National Programs

The U.S. Fish and Wildlife Service's National Wetlands Inventory

by

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ABSTRACT.—In 1974, the U.S. Fish and Wildlife Service directed its Office of Biological Services to design and conduct an inventory of the Nation's wetlands. The mandate was to develop and disseminate a technically sound, comprehensive data base concerning the characteristics and extent of the Nation's wetlands. This data base should be used to foster wise use of the Nation's wetlands and to expedite decisions that may affect this important resource. To accomplish this, state-of-the-art principles and methodologies pertaining to all aspects of wetland inventory were assimilated and developed by the newly formed project. By 1979, when the National Wetlands Inventory (NWI) Project became operational, it was clear that two very different kinds of information were needed. First, detailed wetland maps were needed for site-specific decisions. Second, national statistics developed through statistical sampling on the current status and trends of wetlands were needed to provide information to support the development or alteration of Federal programs and policies.

Authorization

The Emergency Wetlands Resources Act of 1986 directs the Secretary of the Interior, through the Director of the U.S. Fish and Wildlife Service, to produce by 30 September 1990, and at 10-year intervals thereafter, reports to update and improve the information in the report *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950's to 1970's* (Frayer et al. 1983). This act also requires the Fish and Wildlife Service to produce, by 30 September 1998, National Wetlands Inventory maps for the remainder of the contiguous United States and, as soon as practicable thereafter for Alaska and noncontiguous portions of the United States.

Introduction

The Fish and Wildlife Service (FWS) has always recognized the importance of wetlands to waterfowl and other migratory birds, in part because 10–12 million ducks breed annually in the United States, and millions more overwinter here. Consequently, FWS has a direct interest in protecting wetlands, especially wetlands where waterfowl breed and overwinter.

We know that wetlands also play an integral role in maintaining the quality of human life through material contributions to the national economy (through the food supply, water supply and water quality, flood control, and fish, wildlife, and plant resources) and thus to the health, safety, recreation, and economic well-being of all United States citizens.

Need for a National Wetlands Inventory

In 1954, the FWS conducted a nationwide wetlands survey that focused on important waterfowl wetlands. This survey covered roughly 40% of the lower 48 States. Although this survey was not a comprehensive wetlands inventory by today's standards, it was instrumental in stimulating public interest in the conservation of waterfowl wetlands. These findings were published in a well-known FWS report *Wetlands of the United States,* commonly referred to as *Circular 39* (Shaw and Fredine 1956).

Since this survey, however, wetlands have undergone many changes, both natural and human-induced. These changes, coupled with an increased understanding of wetland values, led FWS to establish the National Wetlands Inventory (NWI) Project. The NWI goal is to generate and disseminate scientific information on the characteristics and extent of the Nation's wetlands. We hope this information will foster wise use of the Nation's wetlands and provide data for making quick and accurate resource decisions. Decision makers are not able to make informed decisions about wetlands without knowing how many wetlands, and of what type, are where.

Needed Wetland Information

Two different kinds of information are needed: detailed maps and status and trends reports. Detailed wetland maps are needed for assessing the effects of site-specific projects. These maps serve a purpose similar to the Soil Conservation Service's soil survey maps, the National Oceanic and Atmospheric Administration's coastal geodetic survey maps, and the U.S. Geological Survey's topographic maps. Detailed wetland maps are used by local, State, and Federal agencies—as well as by private industry and organizations—for many purposes, including comprehensive resource management plans, environmental impact assessments, facility and corridor siting, oil spill contingency plans, natural resource inventories, and habitat surveys.

National estimates of the current status and trends (i.e., losses and gains) of wetlands, developed through statistical sampling, also are needed. These estimates will be used to evaluate the effectiveness of existing Federal programs and policies, identify national or regional problems, and increase general public awareness of wetlands.

Pre-operational Phase

Before actually beginning wetland mapping in 1979, the National Wetlands Inventory Project reviewed existing State and local wetland inventories and existing classification schemes to determine the best way to inventory wetlands. Researchers determined that a remote sensing technique would be the best method to inventory wetlands.

Review of Existing Wetland Surveys

The first step of the pre-operational phase was to review existing wetland inventories. The NWI consulted with Federal and State agencies to learn where and when wetland surveys had previously been completed, what inventory techniques were employed, where to obtain copies of any wetland maps that may have been produced, and the status of State wetland protection. Only a handful of States had inventoried their wetlands, and most of these had only mapped coastal wetlands. These results were published in a 1976 FWS report (U.S. Department of the Interior 1976).

Review of Existing Classification Systems

Before the inventory could begin, NWI researchers had to decide how to classify wetlands. Thus, in 1975, FWS brought together 15 of the Nation's top wetland scientists to evaluate the usefulness of existing wetland classification schemes for the National Wetlands Inventory. These scientists determined that none of the existing systems could be used or modified for the NWI and that a new classification system should be developed.

Development of a New Wetlands Classification System

The FWS's wetlands classification system (Cowardin et al. 1979) was developed by a team of four

wetland ecologists, one each from the U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. National Oceanic and Atmospheric Administration, and the University of Rhode Island, with the assistance of local, State, and Federal agencies, as well as many private groups and individuals. The new system went though four major revisions and extensive field testing before its official adoption by FWS on 1 October 1980.

This classification system describes ecological units having certain common natural attributes, arranges these units in a system that aids resource management decisions, furnishes units for inventory and mapping, and provides uniformity in wetland concepts and terminology throughout the United States. Although it is not an evaluation system, it does provide the information upon which evaluations can be made.

Wetlands are extremely diverse and complex. The FWS classification system defines the limits of wetlands according to ecological characteristics and not according to administrative or regulatory programs. In general terms, wetlands are defined in Cowardin et al. (1979) as lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface.

This state-of-the-art wetland classification system presents a method for grouping ecologically similar wetlands. The system is hierarchical, with wetlands divided among five major systems at the broadest level: Marine, Estuarine, Riverine, Lacustrine, and Palustrine. Each system is further subdivided by subsystems that reflect hydrologic conditions, such as Subtidal versus Intertidal in the Marine and Estuarine systems. Below subsystem is the class level, which describes the appearance of the wetland in terms of vegetation (e.g., Emergent, Aquatic Bed, Forested), or substrate if vegetation is inconspicuous or absent (e.g., Unconsolidated Shore, Rocky Shore, Streambed). Each class is further divided into subclasses. The classification system also includes modifiers to describe hydrology (water regime), water chemistry (pH, salinity, and halinity), and special modifiers relating to human activities (e.g., impounded, partly drained, farmed, artificial).

Below the class level, the classification system is open-ended and incomplete. The dominance type is the taxonomic category subordinate to subclass. Dominance types are determined on the basis of dominant plant species, dominant sedentary or sessile animal species, or dominant plant and animal species. Cowardin et al. only provide examples of the many dominance types possible. Those using this classification system are expected to identify these dominance types and use them as part of the hierarchical classification system. It is also probable that as the system is used in more detail to meet a user's site-specific needs, the need for additional subclasses and special modifiers will become clear.

This classification system has been adopted by many national and international organizations. Illinois, Michigan, and Oregon have passed State wetlands legislation that relies heavily on NWI wetland information for implementation. The NWI was the first phase of a long-range State wetland plan for Illinois. Indiana and Minnesota have wetlands legislation currently under consideration that will also depend heavily on NWI maps and digital data. The first International Wetlands Conference met in New Delhi, India, on 10–17 September 1980. Conference participants passed a motion to adopt this classification system.

Selecting a Remote Sensing Tool

Because of the magnitude of the NWI, remote sensing was the obvious technique for inventory of the Nation's wetlands. The basic choice was between high-altitude photography and satellite imagery (Landsat). After comparing Landsat's capabilities with FWS's and other agencies' needs for wetland information, it was evident that Landsat could not provide the needed data for classification detail and wetland determinations within the desired accuracy requirements.

The National Wetlands Inventory Project has continued testing satellite technologies. Along with the National Aeronautic and Space Administration's Jet Propulsion Laboratory, NWI conducted a year-long test of the multispectral scanner to detect and map wetlands in Alaska. With Ducks Unlimited, NWI also tested Thematic Mapper data, as well as data from the French satellite called SPOT. A year-long test is now being conducted by the Earth Observation Satellite Company to test the feasibility of using Thematic Mapper satellite data to detect wetlands, map wetlands, or update existing wetlands maps. None of these tests has provided any hope that present satellite configurations can provide the needed data for classification detail and wetness determinations within desired accuracy requirements of the National Wetlands Inventory Project and its State and Federal cooperators.

Organizational Structure of the National Wetland Inventory Project

The Fish and Wildlife employs a small staff of biologists assembled into two basic groups; National Wetlands Inventory central control group and regional wetland coordinators. The NWI project leader works out of the Washington, D.C., office and coordinates the budget, annual work plans, and strategic planning.

The NWI Central Control Group in St. Petersburg, Florida, is the focal point for all operational activities of the NWI. This group acquires all materials necessary for performing an inventory, provides technical assistance and work materials to the regional coordinators, and produces the wetlands maps. A private service support contractor is responsible for map production, and provides needed personnel (about 100 technicians and professionals).

Regional wetland coordinators at FWS's seven Regional Offices are responsible for the inventory of wetlands within their regions and ensuring that all NWI products meet regional needs. They manage contracts for wetland photointerpretation, coordinate interagency review of draft maps, secure cooperative funding from other agencies, produce regional wetland reports, and disseminate NWI products. Their addresses, phone numbers, and areas of responsibility are listed in the Appendix.

Photointerpretation and fieldwork are performed by contractors hired by FWS. These contractors photointerpret wetlands with stereoscopes. In addition, they review soil maps, conduct field checks, and examine existing information on an area's wetlands to ensure accurate identification of wetlands.

Operational Phase

The operational phase of the NWI, initiated on 1 October 1979, involves two main efforts: wetlands mapping and wetlands status and trends analysis. In addition to the wetlands maps and trends reports produced through statistical analysis, NWI produces other products that complement the mapping effort, including a preliminary list of hydric soils, the *National List of Plant Species that Occur in Wetlands* (Reed 1988), numerous wetland reports, and textual and geographic computerized data bases.

National Wetlands Inventory Maps

The primary product of the NWI is large-scale (1:24,000) maps that show the location, shape, and characteristics of wetlands and deepwater habitats on U.S. Geological Survey base maps. These detailed maps are excellent for site-specific project evaluation.

To produce final National Wetlands Inventory maps, seven major steps must be completed: (1) preliminary field investigations, (2) interpretation of high-altitude photographs, (3) review of existing wetland information, (4) regional and national consistency quality control of interpreted photos, (5) draft map production, (6) interagency review of draft maps, and (7) final map production. Swartwout (1982) and Crowley et al. (1988) evaluated NWI maps and determined that the maps were 95 and 91% accurate, respectively. Accuracy determinations included errors of omission as well as commission. This high accuracy was achieved because of the NWI technique, which involves a combination of field studies, photointerpretation, use of existing information, and interagency review of draft maps.

Wetland Status and Trends Reports

The national wetlands status and trends analysis study originated from the need for national estimates on the present extent of our Nation's wetland resources in the lower 48 States and on corresponding losses and gains over the past 20 years. A statistical survey of U.S. wetlands in the mid-1950's and mid-1970's was conducted through conventional air photointerpretation techniques. The status of wetlands in the mid-50's and mid-70's was determined, and estimates of losses and gains during that interval were computed. The national sampling grid consists of a stratified random sample of 3,635 4-square-mile plots distributed within strata being formed by State boundaries, and the 35 physical subdivisions described by Hammond (1970). Additional strata were added to include (1) a coastal zone stratum encompassing those wetlands near coastal influence, and (2) the area immediately adjacent to the Great Lakes. Sample units were allocated to strata in proportion to the expected amount of wetland and deepwater habitat acreage estimated as determined by the earlier work of Shaw and Fredine (1956). The

results of this study were published in four major reports by Frayer et al. (1983); Tiner (1984); U.S. Congress, Office of Technology Assessment (1984); and Goldstein (1988).

About 215 million acres of wetlands existed in the conterminous United States (i.e., lower 48 States) at the time of the Nation's settlement. In the mid-1970's, only 99 million acres, or 46% of the original wetland acreage remained; these 99 million acres included 93.7 million acres of palustrine wetlands and 5.2 million acres of estuarine wetlands. Wetlands now cover about 5% of the land surface of the lower 48 States.

Between the mid-1950's and mid-1970's, about 11 million acres of wetlands were lost, while 2 million acres of new wetlands were created. Thus, in that 20-year interval alone, there was a net loss of 9 million acres of wetlands or an average annual net loss of 458,000 acres. This annual loss equals an area about half the size of Rhode Island. Agricultural development was responsible for 87% of recent national wetland losses, urban development caused 8%, and other development caused 5%.

The most extensive wetland losses were in Arkansas, Florida, Louisiana, Mississippi, Nebraska, North Carolina, North Dakota, South Dakota, and Texas. Greatest losses of forested wetlands were in the lower Mississippi Valley, with the conversion of bottomland hardwood forests to farmland. Shrub wetlands were hardest hit in North Carolina, where pocosins in wetlands were converted to cropland or pine plantations, or mined for peat. Inland marsh drainage for agriculture was most significant in the Prairie Pothole region of the Dakotas and Minnesota, Nebraska's Sandhills and the Rainwater Basin, and Florida's Everglades. Between the mid-1950's and mid-1970's, estuarine wetland losses were heaviest in the Gulf States of Louisiana, Florida, and Texas. Most of Louisiana's coastal marsh losses were attributed to submergence by coastal waters. In other areas, urban development was the major direct human-induced cause of coastal wetland loss. Dredge and fill for residential development in coastal areas was most significant in California, Florida, New Jersey, New York, and Texas.

Hydric Soils List (Wetland Soils)

Hydric soils are defined by soil saturation for a significant period or by frequent flooding for long periods during the growing season. To clarify the meaning of "hydric soils," the NWI, in cooperation with the Soil Conservation Service, developed the first list of the Nation's hydric soils. Since then, the Soil Conservation Service has chaired the Interagency National Technical Committee for Hydric Soils. The *National List of Hydric Soils of the United States, December 1987* (U.S. Department of Agriculture 1987) is available from the Soil Conservation Service. This soils list is useful for making wetland determinations in the field, or in the office through use of soil survey maps.

List of Plants that Occur in Wetlands

The U.S. Fish and Wildlife Service published the *National List of Plants Species that Occur in Wetlands: 1988 National Summary* (Reed 1988). The plants in this list[1] are divided into four indicator categories based on the plants' frequency of occurrence in wetlands: (1) obligate—always found in wetlands (greater than 99% of the time); (2) facultative wet—usually found in wetlands (66–99% of the time); (3) facultative—sometimes found in wetlands (33–66% of the time); and (4) facultative upland—seldom found in wetlands (less than 33% of the time).

The wetland plant list data base is a listing of plants associated with wetlands, as defined by the U.S. Fish and Wildlife Service's wetland definition and classification system (Cowardin et al. 1979). It lists scientific and common names of plants, distribution, and regional wetland indicator status of almost 6,700 plant species. It can be accessed by plant name, region, State, and wetland indicator status. The data base is updated as additional information is received.

The wetland plant species data base[2] has two parts. The first, PLANTS, contains detailed

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[1] This list is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, phone (202)783-3235, Stock Number 024-010-00682-0; cost is $12.00. Thirteen regional subdivisions of the list are available from the National Technical Information Service, 5285 Port Royal Rd., Springfield, Va. 22161, phone (703)487-4650. State lists are also available.

[2] Regional subdivisions of the wetland plant list data base are available on floppy disks in ASCII format for use on IBM XT/AT-compatible machines running the equivalent of MS-DOS 2.0 or higher. Contact the Office of Conference Services, Colorado State University, Fort Collins, Colo. 80523, phone (303)491-7767. State subdivisions of the wetland plant list data base are available in a wide variety of formats on floppy disks for use on IBM PC XT/AT-compatible machines running the equivalent of MS-DOS 2.0 or higher. Contact BIO-DATA, INC., P.O. Box 280605, 331 Wright Street, 7-107, Lakewood, Colo. 80228, phone (303)987-2557.

taxonomic, distributional, and habitat information on more than 6,200 wetland plants found in the United States and its territories. The second part, BOOKS, contains bibliographic citations for more than 280 sources such as floras, checklists, and botanical manuals used to compile PLANTS.

Wetland Reports

Two basic wetland reports are developed by the NWI; map reports and State wetland reports. The map reports briefly outline NWI procedures and findings (e.g., list of wetland plant communities, photointerpretation problems). Map reports are available for all mapped areas. By contrast, the State wetland report is a comprehensive publication on the results of the NWI in a given State. It is prepared on completion of the wetlands inventory in a State. The State report includes wetland statistics and detailed discussions of NWI techniques, wetland plant communities, hydric soils, and wetland values. To date, State reports have been produced for Delaware and New Jersey. NWI expects to prepare reports for Connecticut, Florida, Hawaii, Pennsylvania, Rhode Island, and Washington when statistics become available.

The Wetlands Values Citation Data Base

The wetlands values citation data base[3] is a bibliographic listing of more than 12,000 scientific articles about the functions and values of wetlands. Field names include author, year, sequence, title source, and subject.

Status of Mapping

The National Wetlands Inventory has produced wetland maps for 68% of the lower 48 States and 21% of Alaska (Figs. 1 and 2). Mapping priorities are based principally on the needs of FWS and other Federal and State agencies. Priorities include the coastal zone (including the coastline of the Great Lakes), prairie wetlands, playa lakes, floodplains of major rivers, and other areas that reflect the goals of the North American Waterfowl Plan.

The actual priority of mapping depends on the availability of funds and the existence of high-quality aerial photography. Obtaining acceptable photographs for the Prairie Pothole region has been particularly difficult because of the need to capture optimum water conditions. Consequently, the NWI has established a special agreement with NASA to obtain this photography. The NWI produces wetland maps at a rate of 5% per year in the lower 48 States and at 2% annually in Alaska. This is the equivalent of 3,200 1:24,000-scale quads a year in the lower 48 States and 60 1:63,360-scale quads in Alaska.

Map Dissemination

More than one million copies of draft and final wetlands maps have been distributed by the NWI.[4] This figure does not include the secondary distribution made through the State-run distribution centers in Alabama, Connecticut, Delaware, Guam, Hawaii, Illinois, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Mississippi, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas, Vermont, Washington, West Virginia, and Wyoming.

National Wetlands Inventory Digital Data Base

The NWI is constructing a georeferenced wetland data base[5] with geographic information system (GIS) technologies. Digitizing is done in arc-node format, with attributes assigned to the left, center, and right sides of each arc. Wetland attributes are coded according to Cowardin et al. (1979). As digitization occurs, points are converted to latitude/longitude coordinates. As a result, all map data are stored in a common, ground-based geographic reference system.

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[3] The information is available on floppy disks in ASCII format for use on IBM PC/XT/AT-compatible machines running the equivalent of MS-DOS 2.0 or higher. Contact the Office of Conference Services, Colorado State University, Fort Collins, Colo. 80523, phone (303)491-7767.

[4] Information on the availability of the National Wetlands Inventory maps and ordering information may be obtained by calling (toll-free) 1-800-USA-MAPS.

[5] Copies of data-base files can be purchased at cost from the NWI Office in St. Petersburg, Florida, phone (813)893-3873. The data are provided on magnetic tape in MOSS export, DLG3 optional, and ELAS, IGES, GRASS formats. Other products available at cost include acreage statistics by quad, county, or study area, and color-coded wetland maps.

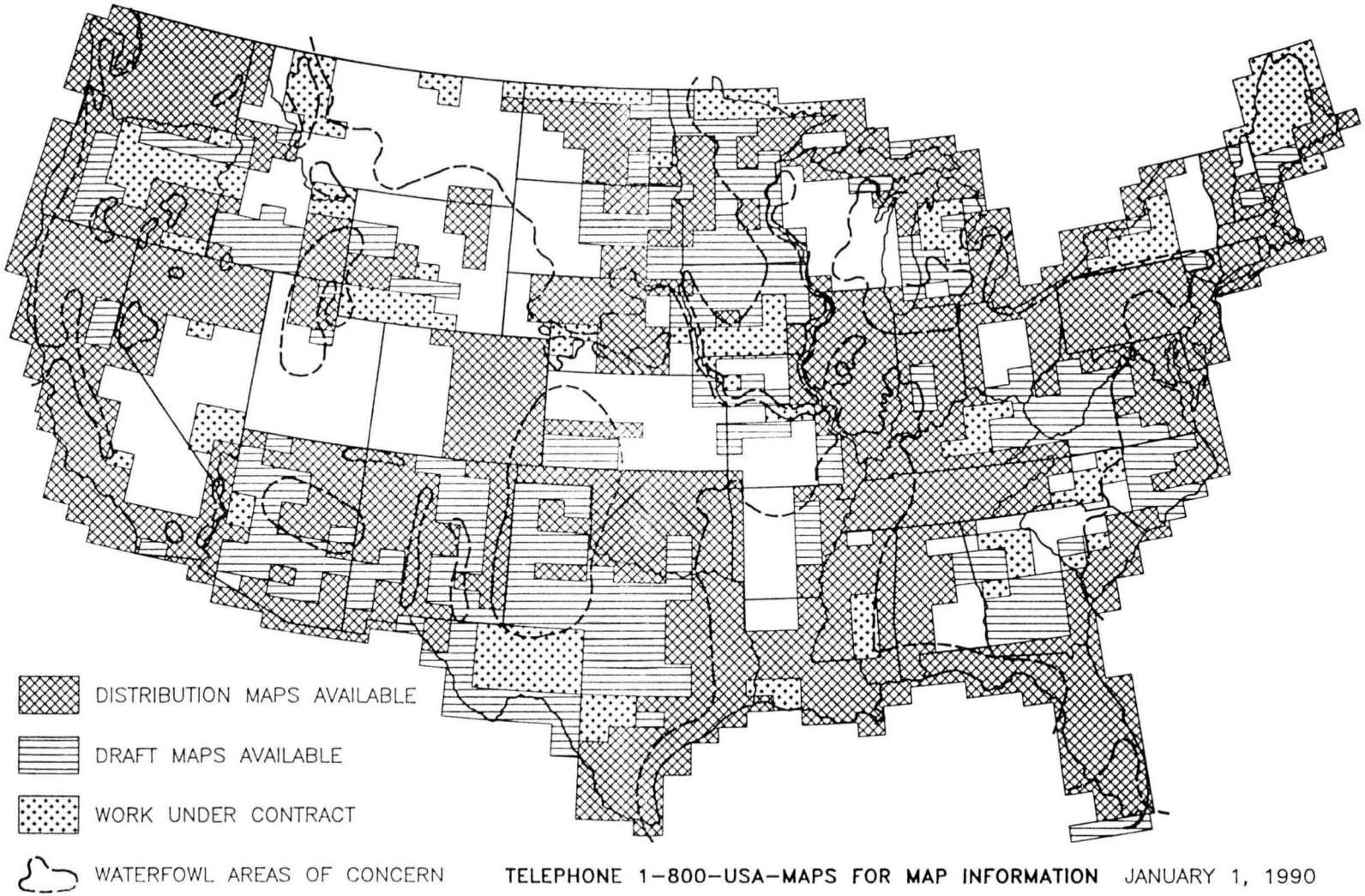

Fig. 1. Status of the National Wetlands Inventory in relation to waterfowl habitat areas.

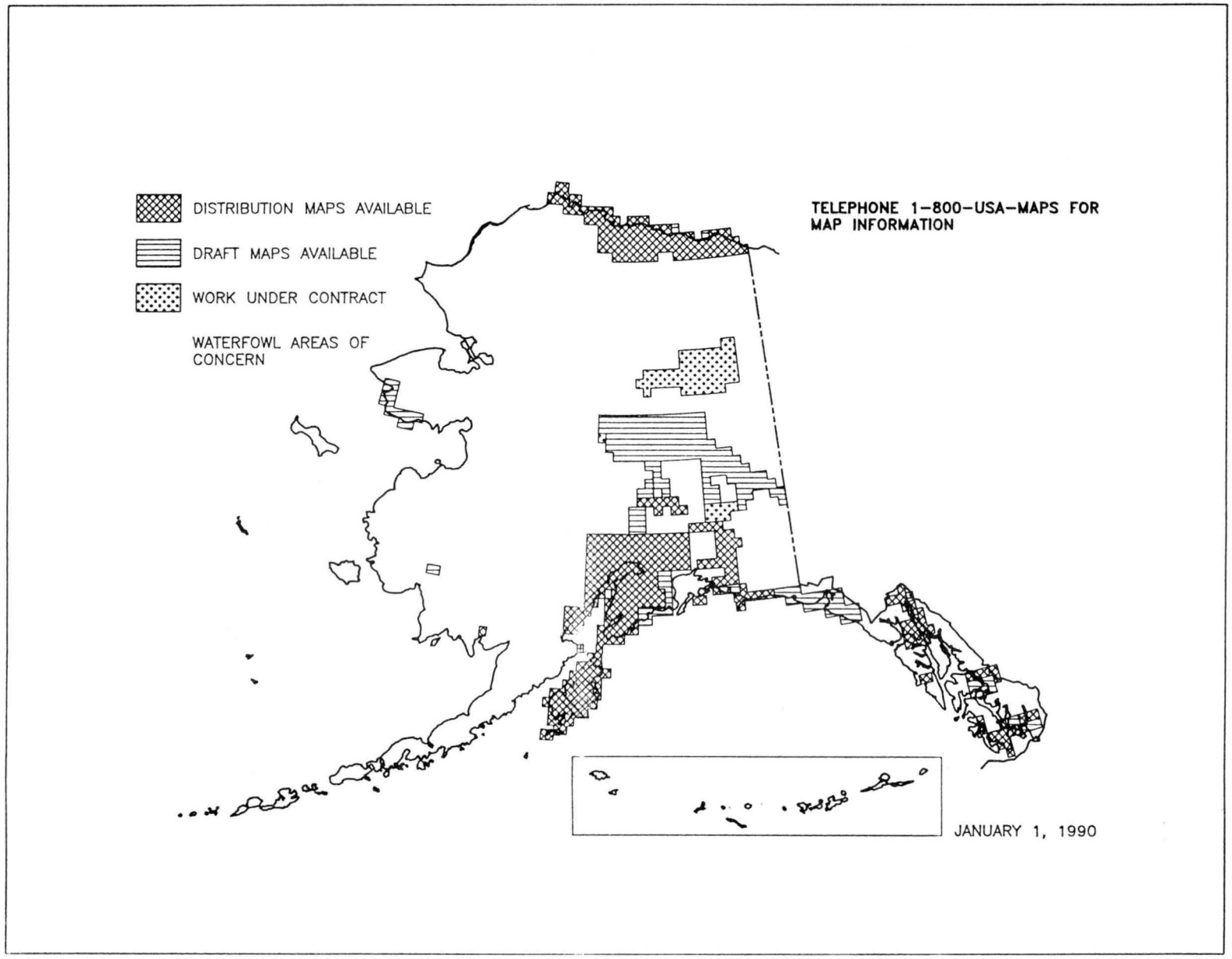

Fig. 2. Status of the National Wetlands Inventory in Alaska in relation to waterfowl habitat areas.

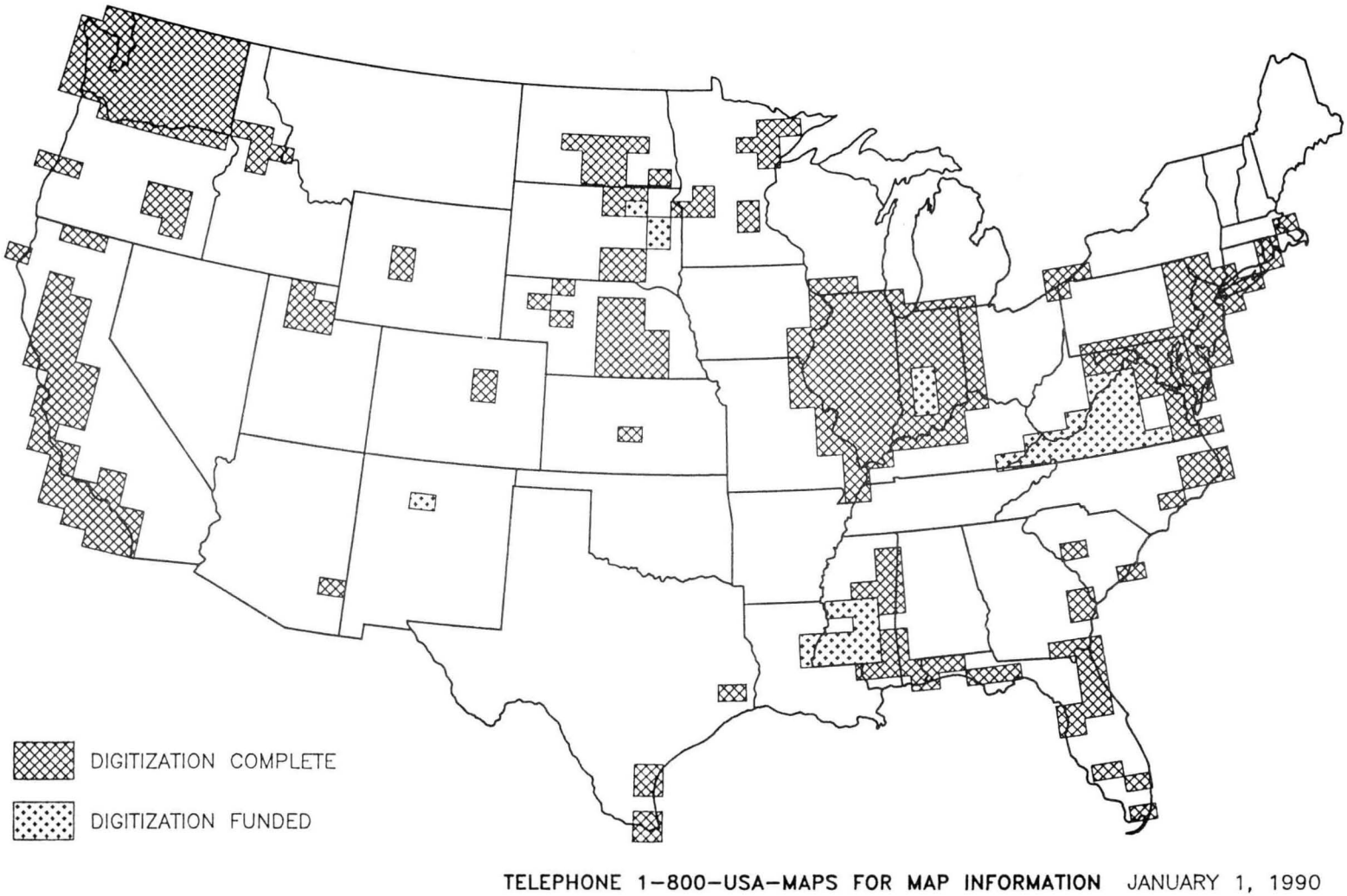

Fig. 3. Status of National Wetlands Inventory digital data.

To date, more than 5,700 NWI maps, representing 10.5% of the continental United States, have been digitized (Fig. 3). Statewide data bases have been built for Delaware, Illinois, Maryland, New Jersey, and Washington, and are in progress for Indiana and Virginia. NWI digital data also are available for portions of 20 other States.

These digital data are being used for applications such as resource management planning, impact assessment, wetland trend analysis, and information retrieval.

Map and Digital Data: Users and Uses

The number of map users has grown steadily since the maps were first introduced. Requests are common from individuals, private organizations, industry, consulting firms, developers, agencies from all levels of government, and educational and research groups. User surveys have documented over 100 different uses of the wetland maps. Resource managers in FWS and in the States are provided with information on wetland location and type, which is essential for effective habitat management and acquisition of important wetland areas. These areas are needed to perpetuate waterfowl populations and other migratory bird populations as called for in the North American Waterfowl Management Plan.

The Department of Agriculture uses the maps as a major tool in the identification of wetlands for the administration of the "Swampbuster" provisions of the 1985 Food Security Act. Copies of all draft and final maps are sent to the Soil Conservation Service's county offices.

Regulatory agencies use the maps to help in advanced identification, determining wetland values, and mitigation requirements. Private sector planners use the maps to determine the location and nature of wetlands to aid in framing alternative plans to meet regulatory requirements. These maps are instrumental in preventing problems that arise because the maps eliminate confusion over whether an area is a wetland. They are also instumental because they provide facts that allow sound business decisions to be made quickly, accurately, and efficiently.

Future Activities

Future activities of the FWS include updating the report entitled *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950's to 1970's* by 30 September 1990, and thereafter at 10-year intervals. Other activities will produce National Wetlands Inventory maps for the remainder of the contiguous United States by 1988 and, as soon as practicable thereafter for Alaska and noncontiguous portions of the United States.

The top priority activity for funding increase is to intensify the national sampling grid used to determine national wetlands status and trends. This would allow accurate regional wetland acreage change and loss information to be developed for the Atlantic and Gulf coasts, Great Lakes watershed, lower Mississippi River alluvial plain, and lower Prairie Pothole region in 1992, 1993, and 1994, respectively. In future years, this funding increase will allow the development of accurate regional data for the southeastern United States and the Playa Lakes region in the Southwest. Regional intensifications of the wetlands inventory will support other resource efforts underway within the States and the Department of the Interior, and will fill a significant wetland information data gap identified by the National Wetlands Policy Forum. The intensifications will provide the information needed to develop or alter management programs to ensure sound stewardship and protection. The coastal intensification will provide the wetlands data needed to support the Secretarial Initiative on Global Change.

A second priority will be to operate the current wetlands status and trends effort in a continuous mode, with reporting done at 5-year intervals, and with interim estimates as necessary. A continuous wetland trends inventory would involve updating a percentage of the plots each year; for example, 10% of the plots would be updated each year on a 10-year cycle. Advantages gained from a continuous trend process include better coordination with resource priorities, better responsiveness to State and regional needs, more accurate and current assessment of wetland resources, and better use of existing data.

Acknowledgments

I thank the staff and contract personnel of the National Wetlands Inventory for their work over the last decade. The accomplishments presented in this paper could not have been achieved without the financial support of many Federal, State, and local cooperators. The accuracy of the maps, in

good part, is the result of the voluntary map review by many Federal, State, local, and private sector agencies and organizations, as well as persons such as G. Fore of Texas. I thank C. Lee for typing the manuscript and M. Bates for her review.

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