FORESTED WETLANDS IN URBANIZING LANDSCAPES

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Abstract.—While the direct conversion of wetlands to urban and agricultural uses in Florida has been reduced in the past decade, there has been a noticeable decline in quality of wetlands throughout areas of rapid urbanization. This is attributed to changes in environmental conditions like hydrologic and nutrient regimes resulting from development of the surrounding landscape. A classification of wetlands using landscape position, nutrient access, and hydrologic regime is introduced and related to sensitivity to change. Successional phasing and timing may be modified as the result of changes in hydrologic and nutrient regimes. Suggestions are given for landscape scale management that might reverse current trends of wetland loss resulting from cumulative alteration of the landscape.

INTRODUCTION

There is no question that wetlands are an important component of the landscape mosaic. Their habitat value, their role in nutrient dynamics, and their value as water detention systems have been alluded to by many individuals in a variety of publications. As a result, there has been increasing attention paid to protecting wetland ecosystems and preserving their important functions.

The State of Florida, through its "Wetlands Protection Act of 1984" (17.12 Florida Statutes) and the rules that were promulgated as a result, have all but stopped the conversion of wetlands into urban land uses and have greatly reduced their conversion into agricultural uses. The five regional water management districts and numerous local governments throughout Florida have developed policy and regulations protecting isolated wetlands that were not under State jurisdiction and have all but eliminated the conversion of these important wetlands. Estimates using U.S. Fish and Wildlife Service data suggest that between 1900 and the end of the 1970's nearly 1.5 million hectares of wetland ecosystems in Florida were directly converted to other land uses. The score card for the last year (1987), as a result of Florida's aggressive legislation and rule making, is quite different:

Category:	Acres
Permanently lost	2,366
Created	2,480
Enhanced	3,026
Permanently Protected	20,299

Source: Florida Department of Environmental Regulation, 1987. With Proper education and continued attention given to the importance of wetland ecosystems, the successes of Florida can easily be duplicated in other States and regions throughout the United States.

However, the protection of wetlands is not simply a matter of eliminating direct conversion to other land uses. The question of wetland loss has become one of degree and timing and no longer one of direct conversion. Increasingly, we have begun to witness the continued deterioration of the quality of wetlands that have been "saved" from conversion and have been incorporated into the urban fabric of rapid growth areas of Florida. Our recent experiences suggest that loss of wetland function and "slow" conversion through changes in surface water and groundwater hydrology and regional nutrient dynamics may be having as severe a consequence as simple direct conversion, only much less noticeable. The implications are serious. The quality of wetlands in rapidly urbanizing landscapes has been greatly compromised and while they still exist after the wave of development has passed them by, their very existence in the long run is questionable.

In this paper the impacts and consequences of urbanization on wetlands are explored, and several long term solutions to the serious implications of recent trends observed and measured throughout rapidly urbanizing areas of Florida are given.

CUMULATIVE IMPACTS OF URBANIZATION

Wetland Community Types

The impacts of development on wetland ecosystems have different consequences and magnitudes depending on the type of community, its position in the landscape, and the development action. Illustrated in Figure 1 are various wetland community types arranged according to nutrient regime and hydroperiod. Since wetlands represent a point of convergence in the landscape, the size of the watershed governs the amount of water and nutrients that are concentrated within the wetland.

Bayheads and bogs, with little or no watershed rely almost exclusively on inputs of rain water or, in some cases, groundwater seepage. Cypress ponds and flatwood marshes have some drainage from the surrounding landscape with increased nutrient concentrations and hydroperiods. Where watershed area is equal to or slightly greater than the area of the wetland, still larger nutrient concentrations and longer hydroperiods are characteristic. Sloughs or strands develop in low relief landscapes where surface waters from a larger

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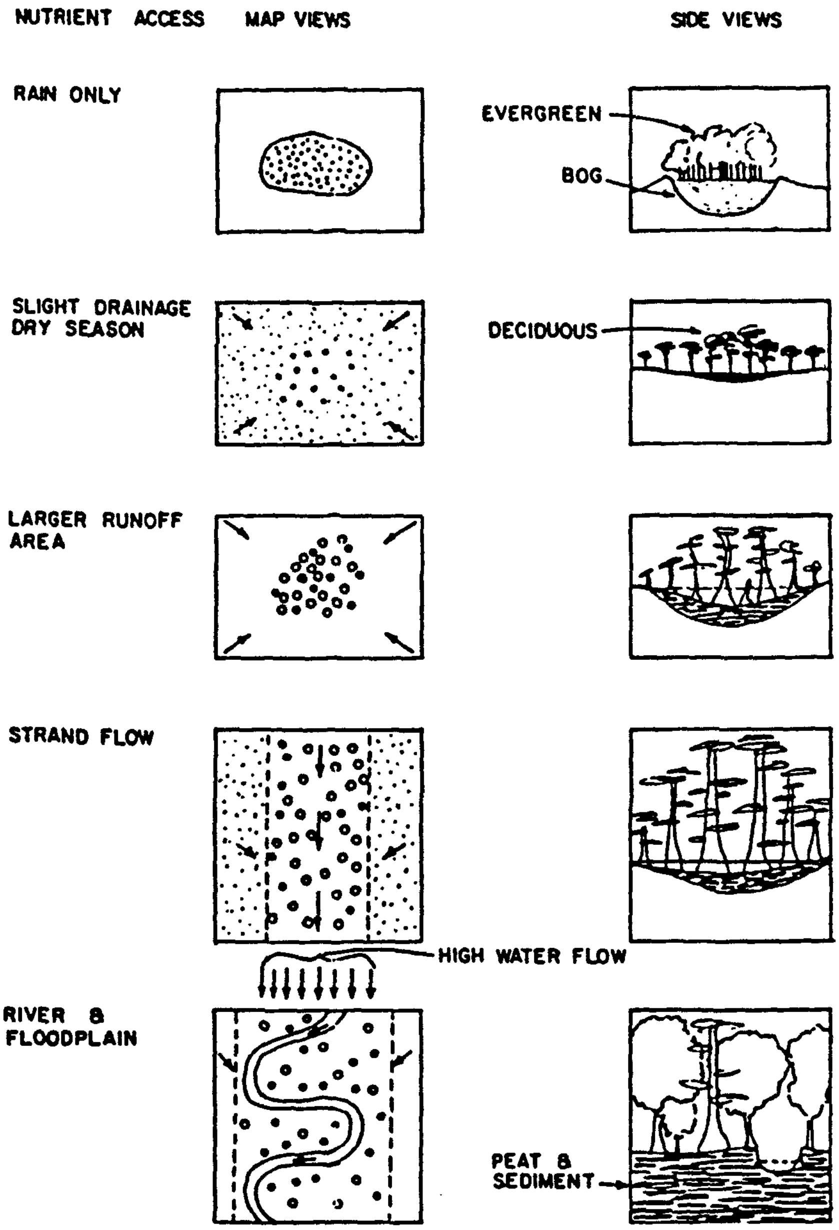

Figure 1.—Landscape position related to nutrient access and water flows. Wetlands are arranged according to nutrients and water from lowest (top) to highest (bottom). In effect, the ranking also suggest sensitivity to modifications to nutrient and hydrological regimes, where most sensitive wetlands are at the top of the diagram. (from Odum 1984)

watershed converge in broad sluggish flows in ill-defined channels. River floodplain forests result where watershed areas are quite large and where highest water flows and nutrient access are characteristic.

Productivity and structural properties of wetlands are related to nutrient loads and hydroperiods. Bogs and bayheads, at the low end of the spectrum, tend to have low species diversity and lower overall biomass, while river floodplain forests have much greater biomass and diversity of species. Thus landscape position, in general, directs availability of nutrients and water and, more or less, the type of wetland community that may develop. Certainly other factors like frequency of drought and fire have an organizing influence and may alter community type and species composition.

Figure 1 can also be thought of as a diagram of wetland sensitivity. Wetlands near the top of the figure have driving energies of lower magnitude and flux than those toward the bottom and are more apt to show signs of community reorganization under a given impact. Low nutrient wetlands with relatively small hydrologic variation are easily disrupted with minor alteration in hydrologic regimes in the surrounding landscape. Whereas minor modification of hydroperiod and depths of inundation of floodplain wetlands usually has relatively inconsequential effect on community structure.

Table 1 lists wetland community types found in central Florida and several of their most important characteristics. The communities span a wide range of environmental conditions; probably the single most important of which are hydroperiod and depth of inundation. Water depths and the duration of flooding within wetlands seems to have a greater organizing influence on community structure than other factors. Changes in hydrologic regime, then, can shift community structure toward an assemblage of species that are better adapted to the new conditions. In some regions where introduced (exotic) species are prevalent, the new hydrologic regime often increases the invasion of introduced species that are better adapted to the new conditions.

In landscapes dominated by humanity, hydrologic regimes are often altered to accommodate changes in land use. In low lying areas and landscapes of low relief, drainage works are often constructed to lower groundwater tables and as a means of managing the increased volumes of storm water that result from increased impervious surface. In higher relief landscapes, storm water systems route increased volumes of runoff to downstream areas increasing magnitude and shortening duration of hydroperiods. These changes usually are accompanied by changes in nutrient availability. In all, urbanization changes hydrologic and nutrient regimes in the local landscape; in some instances decreasing depths and duration of flooding and nutrient availability and in others, increasing water levels and nutrient concentrations.

Modification of the landscape to accommodate development, while not directly infringing on wetland communities, often has long term impacts as the hydrologic regime shifts in response to the characteristics and requirements of urban land uses. In recent studies of created wetlands in central Florida (Brown et al. 1988), a series of undisturbed wetlands were needed as controls. After surveying wetlands within the study area, it was quite obvious that disturbance increased with proximity to urbanizing landscapes. The more urbanized the surrounding area, the lower the "quality" of the reference wetland.

A Landscape Perspective of Wetland Succession

The classic view of wetland succession starts with open water and proceeds through marshes, shrub swamps, forested swamps, and finally mixed hardwood forests. While this may seem to make intuitive sense, the actual process may be quite different.

Table 1.—Characteristics of wetlands in north central Florida (from Brown and Starnes 1983)

	Hydric hammock	Mixed hardwood swamp	Cypress dome	Bayhead	Wet prairie	Shallow marsh	Deep marsh
Water quality enhancement, % removal							
Phosphorus	40	90	98	85	40	98	30
Nitrogen	40	98	92	85	60	97	30
Evapotranspiration (mm/day)	4.8	5.8	3.8	3.0	5.4	5.6	5.6
Hydroperiod (days)	100-150	200-250	250-300	200-250	150-200	365	365
High water (m)	0.10	0.60	0.50	0.30	0.50	0.70	1.00
Low water (m)	0	0	0	0	0	0	0.20
Maximum level (m)	0.30	1.50	1.50	1.00	1.50	2.00	2.00
Recharge potential ($m^3/m^2/yr$)	0.1	0.1	0.84	0.6	0.37	0.68	0.1
Peat depth (m)	0-0.2	0-0.5	0-0.5	0.5-0.3	0-1.5	0.5-3.0	0-1.0
Life form richness	3	4-5	4-5	4-5	2	3	3
Wildlife utilization	86	71	56	32	74	84	84
Gross primary productivity (g organic matter/m^2/day) during growing season	60	52.1	25.3	20.0	23.9	19.6	54.5

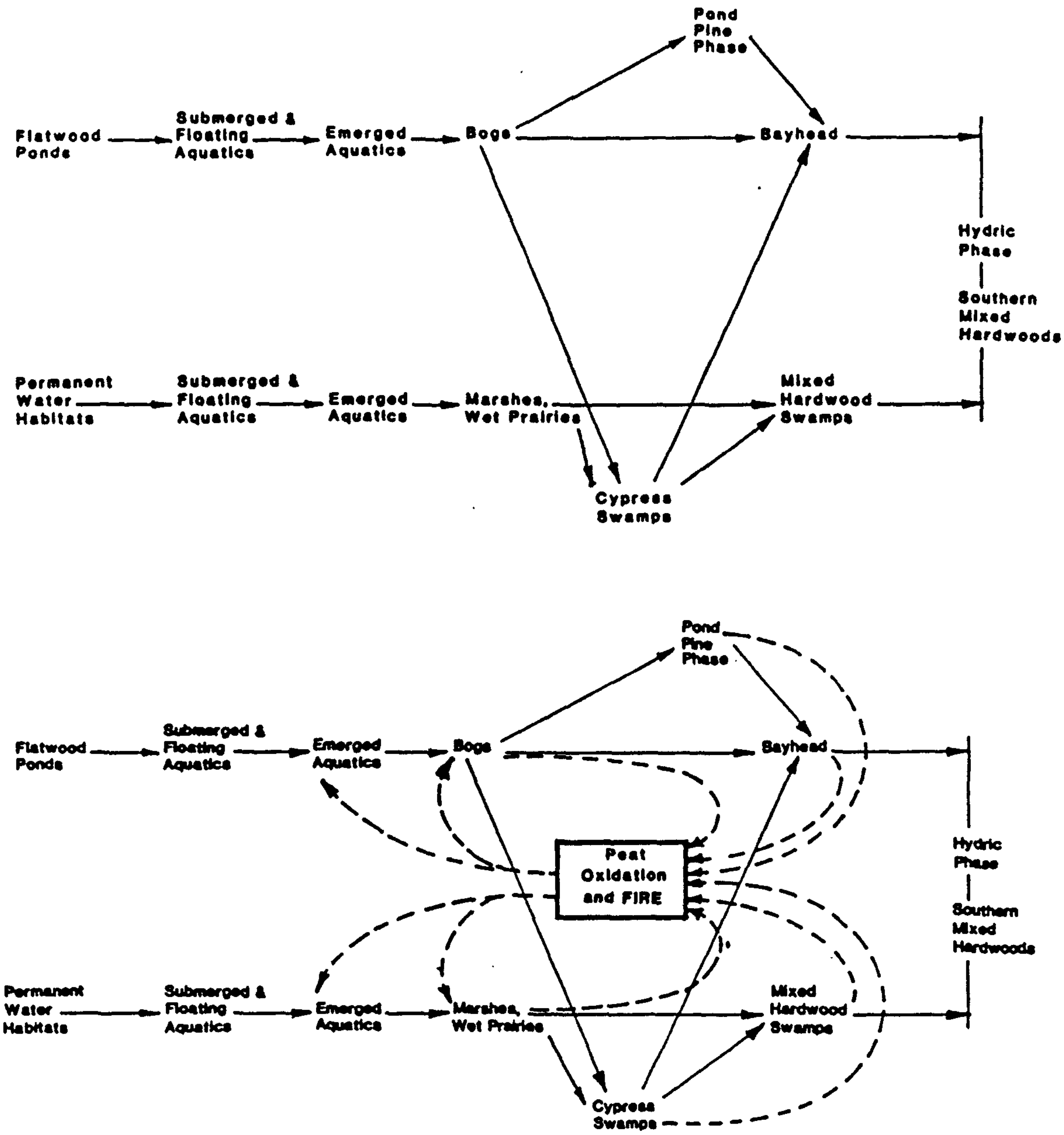

Figure 2.—Diagram (top) showing primary stages in plant succession in north-central Florida suggested by Monk (1968). The bottom diagram has additional pathways of succession toward the left resulting from drought oxidation of peat accumulations and from fire.

Figure 2 illustrates two concepts of wetlands succession in north central Florida. In the classical sense, wetland succession is said to be driven by accumulation of organic matter and a resulting slow change in depth and duration of flooding. As organic matter accumulates, the volume of water detention decreases and hydroperiod is shortened. All other things being equal, these trends would suggest environmental change that favors a shift in species composition to species better adapted to drier conditions. However, all other things are not equal. Imbedded in a dynamic landscape driven by cyclic pulses of drought and flood and occasional fire, wetlands have little chance of attaining textbook succession. In the real landscape where drought increases oxidation and the potential for fire, accumulation of organic matter to levels that would push successional trends toward drier conditions is the exception. Most probably, in the long run, accumulation of organic matter is balanced with oxidation as wetlands dry out from time to time and fire occasionally burns hot enough to kill vegetation and lower ground surface elevations in its wake.

The landscape then, is a dynamic system of driving energies and interrelated components that produces an ever changing mosaic of ecosystems in a continuum of successional stages. Add to this mosaic, human influences, and the net result is still further complexity, fragmentation, and increased cycling between successional stages.

An important consequence of fragmentation and increased urbanization of surrounding lands has been to shift wetland successional patterns. Drier conditions brought on by lowered water tables and the berming effects of roadways coupled with changes in frequency of fire occurrence, have sped up wetland succession in some cases and in others caused the system to revert to earlier successional stages. The exact consequences depends on type of wetland and combination of exogenous impacts. Where groundwaters have been lowered and the wetland protected from burning, succession tends toward the right in Figure 2. If the wetland burns, because of the drier conditions, often the fire burns deep through underlying peat, and succession is toward the left; how far left is controlled by the depth of the burn. Impoundments are less common than drainage, but where waters are impounded within a forested wetland, open water and emergent wetlands are created as the deeper water kills most trees, thus succession is toward the left.

The process of urbanization and agricultural conversion of lands seems to speed up the time constants of the landscape. Clear cutting seems to mimic disastrous fire in its ability to reverse forest succession. General drainage of the landscape seems to push wetland succession toward drier conditions. Fragmentation resulting from sprawling urbanization quickly produces island refuges of wildlife and vegetation. The mosaic of ecological communities, agricultural lands and urban places becomes increasingly fine grained with increased human use. Figure 3 illustrates this point showing changing community structure and landscape organization with increased fragmentation in a portion of central Florida over a time frame of about 40 years. What was once a landscape of sandhills dominated by a large heterogeneous wetland of cypress and marshes, has become over the years a fragmented landscape of shrub swamps and remnant swamp forests dominated by human uses. The imports shown here are less the result of direct conversion than they are of secondary impacts of ditching, draining, and roadway construction. The general pattern throughout developing landscapes is first alteration of environmental conditions through fragmentation and drainage, and then development for urban uses later when wetlands are less viable or completely gone.

IMPLICATIONS FOR MANAGING THE URBANIZING LANDSCAPE

The environmental conditions of the urbanizing landscape are quite different from those of the nonurbanized landscape. The processes of urbanization converts wildlands to urban uses leaving behind pockets of forested lands, old agricultural fields, and wetlands. Drainage works and impervious surfaces alter hydrologic regimes and in turn affect downstream and isolated wetlands. Left untouched, these remnant islands of the former landscape reorganize in response to the new conditions. The extent of reorganization depends on the magnitude of the impacts and the size of the remnant island. Larger islands have greater "buffering" capacity while small isolated systems tend to exhibit less resiliency. Managing the urbanizing landscape to insure the continued productivity and biological functions of forested patches (whether wetland or upland) may be an impossible task if the goal is to maintain these systems in some static unchanging state. Successional changes brought on by changing environmental conditions may force today's wetland toward tomorrow's upland. The loss of wetland function in itself may not be of critical concern, especially in heavily

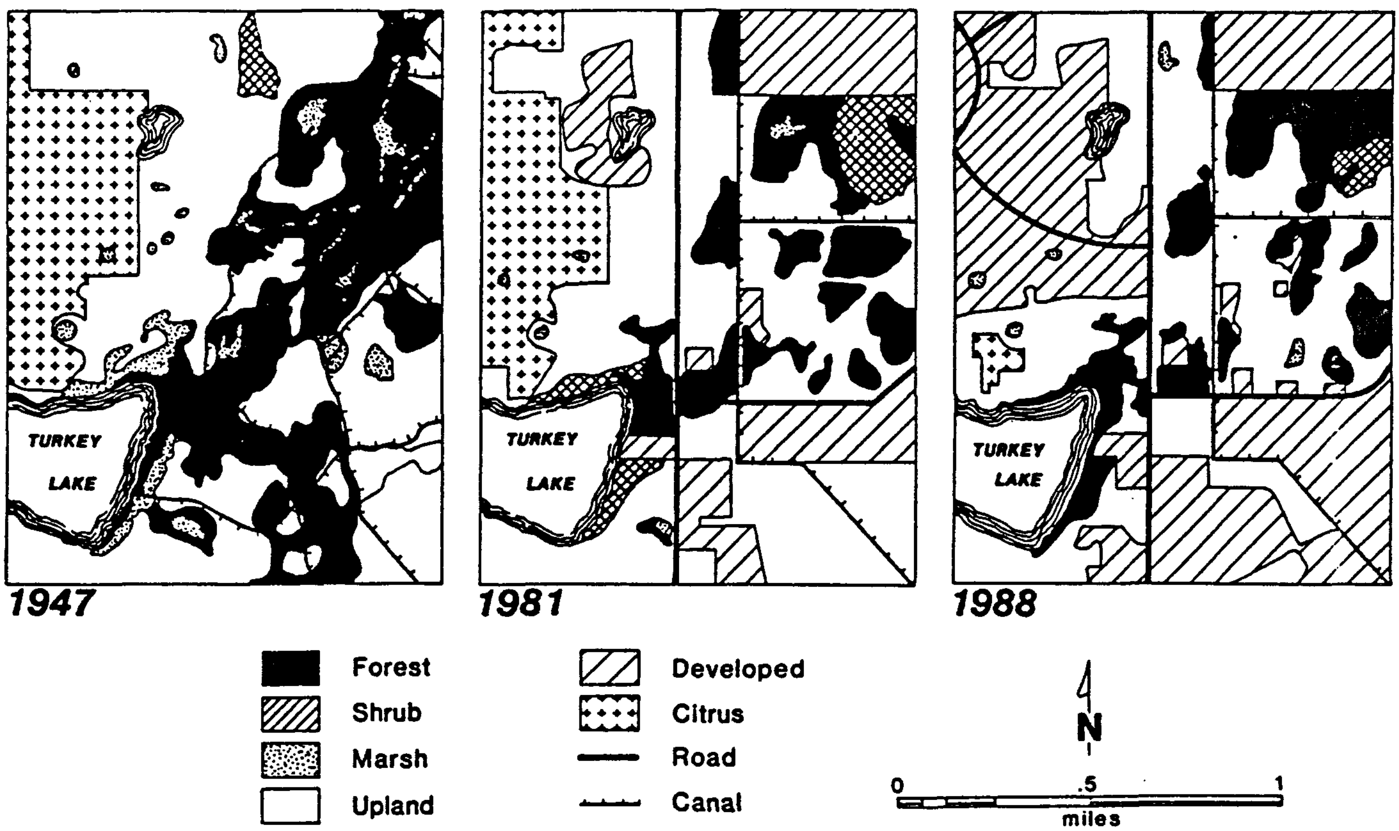

Figure 3.—Map showing the effects of development in and around an extensive wetland system near Orlando, Florida. Aerial photographs were taken from Palmer and Tighe (1988), interpretation and compilation for 1946 and 1981 by the author, wetland interpretation in 1988 by Palmer and Tighe.

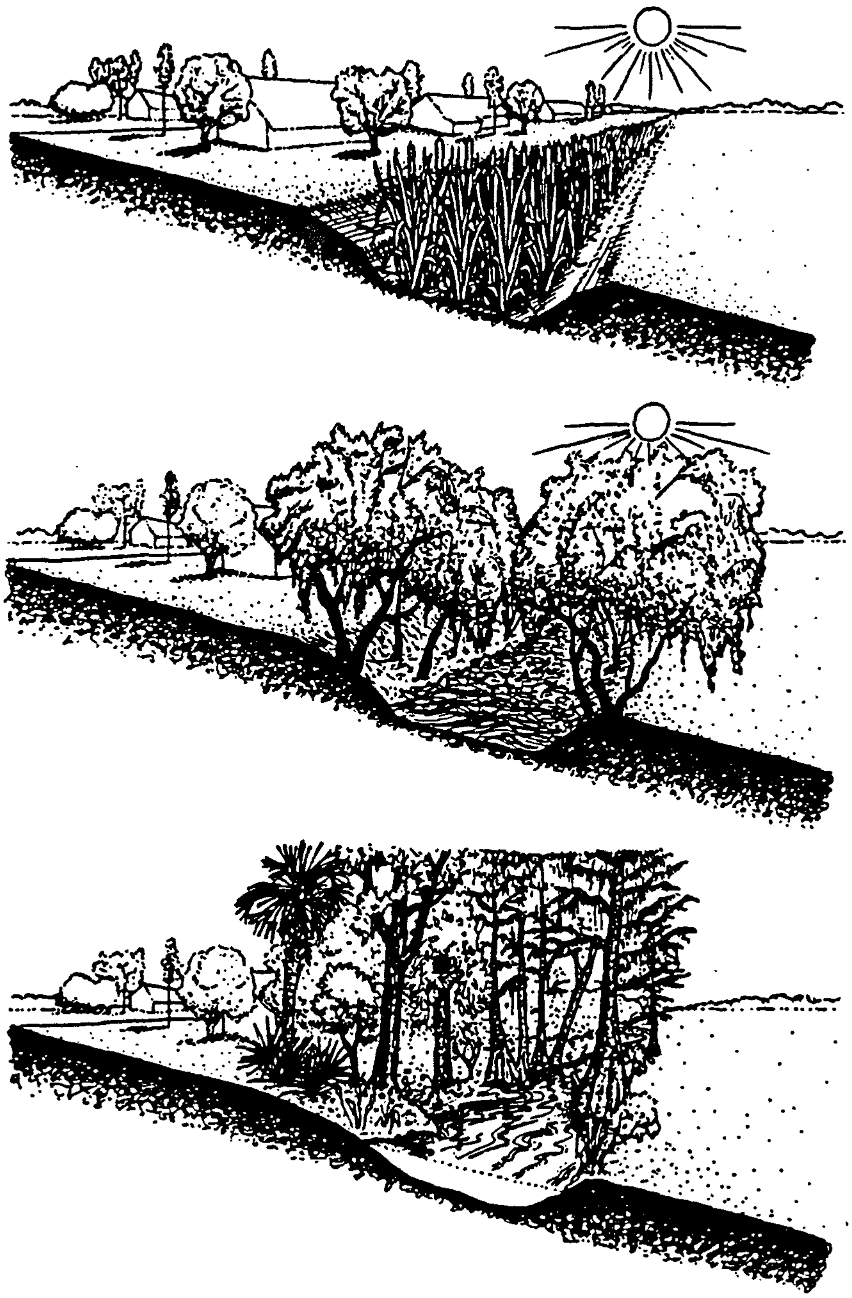

Figure 4.—Time series sequence of succession in urban drainage ditches if vegetation is allowed to colonize. Vegetation acts to retard flow through friction, yet during storm events the system can still function effectively. Once canopy is established, herbaceous vegetation is shaded out and the stream channel resembles a first order stream system.

urbanized areas, if it were not for the fact that a good bit of our regulatory effort now-a-days is concerned with sparing these systems from conversion.

The general trend throughout Florida in the past several decades has been a progressive drying out of the landscape and a consequent shift in wetland ecosystems toward drier and drier community types. While wetlands have generally been "spared" from conversion to other uses, they have not been left unchanged. The cumulative effects of a changing landscape have slowly but surely caused serious erosion in the quality and quantity of wetlands within and adjacent to rapidly urbanizing regions of the state. Public policy has long recognized the value of wetlands, and has been successful in minimizing their conversion to urban uses; however, their continued decline in quality as a result of overdrainage is little recognized. Might it be better policy to discourage overdrainage and seek ways of "rehydrating" the landscape?

To more effectively manage the landscape in the face of increasing development pressure it is imperative that the cumulative, secondary impacts of urbanization be given considerable attention and regulatory initiatives be directed at reversing current trends. To this end, the following management guidelines for urbanizing landscapes are given as a means of establishing a regulatory framework.

Educate the Public

As in most environmental programs, a sound approach to educating the public is extremely important. Public perception has long been that swamps are ok if seen on TV, but not in the backyard. Couple this with the perception that wetlands produce mosquitos and mosquitos carry disease and it is relatively impossible to convince the general public that wetlands are an important part of the urban fabric. Programs need be developed that increase public awareness of the importance of wetlands within the urban fabric.

A second area needing increased public awareness is especially important. The public has come to expect that their cities and neighborhoods will remain dry during any and all rainfall events. Storm waters are expected to drain quickly after any event, and if they do not it is cause for great displeasure. The public must be made aware of the benefits of a wet landscape, and learn to accept some standing water during the wetter times of the year.

Discourage Overdrainage

The lowering of groundwater tables to accommodate housing and roads has a wider influence than just the developed portion of the landscape. A better method of development is to elevate housing and roads and expect some flooding during extreme rainfall events. Encourage the use of vegetated and forested drainage structures (Figure 4) that act to impede surface water discharge, but allow for storm waters to discharge through meandering channels that mimic natural first order streams.

Rehydrate the Landscape

Where overdrainage has occurred, it may be possible to reverse these trends by recycling treated wastewaters back on the land instead of depositing them in surface water bodies, the ocean, or deep well injection. By encouraging landscape recycle through natural wetlands, constructed wetlands, overland flow systems, and spray irrigation systems, area groundwater tables are replenished.

Encourage the use of vegetated wetland retention systems for storm water management. Instead of grassed detention basins that require continual maintenance, wetland retention basins (Figure 5) require no maintenance, add to landscape diversity, increase wildlife habitat values, and act to hold and conserve storm waters on site replenishing local groundwater tables.

Manage Resources at the Landscape Scale

Increasingly, it has become obvious that a piecemeal approach to landscape management can only lead to an ever increasing fragmentation of the landscape. This revelation has recently lead the author to propose a concept for landscape management that incorporates the best of physical land use planning related to growth management and landscape ecology, as well as results of research related to the Florida landscape that suggest a continuing trend of environmental deterioration. The concept has been termed "Wildlands Management" and has as its fundamental objective the identification and preservation of a landscape mosaic of wildlands that are large enough to provide

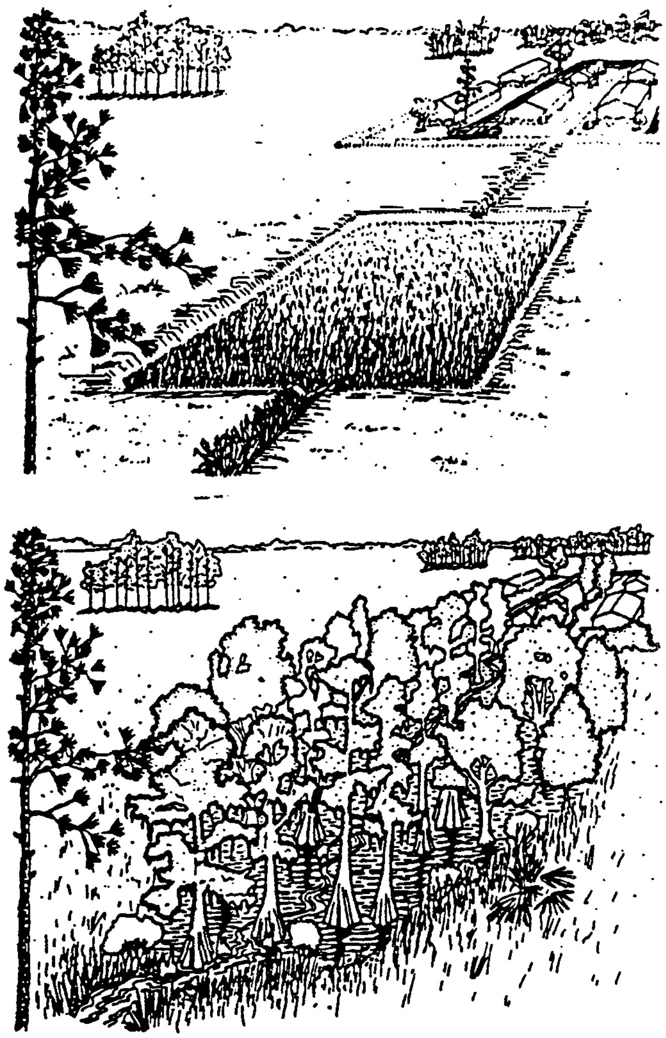

Figure 5.—An illustration of the potential of wetland stormwater retention systems. In the top diagram the retention basin is clogged with herbaceous vegetation and requires continuous maintenance, while if allowed and encouraged to develop forested canopy would be more self-maintaining.

significant wildlife habitat, are capable of suffering development impacts from adjacent lands, can contain urban sprawl and give definition to urban areas, and are ecologically diverse and relatively intact.

The motivation for Wildlands Management has developed as a result of observations of the rapid urbanization of the Florida landscape. As regions experience urbanization, small pieces of the landscape are left undeveloped either because they are "protected" or because they have been purchased for their potentials as preserves. These fragments become islands in a sea of developed land. Often resented by their neighbors, because they contain unwanted vestiges of the former landscape, these patches suffer from either neglect or overexposure. Most often they slowly deteriorate to the point that one must question if they could survive without massive doses of human management.

As long as there is development pressure, urban areas will continue to sprawl ever outward in wider and wider circles of urbanization, leaving in their wake remnants of the former wild landscape mosaic. Soon, if urbanization is complete urban centers begin to merge and the landscape becomes one dominated by developed lands with a smattering of "protected" wetlands, parks, and wildlife management areas. Not only do urban centers spread, but intensity of uses increase as urbanization continues. The greater the intensity, the less likely a remnant forested island can be maintained without significant human management.

Presumably, without a wider perspective, that is, without a landscape perspective, effective landscape planning and management that might preserve portions of the landscape mosaic as wildlands is not possible. The first stage in developing a landscape perspective is to identify mosaics of ecological communities that are relatively intact and that might serve as the beginnings of a statewide wildlands system.

The initial premise upon which wildlands management was based was grounded in the belief that a landscape perspective is absolutely necessary to achieve meaningful regulation and management of our natural resources. Past efforts to develop a landscape perspective in the face of a rapidly growing population and all its attendant infrastructural requirements have been continually frustrated by the lack of a "macroscopic," systematic approach. Resources and authority over them are compartmentalized to such a degree that it is impossible to manage the landscape and regulate its use. We manage and regulate the parts. It has long been known that the sum is greater than the parts, yet our approach to achieving some measure of control over the perceived impacts of human use of the landscape is to delegate the management of water to one agency, air to another, soil to another, wildlife to another, minerals to another, and planning of the whole thing to yet another. The wildlands management approach is an attempt to thwart these impediments to a landscape perspective and achieve consensus between the public and all agencies that the landscape must be planned and managed as a mosaic of contiguous blocks of developed lands and wildlands and not a continuous sprawl of development having remnant patches of recreational amenities. The approach can work if all regulatory agencies, developmental agencies, and the public work in tandem to develop a regulatory environment that recognizes its absolute necessity and implements a wide diversity of mechanisms to achieve it. Every mechanism of "growth management" must be utilized. Transfer of development rights, purchase of development rights, overlay zoning, green belts, transfer of mitigation requirements, impact fees, and performance zoning to name a few, can be used to implement the wildland program. There are other mechanisms, we are only limited by a lack of commitment.

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