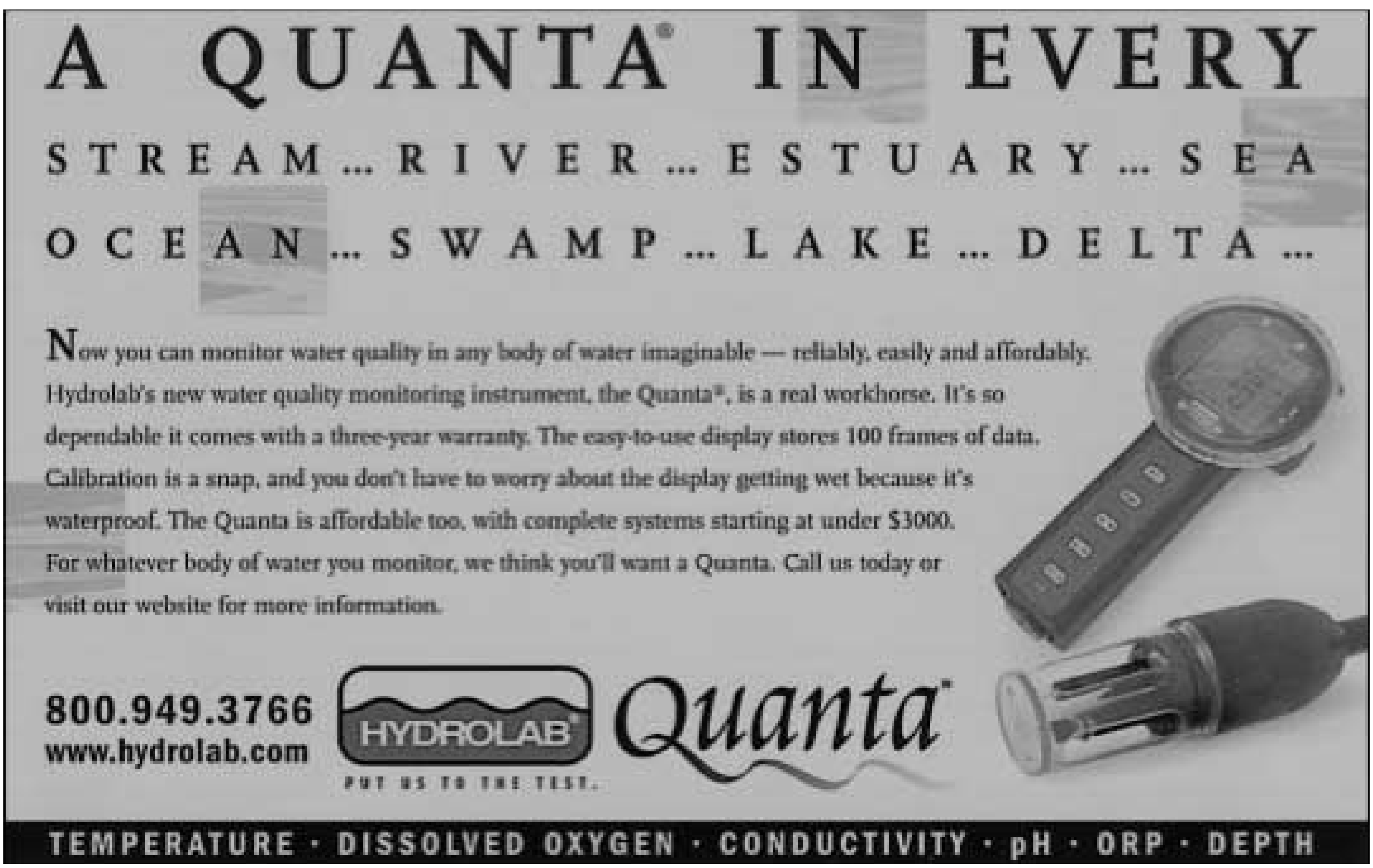

REVISITING FOREST ROAD RETIREMENT

Randy Kolka and Mathew Smidt

INTRODUCTION

Determining the sources of nonpoint source pollution in a watershed is difficult, although the largest source of sediment in forested systems is from skid trails, haul roads, and landings associated with forest harvesting (Ketcheson *et al.,* 1999; Swift, 1988). The transport of sediment to streams and subsequent sedimentation leads to the loss of stream habitat and changes in stream hydrology (NCASI, 1999a; 1999b). Forest road position in the landscape, the soil type and geology present, and method of retirement ultimately determines the amount of sediment flux to the stream (Ketcheson *et al.,* 1999; Swift, 1988).

Over the years the use of best management practices (BMPs) for forest road construction and maintenance has improved water quality. While BMPs have been designed for, and proven to be effective at reducing erosion caused by logging, elevated nonpoint source pollution continues to occur after harvest because of the severe soil disturbance necessary to construct roads (Arthur *et al.,* 1998). The extent of the soil disturbance varies because of topography, seasons, construction methods and harvesting techniques (Kochx, 1991). Soil damage on forest roads is mostly due to compaction and erosion that affects infiltration, surface and subsurface water flow (Wemple *et al.,* 1996). If significant, the resulting erosion can be a major source of sediment and nutrient losses following the harvest. In eastern Kentucky for example, suspended sediment fluxes for the first two years following harvest were 10-40 times greater in a harvested watershed implemented with BMPs than in an unharvested watershed (Arthur *et al.,* 1998). Nitrogen, phosphorus, and cations followed similar patterns.

Since post-havest treatment of severely disturbed areas such as forest roads and trails is already required by BMPs, it may be possible that an alternative retirement or restoration treatment could partially or completely replace current BMPs

Current BMPs for forest roads in many states include seeding, fertilizing, and liming to ensure establishment of the cover crop, diversion of surface water from exposed mineral soil, and restriction of traffic following the harvest (Stringer *et al.,* 1997). With current BMPs, the natural recovery of soil properties, especially bulk density and infiltration, is usually slow and relies on wetting and drying, frost activity, animal activity, and root growth. Subsoil bulk density in forest roads had not recovered to undisturbed levels in 23 years in central Idaho (Froehlich *et al.,* 1985) and 32 years in Oregon (Wert and Thomas, 1981).

The skidding on steep terrain (slopes greater than 30 percent) requires the construction of a relatively dense network of skid trails. In steep terrain 10-25 percent of the land area can be occupied by bladed skid trails (Stuart and Carr, 1991; Miller and Sirois, 1986; Kochenderfer, 1977). The dense network of skid trails throughout steep regions not only leads to enhanced nonpoint source pollution but also to losses in forest productivity. Tree volume in forest roads has been estimated to be as much as 80 perecent less than volume in undisturbed areas (Carr, 1987). Over an entire harvested area growth reductions of 11.8 percent (Wert and Thomas, 1981) and 12 to 15 percent (Smith and Wass, 1979) have been estimated.

Although current BMPs are effective at reducing nonpoint source pollution, few of the current forest road BMPs specifically address the recovery of soil properties, normal hillslope hydrology, and site productivity. We need to develop new techniques to lessen the transport of sediment and nutrients, minimize the altering of hillslope hydrology, and increase overall forest health and productivity. The USDA Forest Service has recently come under fire to protect roadless areas and to retire or possibly restore roads that receive little use. While numerous methods have been used to retire roads, new technologies have evolved that can potentially ameliorate soil damage and lessen the generation of nonpoint source pollution from forest roads.

ALTERNATIVE FOREST ROAD RETIREMENT METHODS

Although not currently part of most state BMPs, others have investigated combinations of practices such as tillage and mulching that are specifically designed for soil and fertility recovery:

- The most effective amelioration techniques for seedling growth included a combination of tillage and fertilization (Reisinger *et al.,* 1988).
- To increase infiltration in areas with deep compaction, subsoil ripping has shown to be effective (Luce, 1997).
- Moll (1996) outlines procedures including different kinds of tillage and partial and complete recontouring for obliteration of forest roads.

The development of Best Management Practices (BMPs) has been heavily influenced by practices that logging contractors could implement to reduce erosion on roads, landings, and skid trails following the timber harvest. The reliance of loggers on logging or road building equipment to implement BMPs has not emphasized retirement practices such as decompaction of soil profiles by deep tillage or full restoration of hillslopes. Deep tillage (subsoiling) restores soil permeability and speeds and improves revegetation of the road surface. Recovery of fill slopes (recontouring) restores hillslope water flow, decreases soil compaction, and reclaims the buried nutrient rich top soil. In eastern Kentucky we have implemented a study to assess the effect of subsoiling and recontouring on nonpoint source pollution, hillslope hydrology, forest productivity and costs associated with alternative BMP implementation.

CASE STUDY IN EASTERN KENTUCKY

Through the cooperation of the USDA Forest Service, Mead Paper, and the University of Kentucky, we have implemented a forest road mitigation study during the spring of 2000 in the Cumberland Plateau region of eastern Kentucky. On three harvest sites in northeastern Kentucky, subsoiled, recontoured, and control plots (normal seeding and water bars) were installed on roads with slopes ranging from 5 to 15 percent and side hill slopes greater than 30 percent. On each site we identified a section of trail 180 meters long that met the slope requirements. The road was divided into two blocks. Each block has a control, subsoiled, and recontoured treatment 25 meters long separated by 5 meter buffers. Treatments were randomly assigned within blocks. We chose the Tilth Self-Drafting Subsoiler to accomplish the subsoiling. The basic criteria for our choice was that the subsoiler be able to till the whole road width to a minimum depth of 50 cm. A contractor completed the recontouring treatments with a Caterpillar E120B tracked excavator with a 0.9 m bucket and rock teeth. After the treatments were installed, we planted 20 white pine and 20 yellow poplar seedlings within each treatment.

The results of the nonpoint source pollution part of the study are very preliminary but encouraging. Through the 2000 growing season we saw significantly less sediment production from the recontoured treatment than the control treatment with the subsoil treatment mean not different from either subsoil or control (Figure 1). We also installed runoff collectors on undisturbed hillslopes

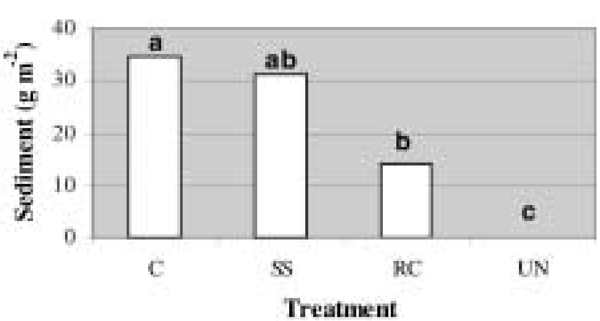

Figure 1. Mean Event Sediment Production From Control (C), Subsoiled (SS), Recontoured (RC), and Undisturbed Hillslope Plots (UN).

and not surprisingly found very little sediment production (Figure 1). The lower sediment production from the recontoured treatment is because of lower runoff volumes due to the generally greater soil porosity (Figure 2). As the study proceeds it will be interesting to follow the sediment production over time to determine what treatment approaches the undisturbed hillslope condition the quickest. Also, we will follow the growth of the planted seedlings to assess if the additional productivity resulting from either subsoiling or recontouring offsets the additional costs of retirement.

CONCLUSION

Since post-harvest treatment of severely disturbed areas such as forest roads and trails is already required by BMPs, it may be possible that an alternative retirement or restoration treatment could partially or completely replace current best management practices. We need to continue to develop and test new and alternative cost effective BMPs that lessen sediment and nutrient transport to streams, minimize the alteration of hillslope hydrology and increase forest productivity.

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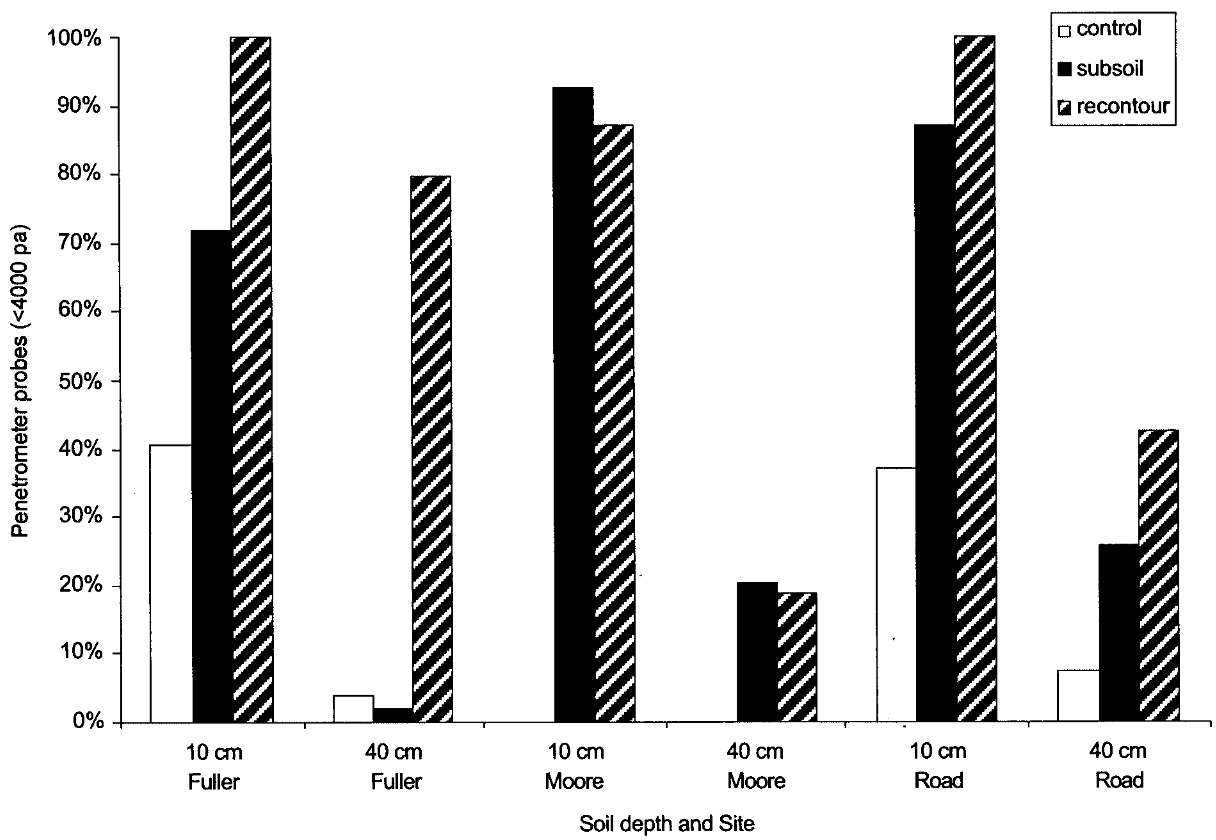

Figure 2. Percent of Penetrometer Probes That Reached or Surpassed 10 cm or 40 cm on Each Treatment on the Three Study Sites (Fuller, Moore, and Road). The higher the percentage the more porous the soil.

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Randy Kolka is an Assistant Professor of Forest Hydrology and Watershed Managment in the Department of Forestry at the University of Kentucky. Dr. Kolka received his undergraduate degree in Soil Science from the University of Wisconsin-Stevens Point and his MS and PhD in Soil Science from the University of Minnesota. His primary research interests include Forestry BMP assessment, wetland and riparian hydrology, and carbon, nutrient, mercury and sediment transport. Prior to coming to the University of Kentucky, Dr. Kolka was a Soil Scientist for two years with the USDA Forest Service Southern Research Station studying riparian restoration in bottomland hardwood communities.

Mathew Smidt (smidtmf@auburn.edu) is Assistant Extension Specialist and Professor of Forest Operations with the School of Forestry and Wildlife Science at Auburn University. Dr. Smidt recieved a B.S. in Biology form Doane College, M.S. from Duke University, and a Ph.D from the University of Minnesota. As an extension specialist he has worked with the logging industry to increase the understanding of the costs and benefits of improving logging practices through education and applied research. Prior to moving to Auburn, Dr. Smidt was an extension specialist in timber harvesting at the University of Kentucky.

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▲ Employment Opportunities

DIRECTOR, WATER QUALITY LABORATORY
HEIDELBURG COLLEGE - TIFFON, OHIO

Heidelberg College is seeking applicants for the position of Director of the Water Quality Laboratory (WQL). The WQL is a 32-year old environmental research, monitoring and educational organization associated with the science departments of Heidelberg College. The WQL's mission is to help protect the aquatic resources of Ohio, the Midwest, and the Lake Erie and Great Lakes ecosystems by assessing impacts of agricultural and other land uses. This is accomplished through research, extension activities, and support of the educational programs of the College.

We seek a Director who can guide the continuing evolution of the WQL programs in response to this mission. Applicants must possess a doctoral degree in environmental science, water resources management, natural resources, or a related discipline. We require a person with a distinguished record of professional accomplishments and a demonstrated ability to maintain and expand a network of contacts in research and funding at local, state, and national levels. The Director has primary responsibility for maintaining ongoing funding from governmental, industrial and private sources, along with securing new funding sources. Administrative and project management skills in an academic, grants-driven environment, excellent oral and written communication skills, and creative leadership are essential in this position.

Heidelberg College is a small private liberal arts college located in a small town one hour south of Toledo, Ohio. The College has an established reputation for academic quality and outstanding teaching.

Please send a letter of application, full curriculum vitae, a 1- to 2-page narrative summarizing your administrative philosophy, and names and contact information for three references to: Dr. Kenneth Krieger, Water Quality Laboratory, Heidelberg College, 310 E. Market Street, Tiffin, Ohio 44883, (419) 448-2226. Additional materials will be requested from applicants selected for further consideration.

Screening of applications will begin on 15 May 2001 and will continue until the position is filled. More information about the WQL and this position can be found at http://www.heidelberg.edu/wql or by contacting kkrieger@heidelberg.edu.

SENIOR GEOGRAPHICAL INFORMATION SYSTEMS (GIS) ANALYST
ORLANDO, FLORIDA

Duties, performed under minimal supervision with responsibility for GIS technician, include preparing water/wastewater master plans and other utility mapping (e.g., map water and wastewater system for city-side master plans, prepare data to be inputed in hydraulic model, map water and wastewater systems for miscellaneous areas); marketing (e.g., proposal preparation and client presentation and conducting in-house seminars); preparing stormwater inventory/mapping master plans (e.g., coordinate with Destin HAI office for the collection and mapping of stormwater structures for county-wide inventory, assist with hydrologic modeling using GIS analysis to obtain storm water model input variables, and coordinate GIS mapping and data management with municipalities drain well inventory); expert witness support (e.g., provide graphic and mapping support, assist civil engineering and hydrogeology departments with permit applications and mapping); site development (e.g., assist civil eingineering departments with site assessment, mapping, and hydraulic model evaluations); planning (e.g., continuing GIS consultations with municipalities and counties); natural resource mapping; and assist with rate studies.

Minimum requirements: Bachelor's Degree in natural resources science or related field; and one year's experience in job offered or related occupation (geographic information systems analysis). Must possess demonstrated job-related knowledge and ability with GIS analysis and cartographic design using ESRI software (ARCINFO/Arcview) and AutoCad; hydrologic processes/modeling and soil-water relations; AML and Avenue and geographic analysis techniques and methodologies particularly as applied to hydrologic modeling; GPS data collection; GIS mapping of water, wastewater, and stormwater systems; and land use/land cover.

Total hours per week: 40 and 0-10 overtime as necessary. Work schedule: 8:00 am-5:00 pm. Rate of pay: $45,000 per year. Job located in Orlando, FL. Send resume to: Agency for Workforce Innovation, Bureau of Workforce Program Support, P.O. Box 10869, Tallahassee, FL 32302, Attn: L. Knight, Re: JOFL#2168424.


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WOODROW WILSON BRIDGE WASHINGTON, D.C.

A bridge is at the center of an on-going dispute in Washington, D.C. Construction of the new Woodrow Wilson Bridge on the Beltway south of Washington, D.C., has been ratcheted up a notch in the last few weeks.

An environmental organization, the National Wilderness Institute (NWI), has filed suit against five Federal departments and agencies contending violation of the Endangered Species Act (ESA). NWI contends that three species – the bald eagle, the shortnose sturgeon, and the dwarf wedge mussel – are threatened if construction of the bridge continues.

What NWI is pressing for is fair application of the Endangered Species Act. NWI officials see a double standard in the application of the ESA. It has been long used in the western U.S. to stop projects of all kinds, but some think the ESA should be enforced in Washington's backyard.

Congressman George Radanovich applauds the suit. "We in the west have seen project after project stopped in its tracks over the very statutes that are at issue in this case. It's no wonder the bureaucrats in Washington have ignored our pleas when they can seemingly ignore the law when it affects where they live."

NWI Director Rob Gordon says the purpose behind the suit is for consistent application of the ESA.

Agencies named in the suit include the Departments of Transportation, Interior (U.S. Fish and Wildlife Service), and Commerce (National Marine Fisheries Service) along with U.S. Environmental Protection Agency (USEPA) and the U.S. Corps of Engineers (Corps).

For more information see: www.nwi.org

U.S. SUPREME COURT DEEMS "ISOLATED" WETLANDS, NOT NAVIGABLE

A January 9th decision handed down by the U.S. Supreme Court deals a blow to the USEPA's and the Corps' efforts to regulate "isolated" wetlands. Isolated wetlands are areas separate from "navigable waters." The nation's highest court ruled that Congress did not intend for the Clean Water Act, Section 404(a), to apply to isolated wetlands, only to wetlands connected to "navigable" waterways.

A group of Chicago area municipalities [Solid Waste Agency of Northern Cook County (SWANCC)] moved to use a former abandoned mine site for solid waste disposal. Over time, trenches around the site became ponds and habitat for waterfowl. Corps officials invoked the Migratory Bird Rule of the Clean Water Act to protect the site. The Corps has long held that the Commerce Clause of the Migratory Bird Rule applies since it involves interstate trade with tourists and hunters traveling from different states to view waterfowl and wildlife.

In a nutshell, the U.S. Supreme Court agreed with the municipalities and said the Corps had overstepped its authority in regulating isolated wetlands. In the majority opinion the court ruled, "We find nothing approaching a clear statement from Congress that it intended Section 404(a) to reach an abandoned sand and gravel pit such as we have here."

In a swipe at the Migratory Bird Rule the opinion delivered by Justice Rehnquist commented, "Permitting respondent to claim federal jurisdiction over ponds and mudflats falling within the 'Migratory Bird Rule' would result in a significant impingement of the States' traditional and primary power over land and water use."

ARSENIC RULES DELAYED

EPA administrator Christine Todd Whitman announced on March 20 that the agency will temporarily delay implementation of the new arsenic rules. Administrator Whitman cited the need for an independent review of the science and cost estimates before the rules should take effect.

At issue is what is a new safe level for arsenic. The EPA press release states in part that while scientists agree that the "... previous standard of 50 parts per billion (ppb) should be lowered there is no consensus on what is a safe level." EPA's proposed rules set 10 ppb as the safe level. Whitman notes, "Certainly the standard should be less than 50 ppb, but the scientific indicators are unclear as to whether the standard needs to go as low as 10 ppb." National Research Council found cancer and arsenic links to be tenuous and advised further study needs to be done to clarify any link.

Costs for arsenic rules are expected to be extremely high, especially for small water systems. Systems serving less than 10,000 people could see annual water bills ranging in price from $32 to $327 per year. The American Water Works Association (AWWA) estimates a $600 million annual price tag not including initial capital needs.

Arsenic is found naturally in the environment and is the 20th most common element found in the earth's crust. Some states have more arsenic than others. Western states appear to have the greatest share of arsenic.

EPA is asking for a 60-day extension of the effective date and is expected to release a timetable soon.

(Please e-mail your submissions or suggestions of timely water quality efforts in your state or industry to me at jedgens@ca.uyk.edu.)

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SUBSCRIPTION RATES / WATER RESOURCES IMPACT

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FOREIGN AIRMAIL OPTION $25.00

CONTACT THE AWRA HQ OFFICE FOR ADDITIONAL INFORMATION OR TO SUBSCRIBE

PRESIDENT'S MESSAGE . . . A Toast to Ken

John S. Grounds III, AWRA President, 2001

"Wasser ist billig, rein und gut; Doch verdünnt es unser Blut."
"Water is cheap, pure, and good but it thins the blood."

As long as water is cheap and we have good, pure supply at our tap, the public will not fully realize the need and importance of our organization. But over the past two decades, the public is starting to become aware. Part of this awareness is due to the efforts of one man, AWRA's Executive Vice President Ken Reid. Ken's 20th Anniversary with the American Water Resources Association is May 1st, 2001. During those 20 years there have been some changes to how we relate to our water resources. When Ken started with AWRA in 1981, we were between the Clean Water Act of 1972 and the Water Quality Act of1987. Since then more Acts have occurred and we have responded with compliance and complaints. We have been introduced to NPDES, TMDL, BMP, SWPPP, and many other acronyms. What has not changed over those 20 years is AWRA's ability to consistently lead the discussions and bring emerging topics to those involved in a holistic understanding of our water resources. Ken has developed leadership within the staff with an understanding of the problems beyond just learning the language. He has energized us to excel and immerse ourselves in the issues. He has fostered younger members. He is the institutional memory that provides a solid foundation for us to consistently provide outstanding service and stability to take risks. And most of all, Ken is a friend.

Please raise a glass and toast his friendship and service to the American Water Resources Association.

"Choose a job you love and you will never work a day in your life." . . . Confucius

I am of the belief that the contents of our publications are the domain of our volunteer leaders, members, and contributing authors. I would like, with your indulgence, to make a brief exception to this rule.

I recently received a card from Cindy LaVigne Hansen who was the Association's Business Manager when I started with AWRA in 1981. I called her to see how she and her family were doing and to catch up on life's happenings. In the course of the conversation we both realized that May 1 marks my 20th anniversary with AWRA. My how time flies! For me the above quote from Confucius is my mantra! I absolutely love this job and the volunteers and members for which I have worked. We are blessed with an exceptional pool of talented leaders and the most wonderful aspect of our leadership is their overwhelming desire to keep on giving.

Complimenting the volunteer leadership is the wonderful team of staff professionals that I work with each day. We have a full-time staff of five people and two part-time people. They are the most incredible team of outstanding professionals and they give you 150% effort every day. Charlene, Mike, Pat, Harriette, Bonnie, and Dick – thank you from the bottom of my heart for everything you do for AWRA. I really appreciate it.

Katherine Graham, the publisher of *The Washington Post* newspaper, observe, "To love what you do and feel that it matters – how could anything be more fun." I am so fortunate to love what I do, believe sincerely in the fact that it matters, and I have fun doing it! Thanks for the privilege of working for you and thanks for your investment in membership in AWRA.

Kenneth D. Reid, CAE
Executive Vice President

MEMBERS ON THE *M O V E . . .*

Dr. N. Earl Spangenberg, University of Wisconsin-Stevens Point Professor, Receives Distinguished Service Award

Dr. N. Earl Spangenberg, Professor of Water Resources in the College of Natural Resources at UW-Stevens Point, received the Distinguished Service Award at the 25th Annual Meeting of the American Water Resources Association (AWRA)-Wisconsin Section in Green Lake, Wisconsin, on March 29, 2001. This Award is made annually to "recognize individuals or groups affiliated with the Section who have made exceptional contributions to enhance the quality of water resources in Wisconsin."

Dr. Spangenberg's achievements include the following: • founding member of the Wisconsin Section-AWRA in 1977 and actively involved ever since; • over 20 years spent as an advisor to the College of Natural Resources students and the UW-Stevens Point Student AWRA Chapter; • oversaw production of over 1000 ground water flow models at UW-Stevens Point that have been used nationwide in classrooms and other educational settings to demonstrate ground water principles; • produced the video "What is this Ground Water?" to accompany the model; • active at National AWRA level, serving as President in 1999 and currently serving as Editor-in-Chief of *Water Resources IMPACT*, a monthly magazine for water resources professionals.

Dr. Spangenberg received his masters and doctorate in Watershed Management at Colorado State University in 1976. He came to Stevens Point in 1971 as an instructor and has been a full professor since 1986. He is a licensed Professional Hydrologist in the State of Wisconsin, and has served in a variety of professional capacities. His research interests include watershed modeling and wetland mitigation. He has authored numerous articles on forestry practices and watershed management. As an instructor, he teaches a variety of courses in Hydrology, Watershed Management, Water Quality Management, Wetlands, and Environmental Impact Preparation.

Timothy Asplund, President of the AWRA Wisconsin Section remarked that Dr. Spangenberg has had a significant impact on the water resources community through his tireless advocacy for professional education and his mentoring and promotion of students. He received support in his nomination for the award from the UW-Stevens Point Student AWRA Chapter and the Past President of the National AWRA, Janet Bowers, who stated that "Earl has been instrumental in developing young minds into contributing adults in the Water Resources community. Plus he is always there for his students. It is impossible to count or measure the ways people have been touched by Earl's advocacy and involvement."

Asplund presented Dr. Spangenberg with a signed print of a quiet rural stream painted by Mt. Horeb artist Steven Kozar. In addition, approximately 30 students in attendance at the meeting presented Earl with a photo collage collected from his years as advisor to the Chapter to recognize the occasion. For further information about the Distinguished Service Award or the AWRA Wisconsin Section, please contact Mr. Timothy Asplund at 608-267-7449 or current President Mike Lemcke at 608-266-2104.

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Dr. N. Earl Spangenberg (center, holding print) surrounded by current and former University of Wisconsin-Stevens Point students and AWRA Wisconsin Section President Tim Asplund (far left).

PAPERS APPEARING IN THE JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION APRIL 2001 • VOL. 37 • NO. 2

TECHNICAL PAPERS

- Effects of Urbanization on Channel Instability
- Chaotic Forecasting of Discharge Time Series: A Case Study
- Inputs of Copper-Based Crop Protectants to Coastal Creeks From Pasticulture Runoff
- Physical Determinants of Economic Value of Riparian Buffers in an Agricultural Watershed
- Implications of Feedback Processes in Plant Water Usage and Resulting Climate Change
- Nitrogen Accumulation in a Constructed Wetland for Dairy Wastewater Treatment
- Determining the Source of Stream Contamination in a Karst-Water System, Southwest Virginia, USA
- The Concept of Hydrologic Landscapes
- A Hypothesis About Factors That Affect Maximum Summer Stream Temperatures Across Montane Landscapes
- Transient Storage Assessments of Dye-Tracer Injections in Rivers of the Willamette Basin, Oregon
- Isotopic Evaluation of Pb Occurrences in the Riverine Ecosystems of the Kankakee Watershed, Illinois-Indiana
- A Windows-Based GIS-AGNPS Interface
- Microbiological Quality of Puget Sound Basin Streams and Identification of Contaminant Sources
- Storm Discharge, Loads, and Average Concentrations in Northwest Ohio Rivers, 1975-1995
- Genetic Programming and Its Application in Real-Time Runoff Forecasting
- Utilizing Induced Recharge for Regional Aquifer Management
- Flood Damages in Changing Flood Plains: A Forensic-Hydrologic Case Study

JAWRA
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FUTURE AWRA MEETINGS

2001

JUNE 27-30, 2001
SUMMER SPECIALTY CONFERENCE
DECISION SUPPORT SYSTEMS FOR WATER RESOURCES MANAGEMENT
Snowbird, Utah

AUGUST 6-8, 2001
INTERNATIONAL SPECIALTY CONFERENCE
GLOBALIZATION AND WATER MANAGEMENT
Dundee, Scotland

NOVEMBER 12-15, 2001
AWRA's ANNUAL WATER RESOURCES CONFERENCE
Albuquerque, New Mexico

2002

NOVEMBER 4-7, 2002
AWRA's ANNUAL WATER RESOURCES CONFERENCE
Philadelphia, Pennsylvania

For additional information / info@awra.org

NATIONAL SCIENCE FOUNDATION RESEARCH PROGRAM IN GIS/WATER RESOURCES FOR JUNIORS AND SENIORS

TWO-MONTH PROGRAM STARTING JUNE 4, 2001

Oklahoma State University plans to bring undergraduate students there to work one-on-one with OSU researchers this summer. Student participants will receive a stipend and room/board in Stillwater, Oklahoma, for two months beginning June 4, 2001. Participants must be juniors or seniors and have completed coursework in GIS and/or water resources. Students will be selected on the basis of their GPA and experience/coursework involving water resources and GIS. All participants must be U.S. citizens.

AN ON-LINE APPLICATION FORM IS AVAILABLE AT
www.seic.okstate.edu/reu/

OR CONTACT
Thomas A. Wikle, Professor
Dept. of Geography • Oklahoma State University
Stillwater, OK 74078
(405) 744-9173 • geogtaw@okstate.edu

▲ Water Resources Continuing Education Opportunities

MEETINGS, WORKSHOPS, SHORT COURSES

MAY 2001

31-June 2/Water & Rural History. Reno, NV. **Contact** W.D. Rowley, History Dept., Univ. of NV, Reno, NV 89557 (e: rowley@scs.unr.edu)

JUNE 2001

3-8/Association of State Floodplain Managers – 25th Annual Conf. Charlotte, N.C. **Contact** asfpm, 2809 Fish Hatchery Rd., Ste. 204, Madison, WI 53713-3120 (608/274-0123; fax: 608/274-0696; e: asfpm@ floods,org; w: www.floods.org)

6-8/2001 Watersheds of Change – Canadian Water Resources Assn. – 54th Annual Conf. Guelph, Ontario, Canada. **Contact** Reid Kreutzwiser, Dept. Geography, Univ. of Guelph, Guelph, ON N2L 3G1 (549/824-4120; f: 519/837-2940; e: reidk@ uoguelph.ca)

6-8/ECOSUD 2001 – 3rd Intern'l. Conf. – Ecosystems & Sustainable Development. Alicante. Spain. **Contact** Conf. Secretariat (w: www.wessex.ac.uk/ conferences/2001/ecosud01/)

10-14/Great Lakes Science: Making It Relevant. Green Bay, WI. **Contact** (http://www.iaglu.org.conference)

10-15/5th Intern'l. Conf. – Diffuse/Nonpoint Pollution & Watershed Mgmt. Milwaukee, WI. **Contact** IWA Conf. c/o Inst. for Urban Environmental Risk Mgmt., Marquette Univ., Milwaukee, WI 53201-1881 (f: 414/288-7521; e: mburkart@nstl. gov; http://www.mu.edu/environment/iwa-page.htm)

11-15/Process Based Channel Design Short Course 2001. Milwaukee, WI. **Contact** Lisa Hughes, Inter-Fluve, Inc. (406/586-6926; e: lhughes@ interfluve.com; w: www.interfluve.com)

13-15/Two Decades of Water Law and Policy Reform. Boulder, CO. **Contact** Natural Resource Law Center, Univ. of Colorado School of Law, 401 UCB, Boulder, CO 80309-0401 (303/492-1272; f: 303/492-1297; e: nrlc@spot.colorado.edu)

15-19/Hands Across the Water: Linking Land, Lake and Sea - Coastal Zone 01. Cleveland, OH. **Contact** NOAA Coastal Services Center, 2234 S. Hobson Ave., Charleston, SC 29405-2413 (w: www.csc.noaa.gov/cz2001)

18-27/6th Scientific Assembly of the Intern'l. Assn. of Hydrological Sciences. Maastricht, The Netherlands. **Contact** IAHS Maastricht 2001, c/o Conf. Agency Limburg, P.O. Box 1402, 6201 BK Maastricht, The Netherlands

25-27/3rd Intern'l. Conf. – Future Groundwater Resources at Risk. Lisbon, Portugal. **Contact** L. Ribeiro, Centro De Valoizacao de Recursos Minerais DO I.S.T., I.S.T. Av. Rovisco Pais 1096, Lisboa, Codex, Portugal (351-1-841 72 47;f: 351-1-841 74 42)

27-30/Joint AWRA/UCOWR Summer Specialty Conf. – Decision Support Systems for Water Resources Mgmt. Snowbird, UT. Contact AWRA, 4 West Federal St., P.O. Box 1626, Middleburg, VA 20118-1626 (540/687-8390; f: 540/687-8395; e: info@awra.org)

27-30/Transbasin Water Transfers – U.S. Committee on Irrigation & Drainage. Denver, CO. **Contact** Larry D. Stephens (303/628-5430; f: 303/628-5431; e: stephens@uscid.org)

JULY 2001

9-11/Waterpower XII. Salt Lake City, Utah. **Contact** Waterpower XII, 410 Archibald, Kansas City, MO 64111 (816/931-1311, x129; f: 816/931-2015; e: waterpower@hcipub.com)

30-Aug. 2/Managing River Flows for Biodiversity: A Conf. on Science, Policy, & Conservation Action. Ft. Collins, CO. **Contact** Nicole Silk (e: nsilk@tnc.org; w: www.freshwaters.org/ccwp/conference.html)

18-27/Intern'l. Association of Hydrological Sciences – 6th Scientific Assembly. Maastricht, The Netherlands. **Contact** IAHS Maastricht 2001, c/o Conf. Agency Limburg, P.O. Box 1402, 6201 BK Maastricht, The Netherlands (+31 43 3619192; f: +31 43 3619020; e: cal.conferenceagency@wxs.nl)

AUGUST 2001

5-8/AWRA International Specialty Conf. on Globalization & Water Mgmt. Dundee, Scotland. Contact AWRA, 4 West Federal St., P.O. Box 1626, Middleburg, VA 20118-1626 (540/687-8390; f: 540/687-8395; e: info@awra.org)

7-10/International Tsunami Sym. 2001. Seattle, WA. **Contact** E.N. Bernard, NOAA/PMEL, 7600 San Point Way N.E., Seattle, WA 98115-6349 (206/526-6800; f: 206/526-4576; e: bernard@pmel.noaa.gov; w: www.pmel.noaa. gov/its2001)

13-16/Water Security for the 21st Century – Building Bridges Through Dialogue – 11th Stockholm Water Sym. **Contact** Stockholm International Water Institute, Stockholm Water Sym., Sveavagen 59, se-113 59 Stockholm, Sweden (f: +46 8 522 139 61; e: symoos@siwi.org)

13-17/Process Based Channel Design Short Course 2001. Bozeman, MT. **Contact** Lisa Hughes, Inter-Fluve, Inc. (406/586-6926; e: lhughes@ interfluve.com; w: www.interfluve.com)

23-27/9th National Nonpoint Source Monitoring Workshop. Indianapolis, IN. **Contact** CTIC, Nonpoint Source Workshop, 1220 Potter Dr., Ste 170, West Lafayette, IN 47906 (765/494-9555; f: 765/494-5969; e: ctic@ctic.purdue.edu; w: www.ctic. purdue.edu/CTIC/NPSCall.html)

SEPTEMBER 2001

2-6/IV Inter-American Dialogue 0n Water Management, Foz do Iguacu, Parana, Brazil. **Contact** Executive Secretariat, Av. Brigadeiro Luiz Antonio, 317-conj. 53,01317-901 Sao Paulo, SP, Brazil (+55 11-3104-6412; f: +55 11-3104-6412; e: dialogo@acquacon. com.br; w: www.ivdialogo.com); or Bernard

Griesinger, Inter-American Water Resources Network, OAS, 1889 F St., N.W., Washington, DC 20006 (202/458-3570; f: 202/458-3560; e: bgriesinger@oas.org; w: www.iwrn.net)

9-12/Dam Safety 2001. Snowbird, UT. **Contact** ASDSO, 450 Old Vine St., 2nd Floor, Lexington, KY 40507 (859/257-5140; f: 859/323-1958; e: info@damsafety. org)

10-12/Environmental Health Risk 2001. Cardiff, Wales, UK. **Contact** Conf. Secretariat RBM 2001, Wessex Inst. of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK (w: www. wessex.ac.uk/ conferences/2001/envh01)

11-13/River Basin Mgmt. 2001. Cardiff, Wales, UK. **Contact** Conf. Secretariat RBM 2001, Wessex Inst. of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK (w: www.wessex.ac.uk/conferences/ 2001/river01/)

11-14/Modflow 2001 & Other Modeling Odysseys – Internat'l. Ground Water Modeling Conf. & Workshops. Golden, CO. **Contact** Internat'l. Ground Water Modeling Ctr., 1500 Illinois St., Colorado School of Mines, Golden, CO 80401; (303/273-3103; fax: 303/384-2037; e: igwmc@mines.edu); submit abstract to: w: www.mines.edu/ igwmc/events/modflow2001)

18-19/EPA Region 6 Nonpoint Source Watershed Conf. Dallas, TX. **Contact** Lee Ann Huseman, TIAER, M.S. T-0410, Stephenville, TX 76401 (254/968-9559; w: Region6ConfAnnouncement.html)

19-21/Introductory & Advanced Workshops on USEPA, SWMM4.4 & PCSWMM GIS 2000 Stormwater Modeling. Toronto, ON, Canada. **Contact** Dr. Lyn James, CHI, 36 Stuart St. Guelph, ON, Canada N1E 4S5 (519/767-0197; f: 519/767-2770; e: info@chi.on.ca; w: www.chi.on.ca)

22-23/Conf. on Stormwater & Urban Water Systems Modeling. Toronto, ON, Canada. **Contact** Dr. Lyn James, CHI, 36 Stuart St. Guelph, ON, Canada N1E 4S5 (519/767-0197; f: 519/767-2770; e: info@chi.on.ca; w: www.chi.on.ca)

24-26/Water Resources Mgmt. 2001. Halkidiki, Greece. **Contact** Conf. Secretariat WRM 2001, Wessex Inst. of Technology, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK (w: www.wessex.ac.uk/ conferences/2001/wrm01/)

OCTOBER 2001

14-17/Hydrologic Science: Challenges for the 21st Century. Bloomington, MN. **Contact** AIH, 2499 Rice St. Ste. 135, St. Paul, MN 55113-3724 (e: AIHydro@ aol.com; w: www.aihydro.org)

18-20/Nonstructural Measures for Water Management Problems. London, Ontario, Canada. **Contact** Dr. S.P. Simonovic (e: imonovic@uwo.ca)

25-27/IV Water Information Summit. Panama City, Panamá. See "Calls for Abstracts" below

NOVEMBER 2001

5-9/Process Based Channel Design Short Course 2001. Vancouver, WA. **Contact** Lisa Hughes, Inter-Fluve, Inc. (406/586-6926; e: lhughes@interfluve.com; w: www.interfluve.com)

6-7/The Practice of Restoring Native Ecosystems. Nebraska City, NE. **Contact** National Arbor Day Foundation, P.O. Box 81415, Lincoln, NE 68501-1415 (402/474-5655; f: 402/474-0820; e: conferences@arborday.org)

7-9/Bridging the Gaps Between Science, Policy, & Practice – NALMS Sym. Madison, WI. **Contact** T. Thiessen (e: thiessen@nalms.org; w: www.nalms.org)

12-15/AWRA's Annual Water Res. Conf. Albuquerque, NM. Contact AWRA, 4 West Federal St., P.O. Box 1626, Middleburg, VA 20118-1626 (540/687-8390; f: 540/687-8395; e: info@awra.org)

26-29/Water for Human Survival – International Regional Sym. New Delhi, India. **Contact** Mr. A.R.G. Rao, Director (Water Resources), Central Board of Irrigation and Power, India (e: cbip@nda.vsnl.net.in)

FEBRUARY 2002

25-March 1/IECA 33rd Annual Conf. Orlando, FL. **Contact** International Erosion Control Association, P.O. Box 774904, Steamboat Springs, CO 80477-4904 (970/879-3010; f: 970/879-8563; e: ecinfo@ieca.org; w: www.ieca.org)

MAY 2002

29-31/Ninth International Conf. on Hydraulic Information Management – HYDROSOFT 2002. Montreal, Canada. See "Calls for Abstracts" below

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ASAP (Abstracts Due) – Ninth International Conf. on Hydraulic Information Mgmt. – HYDROSOFT 2002. May 29-31, 2002. Montreal, Canada. **Contact** Lucy Southcott, Conf. Secretatiat, HYDROSOFT 2002, Wessex Inst. of Technology, Ashurst Lodge, Ashurst, Sjouthhampton, SO40 7AA, UK (+44(0)238-029-3223; f: +44(0)238-029-2853; e: lsouthcott@wessex.ac.uk; w:www. wessex.ac.uk/ conferences/2002/hy02

June 30, 2001 (Abstracts Due) – IV Water Information Summit. October 25-27, 2001. Panama City, Panamá. **Contact** Lenin Montano, CATHALAC, P.O. Box 873372, Panamá 7, Rep. of Panamá (+507/317-0125; f: +507/317-0127; e: wis4@cathalac.org; w: www.cathalac.org; http://www.waterweb.org); or David W. Moody, Inter-American Water Resources Network (603/835-7900; f: 603/835-6279; e: dwmoody@beaverwood.com); or Terry Dodge, Water Web Consortium (561/961-8557; f: 561/ 691-8540; e: tdodge@ces.fau.edu; w: www.waterweb.org)

July 31, 2001 (Abstracts Due) – 9th International Conf. on Urban Drainage. September 8-13, 2002. Portland, OR. **Contact** Ms. Cindy Gold, ASCE Conf. Dept., 1801 Alexander Bell Dr., Reston, VA 20191-4400 (703/295-6197; f: 703/295-6144; or 800/548-ASCE; f: 703/295-6144)

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Vol. 2, No. 6, November 2000, pgs. 23-26 – The New Watershed Tools: Genuine Steel or Chrome-Plated Plastic? – Richard A. Halpern

Editor's Note: The following feedback article by Richard Halpern is in reply to Smith and Knopman's discussion in Vol. 3, No. 2, March 2001, pg. 41. Thanks to all for allowing the opportunity for continuing discussion.

In the November 2000 issue of *IMPACT* I wrote an article urging water resource professionals to weigh carefully the quality of the data they use, and to insist on high quality, real-world data for making far-reaching watershed management decisions (Halpern, 2000). As a corollary I also argued that we not rely on computer models based solely on land-use information as a surrogate or substitute for monitoring data. Citing the concerns of distinguished practitioners in the field of modeling, I drew attention to their caveats regarding the highly subjective and protean nature of mathematical models, including watershed models – limitations that seem often forgotten or insufficiently acknowledged when model output is presented to the public and to decision makers as the basis of public policy.

Now USGS modeler Richard Smith and his former colleague at the agency, Debra Knopman, have written a response in *IMPACT* (March 2001) in which they take me to task for things I did not say, positions I did not take, and ignore completely the most crucial point of the article regarding the limitations of modeling (Smith and Knopman, 2001).

To review briefly . . . Our lack of quality data has become a cause for alarm. In March 2000, a state-by-state survey released by the U.S. Government Accounting Office revealed that fewer than 10 percent of the nation's river miles have ever been monitored on a long-term basis or for a significant number of parameters (Guerrero, 2000). Federal monitoring has also been sparse, uncoordinated, short-lived, and erratic. In 1997, Knopman herself compared the Federal environmental monitoring system to "controlling the heat and air conditioning in a 50-room mansion with one cheap thermostat" (Knopman, 1997).

"The nation's water quality monitoring network," she wrote, "is so sparse and underfunded – just a few million each year at the federal level – that it can barely tell us anything about progress under the Clean Water Act for which about half of the $150 million [*sic*] is spent." (Knopman informed me last year that the number should be $150 billion.)

Knopman and Smith (1993), writing jointly in *Environment,* argued, as I did last November, that the lack of data is a critical hindrance to the development of sound water quality decision making.

The data gap issue has become even more pressing than it was when Knopman and Smith wrote. Last summer, the EPA promulgated a rule requiring an estimated 40,000 pollution-control plans in watersheds all over the country for most of which there are either no real world data or data so sparse, outdated, or purely anecdotal that they are virtually without credibility. In Congressional hearings, David Holm, then President of the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), warned that "states would be required to make decisions based on information that they cannot scientifically or legally defend" (Holm, 2000). Most worrying is that, in the absence of data, the EPA rule will permit streams to be assessed and declared "impaired" based solely on the "professional judgment" of regulators – without objective scientific assessment. Then, in order to remediate these "impairments," the rule permits models based on land uses to become the basis for regulation – even when no real-world data exist.

In their response, Smith and Knopman agree that we do not have sufficient monitoring data for the "overall regulatory task at hand." They also agree that good monitoring data are essential to responsible modeling: "water quality models are only as good as the data used to calibrate and test them." Unless they think that acceptable watershed models can be developed in the virtual absence of good monitoring data, or that modelers should conceal the subjectivity and other limitations of their work from the public and decision makers, then I do not see the grounds for their disagreeing with me, nor do I understand the seemingly perverse accusations they adduce against my position.

Smith and Knopman declare that because I believe that government monitoring has "limitations," that I therefore assert "the use of water quality models is discredited." I neither say nor think anything of the kind. I do argue, and will continue to argue, that important decisions should not be made using models that have been developed without the benefit of good real-world data. Smith and Knopman seem to echo my point: "Water quality management models must be grounded in the reality of direct field observations." Unless by "field observations" they mean something other than site-specific water quality monitoring, we are in perfect agreement.

Smith and Knopman accuse me of setting up "a false choice between monitoring and modeling," to which all I can say is "Huh?" The choice I set up is between water quality assessment and regulation based on real-world data and water quality assessment and regulation based on no real-world data.

This non-existent "false choice" is evidence, they say, of "an incomplete understanding of the appropriate use of models to support decision-making." According to Smith and Knopman, I don't understand model-derived "in-stream pollutant loadings." On the contrary, model output for "in-stream pollutant loading" can be useful under the specific conditions that all of us agree on; i.e., when they are derived from and can be supported by "direct observations" – assuming again that "direct observations" means "site-specific hard data from the real world."

But I add that when model-derived "instream pollutant loading" estimates – and they can only be estimates – are introduced into the regulatory process, the limitations inherent in the modeling enterprise should be publicly acknowledged and explained. In no case should model outcomes, even when supported by monitoring data, be presented as hard fact.

That the model is, in Knopman and Smith's phrase, "an imperfect representation of reality" should be an explicit and not an unstated non-factor in the public policy discussion. What we don't know is at least as important as what we do know in making sound decisions. The Precautionary Principle can be applied as judiciously to the introduction of new regulations as to the implementation of new technologies. There must be an informed evaluation of the risks of both action and inaction.

Despite the substantial agreement among us, Smith and Knopman say that by urging a circumspect use of models, I necessarily imply "that we [should] put off modeling (and, by extension, nonpoint pollution control) until we have adequate data for building models with acceptably small errors everywhere in the nation..." Not only is this illogical and irrational, it is also untrue.

Nothing in my article suggests that we put off dealing with pollution of any kind anywhere, as long as there is reasonable real-world evidence that water quality is, in fact, degraded in some clearly documented way – according to some reasonable criterion – or that we put off modeling, either, for that matter, as long as models are developed from real-world data and are presented honestly to the public and to decision makers. Neither do I suggest that we "put off" dealing with nonpoint source pollution *anywhere* until we have sufficient data to deal with nonpoint pollution *everywhere* – that too is an absurdity.

I do not think it is reasonable (and do not imagine that Smith and Knopman would disagree) that we should be assessing water quality and imposing regulatory regimes without "adequate data" and using models that don't have "acceptably small errors." Moreover, how can we integrate "monitoring and modeling activities," as Smith and Knopman advocate, when, for most of the country, credible monitoring data does not exist?

The fact of the matter is, as Knopman and Smith themselves testify in their 1993 article, we have had a 30-year window of opportunity since the Clean Water Act first directed the states to compile a solid water quality database, and we have blown it – largely because the architects of the CWA had no confidence in water-quality-based programs, such as TMDLs, and explicitly discouraged the states from devoting resources to them. Now, there is strong – verging on hysterical – pressure to implement these programs, and the necessary data are simply not there.

Without real-world data how do we judge the legitimacy of claims that water quality is, in a consequential way, "impaired?" How do we evaluate whether proposed changes in land management are needed or reasonable? Do we place our faith in models that are untethered by real-world monitoring data to the hydro-geologic settings they purport to analyze. How do we protect against the "rogue analyses" that Whittemore and Beebe (2000) warn against, and which they consider not only "possible" but "even probable?"

Smith and Knopman provide two examples of the modeling mindset that gives rise to my concerns regarding interactions between the modeling/regulatory community and stakeholders. Working within the field with like-minded individuals, some modelers – like other specialized professionals – begin to think and use language in specialized ways that do not always translate well into everyday terms. They begin also to believe functionally in the "reality" of their own conceptualizations and thus speak and write of model output as though it were reality. For example, Smith and Knopman define "instream pollutant loadings" as "model-derived estimates based on concentration and flow measurements that are subsequently processed through a statistical model of stream flow specific to the water body." In fact, as we are all ultimately aware, an "instream pollutant loading" is the actual amount of a pollutant really present in the waterbody in the real world, not a statistically derived estimate. Nevertheless, for Smith and Knopman, in practical terms, model output has become the determinative reality referred to in a positivist frame of reference as the "instream pollutant loading." Such jargon – for jargon it is – obscures the subjective and inherently flawed nature of the model as a representation of reality. Most laymen, will uncritically conclude that the modelers really know what they are talking about. They will have performed some "scientific" experiment that allows them to successfully determine exactly the "pollutant load," how much it must be reduced (and in what proportion from which sources) in order to achieve an acceptable "instream pollutant load" and a "healthy" waterbody. In reality, the modeler has done nothing of the kind. Such a scenario, without very significant qualification and indicators of uncertainty, is a deception – a well-intentioned deception, perhaps, but a deception nonetheless.

Then, Smith and Knopman claim that, whereas monitoring "cannot directly determine the contributions of individual point and nonpoint sources" to stream pollution, the "spatially continuous blending of sources and the non-conservative behavior of contaminants" require a model to disentangle [the contributions of different sources]." They are right in saying that monitoring cannot definitively determine the contribution of each source, which was the principle reason water-quality-based regulation was rejected by Congress in favor of the technology-based approach that dominates the Clean Water Act – both for point and nonpoint pollution. But neither can modeling accurately "determine the contributions of individual point and non-point sources." To argue otherwise is absurd. The model provides a complicated and "scientific"-looking estimate that may have an appearance of credibility, but cannot be verified. If it could be verified, it wouldn't be needed. Thus models are habitually used to represent "realities" that we have no way of accurately assessing. The uncomfortable reality is that we've created regulatory frameworks – TMDLs especially – that are far beyond our technical capability.

Models, Smith and Knopman acknowledge, are "imperfect representations of reality." Another way of putting it is that models are, in fact, misrepresentations of reality. By how much they misrepresent, and in what ways, is unknowable. Because of the inherent complexity of natural systems, we do not even know all the parameters involved in creating an environmental outcome, and have a woefully incomplete understanding of even those parameters of which we are aware. Models are appropriately used for analytical purposes, to test hypotheses, not to draw firm conclusions – that is the basis of Konikow and Bredehoeft's (1992) legitimate skepticism. "It is natural," they write, "for people who apply ... models, as well as those who make decisions based on model results, to want assurance that the model is valid ... Case histories of model applications ... illustrate that calibration produces a nonunique solution and that validation, *per se*, is a futile objective ... The terms 'validation' and 'verification' are misleading and their use ... should be abandoned ..." Such terms, they object "tend to lend undue credibility to a process that ... is, in the end, inherently subjective." Konikow and Bredehoeft conclude that a "... competent and reasonable scientist may declare a model as validated while another may use the same data to demonstrate that the model is invalid."

In their critique, Smith and Knopman simply ignore the caveats and skepticism of Konikow and Bredehoeft and Whittemore and Beebe regarding the inherent subjectivity of models and the potential for their abuse. These are the legitimate concerns of experienced and accomplished practitioners of modeling, and ignoring them, or choosing to remain silent about them, will not vitiate them.

Finally, I reiterate the ultimate point of my article: Models are not a substitute for knowledge of the real world, and the only reliable way to attain such knowledge is through intensive, long-term monitoring. I have no intention of discrediting or disqualifying models as legitimate tools for water resource management. I do certainly intend, however, to oppose vigorously the use of models that are created *ex nihilo* as well as the inappropriate representation of model output to the public as a reliable substitute for reality.

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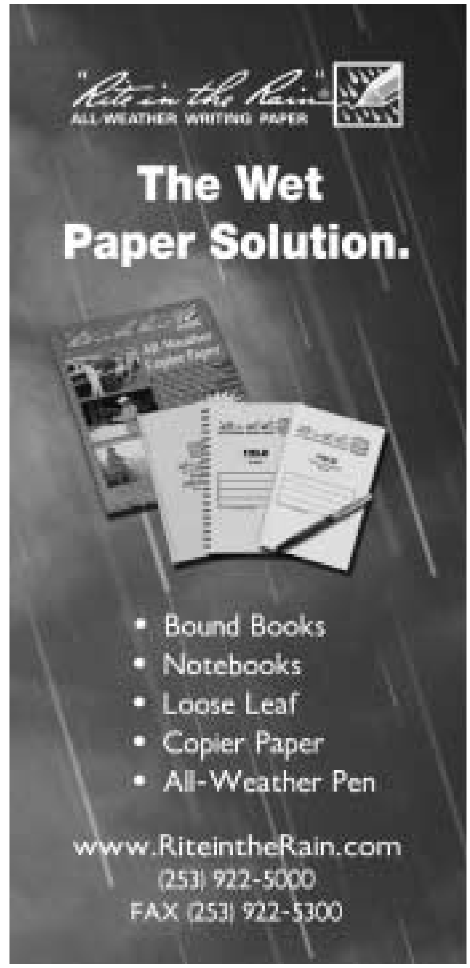

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