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Defining the Riparian Zone: Lessons from the Regulation of Wetlands

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Abstract: The regulation of wetlands has demonstrated many of the problems that may arise in the creation of regulatory systems for the protection or management of riparian zones. A regulatory definition of any specific ecosystem type, such as the riparian zone, should have a scientific foundation, but typically cannot be found in the scientific literature because scientists have put little emphasis on formal definitions of ecosystem types. A regulatory definition will be most useful and enduring if it is scientifically defensible, applicable in the field, and succinct. For the riparian zone, as for wetlands, potential elements of a regulatory definition include hydrology, soil (substrate), and vegetation (biota). It seems unlikely, however, that either biota or substrate will be as useful in defining riparian zones as they have been in defining wetlands. On the other hand, hydrologic definitions are more practical for riparian zones than they are for wetlands. Regulatory initiatives should consider recurrence interval analysis, and particularly the 100-year flood zone, as a means of defining riparian ecosystems, particularly for rivers of moderate to large size. For very small streams, this approach can be supplemented with a minimum distance criterion or a rule of thumb based on channel width.

INTRODUCTION

The Earth's environment consists of air, water, and land. The first ambitious federal attempts to protect environmental resources in the U.S. began with air and water, but did not extend to land. Thus the Clean Air Act and the Clean Water Act have no terrestrial counterpart. This is somewhat illogical, given that air, water, and land are connected, and cannot be managed or protected independently of each other.

Federal lawmakers have avoided dealing broadly with the terrestrial component of the environment for several reasons. First, air and water differ from land in that they move readily across sociopolitical or legal boundaries. Thus it is easy, and actually unavoidable, for society to accept some centralized protection of these resources for the common good. Land, in contrast, stays put, can be owned outright, and is the cornerstone of personal property rights. Thus public resistance to governmental control of land is much greater than public resistance to governmental control of air or water.

It seems unlikely that the United States will ever adopt land-use regulations that cover all lands in the same way that the Clean Air Act and Clean Water Act cover all air and water. At the same time, two decades of intensive environmental regulation have shown that land use is inevitably relevant to the protection of air and water, and particularly of water.

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The unavoidable connection between water quality and land use has opened a new era of federal land-use regulation in the U.S. The first phase of this new era began with promulgation of federal laws and executive orders that were intended to prevent the destruction of wetlands (NRC 1995). The justification for these laws and orders has been in large part the importance of wetlands in the maintenance of water quality.

Wetlands often occupy the junction between uplands and surface waters. They process organic matter, remove sediments and nutrients, and hydraulically moderate the flows of water from upland to surface water (Mitsch and Gosselink 1993). As wetlands are removed, the quality of surface water tends to deteriorate.

From the ecological point of view, wetland regulation is focused on a particular ecosystem type (wetland) that presently accounts for about 5 percent (originally as much as 9 percent) of the landscape area of the lower 48 states (Dahl 1990). Thus wetland regulation does not even approach total federal control of land use, but it does create a precedent—which may be much feared or much welcomed, depending on one's point of view—for selective federal control of land use by ecosystem type.

While wetland ecosystems are more directly connected to the maintenance of water quality than any other ecosystem type, riparian ecosystems are very similar to wetlands in their influence on water quality. Riparian zones account for a small percentage of U.S. land area (about 5 percent for the 48 contiguous states: Brinson et al. 1981). Riparian zones, like wetlands, have been altered significantly; only about one-fifth of the original total can now be considered unimpaired (Brinson et al. 1981). If there were a logical progression in the regulation of ecosystem types for maintenance of water quality, it would lead from wetlands to riparian zones. The progression may or may not occur at the federal level, but it is already clear that many states consider the protection of riparian zones to be critical to the maintenance of water quality within state boundaries, and have adopted or are considering laws that accomplish this end (Hunt 1988). This conference proceedings is an example of the kind of analysis and discussion that will precede the adoption of protection systems for riparian lands in many states.

The challenges to riparian zones differ from state to state. In the case of Minnesota, which is the focus of this conference, motivations for protection outside urban areas include particularly forestry, which may be only a minor consideration in other states that face questions related more to grazing or cultivation of row crops.

As states consider the adoption of regulations that are intended to maintain water quality or other environmental amenities through the protection of riparian lands, they will face many of the same questions that have confronted individual states and the federal government in the regulation of wetlands. The premise of this paper is that the national experience with regulation of wetlands is a source of guidance for the emerging efforts to protect riparian lands.

Differences Between Riparian Lands and Wetlands

Riparian lands have sometimes been considered a subset of wetlands. No reasonable definition of wetlands, however, could include all riparian lands (NRC 1995). The confusion arises in part because some riparian zones are rich in wetlands, or consist mostly of wetlands. For example, the riparian zone along the lower Mississippi River is mostly composed of wetland (Clark and Benforado 1981). In contrast, streams of the western United States have well-defined riparian zones, but only small portions of these zones can be classified as wetland (NRC 1995). Perhaps intermediate between these extremes are the small streams and rivers of the northern half of Minnesota, where the riparian zone contains many wetlands, but cannot be classified entirely as wetland.

In general terms, the riparian zone is an ecosystem type that lies adjacent to surface water and reflects the influence of its proximity to surface water (Malanson 1993). In contrast, wetlands are ecosystems where water remains at or near the surface of the substrate for periods of time of sufficient duration and frequency to induce the development of characteristic physical and chemical conditions corresponding to prolonged and frequent inundation (NRC 1995). While riparian zones, like wetlands, are subject to saturation or inundation, they are not necessarily saturated with great frequency or for prolonged intervals. In addition, riparian zones do not include all wetlands; wetlands may occur outside riparian zones where groundwater maintains saturation of the soil for prolonged intervals in the absence of surface water. Thus riparian zones and wetlands overlap spatially, but are by no means identical (Figure 1).

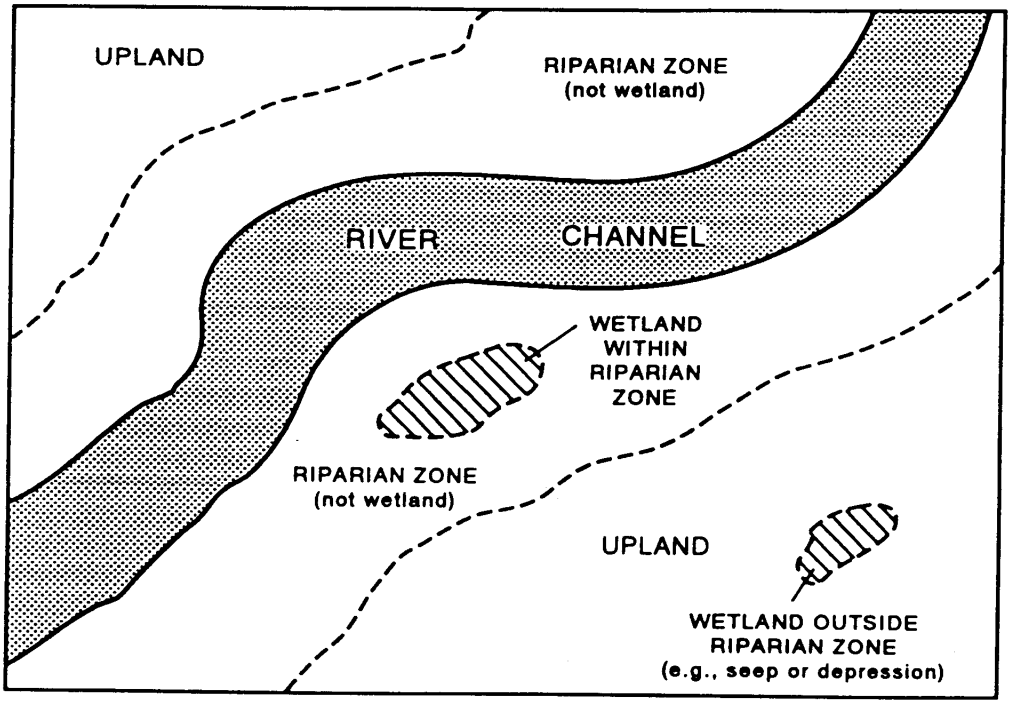

Figure 1. Illustration of spatial overlay between wetlands and riparian zones. Riparian zones are not wetlands but may contain wetlands; wetlands may occur outside riparian zones.

SOME CHARACTERISTICS OF RIPARIAN ZONES

Any vegetated strip of land adjacent to surface water has great potential to slow the passage of dissolved or particulate material, or of the water itself, from upland to surface water (Pinay et al. 1990). Thus riparian zones protect the quality of surface water. Under some circumstances, particularly involving the presence of wetlands in the riparian zone, the passage of dissolved and particulate materials across the riparian zone is sufficiently slow that a considerable amount of entrapment or biogeochemical processing of dissolved and particulate matter occurs in transit. These mechanisms are especially important for the maintenance of water quality.

Discharges that exceed the bankfull capacity of a stream or river are absorbed by the riparian zone, which includes the floodplain. A natural or seminatural vegetative cover in the riparian zone reduces the destructive effects of over-bank flow (Gordon et al. 1992). In spreading and slowing flood waters, and in storing water when it is abundant, riparian zones moderate both high and low extremes of the hydrograph.

Riparian zones also have numerous effects on the quality of the adjoining aquatic habitat. Shade, bank stability, habitat diversity, and biotically beneficial coarse organic debris are some of the benefits that vegetated riparian zones offer adjacent surface waters (Harper et al. 1995).

The riparian zone supports distinctive communities of plants and animals. Some riparian species, such as waterfowl, have value for commerce or sport, while others are simply part of the natural biotic diversity of the United States. Either of these categories of organisms has societal value that must be attributed in part to the presence of the riparian zone.

THE PROBLEM OF DEFINITION

The riparian zone has been recognized as a distinctive element of the landscape in North America for more than a century (e.g., as "overflowed lands" in federal legislation: NRC 1995) and probably in a less explicit way even in pre-Columbian times. There is, however, no broadly used formal definition of the riparian zone, either in law or science. The federal government, which has legally defined wetlands (NRC 1995), has not defined the riparian zone because it has not attempted to regulate the riparian zone as a whole.

One might expect scientists to be able to offer a commonly accepted definition of the riparian zone. This is not the case, however, because scientists do not put much emphasis on formal definitions unless they are encouraged to do so by a societal need such as a law or regulation. This was the case for wetlands, which were defined only very loosely by scientists until the adoption of federal wetland regulations, which forced scientists to accept the task of agreeing on formal criteria for the definition of wetlands. Scientists who have specialized in the study of riparian zones have not yet seen the necessity to produce a common scientific definition of the riparian zone.

Various states and working groups, as well as some federal agencies, have grappled with the question of definition for the riparian zone. Two definitions have been used numerous times, and are a good starting point for a discussion of definitions (Hunt 1988). First, the riparian zone can be defined generally as an ecosystem or landscape zone that lies adjacent to surface water and that shows the effects of its proximity to surface water. Second, the riparian zone can be defined as the land lying within the extent of the 100-year flood around any surface water.

THE DIFFERENCE BETWEEN USEFUL AND FRUSTRATING DEFINITIONS

In order to stand the test of regulatory use, legal challenge, and public scrutiny, a definition of the riparian zone or any other landscape feature must be scientifically defensible, feasible for application, and succinct. The value of each of these attributes is well-illustrated by controversies surrounding the definition of wetlands.

The merits of scientific defensibility in a definition seem patently obvious. Even so, this attribute may be quite difficult to achieve. Scientists, of course, are taught from their earliest days as students to maintain their independence, and they tend to resist standardization of their ideas in the form of formal definitions. Even so, much evidence shows that scientists can be induced to agree on definitions, while perhaps grumbling about minor points, in the face of a societal need (NRC 1995). The ultimate problem in maintaining the scientific validity of a definition is not with scientists, but rather with politicians.

In the long run, the regulated public is best served by definitions that are technically or scientifically defensible. In the short term, however, political expediency may dictate that the meaning of a technical term be influenced by political objectives. For example, the 104th Congress, as it has considered various versions of bills intended to reform the regulation of wetlands, has debated whether or not scientists have any business whatsoever defining things such as wetlands (Lewis 1995). Some members of Congress maintain that any term can and should be defined by Congress according to its own goals and purposes. The counter argument, which has been given by the National Research Council Wetlands Committee in its congressionally mandated wetlands report (NRC 1995), is that the constant redefinition of technical terms for political purposes hopelessly muddles the triangular communication that must occur between technical experts, legislators, and the regulated public.

Putting definitions in the hands of scientists or technical experts does not endow them with power over the law, contrary to the claim of legislators who favor legal fiat as a means of defining technical terms. Wetlands, for example, can be defined on a scientific basis. Lawmakers can then decide whether they wish to protect all wetlands, or whether they wish to protect only certain classes of wetlands. Thus legitimate use of political compromise need not interfere with the maintenance of scientifically sound definitions that promote easy communication and common understanding. We should seek a separation between the technical or scientific work of making a definition, and the political work of applying the definition to a societal problem.

A purely technical approach to definitions presents difficulties of its own, however. Feasibility in application is the greatest challenge for the technical expert. For example, a scientifically correct definition of wetland could be based exclusively on hydrology. Unfortunately, the requirements for applying a definition based entirely on hydrology are extremely unrealistic (NRC 1995). Hydrologic definitions are inherently probabilistic, and must be evaluated over a period of many years for a particular site. Hydrologic records for individual sites typically are not available for a single year, much less a long run of years. Thus a feasible definition must invoke not only hydrology, but also strong correlates of hydrology (hydric soil, hydrophytic vegetation) that can be evaluated on a site-specific basis for regulatory purposes. Similarly, definitions of the riparian zone must be feasible in order to be useful in a regulatory context.

The push for technical correctness may also lead to excessive elaboration in definitions, which may not be any more useful or valid than simple ones. Elaboration supposedly resolves ambiguities in definitions. Typically this is not the case, however, in that each elaboration in a definition in turn produces further ambiguities, which demand other elaborations, and so forth. Regulators are accustomed to making common-sense application of definitions, and typically can be counted on to develop reasonable guidance or protocols around a simple definition; they should be allowed to do so under appropriate review.

Where the Wetland Analogy Fails

Formal definitions of wetlands acknowledge hydrology as a cause of wetlands, and accept certain characteristics of soil and vegetation as reliable indicators of the existence of wetland hydrology. Given the great amount of effort and expertise that has gone into the formulation of these definitions, it is tempting to follow the same track in defining riparian lands. A point-by-point comparison of wetlands and riparian zones will show why this approach fails.

Hydrology

For both wetlands and riparian zones, hydrology is the primary cause or explanation for distinctive ecosystem features. Definitions of wetlands hinge on three aspects of hydrology: duration of saturation, frequency of saturation, and proximity of water to the surface. For a wetland to form, soil must be saturated with water for a sufficiently long period of time to induce a distinctive biological response (i.e., development of a community specifically adapted to soil saturation). Furthermore, saturation must occur with sufficient frequency to sustain the distinctive community that it causes. Finally, the zone of saturation must correspond to the biologically active zone within the soil (approximately the upper one foot).

For riparian zones, the critical hydrologic conditions are different. Flooding is one feature of the riparian zone, but it need not be particularly frequent in order to contribute to the maintenance of a characteristic biotic association near a surface water. Flooding even at very long intervals may remove some kinds of vegetation, deposit alluvial materials that are highly suitable for some organisms and not suitable for others, and cause the germination or propagation of specialized riparian species (e.g., Friedman 1993). Proximity of groundwater to the surface plays a role because riparian vegetation may be encouraged by or dependent upon phreatic water, particularly in arid climates. In other instances, riparian zones, particularly those that include large amounts of wetland, may exclude plants that are intolerant of prolonged saturation within the root zone. Thus the hydrologic considerations are similar to those of wetlands, but the boundary conditions (thresholds) are different: riparian zones are recurrently inundated by surface water, but not necessarily in most years or for extended intervals.

Biota

Biotic associations are reliable indicators of hydrologic conditions leading to the formation of wetlands, except where hydrology has been changed in the recent past. The same will sometimes be true of riparian zones, particularly where the riparian zone contains large amounts of wetland or is located in an arid region (Stromberg 1993). In general, however, the biotic distinctions between riparian zones and adjacent uplands will be far less well-defined for riparian zones than they will be for wetlands, because the threshold frequency and duration of saturation or inundation is less for riparian zones than for wetlands.

Plants that live in wetlands must be adapted to prolonged and frequently recurrent saturation within the upper rooting zone. Only about 30 percent of the plant species within the United States can withstand prolonged and frequent saturation of the upper root zone (Reed 1988). Thus the vascular plants of wetlands are quite distinctive, and this leads to the use of vegetation analysis in the setting of boundaries for wetlands. Riparian zones are adjacent to surface water and are influenced by surface water, but the degree of influence is less extreme than for wetlands. Many parts of riparian zones are not saturated with sufficient frequency or for sufficient duration to exclude species that are found on adjacent wetlands. The riparian zone may contain exceptional numbers of species that require shallow groundwater (e.g., willow, cottonwood, alder), but may also contain an abundance of species that do not have any special requirements for phreatic water. The vegetative association will show the historical influence of floods, but the evidence for this may be subtle (Malanson 1993).

The problem, then, is that the vegetative associations of riparian zones often will be less distinctive and less clearly bounded than those of wetlands. This means that the use of plant community analysis to mark the boundaries of riparian zones will not be feasible in many locations. The same is true for the animals and nonvascular plants of riparian zones: they may differ from those of adjacent uplands, but often only in subtle ways that will be difficult to use for setting boundaries. Thus while we value riparian zones for their exceptional ability to support biotic diversity, the use of biotic communities for finding the boundaries of riparian zones will probably be too difficult to be practical in many settings.

Substrate

Wetlands are often characterized by hydric soils, which share a suite of characteristics called hydrogeomorphic features and a characteristic range of chroma (brightness) that can be diagnosed in the field (NRC 1995). The cause for these distinctive features in soils is prolonged and frequent saturation of the soil with water. For example, prolonged and frequent saturation at or near the surface leads to the accumulation of organic matter and the liberation of iron in reduced form that is subsequently oxidized in a way that produces mottling of the soil.

The substrates of riparian zones often reflect the influence of flooding, but not always so. Along large rivers, extensive alluvial deposits, some of which may not even be classifiable as soils, mark the extent of flooding at various intervals of recurrence. The use of these alluvial deposits for marking the boundaries of floodplains is problematic, however. Alluvial deposits may mark an extent of flooding that is not relevant on a 100-year time scale, for example, or that does not correlate with a present floodplain or riparian flora and fauna. In addition, soils along small streams may show little evidence of flooding because headwaters often carry only small amounts of alluvial materials, and for this reason are less likely to mark flood zones with alluvial deposition. Thus while substrate may prove to be useful in some situations, it does not offer the great potential for identification of riparian zones that hydric soils do for the identification of wetlands.

Another Look at Hydrology

Delineators of wetlands use hydrologic data only when absolutely necessary. The availability of substrates and vegetative associations that characterize wetlands in a reliable way usually obviates the need to evaluate hydrology directly. When evaluation of hydrology is unavoidable, as can be the case for altered landscapes, it can be quite imprecise because long-term records of soil saturation are not available in most locations.

Definition of riparian zones must be approached somewhat differently from definition of wetlands. Indicators from the biota and the substrate that are highly useful for identifying wetlands will be unreliable or very imprecise in many instances for identifying riparian zones. On the other hand, the evaluation of hydrology for riparian zones is much more feasible than it is for wetlands. Thus the direct evaluation of hydrology probably offers the most reliable basis for defining riparian zones.

Hydrology as the Basis for a Definition

The hydrologists of the United States have long kept records of the stage height and discharge of streams and rivers. Whereas long-term records on groundwater, which could be relevant to the definition of wetlands, are typically unavailable, long-term records on surface waters are commonplace and can be used, along with various statistical tools and models, in the prediction of inundation frequency for a given location in close proximity to surface waters. In fact, the business of prediction has become highly developed in connection with flood protection and projection of water storage requirements for water supply. Thus there exists not only an extensive data base, but also a highly developed technical infrastructure for estimating the extent to which surface waters influence the adjacent lands beyond their banks. For this reason, the direct use of hydrology in defining riparian zones is far more feasible than the direct use of hydrology in defining wetlands.

The hydrologist's way of projecting the frequency and amount of inundation adjacent to surface water channels is recurrence analysis (Gordon et al. 1992), which involves the use of historical data to show the frequency with which discharges of various magnitudes will occur. By use of graphical or mathematical approaches, the hydrologist can estimate the mean frequency with which an event exceeding any particular size will recur (Matthai 1990). This type of analysis gives rise to the well-known 100-year flood prediction, which is merely the magnitude of the flood that recurs with 100-year frequency as a long-term average.

The historical record of flooding for any particular site can also produce a prediction of the extent of inundation that corresponds to a flood of any given magnitude. This is the means by which maps of the 100-year floodplain are produced. The same technology could be used to produce maps of inundation at any specific frequency that might be useful in defining riparian zones.

Given that zones along a river or stream corresponding to any particular flood frequency could be mapped by use of existing technology, it is tempting to use a recurrence threshold as the basis for defining the riparian zone. The key practical problem is selection of a recurrence interval that is defensible as the threshold defining the riparian zone.

A strong case can be made for use of the 100-year recurrence interval to separate the riparian zone from the upland adjacent to it. A 100-year interval corresponds roughly to the life cycle of the most long-lived woody vegetation in much of the U.S. One hundred years is also sufficient time for a mature vegetative complex to establish itself on a riparian surface denuded by flood (Friedman 1993). Thus to the extent that floods influence the development of riparian vegetation, vegetation within the 100-year floodplain should show this influence. This is a good reason for using the 100-year threshold. In addition, the 100-year flood zone will contain the bulk of alluvial deposits of recent origin, and will typically have alluvial groundwater near the surface over much of its extent.

A happy coincidence favoring the use of the 100-year threshold for definition of the riparian zone is that the 100-year threshold is already used by a major federal program for the regulation of floodplains (Hunt 1988). The agency in question is the Federal Emergency Management Agency (FEMA), whose jurisdiction only extends to those lands within political zones that have voluntarily accepted the benefits of federal flood insurance subsidy. Within these zones, FEMA places restrictions on the development and improvement of structures serving residential or commercial purposes. The purpose of the program is to conserve public and private wealth that is lost to catastrophic flooding.

The coincidence between the FEMA threshold and the prospective threshold for defining the riparian zone comes about because the longevity of human beings and the longevity of large woody plants is about the same. Thus a critical recurrence interval for major disturbances affecting riparian vegetation is much the same as for disasters affecting riparian property. The benefit of this coincidence is that a great deal of effort has already been expended in the development of techniques for mapping the 100-year flood zone along waterways of the United States, and many of these zones have already been mapped for large rivers. Thus the definition of riparian zones for purposes other than the protection of property would be complementary to an existing federal program and technical infrastructure. An overlap in thresholds for ecological and economic protection would provide regulatory reinforcement, promote public acceptance, and offer the benefit of established technology.

Other Ways of Defining the Riparian Zone

Recurrence analysis need not stand alone as the basis for defining the riparian zone. A definition could be made less rigid by use of the 100-year flood zone as a first approximation. Documentable riparian features not lying within the 100-year flood zone could then serve as justification for extending the boundary of the riparian zone in selected areas. In addition, the smallest streams might present great technical difficulties in the mapping of 100-year flood zones, or might not show any significant overbank flooding in steep terrains. In these instances, it might be most appropriate to use a minimum buffer zone concept (e.g., 25 m) applicable to any surface water, so that the floodplain concept comes into use where it can be applied most easily.

Another approach to the definition of the riparian zone is with reference to the morphology of channels. This approach is suggested in one of the papers of this conference. For example, the riparian zone could be defined as a fixed multiple of the channel width (e.g., 10 channel widths). This approach probably is most suitable for small channels, but prone to error for wide channels. Potential problems include variability in width of the channel along a given reach of stream and topographic irregularities that cause an incongruity in the width of the riparian zone and the width of the channel.

CONCLUSIONS

The history of wetland regulation offers much hope that riparian zones can be defined in a way that is scientifically credible, applicable in the field for regulatory purposes, and sufficiently general to be robust in application from one watershed or region to another. The adoption of such a definition is a major step toward effective management or regulation of riparian zones. Whereas the direct use of hydrologic information is much more difficult and imprecise than the use of soils and vegetation for the mapping of wetlands, the opposite is probably true for riparian zones. The widespread availability of surface water records, in addition to a well-established technical basis for the prediction of inundation associated with surface waters, argues that definitions directly based on hydrologic criteria will be feasible and useful for the riparian zone. The 100-year recurrence intervals for floods offers a defensible hydrologic threshold for defining the riparian zone, and corresponds to a widely recognized and extensively documented threshold for separating uplands from portions of the landscape that are subject to recurrent inundation.

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