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This paper describes the method used for selecting natural wetlands to compare with created wetlands. The results of the selection process and the advantages and disadvantages of the method are discussed.

The random site selection method required extensive field work and may have yielded fewer sites with potential for long term comparison than a more subjective approach. However, valuable information was derived on trends in wetland loss and public attitudes toward government research. Most important, the method provided a statistically defensible means of obtaining a set of sites. The data from the pilot study will estimate the variability of natural wetlands within the ecoregion. Analysis of the variability between ecoregions will be possible with similar studies in other areas of the country. These studies will give EPA a framework for setting standards for wetland creation and restoration.

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SELECTING SITES FOR COMPARISON WITH CREATED WETLANDS

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ABSTRACT

A pilot study was conducted in the state of Oregon for the US Environmental Protection Agency (EPA). The purpose of the study was to evaluate the success of wetland creation and restoration required as compensation for wetland losses permitted under Section 404 of the Clean Water Act. This paper describes the method used for selecting natural wetlands to compare with created wetlands. The results of the selection process and the advantages and disadvantages of the method are discussed.

50 natural wetlands in the Portland urban area of the Willamette Valley Ecoregion, representative of the size, type and land use of created wetlands were randomly selected from US Fish and Wildlife Service National Wetland Inventory maps. Field reconnaissance revealed that over 50% of the sites had already been destroyed by agricultural conversions and urban-industrial development. Landowners denied permission to sample 35% of the remaining sites. Access for sampling was granted for 15 sites, which constituted the final set of comparison sites.

The random site selection method required extensive field work and may have yielded fewer sites with potential for long term comparison than a more subjective approach. However, valuable information was derived on trends in wetland loss and public attitudes toward government research. Most important, the method provided a statistically defensible means of obtaining a set of sites. The data from the pilot study will estimate the variability of natural wetlands within the ecoregion. Analysis of the variability between ecoregions will be possible with similar studies in other areas of the country. These studies will give EPA a framework for setting standards for wetland creation and restoration.

INTRODUCTION

The Clean Water Act of 1972 was instituted to "restore and maintain the chemical, physical, and biological integrity of the nation's waters" (Paulson 1985). Section 404 of the Act regulates disposal of solid materials into water bodies.

In 1977, the legislation was strengthened to give additional protection to wetlands.

The US Environmental Protection Agency (EPA) and the Army Corps of Engineers (COE) jointly administer the Section 404 program which issues permits for dumping fill into wetlands and other sensitive aquatic areas. COE is the permitting authority. EPA has power of oversight which includes responsibility for establishing environmental criteria for permit review.

Permit applications may be denied if impacts to water quality and supply, wildlife, and recreation are considered unacceptable. If wetland losses are permitted under Section 404, the creation or restoration of wetlands is often required as mitigation for the losses. The use of wetland creation and restoration as a form of compensation has increased over the years and with it, the number of projects.

EPA is concerned about the effectiveness of mitigation. The question central to the Agency's research on mitigation is "How well do created and restored wetlands replace the ecological functions of the wetlands that were destroyed?" A pilot study was conducted in the summer of 1987 to test methods for evaluating and monitoring created and restored wetlands. A set of sites was needed to compare vegetation, soils, water, and topographic characteristics of natural and created wetlands. The selection of these comparison sites is discussed in this paper.

No systematic, large scale evaluation of mitigation projects has been undertaken; most studies of mitigation are case studies with no sites for comparison. Quammen (1986) reviewed studies of wetland mitigation and found that most rated the success of projects on the basis of compliance with permit requirements, or whether or not the projects had been implemented.

However, a study of created salt marshes in New Jersey (Shisler and Charette 1984) used paired reference sites. Each mitigation project was paired with a naturally occurring wetland. Characteristics of the vegetation, sediment and macro-invertebrates of each pair were compared. The criteria used to select each reference site were proximity to the created site and similarity of age and vegetation type. The research of the COE Dredged Materials Program (Newling and Landin 1985) also used paired sites. Similarity in habitat, hydrology, ownership and level of disturbance were considered in the selection of reference sites for a long term study of habitat development at dredged material disposal sites. Since these studies relied on a limited number of sites, their applicability to a broader geographic area is limited.

Brooks and Hughes (in press) suggest using Omernik's (1987) ecoregions as a geographic framework for the selection of reference wetlands. They also recommend that reference sites should be relatively undisturbed and representative of the region and the population of mitigation sites. A modification of their approach was used for the Oregon pilot study.

A METHOD FOR COMPARISON SITE SELECTION

Goal of Method Development

EPA's wetlands Research Program has a project underway to produce a handbook for evaluating proposals to mitigate for permitted impacts on wetlands through the creation and restoration of wetlands. Regional EPA personnel need a means of determining the success of mitigation projects, without studying each one in comparison to a paired site. Ideally, the results of such studies should be applicable to a broad geographic area. The goal of this approach is to provide EPA with an analytical framework for setting regional goals for mitigation projects and verifying that these goals have been met.

Rationale For The Use of a Regional Framework

Regions are relatively homogeneous areas, defined by the coexistence of several important spatial variables (Hughes et al 1986). Ecoregions are areas with commonality in factors that either cause variations in ecosystems ,e.g., soils, climate, physiography, or integrate these causal factors ,e.g., land use (Omernik, 1987). Since there is typically less variability within a region than between regions, regions form a logical framework from which to select representative sites, design sampling schemes, analyze and evaluate data, and assess attainable ecosystem quality.

Omernik's ecoregions (1987), originally designed to aid in the classification of streams, reflect regional patterns of land use, land surface form, potential natural vegetation and soils. They were shown to be an appropriate framework for the selection of reference sites in studies of streams in Arkansas (Rohm et al 1987), Ohio (Larsen et al 1986), Minnesota (Heiskary et al 1987) and Oregon (Hughes et al 1987). These studies confirmed the integrity of the regions. Most important, they demonstrated that information from one part of a region could be extrapolated to the entire region.

Wetlands and their functions are affected by many of the same terrestrial factors important to stream function and quality. Therefore, ecoregions were chosen as the framework from which to select comparison sites.

Procedure

The approach has four steps: (1) delimiting the study area in space; (2) determining relevant stratification factors; (3) taking a random sample; and (4) conducting field reconnaissance to eliminate highly disturbed wetlands and obtain permission to sample candidate sites. The approach is first described in generic terms, then in relation to its application in the Oregon pilot study.

Delimiting the Study Area--

The locations of the created or restored wetlands (test sites) and ecoregion boundaries were plotted on 1:500,000 scale state maps. The distribution of the test sites was examined relative to ecoregion boundaries to determine which ecoregions would be included in the study.

Determining Relevant Stratification Factors--

Test site locations and ecoregion boundaries were transferred to 1:100,000 scale National Wetland Inventory (NWI) maps for comparison with US Geological Survey (USGS) topographic maps at the same scale. Sampling strata related to spatial patterns of relief, hydrographic features, vegetative cover, and urbanization were identified within the ecoregions of interest.

A grid, with each cell representing approximately 260 hectares (ha) was overlaid on the topographic map and cells falling within strata relevant to the test sites were numbered sequentially. Then the grid was transferred to the NWI map. The parent population of comparison sites consisted of all wetlands within the numbered cells of the grid, i.e., wetlands in sampling strata comparable to the test sites (Fig. 1).

Taking a Random Sample--

A randomized list of the sequentially numbered cells was generated. The sample size (number of grid cells to be sampled) was determined by calculating a progressive mean (Marsh 1978). Groups of five cells from the random list were sampled for wetlands of the size and type of the test sites and the mean number of these wetlands per cell was calculated. This procedure was repeated until the mean number of wetlands per cell did not change more than 0.1. Wetland type was determined using the US Fish and Wildlife Service's wetland classification system (Cowardin et al 1979). Wetland size was measured with a template divided into 64 cells, with each cell equal to approximately ha.

Wetlands included in the sample were numbered sequentially on the NWI maps and recorded on a work sheet by cell number. A random number generator was used to determine the order in which the numbered sites would be considered. A subset of sites was assembled equal to three times the number of sites needed, i.e., the number of test sites. Consideration of a larger number than needed was necessary, since some of the wetlands selected would eventually be eliminated due to alterations, severe disturbance or because access was not permitted.

Reconnaissance of Potential Sites--

Reconnaissance, through discussions with local wetland experts, and site visits, eliminated highly disturbed and inaccessible sites. Permission for the field crews to take samples at the site had to be obtained from the owner(s) of the land.

Application of Method to Oregon Pilot Study

In Oregon, all of the 12 test sites were located within the Portland metropolitan area which is situated in the Willamette Valley Ecoregion (Fig. 2). In addition, they were all within the most typical area of the ecoregion, i.e., the area that shares all the terrestrial characteristics which define the ecoregion (Omernik 1987). Therefore, the study area was the major metropolitan areas within the most typical area of the ecoregion, i.e., Portland, Salem, Corvallis-Albany, and Eugene-Springfield. The boundaries of the metropolitan areas were defined by the grey shading (used to denote urban areas) on USGS 1:100,000 topographic maps. Due to the distribution of the test sites, Portland was treated as one unit; the rest of the urban areas were treated as a separate unit. Theoretically, this would make it possible to determine whether a set of wetlands scattered throughout the urban areas of the ecoregion could be used for comparison or whether subregional differences within the ecoregion needed to be considered, i.e., each urban area is a unique unit.

All of the test sites in the Oregon pilot study were small (1-ha or less) palustrine emergent wetlands, i.e., marshes with emergent vegetation (Cowardin et al 1979). Therefore, all natural wetlands chosen for comparison were of the same size and type. In this paper palustrine emergent wetlands 1-ha or less in size are designated as PEM.

RESULTS

For the sake of brevity, only the results of the site selection and reconnaissance in Portland are discussed here. A total of 50 sites was randomly selected for field reconnaissance. Table 1 shows the distribution of the Portland sites by land use. In spite of the fact that the population of interest was located within urban boundaries, the land use with the highest percentage of sites was agricultural, followed by residential, commercial, industrial and publicly owned land (Table 1).

Field reconnaissance revealed that over half (54%) of the sites nad already been destroyed. Overall, the greatest losses were associated with agricultural land uses (32%). Residential development accounted for the second greatest losses, followed by industrial land use, public land development (including transportation) and commercial land use (Table 1).

Landowners denied access for field sampling in 35% of the remaining 23 sites. Denial of access was greatest among agricultural and commercial landowners, followed by industrial and residential landowners. The 15 sites to which EPA was granted access constituted the final population of sites. The distribution of these sites among the various land uses was similar to that of the original group of potential sites (Table 1). Of the 15 final comparison sites, 12 were selected for comparison with the 12 test sites.

The distribution of the final comparison sites in the Portland urban area, including associated communities, such as

Hillsboro, Beaverton, and Gresham, was similar to that of the test sites (Fig. 3). Both sets of wetlands are located in agricultural areas in the outskirts of the metropolitan area and in the newer communities of Hillsboro and Beaverton where population growth is occurring.

DISCUSSION

The pilot study will provide valuable data on naturally-occurring and created wetlands, and assist in recommending methods for conducting evaluations of such systems. Moreover, the process of site selection, in particular the field reconnaissance, has provided information critical to understanding the status of wetlands in the study area. It also provided insight into public attitudes toward government research on private land. These attitudes may profoundly influence the ability to conduct similar studies in other parts of the country.

As stated previously, ecoregions are areas that share a combination of geographic characteristics. One would expect the wetlands within an ecoregion to have greater similarity to each other than to wetlands of the same type in other ecoregions. However, it was noted in this study that there are subregional variations within the Willamette Valley Ecoregion that may account for a higher wetland density in the Portland metropolitan area than in the rest of the Valley. Portland is at a lower elevation and is closer to the floodplain of the Columbia River, the fourth largest river system in the continental United States (Willamette Basin Task Force Pacific Northwest River Basins Commission 1969). Other subregional differences in wetland structure and function may emerge when analysis of the data from the pilot study is completed. Comparison of the Portland and lower Willamette Valley populations will help to determine the extent of these differences and, therefore, the need for sets of comparison sites unique to each urban area.

The fact that greatest loss of PEM's in the Portland urban area is associated with agricultural land use is consistent with general loss patterns in the United States. According to a recent wetlands trends study, 87% of the losses between the mid-1950's and mid-1970's were due to agricultural practices (Tiner 1984).

The high rate of denial of access for sampling (35%) was a frustrating complication of the site selection process. Landowners were provided with a letter describing EPA's research and assuring them that their names and the locations of the sites would remain anonymous. However, this did not eliminate concerns. A general distrust of government research or fear that the results of the study would be used to interfere with landowner rights was often communicated.

The selection of sites for comparison with created wetlands in the Portland urban area did provide the required number of sites, i.e., equal to the number of test sites being evaluated. In addition, information derived from the field reconnaissance provided a basis for future analysis of trends in wetland loss.

The advantages and disadvantages of randomly selecting sites from an ecoregion, as opposed to some more subjective approach, should be considered before applying this method in other studies. The random selection method offers a statistically defensible means of obtaining a set of sites representing the range of wetland conditions within an ecoregion. Therefore, information from the study may be extrapolated to the total population of wetlands of the same size and type in the ecoregion. The estimate of the variability of natural systems obtained can be used as a basis for evaluating wetland creation and restoration projects and for the establishment of realistic standards for the performance of such projects within an ecoregion.

Furthermore, a quantitative characterization of the wetlands can be used to improve project design. The data can be analyzed to identify threshold values of wetland parameters where there may be a significant positive benefit for structure, and with it, a possible gain in function gain in function. For example, it may be determined that when slopes are less than a certain amount plant diversity increases dramatically and, possible, so does life support value. Such features can then be incorporated into plans to create or restore wetlands.

On the other hand, the field work involved in checking a large number of sites and obtaining landowner permission represents a major expenditure of time and funds. It took two weeks of field work for one individual to select 15 sites. Since access for sampling is always granted on public lands, it might be more cost effective to limit site selection to public lands or lands held in trust by foundations such as the Nature Conservancy. The publicly owned sites did not seem to differ qualitatively from sites on privately owned land. In addition, publicly owned sites or lands held in trust are more likely to be available for resampling at some date in the future. However, choosing sites subjectively would place the representativeness of the sites in question.

Analysis of the data from the field study will provide further insight into the considerations posed above and, as a result, the method for the selection of comparison wetlands described in this paper will be further refined.

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Table 1. Influence of wetland loss and denial of access on the size of the sample population of comparison sites available in the Portland urban area. Values are a percentage of the total number (n) of sites considered at that stage of the site selection. For example, of the 50 potential sites, 32% were destroyed by agriculture; of the 23 remaining sites, 13% of agricultural land owners denied access; of the final 15 comparison sites, 40% were on agricultural land. Categories of land use considered are: agriculture (AGR), industrial (IND), commercial (COM), residential (RES), and public (PUB). The actual number of sites in each category is in parentheses.

LAND USE	AGR	IND	COM	RES	PUB
Potential Sites (n=50)	50% (25)	10% (5)	14% (7)	18% (9)	8% (4)
Sites Destroyed (n=50)	32% (16)	6% (3)	2% (1)	10% (5)	4% (2)
Access Denied (n=23)	13% (3)	4% (1)	13% (3)	4% (1)	0% (0)
Comparison Sites (n=15)	40% (6)	7% (1)	20% (3)	20% (3)	13% (2)

Figure 1. Illustration of the grid used to characterize the parent population of sites overlaid on National Wetland Inventory (NWI) map, and two of the final comparison sites. The grid is symbolized by th. bold lines. The NWI map shows wetland types (PEMY, PFOW, etc.) superimposed on a topographic map showing roads, streams, etc. All features from the topographic map were not included.

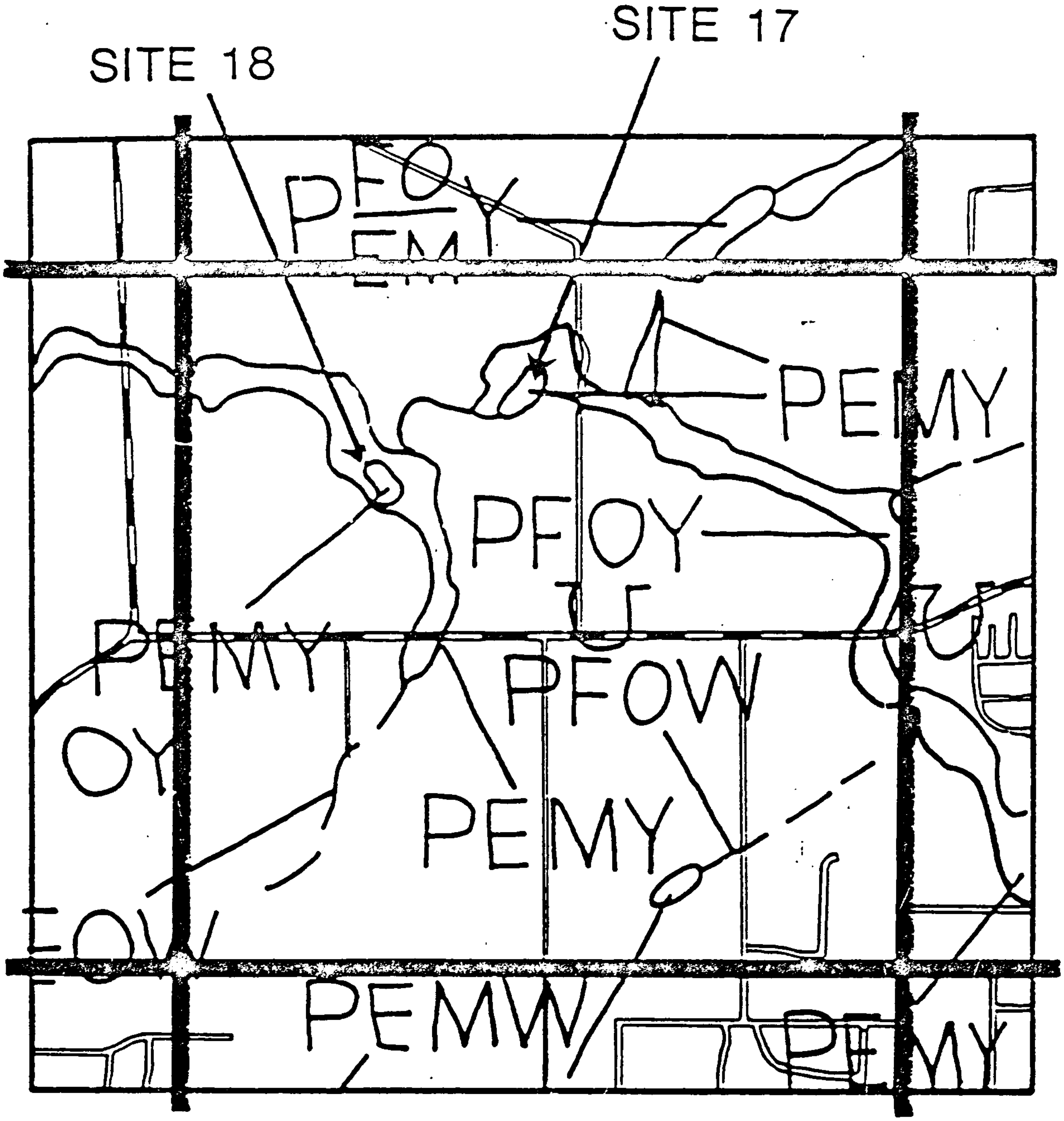

Figure 2. Location of Willamette Valley Ecoregion (after Omernik 1987) and Portland study area in Oregon.

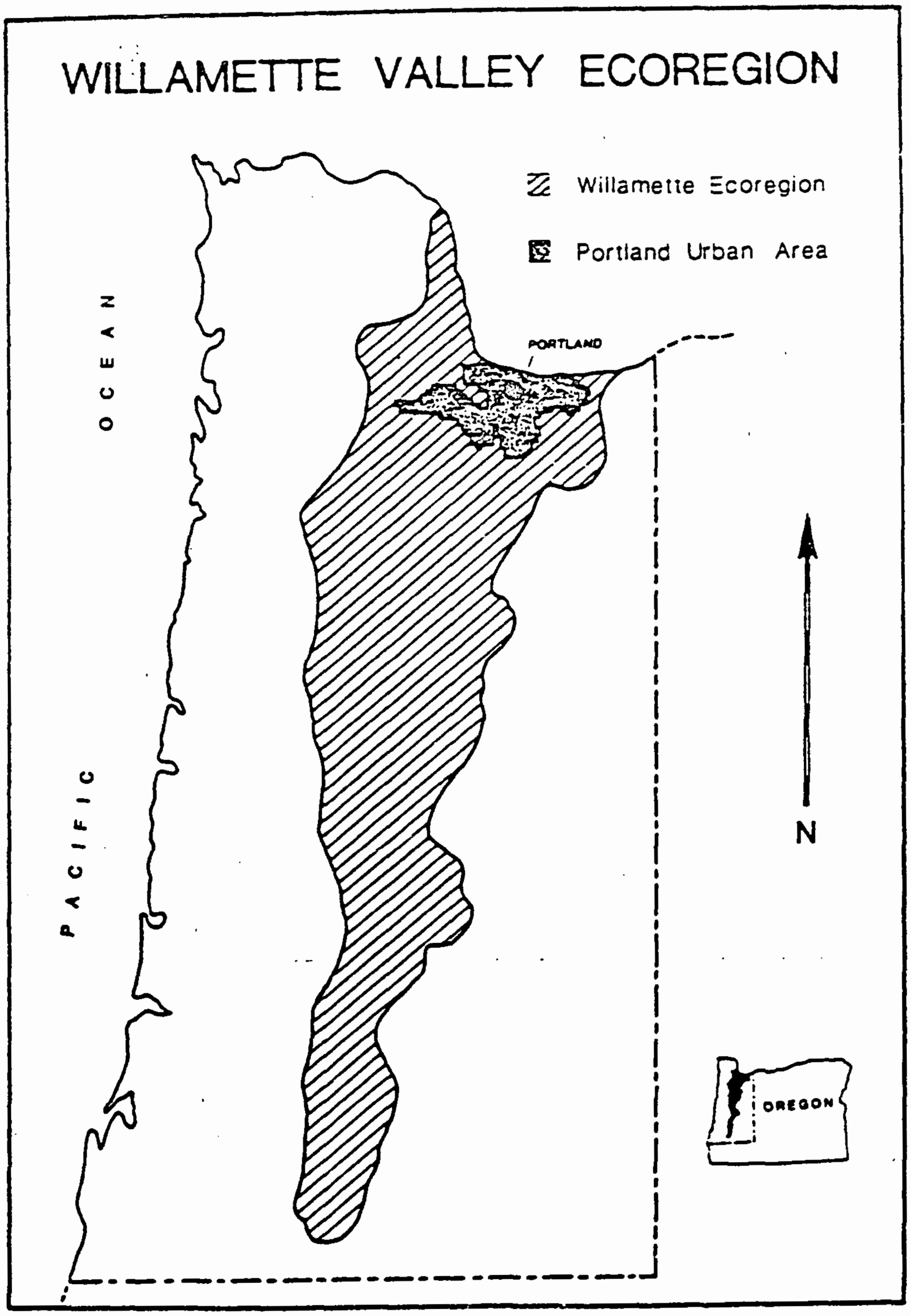

Figure 3. Distribution of test sites (created wetlands) and sites included in field reconnaissance in the Portland urban area (composed of several communities, e.g., Hillsboro, Beaverton and Gresham). Sites included in the field reconnaissance are categorized as destroyed, access denied and comparison sites. Most of the destroyed sites are located along the urban periphery (agricultural land use) and in the Hillsboro-Beaverton area where urban expansion is occurring. The distribution of test sites is similar to that of the comparison sites.