Enhanced Wetland Mapping on the Loomis State Forest
A report to Northwest Ecosystem Alliance

George Wooten, Peter Morrison and Sarah Masco
Pacific Biodiversity Institute
August 1998

Introduction
Pacific Biodiversity Institute (PBI) has produced updated and revised wetland maps to aid in evaluating a timber transfer proposal on two townships of the Loomis State Forest in North Central Washington State. Field reconnaissance of the area indicated that the majority of wetlands were incompletely mapped on existing maps by the National Wetlands Inventory (NWI).

This study was conducted to aid two aspects of the proposed transfer decision. First, refined wetland data will improve the accuracy of overall biodiversity assessment in the Loomis parcels, as wetlands make a large contribution to regional biodiversity. Second, refined mapping of wetlands on the transfer parcels allows a better assessment of timber and land values, as wetlands comprise a considerable land use constraint.

Methods
PBI used a combination of geographic information system (GIS) landscape modeling, field sampling and aerial photointerpretation to improve the accuracy of wetlands mapped within the proposed Loomis Block transfer area.

We used GIS landscape modeling techniques, with a 30-meter resolution digital elevation model, to create new layers for slope, slope curvature and hydrologic accumulation. These layers were combined to create a wetland probability surface. Critical values for wetland boundaries on the probability surface were then field-checked, refined and recalculated through comparison with actual and photo-interpreted wetland delineations. Overlay of the GIS probability polygons with the NWI wetlands allowed creation of a greater or lesser probability estimate, and maps of these polygons were used in field reconnaissance for likely wetland areas and for comparison with other methods.

Field surveys were organized into two trips. The first two-day field visit was a reconnaissance to describe the Loomis wetlands, map wetland edges on aerial photographs, refine the GIS modeling parameters and develop photointerpretation methods. The second two-day trip involved further wetland description and mapping, and refinement and correction of the photographic interpretation procedure. During field visits, many wetlands were visited and mapped on aerial photographs. These aerial photos were subsequently examined using a binocular stereoscope. Descriptions of the wetlands were recorded on standard wetland delineation forms for recording botany, hydrology and soil parameters related to wetlands (see example in Appendix I). Photographs were also taken of many of the wetlands examined in the field (Appendix II).

Aerial photograph interpretation was used to delineate wetlands on the Loomis Block parcels using 1:16,000 scale 1994 color aerial photo stereo pairs loaned by the DNR. In one area of approximately 33 square kilometers at the southern extent of the proposed transfer area, no color photographs were available for complete coverage. In this area one 1:54,000 scale 1973 high-resolution U-2 false-color infrared aerial photograph (IR photo) was used to fill in the information gaps. Photographic interpretation of wetland boundaries was adjusted to correspond to wetland edges mapped on the photographs during reconnaissance and refinement field surveys.

The following indicators were used for aerial photointerpretation, identification and delineation of wetlands:

- Topographic position along slope gradient breaks, benches or valley bottoms.
- Low-gradient slopes.
- Concave slope curvature.
- Association with obvious watercourses, surface water or hydrologic accumulation such as valley bottoms, streams, ponds, low-gradient topographic breaks, or braided flow patterns, and often possessing one or more finger-like radiating inlets.

- Open forest canopies (less than 50% canopy cover) unless other criteria allowed positive delineation.
- Presence of open-grown Englemann spruce on wetland edges.
- Wetland vegetation zonation.
- Lush, bright green vegetation understories visible on aerial photographs.

The use of the stereoscopic views allowed identification of indicators for topographic position, slope and slope curvature, which in turn are indicators of the hydrologic and soils environment. The texture of light and dark patterns on the photographs allowed interpretation of crown width and canopy density. Breaks in canopy density and forest openings indicated areas where stand growth was limited by soil saturation. Crown diameter allowed identification of areas where canopy coverage was predominantly long-lived, open-grown Engelmann spruce, characteristic of wetland edges. Colors in the photographs were used to indicate vegetative composition, which on the Loomis Block correlate well with certain wetland attributes. Tannin-rich fens exhibit a dark brown color; saturated, decaying vegetation exhibits a light tan color; and wetland mosses and sedges (particularly *Carex scopulorum* var*. prionophylla*, saw-leaved sedge, which is nearly ubiquitous in the Loomis Block wetlands), exhibit a brighter green color than plants in the uplands. Using the above information, stereoscopic wetland mapping can be reliably performed. The IR photo was used to indicate where lush understories with sedges, broadleaf and fast-growing species were dominant, indicating the likely presence of wetlands.

Wetlands were identified and marked as polygons or lines (for narrow, usually stream-associated wetlands) onto acetate overlays of the photographic stereo pairs. The aerial photographic overlays were digitally scanned and georeferenced to our high-resolution orthophoto base layer using GIS registration and warping procedures. The lines and polygons were then digitized from the scanned, georeferenced aerial photographs, and corrected where necessary to match the underlying orthophoto. The GIS probability layer was used to eliminate some dubious wetlands. Finally, the polygons were merged into a single layer and non-wetland islands were subtracted from the final layer.

Results

PBI has produced an updated and refined GIS coverage of the wetlands within the proposed Loomis Block transfer area, which updates and enhances existing National Wetlands Inventory (NWI) mapping. Maps comparing the revised wetland mapping and the original NWI wetland mapping are included with this report (Figures 1 and 2).

Figure 1.

Figure 2.

We identified over 483 hectares (1193 acres) of wetlands in the two parcels being considered for transfer (Table 1). This is an increase of 535% over the extent of previous wetland mapping conducted by the National Wetland Inventory. The vast majority of the additional wetlands that we mapped are forested wetlands which varying degrees of tree cover. The mean size of individual wetland patches in the Loomis Forest transfer parcels increased from 1.11 hectares to 1.99 hectares (179% over the previous NWI maps).

Our enhanced wetland mapping extended beyond the proposed transfer parcel boundaries. This enabled us to better assess the landscape context of the transfer parcels. In our entire analysis are we identified 727.2 hectares (1796 acres) of wetlands - a 446% increase over the previous NWI wetland mapping (Table 1).

Table 1. *Comparison of PBI revised wetland mapping with NWI wetlands mapping on the Loomis Forest transfer parcels.*

Note: The PBI biodiversity analysis area refers to a larger area including the transfer parcels used in the overall biodiversity analysis. Linear wetlands are small streams, etc, mapped as lines, with areas calculated for a 6-meter width.

	Original NWI wetland extent	**PBI Revised wetland extent**	**Percent increase**
Wetland area in transfer parcels	90.3 ha (223 ac)	483.0 ha (1193 ac)	535%
Wetland area in PBI wetland study area	162.9 ha (402 ac)	727.2 ha (1796 ac)	446%
Additional linear wetlands in transfer parcels	Not analyzed	90.0 ha (222 ac)	
Additional linear wetlands in PBI wetland study area	Not analyzed	36.4 ha (90 ac)	

The three methods used in our wetland inventory (field surveys, GIS landscape modeling, and aerial photo-interpretation) enabled a rapid, accurate assessment of the extent of wetlands on the Loomis Block lands proposed for timber transfer.

Each method had advantages and disadvantages. Field surveys were the most accurate of the three methods used, and were indispensable for development and verification of our inventory methods. Field surveys are difficult and time consuming in this rugged and largely inaccessible terrain. The GIS landscape modeling process produced the most rapid assessment of where to concentrate mapping efforts, and offered an independent comparison with the other methods with the least amount of observer bias. However, the use of the GIS procedure and the resolution of the digital elevation model is not sufficient to model the subtle effects of slope and hydrology, and cannot be relied upon as a standalone method for wetland delineation. A higher resolution digital elevation model would enable more precise modeling of wetlands using GIS techniques. The photo-interpretation method is the most efficient of the three methods, with relatively high accuracy and rapidity. Our combined approach to be up to 85% accurate in forested wetlands and 95% accurate in open wetlands.

Field visits indicated that the wetlands on the Loomis Forest are relatively easy to identify because the short growing season occurs while the ground is still obviously saturated. Typical wetland dominants include Engelmann spruce (*Picea engelmanii*), a number of *willows (*notably *Salix drummondiana, S. farriae,* and *S. planifolia*), bog birch (*Betula nana*), many sedges (notably *Carex scopulorum var. prionophylla,* and *C. utriculata*), and a diversity of herbaceous and cryptogammic species - the latter approaching 100% ground cover and sometimes including the obligate wetland species of *Sphagnum*.

Color differences on color aerial photos were usually distinct enough to differentiate wetlands from aspen, shrub fields, and alpine meadows, although these communities can also be quite wet. In such areas where it was impossible to be positive about wetland identification, our wetland interpretations were delineated conservatively.

The greatest difficulty in delineating wetland edges on the Loomis Forest was presented by forested wetlands, convoluted wetland edges, very small wetlands, alpine meadows, aspen stands, and moist, but not wet, forests adjacent to wetlands. On long, gradual slopes, the soil saturation changes so gradually that wetland edge delineation is difficult. For instance, some wetlands on north-facing slopes gradually changed to uplands dominated by Engelmann spruce, subalpine fir, lodgepole and white rhododendron. In some wetlands, the edge was straddled by an edge community of spruce, lodgepole pine and Labrador tea, *Ledum* (*Rhododendron*) *glandulosum*, hiding the exact boundary. Isolated small wetlands, linear wetlands and wetlands with convoluted edges narrower than the photo marking pen were often recorded as linear wetlands. Photointerpretation was unreliable in closed canopy forest, without confirming field data. If the wetland indicators could not be positively identified, polygons and lines were delineated conservatively to minimize false positives. Forested wetlands are still the largest source of error in wetland identification on this portion of the Loomis Forest. We estimate our accuracy for identification of forested wetlands to be approximately 85%.

Unlike photo-interpretation, the GIS model was able to predict wetlands in closed canopy forests. The use of IR photos was useful in some densely forested areas. These photos allowed a view from a point backwards in time when the forest canopy was less dense, having elapsed only 50 years since the last major fire, and thus making more details of the understory visible.

Wetland delineation in non-coniferous alpine and subalpine communities in the Loomis Block is confounded by the lack of existing data about wetland characteristics in these poorly studied communities. Even in the prime peatlands of the Loomis Block which were unquestionably wet in our field visits, soil pits indicated peat buildup was far less than in more temperate or tropical wetlands, possibly due to a lack of soil nutrients, a harsh, cold climate, and relatively recent deglaciation that left behind poorly developed soils. Thus, the standard wetland delineation protocol may be in need of revision in this area.

Conclusions

Using a combination of GIS landscape modeling, aerial photo interpretation and field surveying, PBI mapped wetlands to a much greater degree of accuracy than previous NWI maps. The enhanced wetland maps indicate that the extent of wetlands on the Loomis Block is more extensive than previous maps indicated. On the two parcels being considered for transfer we identified 1193 acres of wetlands - an increase of 535% over the NWI wetland mapping for that same area. In addition to this we identified about 90 acres of linear wetland features within the transfer parcels. The increase in wetland extent (over NWI mapping) was matched by a 179% increase in the mean size of individual wetlands.

Relatively pristine wetlands - such as found on the Loomis Block - make a significant contribution to regional biodiversity. The considerable extent of wetlands on the transfer parcels enhances their value from the perspective of a conservation purchase. Likewise, these same wetlands constitute severe environmental constraints on resource extraction activities. It is difficult to build roads or log these areas without causing significant ecological damage. The wetland areas that we have mapped should not be considered part of the timber base on the Loomis Block DNR lands.

Appendix I
Example of wetland delineation form filled out for wetlands at the Chopaka Mountain Trailhead.

DATA FORM
Wetland Summary Report

Field Investigator(s): George Wooten, Martha Stauss Date: 8/6/96
Project/Site: Chopaka Mt Trailhead State: WA County: Okanogan
Owner: DNR Community #/Name: ____________________

VEGETATION

Scientific Name	Common Name	Code	Percent Cover	Indicator Status	Stratum
Picea engelmanii	spruce	PIEN	10	FAC	Tree
Pinus contorta	Lodgepole	PICO	3	FAC	Tree
Ledum glandulosum	Labrador tea	LEGL	40	OBL	Shrub
Salix drummondiana	Drummond willow	SADR	10	OBL	Shrub
Salix farriae	Farr willow	SAFA	1	OBL	Shrub
Carex scopulorum v. prionophylla	Saw-leaved sedge	CASCP	15	OBL	Herb
Mitella pentandra	Mitre-wort	MIPE	5		Herb
Aster foliaceus	Leafy aster	ASFO	5	FAC+	Herb
Valeriana sitchensis	Valerian	VASI	1	FAC+	Herb
Epilobium		EPILO	T		Herb
Taraxacum officinalis	Dandelion	TAOF	T		Herb
Thalictrum occidentalis	Meadow rue	THOC	1		herb

Percent of dominant species that are OBL, FACW, and/or FAC: 100%
Is the hydrophytic vegetation criterion met? Yes
Rationale:____

____

SOILS

Series/Phase: Histosol Subgroup: ________________________
Is the soil on the hydric soils list? Yes
Is the soil a histosol? Yes Histic Epipedon Present? Yes
Is the soil: Mottled? No Gleyed? Yes______ No______ Evidence of Erosion? __________
Matrix Color: ___________________ Mottle Colors: ______________________

Soil Log - Horizon Depth	Profile Description
0-12"	Histic epipedon
12-18"	A layer

Other hydric soil indicators: wet, spongy

Is the hydric soil criterion met? Yes
Rationale: ____

____

HYDROLOGY

Is the ground surface inundated? Yes   Surface water depth:___________
Is the soil surface saturated? Yes
Depth to freestanding water in pit/soil probe hole: 12-14"
List other field evidence of surface inundation or soil saturation________________________________
Is the wetland hydrology criterion met? Yes
Rationale: ____

OTHER DOCUMENTATION

Unusual conditions or problems noted in the area: steep slope - 5%, high elevation, histic epipedon borderline deep
Is the area functioning as a wildlife habitat? Yes
Note fish, macroinvertebrate, or wildlife signs observed: ________________________________

____

____

PLANT CONDITION ASSESSMENT

Live ________ %	Stressed 5%	Tip Die Back ________ %
Basal Sprouts ________ %	Dead ________ %	Other________ %

HABITAT ASSESSMENT - underline choice

Wetland or stream areal cover:

No Cover									Full Cover
1	2	3	4	5	6	7	8	9	<u>10</u>

Disturbances such as mowing or grazing:

Very Disturbed								None	
1	2	3	4	5	6	7	<u>8</u>	9	10

Snags present (#)

0	1	2	3	4	5	6	7	8	9	<u>Many</u>

Hiding places for fish (logs in water, overhung banks, large boulders)

None   Few   Some   Lots   <u>Many</u>

Eroded bank

75-100%   50-75%   25-50%   1-25%   0%

Amount of sediment covering rocks in streambed

75-100%   50-75%   25-50%   1-25%   0%

Wetland buffer zone

0ft   25-50ft   50-100ft   100-300ft   300+ft

Amount of vegetation in water

0%   5-20%   20-50%   50-75%   75-100%

Manmade structures present

Yes   No

Describe bottom

Muddy   Rocky   Sandy   Peaty