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## **ON THE COVER**

**Management and protection of wetlands requires knowledge about the locations and vulnerabilities of these important natural systems. In this issue, two resource managers describe their methods for assessing the accuracy of readily available National Wetland Inventory (NWI) maps in Sequoia and Kings Canyon National Parks (page 19), and Point Reyes National Seashore and Golden Gate National Recreation Area (page 34). For example, lakes (like this one at Sequoia) are labeled on the maps for their deep-water areas, although they often have extensive shallow areas. Another problem is illustrated by the photograph in the upper right portion of this page. It shows a wet meadow (called a palustrine emergent wetland or PEM) in front of a palustrine scrub-shrub (PSS) wetland. Although the NWI maps correctly classified these particular wetlands in the Mineral King area of Sequoia National Park, sampling found that 26% of the wetlands classified as PEM on the NWI maps for Sequoia and Kings Canyon were actually PSS and 22% of PSS wetlands were actually PEM.**

# Accuracy assessment of National Wetland Inventory maps at Sequoia and Kings Canyon National Parks

By Harold W. Werner

## Introduction

Both long-term planning and daily management of wetlands require knowledge of where wetlands exist and their vulnerabilities. For example, uncontrolled visitor use or poorly located facilities can damage wetlands, many of which, like marshes, are obvious, but identifying other types of wetlands requires technical skills. The National Park Service's policy of "no net loss of wetlands" mirrors a policy that originated with the National Wetlands Policy Forum in 1987 (Mitsch and Gosselink 1993), which strives to avoid and minimize wetland impacts wherever practicable and to compensate for unavoidable impacts through restoration of degraded wetlands (National Park Service 2001).

The U.S. Fish and Wildlife Service produces National Wetland Inventory (NWI) maps that provide information on the characteristics, extent, and status of wetlands and deep-water habitats (U.S. Fish and Wildlife Service 2003a). Maps that included Sequoia and Kings Canyon National Parks, California, were produced in 1996. This information is in the public domain and is important for planners, managers, and scientists. We used these maps because they provided the most readily available information on wetland types and their locations.

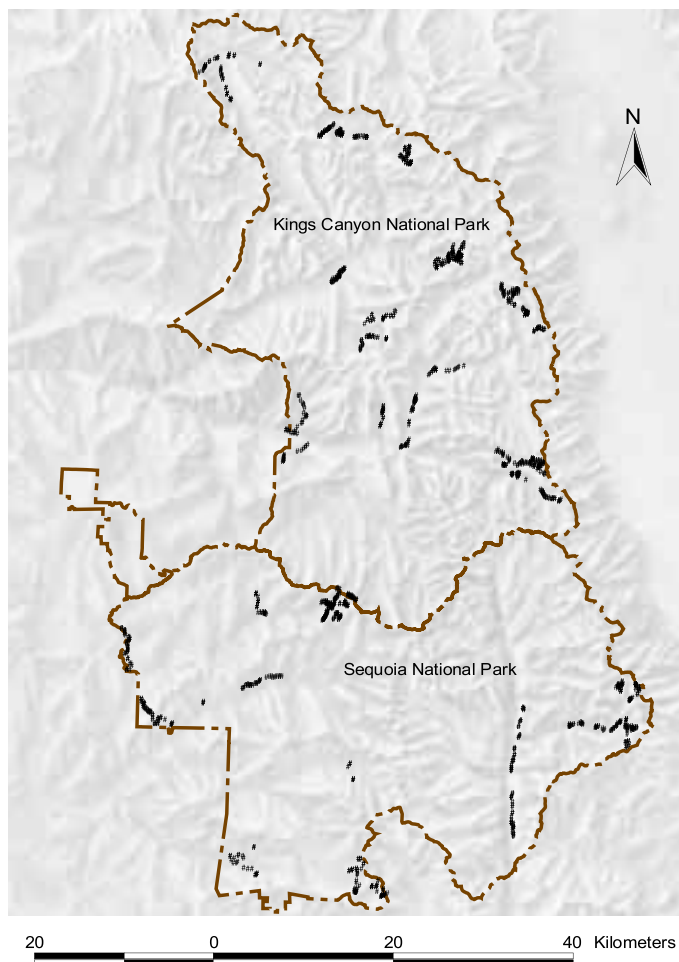
The NWI maps do not replace the accuracy of on-site wetland delineation, but they should provide meaningful data about the wetlands of an area. Our field surveys were not intended to characterize the parks' wetlands; rather, our purpose was to assess the accuracy of the NWI maps for Sequoia and Kings Canyon National Parks. We classified all sites on the basis of definitions and descriptions in Cowardin et al. (1979) and used NWI map codes (U.S. Fish and Wildlife Service 2003b).

## Methods

We performed fieldwork during summer in 2000 and 2001. The work resulted in two basic data collection strategies: (1) field verification of a sample of NWI sites for identifying errors of commission (in this case where wetlands were misclassified or upland areas were classified as wetlands) and (2) sampling along transects for identifying errors of both omission and commission. We

selected "verification sites" with the fullest range of NWI wetland taxa available and "transect sites" to represent the spatial extent and diversity of landscapes in the parks (fig. 1). The field crew, consisting of two biological science technicians, surveyed all wetlands encountered (mapped and unmapped) along selected transects.

The NWI maps show 23,091 wetland sites within Sequoia and Kings Canyon National Parks. The crew surveyed 900 wetland sites, which included 294 verification



**Figure 1.** To assess the National Wetland Inventory maps, investigators selected validation sites that represented the fullest range of wetland taxa available, and surveyed transects representing the spatial extent and diversity of landscapes in Sequoia and Kings Canyon National Parks. Surveyed sites are marked in black on the figure.



sites, encounters with 596 sites along transects, and 10 incidental encounters of unclassified sites during validation. Of the 900 wetland sites examined, 620 were on the NWI maps. These 620 sites included all of the verification sites and 326 transect sites. All 620 sites were used for evaluating the accuracy of the points, lines, and polygons delineating wetlands on the digital GIS layer representing the NWI maps. Our classification scheme allowed for one taxon per site; therefore, crew members classified each of the 900 sites on the basis of the dominant taxon. Because some sites contained multiple wetland taxa, field investigators made 1,257 taxonomic determinations at the 900 sites.

The crew classified wetlands to subclass and estimated hydrologic regime. For each site they identified the location using Universal Transverse Mercator (UTM) coordinates, elevation, slope, aspect, adjacent substrate, average feature width, vegetation type, and predominant vegetation.

## Results

### Validation of NWI wetland sites

Of the 294 NWI wetland sites that the field crew validated, only one was an upland. On the NWI map, investigators had classified it as Palustrine Emergent Wetland (PEM, see table 1). This is an error of only 0.34% (3.4 per thousand) for misclassifying upland as wetland.

Few discrepancies occurred between the NWI maps and field surveys for the Lacustrine data (fig. 2). Putting subsystem differences aside (e.g., L1 vs. L2, see table 1), the field crew determined that 97% of the sites identified as Lacustrine on NWI maps were correct. They determined that 3% were Palustrine (PUB, see table 1).

Our survey found considerably more problems at the NWI Palustrine sites than at the Lacustrine sites. At the system level (see table 1), 6% of the Palustrine sites identified on NWI maps were not actually Palustrine. At the class level (see table 1), only 67% of the sites identified as Palustrine Emergent Wetland (PEM) were identified correctly (fig. 3). Twenty-six percent of the Palustrine Emergent Wetland were actually Palustrine Scrub-Shrub Wetland (PSS). Only 64% of the Palustrine Forested Wetland (PFO) were correct. Sites classified erroneously as Forested Wetland (PFO) were primarily meadows (PEM) or Scrub-Shrub Wetland (PSS). Sites classified as Palustrine Scrub-Shrub Wetland were correct 66% of the time. Twenty-two percent of the Palustrine Scrub-Shrub Wetland sites were meadows (PEM), and 8% were forested (PFO). In general, a two-thirds probability exists that sites identified as Emergent Wetland, Scrub-Shrub Wetland, or Forested Wetland on the NWI maps are correct, but there is a 96% likelihood of the site being one of these three. National Wetland Inventory maps incorrectly

classified 55% of the Palustrine Unconsolidated Bottom (PUB) sites. Twelve percent were ponds, but either with Rock Bottom (PRB, 8%) or vegetated bottoms (PAB, 4%); 23% were lakes; 13% were meadows; and the remainder (7%) was Scrub-Shrub Wetland, Palustrine Unconsolidated

Table 1. Wetland classification terms used in text

| System, subsystem, and class | Symbol | Example   |
|------------------------------|--------|---|
| <b>Palustrine</b>            |        | <b>Pond or emergent vegetation</b>                |
| Emergent Wetland             | PEM    | Wet meadow  |
| Unconsolidated Bottom        | PUB    | Pond with mud/sand/cobble/gravel bottom           |
| Scrub-Shrub Wetland          | PSS    | Willow stand                                      |
| Forested Wetland             | PFO    | Alder or riparian forest                          |
| Aquatic Bed                  | PAB    | Pond with vegetated bottom                        |
| Unconsolidated Shore         | PUS    | Pond shore of mud/sand/gravel/cobble              |
| Rock Bottom                  | PRB    | Pond with bedrock/boulder bottom                  |
| <b>Lacustrine</b>            |        | <b>Lake</b>                                       |
| Limnetic                     | L1     | Lake area >2 m deep (deep open water)             |
| Unconsolidated Bottom        | L1UB   | Lake margin with mud/sand/gravel/cobble bottom    |
| Littoral                     | L2     | Lake area <2 m deep (shallow, usually near shore) |
| Rocky Shore                  | L2RS   | Lake shore of bedrock or boulders                 |
| Unconsolidated Bottom        | L2UB   | Lake with mud/sand/gravel/cobble bottom           |
| Rock Bottom                  | L2RB   | Lake with bedrock/boulder bottom                  |
| Aquatic Bed                  | L2AB   | Lake with vegetated bottom                        |
| <b>Riverine</b>              |        | <b>River or stream</b>                            |
| Upper Perennial              | R3     | High gradient, fast permanent flow                |
| Unconsolidated Bottom        | R3UB   | Stream with mud/sand/gravel/cobble bottom         |
| Rock Bottom                  | R3RB   | Stream with bedrock/boulder bottom                |
| Intermittent                 | R4     | Seasonal flow                                     |
| Streambed                    | R4SB   | Any intermittent stream                           |

Source: Cowardin et al. (1979) and U.S. Fish and Wildlife Service (2003b).

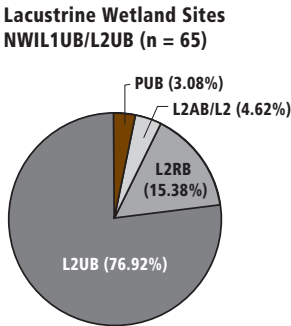


Figure 2. Few discrepancies occurred between NWI maps and field surveys for Lacustrine sites. Ninety-seven percent of the Lacustrine sites were correct. The remaining 3% were Palustrine (ponds).

Shore (PUS), or Upper Perennial (R3) stream. Twenty percent of the sites classified as Palustrine Unconsolidated Shore (PUS) were correct. Most sites were either Lacustrine Littoral Rocky Shore (L2RS, 40%) or Palustrine Emergent Wetland (40%).

The classification of Riverine systems on the NWI maps also had many problems (fig. 4). The crew found only half (51%) of the NWI Riverine sites actually to be Riverine. The remaining misclassified sites were actually Palustrine, primarily Scrub-Shrub Wetland (22%), meadow (PEM, 16%), and forested (PFO, 9%). Only 45% of the sites labeled Upper Perennial streams with Rock Bottom (R3RB) were correct (fig. 4). Eight percent were Upper Perennial streams with Unconsolidated Bottom (R3UB), 3% were Intermittent Streambed (R4SB), and the remainder was Palustrine (44%). The only Riverine site labeled as Unconsolidated Bottom was a meadow (PEM). Less than

one-third (29%) of the sites labeled as Rocky Shore (L2RS) were re-classified correctly. The remaining misclassified sites were actually Riverine Rock Bottom (14%) or Palustrine (primarily PEM, 57%). Only 37% of the sites labeled on the NWI maps as Intermittent Streambed (R4SB) were correct. Six percent were Upper Perennial Rock Bottom (R3RB) and the others were Palustrine (57%).

#### Wetland transects

Overall, 45% of the sites encountered on transect surveys were not on NWI maps. This suggests that about half again as many wetlands and deep-water habitats may exist in the parks as are displayed on the NWI maps. Few (5%) of the omissions were found to be Lacustrine systems. Most omissions were Palustrine and Riverine (fig. 5, page 22).

Forty-two percent of surveyed Palustrine wetlands were not on the NWI maps. More than half of these were meadows (PEM, 55% of unmapped Palustrine wetlands). The remainder was primarily Scrub-Shrub Wetland (PSS, 21%) or forested (PFO, 20%). A few ponds (either PUB or PRB, 4%)

Overall, 45% of the sites encountered on transect surveys were not on NWI maps.

#### Palustrine Wetland Sites

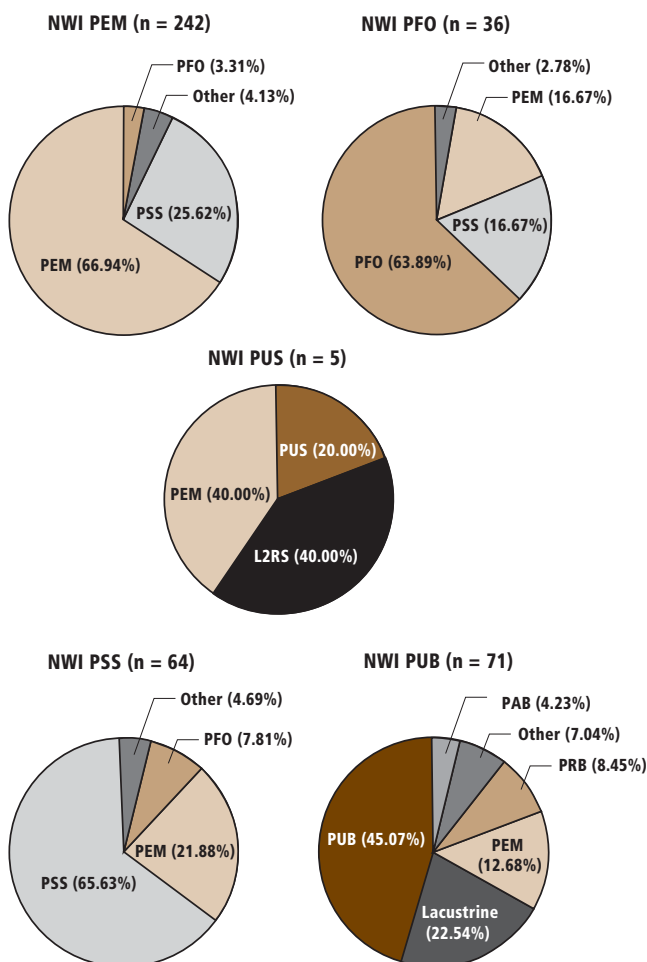


Figure 3. Field investigations revealed considerable problems with Palustrine sites shown on NWI maps. For example, of the 242 Palustrine Emergent Wetland (PEM) sites classified on the NWI maps, only 67% of the sites were classified correctly at the class level.

#### Riverine Wetland Sites

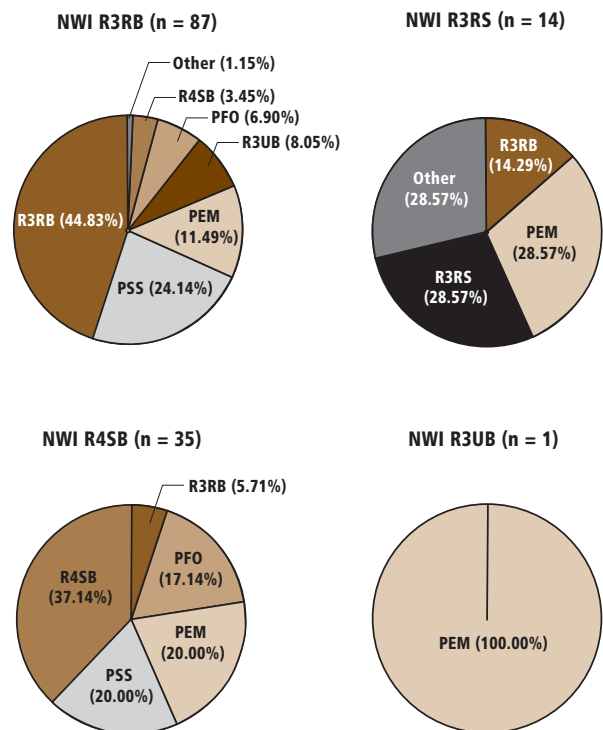
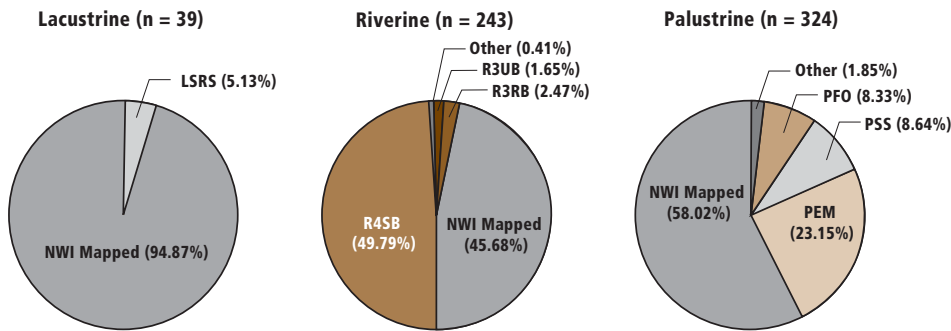


Figure 4. Field surveys revealed the greatest errors in classifying Riverine wetlands. Comparing all four Riverine classes combined, only half (51%) of the sites classified on the NWI maps were correct. The pie charts show what was actually observed in the field for each of the Riverine classes. For example, on the NWI maps used for the survey, Riverine Unconsolidated Bottom (R3RB) was correct about 45% of the time.





## Errors of Omission



**Figure 5.** Surveys along wetland transects showed that about half again as many wetlands and deep-water habitats may exist in the parks as are displayed on the NWI maps. The pie charts show for each system the proportion of wetlands mapped during the National Wetlands Inventory compared to newly identified sites during field surveys. Most sites not included on NWI maps were Palustrine and Riverine.

and some Unconsolidated Shore (PUS, 1%) also occurred.

Wetlands in the Riverine system had the highest frequency of not occurring on NWI maps. Fifty-four percent of the Riverine wetlands surveyed were not on NWI maps. Ninety-two percent of these were Intermittent Streambed (R4SB), which are probably the most cryptic and ubiquitous of the Riverine classes. The remainder was Upper Perennial somewhat evenly distributed between Rock Bottom and Unconsolidated Bottom.

### Water regime

The NWI maps include water regime in addition to wetland taxa. Water regime is a difficult parameter to estimate without long-term knowledge of a site. However, a site's water regime does have indicators: floristic community, fauna, current condition for time of year, soil, and high-water marks.

The NWI maps and field determinations concurred best for the wettest and one of the driest water regimes, with 81% agreement for "permanently flooded" sites ( $n = 208$ ) and 56% agreement for "temporarily flooded" sites ( $n = 46$ ). Of the other predominant water regimes, only 35% of the NWI sites labeled "seasonally flooded" matched field observations ( $n = 161$ ). Many were "temporarily flooded" (20%) or "seasonally flooded/saturated" (16%). Only 17% of sites ( $n = 156$ ) labeled as "saturated" actually were. Most "saturated" sites were "seasonally flooded/saturated" (22%), "temporarily flooded" (19%), or "seasonally flooded" (17%). The greatest disparity existed with sites labeled "semipermanently flooded" with only 11% agreement ( $n = 28$ ). Most of them were "permanently flooded" (36%) or "seasonally flooded" (21%).

Our findings are not necessarily applicable to other localities, and may have declining relevance outside the southern Sierra Nevada.

## Discussion

The discrepancies between NWI maps and our field investigations need to be considered within the context of where, when, and how they were measured. Our findings are not necessarily applicable to other localities, and may have declining relevance outside the southern Sierra Nevada.

Temporal change may have induced some errors. These NWI maps are based on aerial photography that was flown primarily in August 1985, 15 years before we initiated this assessment. Fires, floods, and succession could have caused some of the differences. Furthermore, our field crew had a distinct advantage over personnel

working from 1:58,000-scale aerial photography. The NWI investigators classified the sites on the basis of what taxonomic attributes were available to them on film, which were calibrated with some field investigations. Members of our field crew saw and measured features that probably were not visible on the photographs (fig.

6), particularly where canopy obscures the

sites. Some errors may reflect differences in the interpretation of definitions in Cowardin et al. (1979). However, inconsistencies should be minimal because the definitions are very explicit.

Although we found considerable discrepancies between the NWI maps and our field observations, I continue to find the NWI maps useful. For example, where wetlands were indicated, they typically existed, and the taxonomy was generally correct. The NWI maps provide a quick representation of the types and distribution of wetlands to be expected.



**Figure 6.** Investigators on the ground often observed far more complexity than was evident on the NWI map. Here a small Riverine unit (R3UB) flows through a wet meadow (PEM) after emerging from a stand of willows (PSS). This Riverine unit was not on the NWI map. NPS PHOTO

## Recommendations

1. Users of the NWI maps should trust that the wetlands and deep-water habitats shown probably exist. However, they should expect that the maps may have omitted nearly half as many additional wetlands.
2. Users should be suspicious of the accuracy of taxonomy on the maps. However, the Lacustrine sites are the most trustworthy.
3. For applications where accuracy is critical, such as planning of research or monitoring projects or preparing for Section 404 compliance of the Clean Water Act, on-site delineation or evaluation is essential. The maps should be used only as an indicator of what to expect.
4. Managers wishing more detailed information about this survey should see Werner (2003).

## Acknowledgments

Pat Lineback initiated this project and secured funding from the NPS Water Resources Division. Sylvia Haultain, Jennifer Akin, and Julia Evans provided field oversight and support for the crew. Elizabeth Van Mantgem, Allison Roll, Cheryl Bartlett, and various members of the vegetation mapping crew collected the data. Joel Wagner provided valuable suggestions for improving this manuscript.

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## About the author

**Harold Werner** is the wildlife ecologist at Sequoia and Kings Canyon National Parks. He can be reached at 559-565-3123 or [harold\\_werner@nps.gov](mailto:harold_werner@nps.gov).