

# Cleawox Lake, Oregon: The Coastal Sands of Cultural Omission

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Nearly 50 years have passed since I first plied the crystal clear waters of Oregon's Cleawox Lake, collecting water samples while marveling at the towering, steep-faced sand dune rising majestically along the lake's south shoreline (Figure 1). The dune, referred to as one of the largest single dunes in the world, is part of the vast Coos Bay dunal sheet that extends for about 80 kilometers along Oregon's central Pacific Coast. Winding along this coastal region is a chain of maritime lakes, most of which are sand-barrage lakes including Cleawox (Figure 2). As their designation implies, these lakes were originally coastal streams impounded by ocean sand dunes advancing inland. Cleawox Lake owes its existence largely to its imposing south-shore dune that blocked the lake's drainage to the ocean (Figure 3).

During a recent visit to the Oregon coast to photograph lakes, I stopped at Cleawox Lake to once again observe the lake's condition and shoot the dune, so to speak, as I had done many times in years past. What my camera captured was a forlorn remnant of a scenic wonder (Figure 4), its former grandeur lost forever and a large portion of its luminous sand lying submerged in the lake. Although wind and other natural processes contributed significantly to the dune's in-lake encroachment, humans bear much of the responsibility for the irreversible impact to dune and lake. The main damage appears to have taken less than 50 years, the result of (1) human failure to recognize the dune's vulnerability and its fragile structure, (2) failure of individual dune-users to perceive how their self-serving actions affected the common good, and (3) failed stewardship on the part of federal and



Figure 1. Cleawox Lake and south-shore dune, July 1968. Visitors are seen climbing a trail that cuts diagonally across the dune's slip face. Photo by the author.

state resource agencies to protect and preserve a natural treasure.

## Hydrology

Despite its dunal impoundment, Cleawox Lake continues to drain through a small, intermittent creek that flows northward before more or less disappearing into a complex of dunal sands, riparian vegetation, and wetlands somewhere between the lake and the Siuslaw River (Figure 2). The extent of drainage into the Siuslaw River is uncertain. Creek outflow has steadily diminished over the years due to various obstacles in the channel, principally beaver dams and proliferating vegetation planted to stabilize dunes. Efforts to clear the waterway and improve drainage have largely failed. This restricted outflow

likely explains why lake surface elevation rose an estimated 1.1 meters between 1937 and 2008 (Witter et al. 2008).

Inflowing drainage is derived from a relatively small area covering about four square kilometers (Johnson et al. 1985). Surface inflows include Buck Creek, which enters near the upper end of the lake's two-kilometer-long northerly arm (Figure 2), and several intermittent unnamed rivulets.

Water also enters the lake from direct precipitation and subsurface seepage. Rainfall, normally heaviest during winter and measured at the U.S. Weather Bureau's Canary station located about five kilometers east of the lake, averaged 213.1 centimeters annually during the period 1948-1970 (NOAA). Due to the permeability of dunal sand,

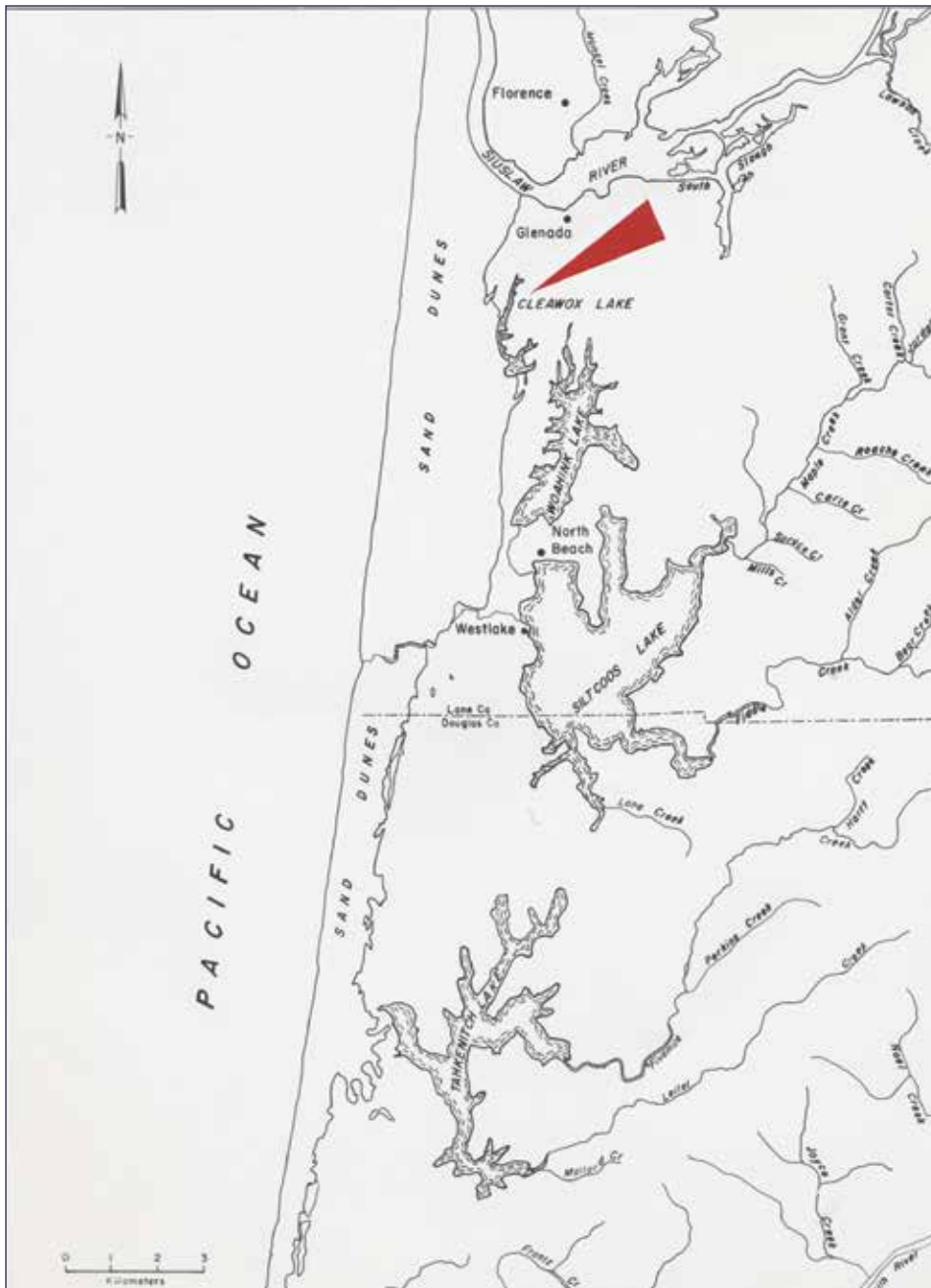


Figure 2. Map showing Cleawox Lake and other sand-dunal lakes.

only a small percentage of total rainfall is discharged as surface runoff while the balance infiltrates into the sand to recharge the ground-water supply. In a study of dunal sands a few miles north of Cleawox, Hampton (1963) estimated that about 85 percent of precipitation enters ground-water storage through infiltration. Assuming that this high infiltration rate also occurs in the dunal sands around Cleawox, approximately 6,000 acre-feet of water per year recharges the ground-water supply for the Cleawox drainage

area. Much of this ground water probably flows into the lake's relatively small basin (lake volume equaled 1,391 acre-feet in 1960), resulting in a short hydraulic water residence time of about four months (Johnson et al. 1985) and thus considerable basin flushing.

### Limnology

The limnology of Cleawox Lake and other sand-dunal lakes on the Oregon Coast was described in earlier reports (Daggett et al. 1996; Larson 1970, 1974,

1999; McHugh 1972). Cleawox Lake is generally oligotrophic, as exhibited by its water chemistry, relatively high water-transparency, and microbiota (Table 1).

The lake's current morphometry is largely unknown. The lake has steadily filled with sand since the lake's complete bathymetry was last mapped 54 years ago, in March 1960 (Figure 5). Back then, the few morphometric variables reported included the lake's surface elevation (23 meters above mean sea level), surface area (33 hectares), volume (1,391 acre-feet), and maximum depth (15 meters). Shoreline length was approximately eight kilometers.

More recently, in January 2008, Witter and others (2008) obtained depth soundings along five transects extending across the western one-third of the main lake and along three transects across the lake's northerly arm. A maximum depth of about 12 meters was recorded along the transect positioned about 140 meters from shore. Closer to shore, however, shallower waters indicated substantial shoaling due to sand-dune encroachment. Shoaling was also evident in the arm, with depths being somewhat less than they had been in 1960. Then, the distance across the arm at its juncture with the main body of the lake was about 120 meters and the depth at that point was 3-6 meters (Figure 5). But by 1980, the arm was essentially isolated from the main body by an advancing tongue of dunal sand. Dredging during the mid-1980s removed the sand, presumably for the purpose of allowing boats to enter the arm (Witter et al. 2008). Still, aerial photos taken in 1989 indicated renewed shoaling of the arm at its juncture with the main body and at a second point about 100 meters upstream (Figure 6).

As a warm monomictic lake, Cleawox is thermally stratified during much of the summer, with the thermocline located around ten meters. By late summer, the lake begins to turn over and undergo vertical mixing. During winter, the lake is completely mixed at temperatures of 8-9°C throughout the water column (Saltzman 1961; Larson 1974).

When thermally stratified, the lake's dissolved-oxygen (DO) tends to diminish at depths below ten meters. In late September 1992, for example, Whereat

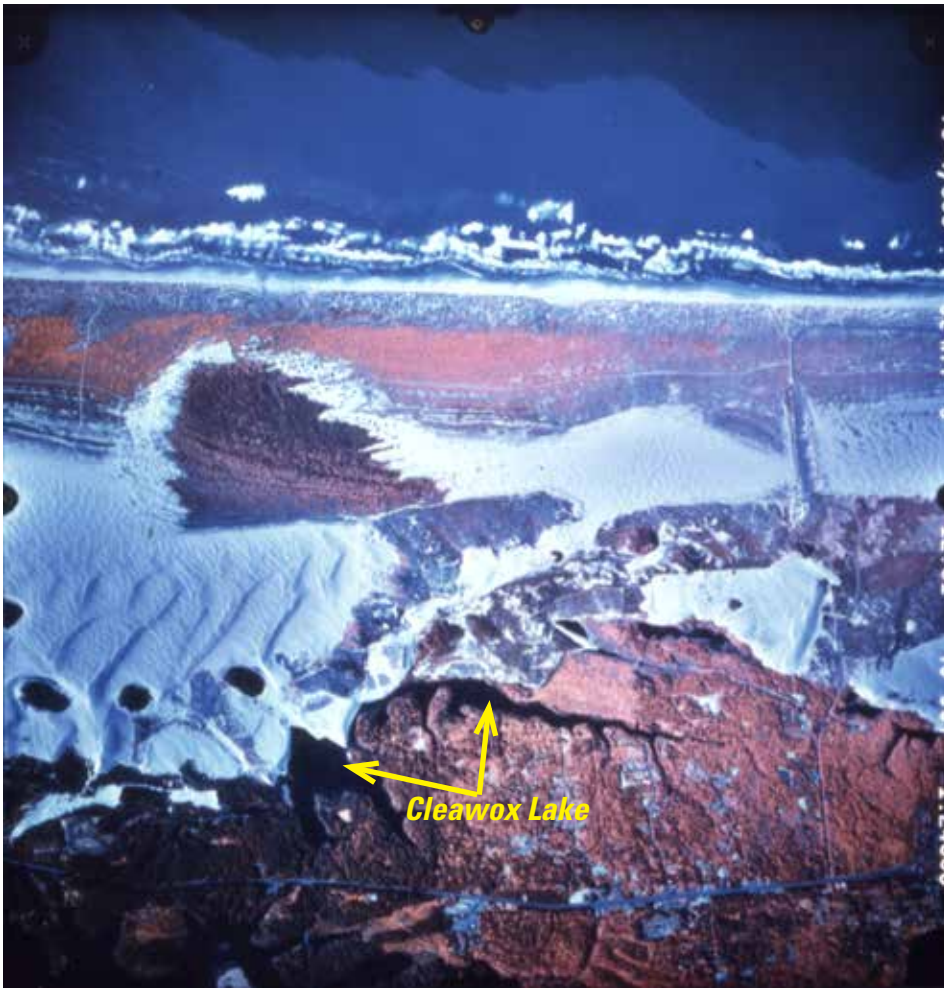


Figure 3. Vertical aerial photo of Cleawox Lake and adjoining dunes, color infrared, October 13, 1978, 1200 hours. Scale=1:24,000. Source: U.S. Army Corps of Engineers.



Figure 4. South-shore dune, August 16, 2013. Photo by the author.

and Merritt (1993) obtained a DO reading of 0.5 milligrams per liter at eight meters, indicating that the hypolimnion was anoxic, possibly due to sediment oxygen demand. Conversely, when vertically mixed during winter, the lake is oxygen-saturated throughout the water column (Saltzman 1961; Larson 1974). Although the lake is considered oligotrophic, macrophytes are prolific nevertheless in shallow-water zones where dunal sand and more fertile soils have accumulated. Macrophytes include a water lily (*Nuphar polysepalum*), a buttercup (*Ranunculus* sp.), and a pondweed (*Zannichellia* sp.). *Utricularia gibba*, a bladderwort discovered in 1991, has been listed by the Oregon Natural Heritage program, as endangered or threatened in Oregon (Whereat and Merritt 1993).

Little is known about the lake's benthic macroinvertebrates: Only two known benthic surveys have been conducted, in October 1960 (Saltzman 1961) and again in October 1992 (Whereat and Merritt 1993). The 1960 survey collected 45 Ekman dredge samples, yielding a total of 111 organisms, 90 percent of which were mayflies, snails, and midges. Results of the 1992 survey were similar, both in total abundance and species diversity. Fish production is limited, largely due to the scarcity of zooplankton and macroinvertebrates. In 1951, the Oregon Game Commission (OGC) launched a "put and take" sport fishery by stocking the lake with 56 large rainbow trout. After a seven-year hiatus, OGC resumed stocking in 1958, introducing around 6,000 trout (roughly 70 percent rainbows, 30 percent cutthroat) that year followed by a similar batch in 1959 and 1,500 rainbows in 1960. Since then, both rainbows and cutthroat have been restocked annually (Saltzman 1961; Whereat and Merritt 1993). With over 18,000 rainbows introduced in 2012, the lake has acquired the reputation as the second most heavily planted lake on the Oregon coast.

Various "warm-water" species are also present, most if not all of which were introduced unofficially and perhaps illegally by anglers and other lake visitors. These species include yellow perch, largemouth bass, black crappies,

**Table 1.** Limnological Data, Cleawox Lake, Oregon.

<i>Water Chemistry</i>	8/6/68 <sup>1</sup>	8/27/73 <sup>2</sup>	8/16/82 <sup>3</sup>	9/29/92 <sup>4</sup>
number of samples/variable	6	2	1	1
pH	6.3-6.9	6.7, 6.8	6.8	7.2
specific conductance, $\mu\text{mos}/\text{cm}$	112-119	109,110	94	102.3
total alkalinity, mg/liter as CaCO <sub>3</sub>	8.9-9.0	7.0, 8.0	7.0	3.03(?)
total hardness, mg/liter as CaCO <sub>3</sub>	12.2-12.6	12.0, 12.8		
sodium, mg/liter		13.0	11.4	12.0
potassium, mg/liter		0.5, 0.6	1.2	0.87
magnesium, mg/liter			1.9	1.96
chloride, mg/liter			14.8, 15.6	29.1
sulfate, mg/liter			3.9, 4.4	4.6
nitrate-nitrogen, $\mu\text{g}/\text{liter}$				<100, <100
nitrate-nitrite nitrogen, $\mu\text{g}/\text{liter}$				000.0
ammonia-nitrogen, $\mu\text{g}/\text{liter}$				100,100
soluble reactive phosphorus, $\mu\text{g}/\text{liter}$		<100, 200	1.0	
total phosphorus, $\mu\text{g}/\text{liter}$			500	10
<i>Transparency</i>	8/6/68 <sup>1</sup>	8/27/73 <sup>2</sup>	8/16/82 <sup>3</sup>	9/29/92 <sup>4</sup>
number	1	3	1	1
Secchi depth, meters	4.0	4.3-5.0	5.0	3.9
<i>Phytoplankton (no data for '68 and '74)</i>	8/16/82 <sup>3</sup>		9/29/92 <sup>4</sup>	
chlorophyll a, $\mu\text{g}/\text{liter}$	0.9 (n=1)		1.62 (n=1)	
predominant species	Dinobryon sertularia		Aphanocapsa elachista Aphanocapsa delicatissima Dinobryon sertularia Dinobryon bavaricum Chlorella vulgaris Oocystis solitaria Crucigenia tetrapedia Dictyosphaerium pulchellum Merismopedia tenuissima Ophiocytium capitatum	
<i>Zooplankton (no data for '68, '74, or '82)</i>	9/29/92 <sup>4</sup>			
<i>rotifers</i>	<i>copepods</i>	<i>clodocerans</i>		
Polyarthra dolichoptera	Diaptomus franciscanus	Diaphanosoma leuchtenbergianum		
Conochilus unicornis		Bosmina longirostris		
Keratella cochlearis		Daphnia longiremis		
Ploesoma truncatum				

<sup>1</sup>D.W. Larson, unpub.; <sup>2</sup>Larson 1974; <sup>3</sup>Johnson et al. 1985; <sup>4</sup>Whereat and Merritt 1993.

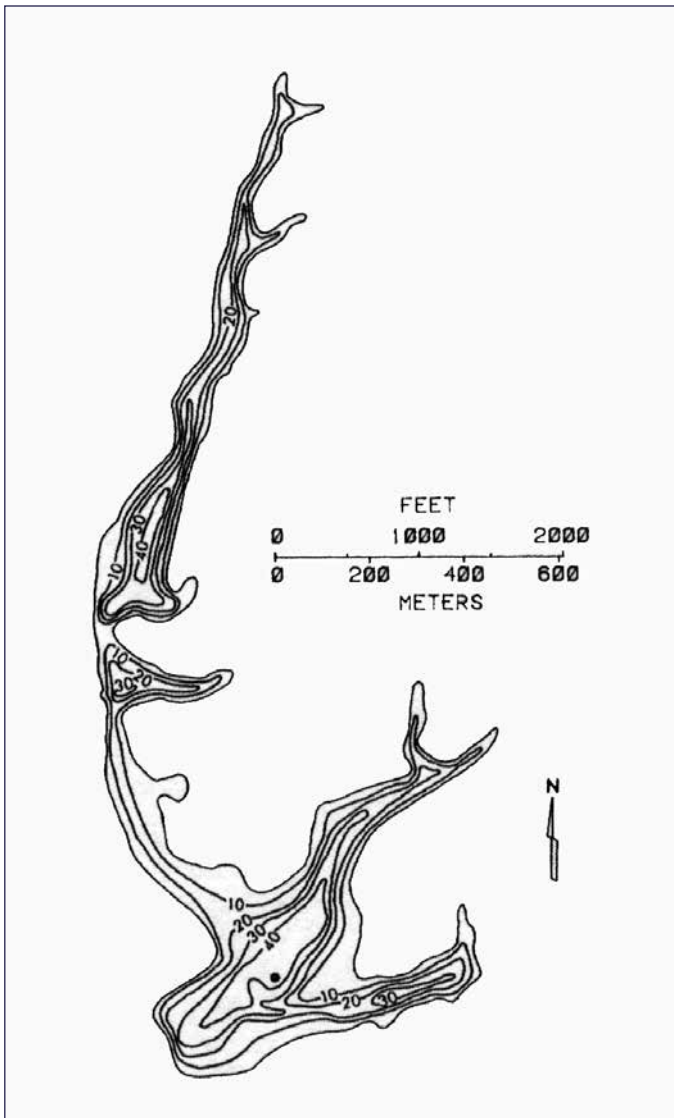


Figure 5. Bathymetric map of Cleawox Lake. Maximum recorded depth (15 meters) is indicated by a dot near lake center. The map is based on depth soundings by the Oregon Game Commission in March 1960. Source: Saltzman 1961.



Figure 6. Sand has nearly blocked the lake's northerly arm where the arm meets the lake's main body and at a second point about 100 meters upstream, as indicated by arrows, September 1989. Photo by the author.

brown bullheads, bluegills, sculpins, and golden shiners (Whereat and Merritt 1993). Other species (northern pikeminnows, coarse scaled suckers, sticklebacks) were found in nearby Lily Lake, a small pond connected to Cleawox Lake by a short channel. In 1960, aware that these species had access to Cleawox where they could threaten planted trout, OGC treated the pond with fish-killing rotenone. This might have been unnecessary, however, since extensive gillnetting in Cleawox during 1957, 1958, and 1959 captured only one pikeminnow (Saltzman 1961).

### Stewardship of Lake and Dune

Cleawox Lake is surrounded almost entirely by public lands administered by both the federal government and the State of Oregon. Much of the lake lies within the Oregon Dunes National Recreation Area (NRA), managed by the U.S. Forest Service. Land south and east of the lake is the Jessie M. Honeyman Memorial State Park, administered by the Oregon Parks and Recreation Department (Figure 7).

The Oregon Dunes NRA was established by the U.S. Congress in March 1972 (Public Law 92-260) for the “conservation of scenic, scientific, historic and other values contributing to public enjoyment.” Congress then

directed the U.S. Forest Service to “manage and protect this *rare and beautiful gem....*” (author’s italics). The Forest Service accepted this assignment with considerable zeal, proclaiming in the agency’s 1972 NRA Resource Inventory that “the dunal area is fragile and easily altered. Its ecology is complex and can be turned, reversed, or even destroyed within one man’s lifetime” (Pinto et al. 1972). Renowned for its sand dunes that exist nowhere else in the Northern Hemisphere, the Oregon Dunes NRA covers about 110 square kilometers and extends for about 65 kilometers between the coastal cities of Florence and Coos Bay. Between one and two million people visit this reserve

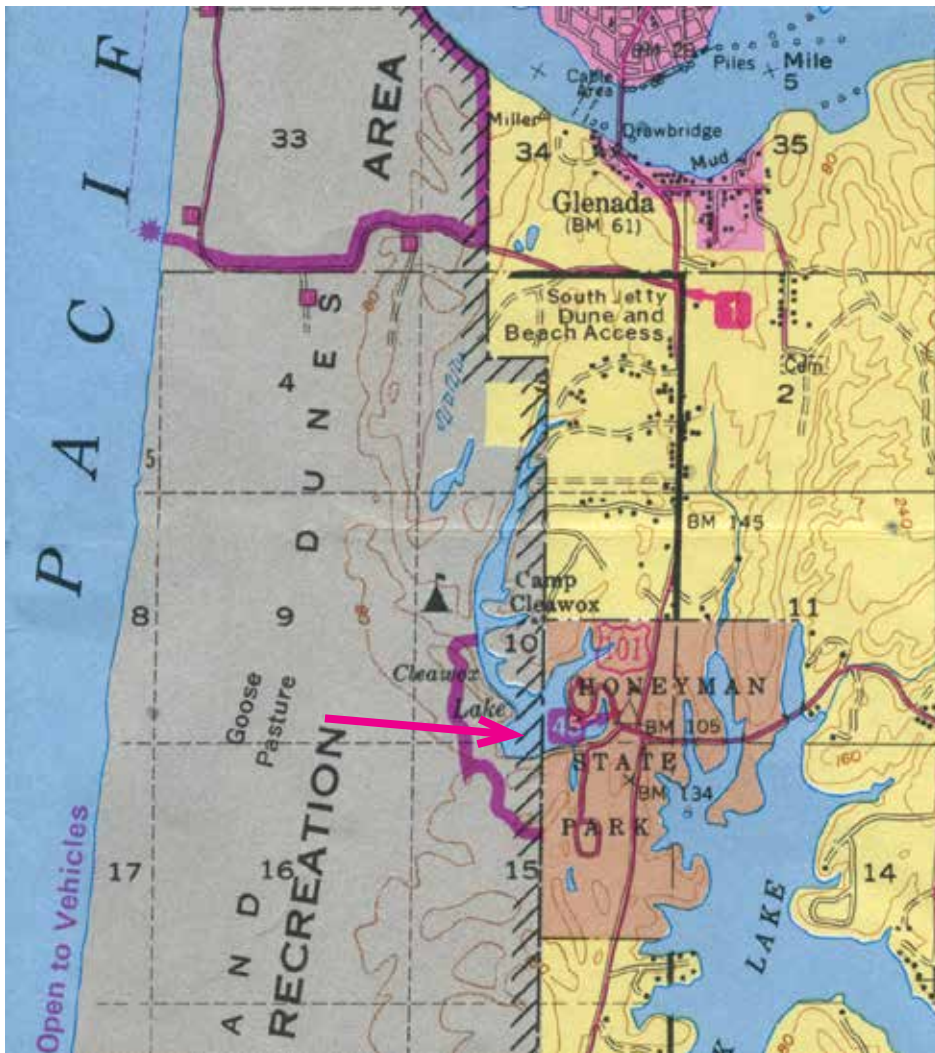


Figure 7. Map, dated 1981, showing location of Cleawox Lake relative to Honeyman State Park and the Oregon Dunes National Recreation Area. Purple boundary along west shore of the lake indicates lake closure to off-road vehicles. Source: Oregon Dunes NRA, Siuslaw National Forest, U.S. Forest Service.

annually. More than 400 bird species are also present, a few of which are threatened, notably the snowy plover. The Jessie M. Honeyman Memorial State Park was constructed between 1935 and 1940 by the Civilian Conservation Corps. The park, covering about two square kilometers (Figure 7), offers visitors a variety of recreational opportunities, including overnight camping (200 campsites), swimming, fishing, boating, hiking, bird-watching, ATV access, dune-buggy rides, and sandboarding. Other shoreline facilities include a Girl Scout camp (Camp Cleawox), a stone-and-log concession building built in 1938 as the Cleawox Lake Bathhouse, and the park office building constructed in 1936-37 as the park caretaker's house and garage.

The park is heavily used, logging nearly 20 million visitors between 1989 and 2013, including 4.3 million visitors to the sand-dune area during the same period (source: Honeyman State Park). As stewards, park officials assure the public that the agency's mission is "to provide and protect outstanding natural, scenic, cultural, historic and recreational sites for the enjoyment and education of present and future generations."

#### **Dune Migration and Lake Filling: The Legacy of Cultural Omission**

There's a bit of irony in the history and fate of Cleawox Lake: Created by sand dunes, it is conceivable that the lake will someday cease to exist as migrating dunes finally overwhelm

the entire basin. Since 1939, the south-shore dune has migrated northeastward for a total distance of about 150 meters at the average rate of about 2.3 meters annually (Figure 8). The rate of migration was highest between 1972 and 1979, averaging between 3.9 and 4.8 meters per year. Dune migration has since diminished somewhat, averaging around 1.5 meters or less per year between 1984 and 2005 (Witter et al. 2008). Nevertheless, the process continues as human intervention in this rare and fragile environment prevails.

I have tracked this process over the past 40 years, photographing the lake and its encroaching dune from both the ground and the air (Figures 9-13 showing stages of dune migration between 1973 and 1990). During that period, hundreds of thousands if not a million or more park visitors have scrambled up the face of the dune to its summit before sliding, striding, or galloping back down toward the lake, pushing sand ahead of them as they descended, with many repeating their descents (Figure 14). In recent years, dune users have introduced the sandboard, a surfboard-like device that further "bulldozes" sand toward the lake. Sandboarding has become a major attraction, advertised in travel brochures and in other media. The boards are readily accessible, sold or rented by vendors outside the park.

Adding to the turmoil are scores of dune buggies, all-terrain vehicles, jeeps, and motorcycles barreling across the surrounding dunes year-round, uprooting vegetation, plowing over dunes and scattering resting birds. Vehicular impacts to dunes and dunal vegetation have contributed sizably to accelerated sand-dune encroachment and, consequently, the in-filling of Cleawox and other dunal lakes. Oregon Wild, a Portland-based environmental organization, reported that off-road vehicles have "established more than 100 miles of unauthorized trails through vegetated areas" throughout the Oregon Dunes NRA. These sensitive areas, replete with rare plants and vegetation planted for dune stabilization have been partly denuded and scarified, the end result of a 15-year delay by the U.S. Forest Service, the NRA's custodian, to begin implementing zoning rules for off-roader usage (Oregon Wild 2012).

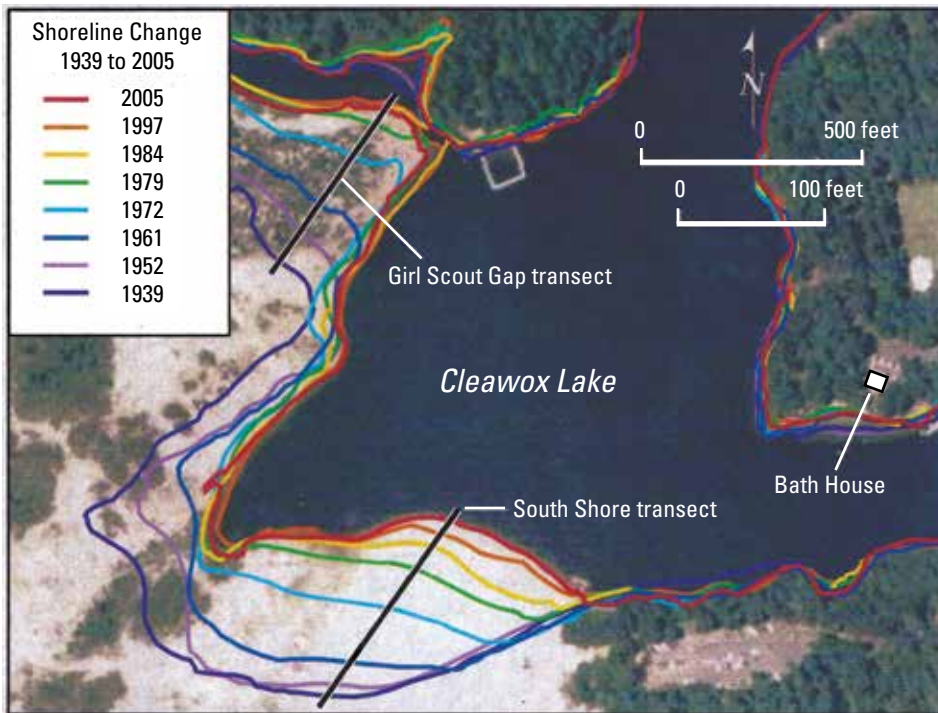


Figure 8. Illustration showing northeast migration of south-shore dune between 1939 and 2005. Illustration printed with permission from R.C. Witter, U.S. Geological Survey and lead author of 2008 publication by R.C. Witter, G.H. Grondin and J.C. Allan.

Dr. Joseph Miller Jr., the Portland physician who single-handedly halted illegal and destructive industrial logging in Oregon's Bull Run Watershed, the City of Portland's primary source of municipal drinking water, often said that battles to protect and preserve environmental treasures were won by educating the public. At Cleawox Lake, unfortunately, the public was not educated about how their footprints, actually and metaphorically, trampled the dune to a near-level profile (Figures 15 and 16), partially filling the lake and causing irreparable ecological harm.

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Figure 9. Aerial photo of Cleawox Lake, September 1973. Arrow indicates south-shore dune. Photo by the author.



Figure 10. Aerial photo of Cleawox Lake, November 1978. South-shore dune visible in photo's upper right-hand corner. Note the dune's arching oblique ridge that has developed. Photo by the author.

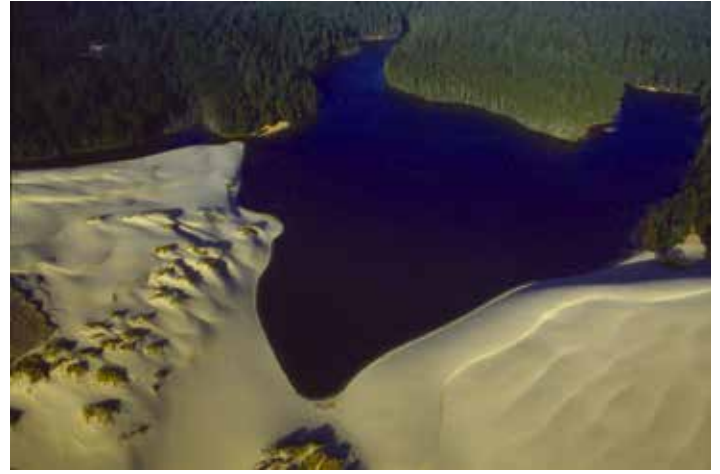


Figure 11. Aerial photo of Cleawox Lake, October 1980. Photo by the author.



Figure 12. Aerial photo of Cleawox Lake, September 1989. Photo by the author.



Figure 13. Aerial photo of Cleawox Lake, August 1990. Photo by the author.



Figure 14. Visitors waded out into shallow waters from the dune's leading edge, July 2000. Photo by the author.

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Figure 15. Side profile of south-shore dune looking east, August 1990. Photo by the author.



Figure 16. Side profile of south-shore dune looking east, July 2000. Photo by the author.

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