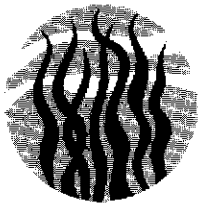


A Q U A P H Y T E

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Aquatic Vegetation in Volcanically Impacted Spirit Lake near Mount St. Helens, Washington

by Douglas W. Larson, Adjunct Professor, Department of Biology, Portland State University, Portland, Oregon 97207

[Editors' note. We asked Dr. Larson if anyone had studied the reestablishment of macrophytes in Spirit Lake after the Mount St. Helens eruption of 1980. Nobody had. Subsequently, Dr. Larson and Ms. Kristie Duyckinck made a trip to the lake to identify macrophytes that might have appeared there. Here is their report. The second part of this article is a review of the kinds of studies that have been conducted on the lake in the years since the eruption.]

Surprisingly, with the exception of limited work on post-eruption benthic algae (Ward *et al.*, 1983), studies to determine the reestablishment or introduction of higher plant life in Spirit Lake have not been attempted. As indicated in the second part of this article, post-eruption limnological research focused primarily on the lake's phytoplankton community.

Recently, on 15 September 1991, we hiked across the blast zone of Mount St. Helens (alas, helicopter transportation is no longer available to visiting scientists) to collect macrophytes and other vegetative materials from Spirit Lake.

[See SPIRIT LAKE on page 4]



Ten years after the Mount St. Helens eruption, which macrophyte do you think is now dominant in Spirit Lake?



Ms. Judy Ludlow, DNR Regional Biologist and winner of the Equipment Demonstration Award, shows how a LORAN navigation device can be used to lay transects and large treatment areas on the open water.

Record Meeting

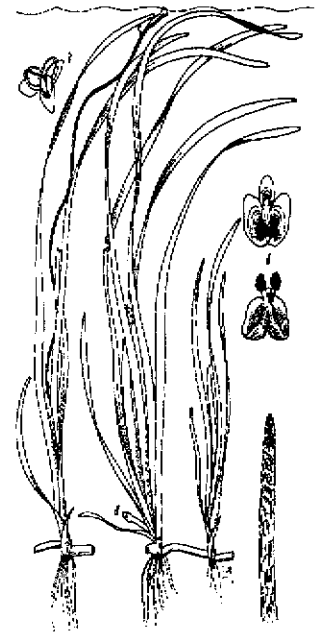
In spite of lean budgets, a record 480 people attended the annual meeting of the Florida Aquatic Plant Management Society (FAPMS) in Daytona Beach. They included former state senator, Tom Brown, new DNR Bureau Chief (see page 7).

At the three-day meeting, scientists, regulators, management people, and interested citizens heard each others' problems and solutions, and earned continuing education units (C.E.U.s) in the process.

Next year's meeting is in October in Clearwater.



Cows eat *Egeria*, *Vallisneria*, *Potamogeton* and *Sagittaria* on the St. Marks River, Florida.



Vallisneria americana

APM Spotlight

MR. FRED SCHUDEL

■ **Job Title:** Aquatic Plant Technician, Lee County Hyacinth Control, Recipient, FAPMS 1991 Applicator of the Year Award.

■ **Duties:** Helps manage the growth of nuisance aquatic plants in the Caloosahatchee River and in the canals of Cape Coral, and assists in the department's public education efforts, such as its annual Pond Management Workshop.

■ **Biggest Challenge:** "I want to help new residents [from 'up north'] to understand how important aquatic vegetation is for maintaining healthy food webs."

■ **Personal Goal:** A bachelor's degree in biology is in the future; Schudel takes junior college night classes, one course at a time.

■ **Community Activities:** Fred is an active member of the New Life Fellowship Church of Punta Gorda.

■ **Family Matters:** This "family man" enjoys the rest of his time with wife, Mary, and their five children, Becca, 1; Stephen, 3; Kate, 8; Sally, 16; and Kelly, 19. With a range of ages like that, we can see that Fred maintains a very active life indeed.



A T T H E C E N T E R

EDUCATIONAL VIDEOTAPE PROGRAMS

A variety of subjects relating to aquatic plant management in Florida are treated in a number of videotapes being produced by the Center. This is the last year of a four-year grant, co-sponsored by the Florida Department of Natural Resources and funded from the Aquatic Plant Trust Fund. The programs produced under the grant so far are:

Florida's Aquatic Plant Story

For general and school audiences, this program describes the benefits of native aquatic plants, recounts problems caused by some exotic "aquatic weeds", and introduces the major methods of aquatic plant management. 24 minutes, IFAS - VT 315.

Istokpoga - Lake of Legends

This program tells the story of one of Florida's largest lakes, and the hydrilla infestation that made its waters all but unusable. 39 minutes, IFAS - VT 285.

Calibration - A Field Approach

For applicators and managers, this program "takes the mystery" out of calibrating handguns, booms and granular spreaders. 35 minutes, IFAS - VT 284.

How To Determine Areas and Amount of Aquatic Herbicide to Use

For applicators and managers, this program introduces some of the mathematics essential to the proper use and application of aquatic herbicides. 34 minutes, IFAS - VT 310.

Aquatic and Wetland Plant Identification

For everyone, this series is in seven parts, the first five of which are available immediately. See page 9 for more information.

Floating and Floating-leaved Plants (IFAS - VT 360)

Emerged Plants (Part I) (IFAS - VT 361)

Emerged Plants (Part II) (IFAS - VT 369)

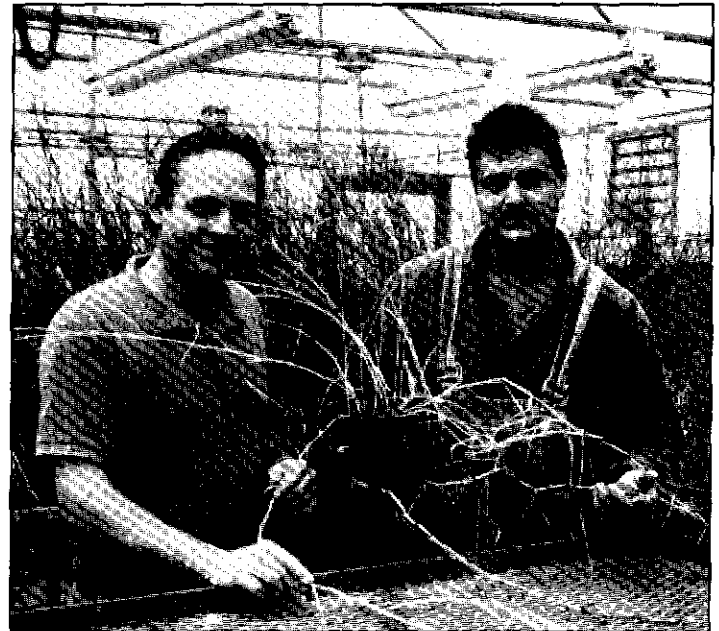
Submersed Plants (Part I) (IFAS - VT 362)

Submersed Plants (Part II) (IFAS - VT 370)

Grasses, Sedges, Rushes (Part I) (IFAS - VT 363)

Grasses, Sedges, Rushes (Part II) (IFAS - VT 371)

Available in VHS, S-VHS, or PAL formats. All programs cost \$15.00 each, plus .90 tax for Florida residents (\$15.00, non-Florida). Make checks payable to *University of Florida*. Order from: IFAS Publications, IFAS Building 664, Gainesville, Florida 32611-0001.



Dr. Donn Shilling and graduate student, Mr. Brian Smith, are studying the biology, ecology and management of torpedograss, *Panicum repens*. This weed is a serious pest in Florida where it is treated with the herbicide, glyphosate. However, extensive rhizomes and relatively little emerged foliage make the plant difficult to control. Shilling and Smith are trying to determine the right time of year or growth stage for maximum effect of herbicide treatment.

Florida Helps Minnesota

The Minnesota Department of Natural Resources Aquatic Nuisance Program recently contracted with the Center to review that state's aquatic plant management program, including its organization, research, permitting, funding and education efforts. Minnesota has emerging infestations of Eurasian water milfoil (*Myriophyllum spicatum*).

During September, Drs. William Haller, Alison Fox, Daniel Canfield and Joseph Joyce visited the Minneapolis-St. Paul and Brainerd areas. For their review, they toured milfoil infestation sites and interviewed DNR biologists, private applicators, harvester operators, homeowners and others.

Center Director Joyce noted that the water-using public in Minnesota "share many of the same concerns as Floridians" about how best to manage and protect their lakes and rivers.

The review should be complete by the end of this year.

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DR. JOSEPH JOYCE, DIRECTOR

[From SPIRIT LAKE on page 1]

Plant collections during this initial investigation were made entirely along the lake's south shore, which still receives high-temperature, chemically enriched geothermal seepwaters from the debris avalanche at the base of Mount St. Helens. This part of the lake is also shoaled by organically rich, chemically reduced muds, which provide a favorable substrate for the growth of benthic algae and rooted plants.

During the 15 September lake-visit, we collected 5 plant specimens, including *Rhizoclonium hieroglyphicum*, *Chara vulgaris*, *Myriophyllum spicatum*, *Juncus effusus*, and *Typha latifolia*. A cursory inspection of the lake's south shore indicated that these particular plants were preeminent; no other plants were observed.

Myriophyllum spicatum, Eurasian water milfoil, was by far the most abundant plant present. The significance of Eurasian water milfoil in Spirit Lake is twofold: first, milfoil - which was probably nonexistent in the lake before the eruption given the fact that the lake then was an ultraoligotrophic body of water occupying a relatively deep, steep-sided basin with minimal littoral area - was somehow introduced to the lake after the eruption and now proliferates in shallower, more fertile lakewaters. And second, because access to Spirit Lake is still greatly restricted, and is off-limits to recreation of any sort, milfoil was probably introduced by waterfowl flying in from milfoil-infested lakes and ponds.

There are no plans to eradicate the milfoil or control its spread, which is consistent with the Forest Service's policy of not interfering with the lake's natural evolution in a volcanically impacted setting. This insistence on letting natural processes prevail during the lake's recovery is evident in the fact that the Forest Service will not allow the restocking of Spirit Lake with fish, which reportedly were annihilated by prolonged whole-lake anoxia following the catastrophic eruption of Mount St. Helens.

POST-ERUPTION STUDIES

The catastrophic volcanic eruption of Mount St. Helens, Washington, on 18 May 1980, devastated vast forestlands, triggered massive landslides and mudflows, and filled several nearby lakes with timber and volcanic debris (Rosenfield, 1980; Kerr, 1980; Findley, 1981). The largest of the lakes impacted was Spirit Lake, located about 8 km north-northeast of the mountain's summit at elevation 975 m (above msl). What had been a pristine, ultraoligotrophic, relatively large (area = 5.1 km²; maximum depth = 56 m; Wolcott, 1973), alpine lake was reduced within minutes to a roiling, steaming body of water choked with logs and mud (Rosenfeld, 1980; Findley, 1981).

Spirit Lake received enormous quantities of debris avalanche materials, timber, pyrolyzed forest vegetation, and minerals of magmatic and lithic origin. This influx greatly increased lake-water concentrations of inorganic chemical constituents,

as well as dissolved and particulate organic matter. Much of the deposited organic material was incorporated in the lake's new sediment layer, which was roughly 50 to 60 m thick. The lake was also a depository for high-temperature pyroclastic flows and mudflows, ashfall, and geothermal waters, which increased lake-water temperatures to 33°C or higher (Dion and Embrey, 1981).

Unusually warm lake waters, acting in concert with the massive inorganic and organic loadings to Spirit Lake, prompted the lake's bacteria to proliferate rapidly: by 30 June 1980, aggregate bacteria in surface waters numbered 4.9×10^6 cells per ml, of which about 1×10^4 cells per ml were viable heterotrophic bacteria (Staley *et al.*, 1982). These latter bacteria proceeded to decompose and oxidize organic matter found abundantly in the lake's water column and sediments. This process soon depleted the lake's supply of dissolved oxygen, except in the uppermost 1 to 2 meters where wind-driven surface aeration maintained a relatively small concentration of dissolved oxygen (about 2.5 mg/l) as late as 30 June 1980 (Wissmar *et al.*, 1982). By early July, however, the lake became completely anoxic and remained so until November 1980 (Dahm *et al.*, 1982; Larson and Geiger, 1982). Consequently, when all dissolved oxygen had



The exotic plant, Eurasian water milfoil (*Myriophyllum spicatum*), was found to be the most abundant macrophyte present in Spirit Lake, eleven years after its destruction by Mount St. Helens. Ms. Kristie Duyckinck stands in the new littoral zone of the greatly altered lake.

been depleted, the only organisms capable of surviving in Spirit Lake were obligately or facultatively anaerobic microorganisms (Dahm *et al.*, 1982).

The fate of other biological components of the lake's pre-eruption ecosystem, such as protozoans, phytoplankton, zooplankton, periphyton, macrophytes, insects, fish, and amphibians is largely unknown, although protozoans and some phytoplankton were collected or observed at Spirit Lake during the late summer and fall of 1980 (Larson and Geiger, 1982; Ward *et al.*, 1983; Larson and Glass, 1987). The water chemistry of Spirit Lake, described shortly before and after the eruption, is presented in Table 1:

Table 1. Water Chemistry of Spirit Lake, Washington, Before and After the Eruption of Mount St. Helens. Data from Wissmar *et al.*, 1982.

Variable	4 April 80	30 June 80
Temperature (degrees C)	4.0	22.4
pH	7.35	6.21
Alkalinity (mg/l as CaCO ₃)	6.95	150.5
Carbon, organic, dissolved (mg/l)	0.83	39.9
Carbon, organic, particulate (mg/l)	0.435	0.570
Calcium, dissolved (mg/l)	2.15	66.9
Magnesium, dissolved (mg/l)	0.48	13.2
Sodium, dissolved (mg/l)	2.00	67.2
Potassium, dissolved (mg/l)	0.40	16.0
Manganese, dissolved (mg/l)	undetected	4480.0
Iron, dissolved (mg/l)	undetected	1080.0
Silica, dissolved (mg/l)	4.82	21.9
SiO ₄ , dissolved (mg/l)	5.06	72.5
Copper, dissolved (micrograms/l)	undetected	109.3
Lead, dissolved (micrograms/l)	undetected	25.9
Zinc, dissolved (micrograms/l)	undetected	24.2
Arsenic, dissolved (micrograms/l)	undetected	5.2
Chromium, dissolved (micrograms/l)	0.624	3.1
Antimony, dissolved (micrograms/l)	undetected	19.5
Aluminum, dissolved (micrograms/l)	9.98	301.0
Phosphorus, dissolved (micrograms/l)	7.12	236.0
Orthophosphate (micrograms/l)	2.85	707.0
Nitrate-nitrogen (micrograms/l)	3.72	9.0
Nitrite-nitrogen (micrograms/l)	1.84	12.0
Ammonia-nitrogen (micrograms/l)	1.19	16.0
Nitrogen, organic, part. (micrograms/l)	47.0	70.0
Sulfate, dissolved (mg/l)	0.795	124.9
Chloride, dissolved (mg/l)	1.04'	88.7

After these initial post-eruption surveys of Spirit Lake had been made in 1980, the lake's limnological recovery was tracked for a period of about 6 years (Larson and Glass, 1987). Some findings of this research follow: 1) The quality of Spirit Lake had improved greatly by 1986, with the strongest improvement occurring between 1980 and 1982; 2) the lake's epilimnion was always well-oxygenated during the summers that followed 1982, with dissolved-oxygen concentrations ranging from 6 to 8 mg/l; 3) the lake's hypolimnion continued to remain anoxic during the summer thermal stratification, although the rates of hypolimnetic oxygen consumption steadily diminished year after year; 4) concentrations of most ionic constituents, particularly iron and manganese, had decreased considerably by 1986, some falling close to pre-eruption levels; 5) densities of total bacteria were far less than what they had been shortly after the eruption; 6) the clarity of the lake had increased to such an ex-

tent that solar radiation during the summer of 1986 reached depths of 18-20 m (Secchi depth readings during September 1986 were 9 m, similar to pre-eruption measurements); and 7) greater lakewater clarity probably contributed to the recovery of the lake's phytoplankton community, with 135 post-eruption species identified by October 1986.

Information concerning lake phytoplankton provided an important index for ascertaining the rate of limnological recovery. Unfortunately, information about Spirit Lake phytoplankton prior to the 1980 eruption of Mount St. Helens is virtually nonexistent, and aside from the possibility of obscure, unpublished records, we have only a brief mention of "diatoms" and "green algae" collected during the first limnological survey of the lake in 1937 (Crawford, 1986).

During the summer of 1980, when Spirit Lake was in its most degraded condition, investigators (Ward *et al.*, 1983) found fewer than 10 species of phytoplankton in the lake. These populations were also quite sparse, totalling 2.59×10^5 cells/liter. Later, on 21 October 1980, a surface-water sample collected by helicopter near the center of the lake yielded only 13 species, all of which were diatoms with a total density, 2.6×10^5 cells/liter, essentially the same as the first observation (Larson and Geiger, 1982). Other one-shot phytoplankton surveys of Spirit Lake were conducted in June 1981 (Dahm *et al.*, 1981), August 1982 (Smith and White, 1985), and September 1983 (Larson and Glass, 1987). The maximum number of species reported from these surveys was 20, by Smith and White in 1982. The total phytoplankton densities reported varied widely from 700 cells/liter (in June 1981) to a value given as less than 1×10^6 cells/liter (in August 1982). Phytoplankton growth and production in Spirit Lake during the first 2 years following the 1980 eruption may have been suppressed by chemicals derived from volcanic ash leachates (McKnight *et al.*, 1981), in addition to extremely poor water clarity which restricted photosynthesis.

A total of 135 phytoplankton species were identified in Spirit Lake between 1983 and 1986; 62 percent of these species were diatoms (Larson and Glass, 1987). Additionally, one possibly rare species remains unidentified. Phytoplankton primary production data (Table 2) indicate that the production of organic matter in Spirit Lake - resulting entirely from chemosynthetic processes in 1980 and 1981 (Dahm *et al.*, 1982; Ward *et al.*, 1983) - is now carried on photosynthetically by phytoplankton and higher vegetative communities.

The post-eruption limnological study of Spirit Lake was terminated in October 1986 because of funding and authorization limits. During the previous 6 years (1980-1986), over 100 helicopter-borne field trips had been made

Table 2. Phytoplankton Primary Production (carbon-14 technique), Spirit Lake, Washington. Data from Larson and Glass, 1987. These are the only primary productivity measurements on record for Spirit Lake.

Date	mgC/m ² /hr
23 Jul 1984	19.91
17 Jun 1985	12.57
18 Aug 1986	41.68
22 Sep 1986	23.32

to the lake to obtain limnological data, at a cost of roughly \$1.5 million (Larson and Glass, 1987). Since 1986, the lake has been visited only once (on 29 September 1989) to update the limnological database to further ascertain the lake's recovery (D.W. Larson, unpublished data).

Although Spirit Lake is a major feature in the Mount St. Helens National Volcanic Monument, which is managed by the U.S. Forest Service, no effort is being put forth presently to continue the important task of tracking the lake's limnological resurgence. This is highly unfortunate because Spirit Lake offers a rare opportunity to measure ecosystem restoration following a sudden and complete ecological disaster.

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Acknowledgements

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VIDEOPHILE

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Produced by the Iowa Department of Natural Resources. For more information, contact Ross Harrison, Iowa Department of Natural Resources, Wallace State Office Building, Des Moines, IA 50319-0034, 515/281/8395.

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Ames is well-known for his dissent from popular notions about man-made chemicals and whether or not they increase our risk of cancer.

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