Revised January 10, 2014

JUDICIAL INTERN HIRING INFORMATION

Lorna G. Schofield, United States District Judge

Chambers Contact Information:
United States District Court
Southern District of New York
40 Centre Street, Room 201
New York, NY 10007
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Positions: Judge Schofield hires first- and second-year law students as interns during the school year and for summer employment. During the school year, interns must be available for a semester at least 20 hours a week. During the summer, interns must be available to work full time for at least eight weeks.

Applications: Applications should include a resume, transcript and writing sample. First-year students should not apply until they have received grades from all of their first semester classes.

A CareerZone Occupational Brief for:

Broadcast Technicians

An occupation in Engineering and Technologies

New York State Department of Labor
David A. Paterson, Governor

Job Description

Set up, operate, and maintain the electronic equipment used to transmit radio and television programs. Control audio equipment to regulate volume level and quality of sound during radio and television broadcasts. Operate radio transmitter to broadcast radio and television programs.

Interests

Realistic - Realistic occupations frequently involve work activities that include practical, hands-on problems and solutions. They often deal with plants, animals, and real-world materials like wood, tools, and machinery. Many of the occupations require working outside, and do not involve a lot of paperwork or working closely with others.

Tasks

1. Maintain programming logs, as required by station management and the Federal Communications Commission.

2. Control audio equipment to regulate the volume and sound quality during radio and television broadcasts.

3. Monitor strength, clarity, and reliability of incoming and outgoing signals, and adjust equipment as necessary to maintain quality broadcasts.

4. Regulate the fidelity, brightness, and contrast of video transmissions, using video console control panels.

5. Observe monitors and converse with station personnel to determine audio and video levels and to ascertain that programs are airing.

6. Preview scheduled programs to ensure that signals are functioning and programs are ready for transmission.

7. Select sources from which programming will be received, or through which programming will be transmitted.

8. Report equipment problems, ensure that repairs are made, and make emergency repairs to equipment when necessary and possible.

9. Record sound onto tape or film for radio or television, checking its quality and making adjustments where necessary.

10. Align antennae with receiving dishes to obtain the clearest signal for transmission of broadcasts from field locations.

11. Substitute programs in cases where signals fail.

Skills

Operation Monitoring - Watching gauges, dials, or other indicators to make sure a machine is working properly.

Reading Comprehension - Understanding written sentences and paragraphs in work related documents.

Operation and Control - Controlling operations of equipment or systems.

Troubleshooting - Determining causes of operating errors and deciding what to do about it.

Active Listening - Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times.

Active Learning - Understanding the implications of new information for both current and future problem-solving and decision-making.

Critical Thinking - Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems.

Knowledge

Telecommunications - Knowledge of transmission, broadcasting, switching, control, and operation of telecommunications systems.

Communications and Media - Knowledge of media production, communication, and dissemination techniques and methods. This includes alternative ways to inform and entertain via written, oral, and visual media.

Computers and Electronics - Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.

English Language - Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.

Engineering and Technology - Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.

Education and Training - Knowledge of principles and methods for curriculum and training design, teaching and instruction for individuals and groups, and the measurement of training effects.

Mechanical - Knowledge of machines and tools, including their designs, uses, repair, and maintenance.

Education

Job Zone Three: Medium Preparation Needed

Education: Most occupations in this zone require training in vocational schools, related on-the-job experience, or an associate's degree. Some may require a bachelor's degree.

Training: Employees in these occupations usually need one or two years of training involving both on-the-job experience and informal training with experienced workers.

School Programs

Communications Technology/Technician. - A program that generally prepares individuals to function as workers and managers within communications industries. Includes instruction in business economics; basic management; principles of interpersonal and mediated communications; radio, television, and digital media production; and related aspects of technology and communications systems.

Radio and Television Broadcasting Technology/Technician. - A program that prepares individuals to apply technical knowledge and skills to the production of radio and television programs, and related operations, under the supervision of broadcast and studio managers, directors, editors, and producers. Includes instruction in sound, lighting, and camera operation and maintenance; power and feed control; studio operations; production preparation; broadcast engineering; related computer applications; and specialized applications such as news, entertainment, live talk, sports, commercials, and taping.

Audiovisual Communications Technologies/Technicians, Other. - Any instructional program in audiovisual communications technologies not listed above.

Wages

In NY the average wage for this occupation was:

$33,030 for entry level workers, and $65,350 for experienced workers.

Job Outlook

Based on the total number of annual openings and its growth rate, the employment prospects for this occupation are described as Favorable.

In 2006, employment for Broadcast Technicians in NY was: 3,630.

It is anticipated that in the year 2016, employment in this area will number 3,930. There will be an increase of 30 new positions annually (0.01%). In addition, 120 jobs per year (0.03%) will become available due to employee turnover.

Similar Jobs

Computer Support Specialists - Provide technical assistance to computer system users. Answer questions or resolve computer problems for clients in person, via telephone or from remote location. May provide assistance concerning the use of computer hardware and software, including printing, installation, word processing, electronic mail, and operating systems.

Network Systems and Data Communications Analysts - Analyze, design, test, and evaluate network systems, such as local area networks (LAN), wide area networks (WAN), Internet, intranet, and other data communications systems. Perform network modeling, analysis, and planning. Research and recommend network and data communications hardware and software. Includes telecommunications specialists who deal with the interfacing of computer and communications equipment. May supervise computer programmers.

Radio Operators - Receive and transmit communications using radiotelegraph or radiotelephone equipment in accordance with government regulations. May repair equipment.

Sound Engineering Technicians - Operate machines and equipment to record, synchronize, mix, or reproduce music, voices, or sound effects in sporting arenas, theater productions, recording studios, or movie and video productions.

Film and Video Editors - Edit motion picture soundtracks, film, and video.

Telecommunications Equipment Installers and Repairers, Except Line Installers - Set-up, rearrange, or remove switching and dialing equipment used in central offices. Service or repair telephones and other communication equipment on customers' property. May install equipment in new locations or install wiring and telephone jacks in buildings under construction.

Electronic Home Entertainment Equipment Installers and Repairers - Repair, adjust, or install audio or television receivers, stereo systems, camcorders, video systems, or other electronic home entertainment equipment.

Telecommunications Line Installers and Repairers - String and repair telephone and television cable, including fiber optics and other equipment for transmitting messages or television programming.

Nuclear Power Reactor Operators - Control nuclear reactors.

UNITED STATES OF AMERICA
Before the
SECURITIES AND EXCHANGE COMMISSION

SECURITIES EXCHANGE ACT OF 1934
Release No. 63030 / October 4, 2010

INVESTMENT ADVISERS ACT OF 1940
Release No. 3096 / October 4, 2010

ACCOUNTING AND AUDITING ENFORCEMENT
Release No. 3194 / October 4, 2010

ADMINISTRATIVE PROCEEDING
File No. 3-14084

In the Matter of **Altschuler, Melvoin and Glasser LLP, and G. Victor Johnson, II, CPA,** **Respondents.**	**ORDER INSTITUTING PUBLIC ADMINISTRATIVE AND CEASE-AND-DESIST PROCEEDINGS PURSUANT TO SECTION 4C OF THE SECURITIES EXCHANGE ACT OF 1934, SECTION 203(k) OF THE INVESTMENT ADVISERS ACT OF 1940 AND RULE 102(e) OF THE COMMISSION'S RULES OF PRACTICE, MAKING FINDINGS, AND IMPOSING REMEDIAL SANCTIONS AND A CEASE-AND-DESIST ORDER**

I.

The Securities and Exchange Commission ("Commission") deems it appropriate that public administrative and cease-and-desist proceedings be, and hereby are, instituted against Altschuler, Melvoin and Glasser LLP and G. Victor Johnson, II, CPA (the "Respondents") pursuant to Section 203(k) of the Investment Advisers Act of 1940 ("Advisers Act"), Section 4C[1] of the

[1] Section 4C provides that:

The Commission may censure any person, or deny, temporarily or permanently, to any person the privilege of appearing or practicing before the Commission in any way, if that person is found . . . "(1) not to possess the requisite qualifications to represent others (2) to be lacking in character or integrity, or to have engaged in unethical

Securities Exchange Act of 1934 ("Exchange Act") and Rule 102(e)(1)(ii) of the Commission's Rules of Practice.[2]

II.

In anticipation of the institution of these proceedings, the Respondents have each submitted an Offer of Settlement (the "Offers"), which the Commission has determined to accept. Solely for the purpose of these proceedings and any other proceedings brought by or on behalf of the Commission, or to which the Commission is a party, and without admitting or denying the findings herein, except as to the Commission's jurisdiction over the Respondents and the subject matter of these proceedings, which are admitted, Respondents consent to the entry of this Order Instituting Public Administrative and Cease-and-Desist Proceedings Pursuant to Section 4C of the Securities Exchange Act of 1934, Section 203(k) of the Investment Advisers Act of 1940 and Rule 102(e) of the Commission's Rules of Practice, Making Findings, and Imposing Remedial Sanctions and a Cease-and-Desist Order ("Order"), as set forth below.

III.

On the basis of this Order and the Respondents' Offers, the Commission finds[3] that:

A. SUMMARY

This matter concerns the roles of audit firm Altschuler, Melvoin and Glasser LLP ("Altschuler") and engagement partner George Victor Johnson, II ("Johnson") in violations of Section 206(4) of the Advisers Act and Rule 206(4)-2 (the "Custody Rule") under the Advisers Act by Sentinel Management Group, Inc. ("Sentinel"), a registered investment adviser. At the relevant time, 2002 through 2006, Sentinel was required by the Custody Rule to have an independent public accountant verify all client funds and securities by surprise examination at least once each calendar year. Altschuler was the independent public accounting firm that Sentinel retained to perform its surprise examinations from 2002 through 2006, and Johnson was the engagement partner at Altschuler overseeing the Sentinel surprise examinations for every year except 2004.[4] The Respondents negligently failed to conduct the examinations in accordance with the professional standards applicable to examinations under Advisers Act Rule 206(4)-2, thereby causing Sentinel's violations of the Custody Rule and Section 206(4) of the

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or improper professional conduct; or (3) to have willfully violated, or willfully aided and abetted the violation of, any provision of the securities laws or the rules and regulations thereunder."

[2] Rule 102(e)(1)(ii) provides, in relevant part, that:

> The Commission may censure or deny, temporarily or permanently, the privilege of appearing or practicing before it … to any person … who is found … to have engaged in improper professional conduct.

[3] The findings herein are made pursuant to the Respondents' Offers of Settlement and are not binding on any other person or entity in this or in any other proceeding.

[4] Johnson did not act as the engagement partner for 2004 because Johnson and Altschuler, without admitting or denying its findings, consented in June 2005, to the entry of an order, which required Johnson to refrain from serving as an engagement partner in any audit of any CFTC registrant for six months. *See In the Matter of G. Victor Johnson and Altschuler, Melvoin and Glasser*, LLP, CFTC Docket No. 04-29 (June 13, 2005).

Advisers Act. The conduct related to the exams also constituted improper professional conduct pursuant to Section 4C(b)(2) of the Exchange Act and Rule 102(e)(1)(ii) of the Commission's Rules of Practice.

B. RESPONDENTS

<u>Altschuler, Melvoin and Glasser LLP</u> is an Illinois limited liability partnership that maintained its principal place of business in Chicago, Illinois. Altschuler performed annual Advisers Act surprise examinations for Sentinel, a registered investment adviser, for the years 2002 through 2006 and also served as Sentinel's independent auditor from 2002 through 2005. On November 1, 2006, Altschuler sold most of its assets to another public accounting firm and is now in liquidation. Altschuler is, however, contractually required to complete any pending engagements, sign-off on report reissuance and consents, and defend malpractice claims.

<u>George Victor Johnson, II, CPA</u> age 69, of Arlington Heights, Illinois is a certified public accountant licensed in Illinois and currently a director of a public accounting firm. Johnson served as the engagement partner for the 2002, 2003, 2005 and 2006 Advisers Act surprise examinations of Sentinel and the 2002 through 2005 financial statement audits of Sentinel on behalf of Altschuler.

C. OTHER RELEVANT ENTITY

<u>Sentinel Management Group, Inc.</u> (SEC File No. 801-15642) is an Illinois corporation based in Northbrook, Illinois, that has been registered with the Commission as an investment adviser since 1980. Sentinel is registered with the Commodity Futures Trading Commission as a futures commission merchant. On August 17, 2007, Sentinel filed for Chapter 11 bankruptcy. At the time of Sentinel's bankruptcy, Sentinel managed approximately 180 accounts for around 70 clients and had approximately $1.4 billion in assets under management.

D. FACTS

1. <u>The Commission's Action Against Sentinel</u>

a. Prior to its bankruptcy on August 17, 2007, Sentinel primarily managed investments of short-term cash for advisory clients, including futures commission merchants, hedge funds, financial institutions, pension funds, and individuals. Sentinel purported to invest all of its clients' assets in pooled investment vehicles (the "Securities Pools") [5] and to hold the underlying securities in three segregated accounts at a qualified custodian bank (the "Custodian").

b. Sentinel obtained a loan, for its own benefit, from the Custodian and established a collateral account at the Custodian to maintain securities pledged as collateral for this loan. During the relevant period, the loan from the Custodian to Sentinel was similar to a line of credit in that it fluctuated on a daily basis. The outstanding balance of the loan grew significantly from when Altschuler first began performing Advisers Act surprise examinations for Sentinel to the days leading up to Sentinel's bankruptcy. For example, the loan balance was approximately

[5] Advisory clients owned *pro-rata*, undivided interests in the Securities Pools.

$20 million at December 31, 2002, approximately $120 million at December 31, 2004, and approximately $230 million at December 31, 2006. On August 20, 2007, the Commission filed an emergency enforcement action against Sentinel in the United States District Court in Illinois alleging multiple violations of the antifraud provisions of the Advisers Act. According to the Commission's complaint against Sentinel, Sentinel misused Securities Pools' securities to collateralize the loan. When Sentinel collapsed in August 2007, the Custodian claimed ownership of several hundred million dollars in Securities Pool securities that had been improperly held in Sentinel's account to collateralize the loan made by the Custodian to Sentinel for the benefit of Sentinel. On December 17, 2008, the court entered a judgment by consent against Sentinel permanently enjoining it from violating the antifraud provisions of the federal securities laws.

2. <u>Altschuler's and Johnson's Unreasonable Advisers Act Surprise Examinations Caused Sentinel's Violations of the Custody Rule</u>

a. Section 206(4) of the Advisers Act prohibits investment advisers from engaging in "any act, practice, or course of business which is fraudulent, deceptive, or manipulative," as defined by the Commission by rule. During the relevant period, Rule 206(4)-2 stated in pertinent part that it constitutes a fraudulent, deceptive, or manipulative act, practice or course of business within the meaning of Section 206(4) of the Advisers Act for any registered investment adviser to have custody of client funds or securities unless a qualified custodian or the adviser sends a quarterly account statement to each of the clients for which it maintains funds or securities, or to each beneficial owner of a pooled investment vehicle, identifying the amount of funds and of each security in the account at the end of the period and setting forth all transactions in the account during the period.[6] If the adviser sends the quarterly account statements itself, which Sentinel did, an independent public accountant generally must verify all of the funds and securities by actual examination at least once during each calendar year on a date chosen by the accountant without prior notice to the investment adviser (a "surprise examination"). [7]

b. The Commission provided guidance for accountants conducting surprise examinations in Accounting Series Release No. 103[8] which indicates, among other things, that the accountant should express an opinion as to whether the investment adviser was in compliance with Rule 206(4)-2(a)(1) as of the examination date. Rule 206(4)-2(a)(1) requires, among other things, client assets of which the adviser has custody to be maintained by a qualified custodian (i) in a separate account for each client under that client's name or (ii) in accounts that contain only [the adviser's] clients' funds and securities, under [the adviser's] name as agent or trustee for the clients.

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[6] Prior to the effectiveness of the 2003 amendments to Rule 206(4)-2, Rule 206(4)-2 was not materially different with regard to those parts of the rule relevant to the violations at issue in this matter.

[7] Rule 206(4)-2(b)(3) provided an exception from the surprise examination requirement for a pooled investment vehicle if certain criteria were met, including, among other things, a financial-statement audit of the pool. This provision, however, is not relevant here because the Securities Pools were not audited.

[8] *Statement of the Commission describing nature of examination required to be made of all funds and securities held by an investment adviser and the content of related accountant's certificate*, Accounting Series Release No. 103, Investment Advisers Act Release No. 201 (May 26, 1966) ("ASR No. 103").

c. During the relevant period, Sentinel was required to undergo surprise examinations by an independent public accountant.[9] To conduct an appropriate examination under Rule 206(4)-2, an accountant should have, among other things:[10]

- Confirmed all Securities Pool securities held by the Custodian.
- Reconciled *all* securities between the Custodian's records and the adviser's records of the client accounts.
- Conducted the examination by "*surprise*."
- Completed the surprise examination in accordance with U.S. Generally Accepted Auditing or Attestation Standards as established by the American Institute of Certified Public Accountants ("AICPA Attest Standards")(emphasis added).

d. Rule 206(4)-2 also states that the accountant is to transmit to the Commission, within 30 days after the completion of the examination, a certificate, attached to a Form ADV-E, stating that an examination of such funds and securities has been made, and describing the nature and extent of the examination.

e. The AICPA also provided guidance concerning the examination and reporting requirements of Rule 206(4)-2 in the AICPA Audit and Accounting Guide: *Audits of Investment Companies* ("AICPA Guide"). The AICPA Guide contained an illustrative attestation report for independent public accountants for surprise examinations performed pursuant to Rule 206(4)-2.[11] According to the AICPA Guide, the attestation report should, if applicable, include specific references to the following procedures performed by the independent accountant in connection with the surprise examination: (1) confirmation of all cash and securities held by a third party, such as a custodian bank or broker, in the name of the investment adviser as agent or trustee for clients; and (2) reconciliation of all such cash and securities to books and records of client accounts maintained by the investment adviser. These procedures were applicable to the Sentinel surprise examinations. Additionally, the illustrative attestation report contained an opinion on management's assertion regarding compliance with, among other things, Rule 206(4)-2(a)(1) based on the aforementioned procedures.

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[9] Prior to Nov. 5, 2003, the Custody Rule required all registered advisers to have surprise examinations. *See* Advisers Act Release No. 2176 (Sept. 25, 2003) (amending the rule). Thus, Sentinel was required to have the Securities Pools' assets verified by surprise examination under the Custody Rule, as it existed prior to Nov. 5, 2003. It also was required to have surprise examinations after the rule's amendment in 2003 because it, not its custodian, sent account statements to the investors in the Securities Pools. *See* Rule 206(4)-2(a)(3)(iii) (the account statements required to be sent under Paragraph (a)(3)(ii) of the Rule must be sent to each beneficial owner of a pooled investment vehicle). The Commission amended Rule 206(4)-2 in December 2009 to require registered investment advisers with custody of client assets to have surprise examinations annually, subject to certain exceptions, as well as require that qualified custodians holding those assets send out account statements. *See* Advisers Act Release No. 2968 (Dec. 30, 2009). Unless otherwise noted, references to the Rule refer to its provisions as it existed prior to its most recent amendment.

[10] *See* Rule 206(4)-2; ASR No. 103 and Advisers Act Release No. 2176 (Sept. 25, 2003).

[11] *See, e.g.*, paragraph 11.12 of the AICPA Audit and Accounting Guide, *Audits of Investment Companies*, with conforming changes as of May 1, 2002.

f. While conducting these examinations, Altschuler and Johnson negligently failed to meet the AICPA attestation standard requiring "due professional care." *See AT 101A.39 (AICPA 2002).* For example, Johnson knew in 2002 of Sentinel's loan from the Custodian. He also was informed that Sentinel regularly transferred securities, originally purchased for the Securities Pools, from segregated accounts held at the Custodian to Sentinel's collateral account at the Custodian. In addition, Altschuler and Johnson obtained documents from the Custodian during each of the surprise examinations (e.g., collateral account statement confirmations from the Custodian) that reflected securities purportedly owned by the Securities Pools were held in Sentinel's collateral account at the Custodian, which Johnson knew or should have known also contained Sentinel owned securities. Although the collateral account statements they received from the Custodian were in Sentinel's name and the securities in the account were not marked for the benefit of the Securities Pools, Altschuler and Johnson included the securities in this account in their reconciliations of the Custodian's records to the Adviser's records. Altschuler and Johnson should have recognized that Sentinel was holding some securities purportedly owned by the Securities Pools in a Sentinel account at the Custodian and that such practice did not comply with Rule 206(4)-2(a)(1). Moreover, certain securities were shown in Sentinel's records as being held in the Securities Pools' segregated accounts, whereas such securities were shown in the Custodian's records as being held only in Sentinel's collateral account. The examination work papers further reveal that Altschuler and Johnson obtained certain schedules (including account statements of investors in the Securities Pools) that showed Sentinel was using as collateral for its loan certain Securities Pools' securities which were maintained in Sentinel's collateral account, commingled with Sentinel's own assets.

g. Nonetheless, based primarily on oral statements from Sentinel's management, Altschuler and Johnson had reached the conclusion that Sentinel owned the securities used to collateralize the loan, contrary to certain documentary evidence in the examination work papers and elsewhere, and therefore they failed to follow up adequately on the inconsistencies or to design procedures to discover whether the Securities Pools' securities were being commingled.

h. In addition, from 2002-2006, Johnson (for every year other than 2004) and Altschuler issued unqualified attestation opinions that stated that Sentinel's assertions regarding its compliance with Rule 206(4)-2(a)(1) for the examination periods were fairly stated in all material respects. However, as a result of procedures performed and evidence obtained, Altschuler and Johnson should have known that Sentinel was not complying with Rule 206(4)-2(a)(1) because Sentinel was commingling the Securities Pools' securities in its collateral account. Therefore, Altschuler and/or Johnson should not have issued unqualified attestation opinions.

i. In addition, contrary to the Custody Rule, Altschuler and Johnson failed to conduct all of their examinations of Sentinel by surprise either by providing prior notice of the examination or in one instance allowing Sentinel to choose the date of the exam.

j. Finally, Johnson also failed to provide sufficient supervision to the Altschuler staff members that were tasked to complete the surprise examinations. Johnson billed only 1.5 hours a year on the examinations and during that time provided little apparent guidance to the staff members carrying out the examinations. Such inadequate guidance and poor supervision fall short of the requirement of the AICPA Attestation Standards' first standard of field work that "assistants, if any, shall be properly supervised." *See AT 101A.42 (AICPA 2002).*

3. Altschuler and Johnson Engaged in Improper Professional Conduct

a. During the examinations of Sentinel from 2002 through 2006, the Respondents engaged in improper professional conduct.

b. During each examination conducted, the Respondents (1) failed to recognize that certain custodial-client securities (i.e., some of those of the Securities Pools) were held in accounts that did not comply with subparagraph (a)(1) of Rule 206(4)-2 because such securities were in Sentinel's collateral account which was not marked as for the benefit of the custodial clients (i.e., the Securities Pools); (2) failed to properly reconcile Sentinel's Securities Pool accounts to the account statements received directly from the Custodian; (3) inaccurately stated in their opinions that Sentinel complied with subparagraph (a)(1) of Rule 206(4)-2; (4) failed to conduct all of their examinations on a surprise basis; and (5) failed to file the examination report within 30 days of completing the examinations. The Respondents also failed to appreciate that heightened scrutiny was warranted in connection with their examinations of Sentinel because of the growing size of Sentinel's loan from the Custodian, which resulted in Sentinel transferring securities from the Securities Pools' segregated accounts to its collateral account to collateralize its loan.

c. The Respondents failed to conduct the examinations in accordance with the AICPA Attestation Standards, which are the professional standards applicable to the examinations performed under Advisers Act Rule 206(4)-2.

d. Section 4C of the Exchange Act and Rule 102(e)(1)(ii) provide that the Commission may censure or temporarily or permanently deny an accountant the privilege of appearing or practicing before it if it finds, after notice and opportunity for hearing, that the accountant engaged in "improper professional conduct." In relevant part, Section 4C(b) and Rule 102(e)(1)(iv) define 'improper professional conduct' to include either of the following two types of negligent conduct:

> (1) A single instance of highly unreasonable conduct that results in a violation of applicable professional standards in circumstances in which an accountant, or a person associated with a registered public accounting firm, knows, or should know, that heightened scrutiny is warranted, or
>
> (2) Repeated instances of unreasonable conduct, each resulting in a violation of applicable professional standards, that indicate a lack of competence to practice before the Commission.

4. FINDINGS

a. Based on the foregoing, the Commission finds that Altschuler and Johnson caused Sentinel's violations of Section 206(4) of the Advisers Act and Rule 206(4)-2 thereunder.

b. Based on the foregoing, the Commission finds that Altschuler and Johnson engaged in improper professional conduct pursuant to Section 4C(b)(2) of the Exchange Act and Rule 102(e)(1)(ii) of the Commission's Rules of Practice.

IV.

In view of the foregoing, the Commission deems it appropriate to impose the sanctions agreed to in the Respondents' Offers.

Accordingly, Pursuant to Sections 203(k) of the Investment Advisers Act of 1940 ("Advisers Act"), and 4C of the Securities Exchange Act of 1934 ("Exchange Act") and Rule 102(e)(1)(ii) of the Commission's Rules of Practice, it is hereby ORDERED, effective immediately, that:

A. Altschuler and Johnson shall cease and desist from causing any violations and any future violations of Section 206(4) of the Advisers Act and Rule 206(4)-2 thereunder.

B. Altschuler is censured.

C. Johnson is denied the privilege of appearing or practicing before the Commission as an accountant.

D. Altschuler shall within 7 days of the entry of this Order, pay disgorgement of $18,700.00 in fees collected during the 2002 through 2006 Advisers Act examinations and prejudgment interest of $5,476.00 to the Securities and Exchange Commission. If timely payment is not made, additional interest shall accrue pursuant to SEC Rule of Practice 600. Payment shall be: (A) made by United States postal money order, certified check, bank cashier's check or bank money order; (B) made payable to the Securities and Exchange Commission; (C) hand-delivered or mailed to the Office of Financial Management, Securities and Exchange Commission, Operations Center, 6432 General Green Way, Stop 0-3, Alexandria, VA 22312; and (D) submitted under cover letter that identifies Altschuler as a Respondent in these proceedings, the file number of these proceedings, a copy of which cover letter and money order or check shall be sent to John Dugan, Division of Enforcement, Securities and Exchange Commission, Boston Regional Office, 33 Arch Street, Boston, MA, 02110.

By the Commission.

Elizabeth M. Murphy
Secretary

Service List

Rule 141 of the Commission's Rules of Practice provides that the Secretary, or another duly authorized officer of the Commission, shall serve a copy of the Order Instituting Public Administrative and Cease-and-Desist Proceedings Pursuant to Section 4C of the Securities Exchange Act of 1934, Section 203(k) of the Investment Advisers Act of 1940 and Rule 102(e) of the Commission's Rules of Practice, Making Findings, and Imposing Remedial Sanctions and a Cease-and-Desist Order ("Order"), on the Respondents.

The attached Order has been sent to the following parties and other persons entitled to notice:

Honorable Brenda P. Murray
Chief Administrative Law Judge
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New Study Reveals U.S. to Lose $785 Million, Canada $1.7 Billion Annually with WHTI

Slaughter Repeats Call for Cost-Benefit Analysis of Passport Initiative

Washington, DC - Rep. Louise M. Slaughter (D-NY-28), Ranking Member of the House Rules Committee, today repeated her call for a cost-benefit analysis of the Department of Homeland Security's Western Hemisphere Travel Initiative (WHTI) following the release of a new study from the BESTT Coalition (Borders for Economic Security, Trade and Tourism). The study concluded that the United States stands to lose $785 million annually if the WHTI is implemented in its current form.

"This new study is only more evidence that the Travel Initiative is deeply flawed and needs to be changed," Rep. Slaughter said. **"If we don't conduct a comprehensive economic analysis of this plan before ground is broken, we will simply be writing off the economic security of millions of Americans and Canadians. And they deserve better."**

Rep. Slaughter was today joined by 20 New York Members of Congress in requesting that the Office of Management and Budget (OMB) oversee the proposed analysis. She had previously employed an Executive Order in a further attempt to force the federal government to study the economic impact of its plan.

The Conference Board of Canada confirmed BESTT's findings. It concluded that the WHTI would result in 3.5 million fewer nationwide crossings from Canada to the United States, and more than twice this number from the U.S. to Canada. In addition to the $785 million annually lost by America, the Canadian economy would stand to lose $1.7 billion per year in revenue.

The BESTT study used a Zogby International poll taken of individuals living in cities along the border. The poll found that such citizens would be less likely to visit the United States if they were required to use a passport or another secure document at the border, a requirement of the WHTI. The study also revealed that:

- Vacation is the top reason why Americans and Canadians travel to Canada and the United States, respectively. Many poll respondents also said that they would not participate in a program requiring a new identification card for cross-border travel.
- Most Canadian visitors to the United States travel more than 100 miles to get there. They are also two times as likely as American tourists to spend over $500 during their visit. Consequently, their trips contribute significantly not just to border economies, but to a broader array of communities in both countries.
- A majority of the poll's respondents said that they supported an enhanced driver's license that could combine a normal license with a border crossing ID card, and that such a document would increase the likelihood that they would continue to cross the border.
- Most poll respondents also said that they did not believe that new border-crossing restrictions were necessary.

Ayudar a los Victimas de los Huracanes Katrina y Rita

El 2 de septiembre de 2005, la Agencia Federal de la Administración de Emergencia (conocida como FEMA) estableció una linea telefonico gratuita, 1-800-440-6728, para aceptar la generosa asistencia para ayudar a las víctimas de Huracán Katrina.

El Departamento de Seguridad Nacional ha establecido una pagina de web para razones similares. Si tiene los recursos para donar o vender a las agencias de emergencia, por favor registran esos artículos en el Registro de Recurso de Crisis Nacional, accesible en: www.SWERN.gov
. Las agencias de emergencia estarán verificando esta lista cuando la necesidad para las materias y servicios sean necesarios.

En el Condado de Orange

OperationOC es una cooperativa de asociaciones privados y públicos en el Condado de Orange que ayuda proveer las necesidades de los evacuados del Huracán Katrina traslados en el Condado de Orange. Al día, el Centro de Recursos de OperationOC ha proporcionado servicios para 474 evacuados de 205 familias. 210 evacuados han vuelto para servicios adicionales. El total del Condado de Orange reportada 472 familias que representan 951 evacuados de los Huracanes Katrina y Rita como reportado por la Cruz Roja Americana del Condado de Orange.

OperationOC ha proporcionado ayuda de prevención y emergencia, estabilización y transición para dar esperanza a por lo menos 100 familias desplazadas. También ha establecido una cuenta para Emergencia & Transición de Ayuda (conocida como ETA) que cuando financiada utilizará el programa Strong Beginnings para proporcionar ayuda personal y administración de casos individuales; ayuda de transporte; ayuda de emergencia, transición y vivienda permanente; entrenamiento de trabajo; asistencia médica; proveer alimentos nutritivos; ropa profesional; artículos de higiene; consejo; y ayuda financiera.

Con el programa OperationOC residentes pueden proporcionar artículos urgentes de necesidad, donativos, proporcionar para familias desplazadas y ser voluntarios. Para más información, llame al **211, (714) 247-4328 o (800) 956-1613 (California y Texas sólo) o la visita** **www.operationoc.org**

Si usted tiene una oferta de bienes o servicios, llama por favor nuestra línea directa en 1-800-440-6728. Un representante tomará su nombre y la información en cómo contactarle, así como qué tipo de bienes o le atienden a desea donar. Las ofertas del donativo pueden incluir envoltura temporaria para víctimas de desastre, para los vehículos, para el equipo de la construcción, para el alimento, para la ropa, o para otras ofertas que pueden ayudar esos desplazado por Huracán Katrina.

También puede donar dinero a varias organizaciones notables con años de experiencia en responder a desastres. Incluyen la American Red Cross (Cruz Roja), Salvation Army y otras organizaciones. Pueden encontrar la lista de organizaciones de estan activas durante desastres en la red: www.nvoad.org .Tambien pueden llamar nuestra línea directa de donativos y un representante los puede referir a una de estas organizaciones.

Si usted tiene una oferta de materiales o servicios, por favor llamen nuestra línea directa al **1-800-440-6728**. Un representante tomará su nombre y información para contactarle, así como el tipo de materiales o servicios desean donar. Donativos pueden incluir vivienda temporal para las víctimas de desastre, vehículos, equipo o materiales de construcción, alimentos, ropa, o otras donaciones que pueden ayudar a los victimos del Huracán Katrina.

Individuos que tienen acceso a los medios de comunicación fuera de las áreas afectadas en el Gulfo Costa encuentran esta compilación de los recursos del Huracán Katrina útil.

Si Californianos Oyen de Víctimas Atrapadas :
La Oficina de Servicios de Emergencia de California (OES) ha aprendido que las víctimas atrapadas en la Costa del Golfo estan llamando a sus familias, amigos, los adorar, o cualquiera persona que pueden hacer una llamada desde California para que los rescaten. Contacte el U.S. Coast Guard línea del rescate al 800-323-7233 y asistencia inmediata será mandada.

Las Personas Perdidas

Si usted sabe de una persona perdida en la Costa de Golfo, llame a la línea directa de la Cruz Rojo al 1-866-GET-INFO o 1-866-438-4636.

Además, una variedad de sitios de web fueron establecidos para ayudar a reunirse con sus familiares que fueron afectados por el huracán. Estos sitios fueron programados independientemente de una agencia oficial del gobierno: www.nola.com , www.nolarefugees.com o http://batonrouge.craigslist.org/laf/ .

Voluntarios

La situación en las partes afectadas hacen difícil para voluntarios generales que alcanzen las zonas catastróficas. Se recomienda que personas quienes desean ayudar animen a miembros de su comunidad que hagan donativos (ver abajo).

El programa "Early Show" pasó un segmento con información general en como aseguirse que su donativo es donado a una organización notable para ayudar las vicitmas del Huracán Katrina, para evitar el fraude. Para ver: www.cbsnews.com/stories/2005/09/01/earlyshow/main811089.shtml

El Servicio de Impuestos Internos (IRS) tiene información acerca de reclamar una deducción por sus donativos a organizaciones caritativas en **www.irs.gov/newsroom/article/0,,id=108362,00.html**

- **Las siguientes organizaciones caritatives estarán aceptando donaciones para ayudar las victimas del Huracan Katrina:**

- Adventist Community Services: (800) 381-7171
- American Red Cross: www.redcross.org Spanish site is www.cruzrojaamericana.org 1-800-HELP NOW (435-7669). Spanish is 1-800-257-7575. Because of the outpouring of assistance, the American Red Cross web site and phone lines have been jammed. Instead, individuals can mail a donation to "American Red Cross - National Disaster Relief Fund", P.O. Box 37243, Washington D.C. 20013.

- America's Second Harvest: www.secondharvest.org

1-800-344-8070
- B'nai B'rith International: www.bnaibrith.org
  1-888-388-4224
- Catholic Charities, USA: www.catholiccharitiesusa.org
  1-800-919-9338
- Church World Service: www.churchworldservice.org
  1-800-297-1516
- Corporation for National & Community Service Disaster Relief Fund: www.nationalservice.gov
  (202) 606-6718
- Feed the Children: www.feedthechildren.org
  1-800-525-7575
- Humane Society: http://www.hsus.org/
  202-452-1100
- Lutheran Disaster Response: www.lwr.org
  800-638-3522
- Mennonite Disaster Service: www.mds.mennonite.net/
  717-859-2210
- Nazarene Disaster Response: http://www.nazarenedisasterresponse.org
  888-256-5886
- Presbyterian Disaster Assistance: www.pcusa.org/pda/
  800-872-3283
- Salvation Army: www.salvationarmyusa.org/USNSAHome.htm
  1-800-SAL-ARMY (725-2769)
- Southern Baptist Convention: www.sbc.net/
  1-800-462-8657, ext. 6440
- United Jewish Communities: www.ujc.org/
  1-800-462-8657, ext. 6440
- United Methodist Committee on Relief: www.methodistrelief.org
  1-877-277-2477 or (800) 554-8583

Asistencia Para las Victimas del Costa del Golfo:

- American Red Cross: (866) GET-INFO or (866) 438-4636
- Salvation Army: 1-800-SAL-ARMY
- Federal Emergency Management Agency (FEMA):

Para aquellos que sostuvieron pérdidas o propiedad dañada en un condado declaró como zona catastrófica por el gobierno federal pueden ser eligibles para obtener ayuda federal y estatal. La ayuda puede incluir: becas para vivienda temporal, reparaciones para propiedad individual y los préstamos del bajo-interés a propietarios.

Para solicitar a los programas de ayuda de desastre de FEMA, llame la línea de registracion de FEMA al 1-800-621-FEMA (3362) o 1-800-462-7585. Esta línea está abierta las 24 horas al día, y los residentes son recomendados a llamar por la noche o en la manana para reducir el tiempo de esperar.

Información adicional acerca de los programs de FEMA puede obtener en   www.fema.gov/about/process/
o
www.fema.gov/rrr/qanda.shtm
,

http://www.fema.gov/hazards/hurricanes/ o www.fema.gov/press/2005/resources_katrina.shtm

Administracion de Negocios Pequeños: (800) 621-3362 or www.sba.gov/disaster_recov/loaninfo/dloanassit.html

National Flood Insurance Program: (888) 379-9531**or** **www.floodsmart.gov/floodsmart/pages/fileaclaim.jsp**

Shelter:
Para aquellos que necesitan hogar, concaten a la Cruz Rojo al 1-866-GET-INFO (438-4636).

http://www.google.com/hostednews/afp/article/ALeqM5g6pjdmBNAEyFXqsYygo-_cqBt5wQ

WASHINGTON (AFP) — The US government watchdog on religious freedom abroad criticized India for refusing to grant its representatives visas, after their planned trip came under fire from Hindu conservatives.

India joins only Cuba in refusing a visit by **the US commission,** which has been allowed to visit even nations whose records it frequently criticizes such as China and Saudi Arabia.

A delegation of the **US Commission on International Religious Freedom (USCIRF)** had planned to leave on June 12 for India, where it has voiced concern about a rise in communal violence.

(3) DOJ-OPR refers to the OIG allegations involving misconduct by Department attorneys or investigators that do not relate to the exercise of an attorney's authority to investigate, litigate, or provide legal advice.

(4) The OIG and the FBI notify each other of the existence of criminal investigations that fall within their joint jurisdiction to investigate crimes involving the operations of the Department, except where such notification could compromise the integrity of an investigation;

(5) All Department components report to the OIG all non-frivolous allegations of criminal wrongdoing and serious administrative misconduct involving any of their employees except allegations involving Department attorneys and investigators that relate to an attorney's authority to litigate, investigate, or provide legal advice.

(6) At the request of the Inspector General, the Deputy Attorney General may assign to the OIG a matter within the investigative jurisdiction of DOJ-OPR. In such instances, the OIG shall either:

(i) Notify DOJ-OPR of its request to the Deputy Attorney General or

(ii) Request that the Deputy Attorney General determine that such notification would undermine the integrity of the investigation nor jeopardize the interests of the complainant.

(7) While an issue of investigative jurisdiction or assignment is pending before the Deputy Attorney General, neither the OIG DOJ-OPR shall undertake any investigative activity without authorization from the Deputy Attorney General.

(b) OIG investigations that result in findings of potential criminal misconduct or civil liability are referred to the appropriate prosecutorial or litigative office.

(c) The OIG advises DOJ-OPR of the existence and results of any investigation that reflects upon the ethics, competence, or integrity of a Department attorney for appropriate action by DOJ-OPR.

(d) OIG investigations that result in findings of administrative misconduct are reported to management for appropriate disposition.

[Order No. 2167–98, 63 FR 36847, July 8, 1998; 63 FR 40788, July 30, 1998, as amended by Order No. 2492–2001, 66 FR 37903, July 20, 2001]

§ 0.29f Confidentiality.

The Inspector General shall not, during the pendency of an investigation, disclose the identity of an employee who submits a complaint to the OIG without the employee's consent, unless the Inspector General determines that such disclosure is unavoidable in the course of the investigation.

§ 0.29g Reprisals.

Any employee who has authority to take, direct others to take, recommend, or approve any personnel action shall not, with respect to such authority, take or threaten to take any action against any employee as a reprisal for the employee making a complaint or disclosing information to the OIG unless the complaint was made or the information was disclosed with knowledge that it was false or with willful disregard for its truth or falsity.

§ 0.29h Specific authorities of the Inspector General.

The Inspector General is authorized to:

(a) Conduct investigations and issue reports relating to criminal wrongdoing and administrative misconduct of Department employees and administration of the programs and operations of the Department as are, in the judgment of the Inspector General, necessary or desirable;

(b) Receive and investigate complaints or information from an employee of the Department concerning the possible existence of an activity constituting a violation of law, rules, or regulations, or mismanagement, gross waste of funds, an abuse of authority, or a substantial and specific danger to the public health and safety;

(c) Have direct and prompt access to the Attorney General when necessary for any purpose pertaining to the performance of the functions and responsibilities of the OIG;

(d) Have access to all records, reports, audits, reviews, documents, papers, recommendations, or other material available to the Department and its components that relate to programs and operations with respect to which the OIG has responsibilities unless the Attorney General notifies the Inspector General, in writing, that such access shall not be available because it is necessary to prevent the disclosure of

(1) Sensitive information concerning ongoing civil or criminal investigations or proceedings;

(2) Undercover operations;

(3) The identity of confidential sources, including protected witnesses;

(4) Intelligence or counterintelligence matters; or

(5) Other matters the disclosure of which would constitute a serious threat to national security or significantly impair the national interests of the United States;

(e) Request such information or assistance as may be necessary for carrying out the duties and responsibilities of the OIG from any office, board, division, or component of the Department, and any Federal, State, or local governmental agency or unit thereof;

(f) Issue subpoenas to individuals, and entities, other than Federal government agencies, for the production of information, records, data, and other documentary evidence necessary to carry out the functions of the OIG;

(g) Obtain information from Federal government agencies by means other than subpoena and advise the head of such agency whenever information is unreasonably refused or not provided;

(h) Select, appoint, and employ such officers and employees as may be necessary for carrying out the functions, powers, and duties of the OIG;

(i) Employ on a temporary basis such experts and consultants as may be necessary to carry out the duties of the OIG;

(j) Enter into contracts and other arrangements for audits, studies, analyses, and other services with public agencies and with private persons, and to make such payments as may be necessary to carry out the duties of the OIG;

(k) Take from any person an oath, affirmation, or affidavit whenever necessary in the performance of the functions of the OIG.

[Order No. 2167–98, 63 FR 36847, July 8, 1998, as amended by Order No. 2492–2001, 66 FR 37903, July 20, 2001]

§ 0.29i Audit, inspection, and review authority.

The OIG is authorized to perform audits, inspections, and reviews of the programs and operations of the Department of Justice and of entities contracting with or obtaining benefits from the Department.

§ 0.29j Law enforcement authority.

Subject to guidelines promulgated by the Attorney General, Special Agents of the Office of the Inspector General are authorized to:

(a) Detect and assist in the prosecution of crimes in violation of the laws of the United States and to conduct such other investigations regarding matters that are within the jurisdiction of the Inspector General;

(b) Serve legal writs, summons, complaints, and subpoenas issued by the Inspector General or by a Federal grand jury;

(c) Receive, transport, and provide safekeeping of arrestees and other persons in the custody of the Attorney General or detained aliens;

(d) Arrest without warrant any person for an offense against the United States committed in the presence of the Special Agent or whom the Special Agent has reasonable grounds to believe has committed or is committing a felony cognizable under the laws of the United States;

(e) Seek and execute search and arrest warrants;

(f) Carry firearms while on-duty; and

(g) Carry firearms while off-duty as authorized by the Inspector General.

[Order No. 2835–2006, 71 FR 54413, Sept. 15, 2006]

Subpart F—Community Relations Service

§ 0.30 General functions.

The following-described matters are assigned to, and shall be conducted, handled, or supervised by, the Director of the Community Relations Service:

STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FORESTRY

NORTHERN REGION DELTA AREA

FOREST LAND USE PLAN

PROPOSED TIMBER SALE

CLIFF HANGER
NC-1395-D ADL-418520

December 9, 2009

PUBLIC DRAFT REPORT

Prepared by
Steven Joslin
Resource Management Forester

Table of Contents

INTRODUCTION: The purpose of this Forest Land Use Plan (FLUP) is to provide sufficient information for reviewers to ensure that the best interest of the State will be served by this proposed timber sale. Pursuant to AS 38.05.35(e) and AS 38.05., and the applicable regulations, the Delta Area Office of the Division of Forestry has made a Preliminary Finding and Decision to offer for sale approximately two hundred twenty thousand board feet of timber. The timber to be offered is located 28 air miles Southeast of Delta Junction and is 5 miles north of the Alcan Highway. The sale has one unit to be harvested having 25.6 acres. The sale is located in the NW¼SE¼, NE¼SW¼, SE¼NW¼ Section 7, Township 12 South, Range 15 East, Fairbanks Meridian, Alaska.

The public is invited to comment on any aspect of the proposed sale. A copy of the decision and Forest Land Use Plan for the proposed sale may be obtained by visiting the Delta Area Office at Milepost 267½ Richardson Highway from 8:00 a.m. to 4:30 p.m., Monday through Friday, or on the Internet at http://www.dnr.state.ak.us/forestry/timber/delta.htm . Comments should be mailed to P.O. Box 1149, Delta Junction, Alaska 99737 or by email at steve.joslin@alaska.gov . For further information call the Delta Area Office at 895-4225.

Objections or comments pertaining to the above proposed action must be received in writing by the Delta Area Office before 4:30 PM on January 12, 2010 in order to ensure consideration. To be eligible to appeal decisions, a person must comment during the comment period.

If no adverse comments or comments requesting substantive change are received, the Preliminary Finding and Decision will be issued as a Final Finding and Decision on or after January 12, 2010. If adverse comments or comments requesting substantive change are received, the Final Finding and Decision, including any changes, will be issued on or after January 22, 2010, along with notification of appeal rights and procedures.

The State of Alaska complies with Title II of the American Disabilities Act of 1990. The State is prepared to accommodate individuals with disabilities by providing auxiliary aids when requested. Individuals with audio impairments who wish to respond to this proposed action by telephone may call the Northern Region Information Counter in Fairbanks between the hours of 8:00 am and 5:00 pm, Monday through Friday, at TTY (907) 451-2770.

1. SUMMARY OF PROPOSED SALE: This sale would harvest approximately 25.6 acres of white spruce sawtimber from Tanana Valley State Forest lands on the west side of the Tanana River located 0.3 miles east of the Cummings Road and 5 miles north of the Alcan Highway. There is existing access to the proposed sale that will be improved.

2. LOCATION OF PROPOSED SALE: The proposed sale is 28 air miles southeast of Delta Junction and is on the southwest side of the Tanana River. The sale is within Unit 10C of the Tanana Valley State Forest (TVSF).

3. STATUTORY AUTHORITY: This sale is proposed to be sold by authority of AS 38.05.035(e) (Best Interest Findings); AS 38.05.110-120 (Alaska Land Act Statutes); 11AAC 71 (Timber Sale Statutes and Regulations); AS 41.17.010-.950 and 11 AAC 95 (Forest Resources and Practices Statutes and Regulations). This sale was listed in two previous Five-Year Harvest Schedules for the Delta Area.

4. TITLE AND CLASSIFICATION: The acquisition authority for the proposed sale area is GS 809. The proposed sale is within Unit 10C of the TVSF. There are no title restrictions on the parcel. The primary land classification is Forestry in Unit 10C of the TVSF, per Classification Order NC-82-065. Management intent is more specifically addressed in the TVSF Management Plan (TVSFMP). The case file ADL 418520 and NC-1395-D constitute the administrative record for this proposed sale.

5. PLAN RESTRICTIONS ON FOREST MANAGEMENT: Proposed boundaries near the Tanana River will be required to comply with buffer restrictions specified in the Alaska Forest Resources and Practices Act.

6. SUSTAINED YIELD AND ALLOWABLE CUT: The Alaska Forest Resources and Practices Act (AS 41.17.060 (c)) and Article VIII Sec. 4 of the State Constitution require that the State forest land be managed on a sustained yield basis. Sustained yield is defined in the Alaska Forest Resources and Practices Act (AS 41.17.950(25)): "Sustained Yield" means the achievement and maintenance in perpetuity of a high level annual or regular periodic output of the various renewable resources of forest land and water without significant impairment of the productivity of the land and water, but does not require that timber be harvested in a non-declining yield basis over a rotation period.

   The Annual Allowable Cut (AAC) is the amount that can be harvested from forest land managed for forestry purposes in a year under sustained yield management. The AAC in the Delta Area is based on a ten-year average as determined by the Parsons and Associates, Inc. report titled "Tanana State Forestry Lands Periodic Sustained Yield Analysis". This sale complies with sustained yield/allowable cut principles outlined in the Delta Area Five-Year Schedule of Timber Sales for FY 2008-2012. The AAC for the Delta Management Area is approximately 5,092 acres. The AAC will not be exceeded for this proposed sale.

7. ESTIMATED VOLUME OF TIMBER IN PROSED SALE: The sale has an estimated volume of 220,000 board feet of white spruce sawtimber.

8. DESCRIPTION OF HARVEST UNIT DESIGN: The sale consists of one unit totaling approximately 25.6 acres. The boundary is located along naturally and man made vegetative type changes. Mature spruce trees will be left around the sale periphery to serve as future seed tree sources. The sale is designed to harvest all the spruce larger than 8 inches DBH. All other trees are to be protected.

9. BOROUGH LAND: The propose sale is not within a borough.

10. LEGAL DESCRIPTION: The sale is located in the NW¼SE¼, NE¼SW¼, SE¼NW¼ Section 7, Township 12 South, Range 15 East, Fairbanks Meridian, Alaska.

11. USGS QUAD PROPOSED SALE IS LOCATED ON: Mt. Hayes D-2.

12. LIST NON-STATE LAND WITHIN 600' OF PROPOSED SALE: The proposed sale is within 600 feet of non-state land. The unit sale boundary is about 300 feet from agriculture Tract 12A as shown on the attached sale map. Tract 12A is generally 3 miles in length and 0.5 miles wide but it also has a 40 acre parcel that extends to the north near the sale area.

   The sale boundary will be marked with pink "Timber Harvest Boundary" flagging and blue tags. The land owner will be notified and provided a copy of this report and proposed sale map during the public review period and given an opportunity to comment.

13. PROPOSED SALE ACCESS ROUTES: The proposed sale is generally all-season accessible with existing access. The primary access route is Cummings Road which is subject to seasonal flooding from the Gerstle River. Flooding sometimes washes out the road and becomes impassable. Road repairs frequently are delayed until the water subsides. Repairs have been completed by a variety of users and agencies, including timber sale contractors.

    The sale can be accessed starting at 5.0 mile on the Cummings Road, going east on a secondary section line easement road for 0.25 miles, and then north 0.25 miles onto a spur road along an east edge of Tract 12A and then northeast about 300 feet to the sale boundary. The spur access road is narrow and can become impassable to logging trucks due to wet weather, spring breakup and snow.

    The existing spur road was constructed as a fire break in 1984 in response to a fire on Tract 12A. The spur was subsequently used in the 1990's to access a timber sale on the north side of the Tanana River during the winter. The spur road going to the sale will be widened and improved.

    An all-season accessible spur road may be constructed in the sale unit to harvest the sale. The spur road location will be at the discretion of the purchaser subject to the approval of DOF (Division of Forestry).

14. ROAD CONSRUCTION DESCRIPTION: The only new construction proposed for this sale is the potential all-season spur road within the sale boundary and shown on the attached sale map. The spur road within the sale will be constructed to the all-season spur road standard as described in Appendix F of the TVSFMP.

    The spur road accessing the sale located on the east side of a 40 acre portion of Tract 12A will be widened and improved to a secondary all-season road standard as described in Appendix F of the TVSFMP. This road clearing width will be widened towards the east (away from Tract 12A), from approximately 25 feet to about 100 feet. DOF plans to move the road bed towards the east, away from the private property. Roads will be constructed by removing the trees, vegetative mat, and constructing the road using cuts and fills with earth-moving equipment. This road will be used to access additional timber sales in the future.

    The timber sale contract may require some maintenance of existing roads such as: grading Cummings Road, brush removal along road edges, ditching or gravel placement in wet spots along the roads. If the Cummings Road washes out from flooding, the timber sale contractor will not be required to repair it.

    The proposed access routes, other than Cummings Road, have little potential to erode due to the relatively level land. The access roads are not expected to have erosion that could not be mitigated and will be left open after the sale to facilitate additional forest management of the area. DOF will be responsible for erosion control after the sale is terminated. Erosion control does not include flood damage to Cummings Road from the Gerstle River.

15. TOPOGRAPHY AND SOILS: The proposed sale is on flat bench adjacent to the Tanana River. The soil in the proposed sale is sandy silt of 1-5 foot depth over gravel and sand.

16. WATER RESOURCES AND FISHERIES: Water bodies near the sale area include the Gerstle and Tanana Rivers. The Gerstle River has been flooding annually along Cummings Road and at times has crossed the road into the west edge of the 40 acre dog leg portion of Tract 12A located near the proposed sale. No flooding was noticed in the proposed sale boundary or along the access route, except for Cummings Road. The Gerstle River goes dry during the winter months in the vicinity of the sale starting in October or November until May. During the summer, the Gerstle is a navigable, glacial stream, and classified as a high value resident fish water body (Type III-B).

A historic high water side channel of the Tanana River is adjacent to the east boundary of the sale has infrequent flooding. The nearest active side channel of the Tanana River is 750 feet from the proposed sale. The Tanana is a navigable, glacial stream, and classified as an anadromous and high value resident fish water body (Type III-B). Salmon and other resident fish species migrate through the Tanana River. The river supports a variety of resident fish species including arctic grayling, northern pike, whitefish species and burbot.

The Alaska Department of Fish and Game, Division of Habitat (Habitat), conducted a site inspection of the historic high water side channel adjacent to the proposed sale on September 17, 2009. Habitat sent DOF a memo and photos of the inspection on September 18, 2009. The memo stated, "The channel was dry and contained and active ATV trail. Vegetation was tallest and denser at the upstream end of the channel, grading younger and less percent cover toward the downstream end. Terrestrial vegetation present in the channel included moss, horsetails, grasses, forbs including yarrow, balsam poplar, willows and spruce seedlings were growing in the channel. No flotsam was observed on the stems of the willows or balsam poplar. Based on these observations, it is my determination that the approximately 30 foot wide channel is not currently within the limits of ordinary high water and is therefore not subject to FRPA riparian standards." Based on these observations, there are no adverse affects anticipated upon the fishery from the proposed sale at this time.

17. WATERSHED MANAGEMENT: The proposed sale is not anticipated to alter the watershed.

18. WATER QUALITY: There are no foreseeable adverse affects on water quality.

19. RECREATION: Recreational use of this area is minimal. Trapping and hunting are the only current recreation activities in the area. Based on responses observed in nearby areas, the timber sale can be expected to increase density of young hardwood stems used as moose browse and increase woody and herbaceous cover beneficial to early-successional wildlife. The increased sunlight penetration onto the forest floor and soil disturbance should be beneficial to production of rose hip, high bush cranberry, and other fruit eaten by ruffed, spruce, and sharp-tailed grouse.

Trappers frequent timber harvest areas because of the improved access. Larry Dorshorst and Dean Cummings, Jr., trappers with 30 years of local experience, report that about three years after an area is harvested, there is an increase in the vole population that provides more food for furbearers such as marten, fox and mink to feed on.

20. CULTURAL RESOURCES: There are no known cultural, historic or prehistoric sites in the sale. If any additional historic or archaeological sites are encountered, DOF will immediately inform the State Historic Preservation Officer and take action to protect the findings.

21. SUBSURFACE RESOURCES: There are no known subsurface resources in the sale area.

22. WILDLIFE: Most common species of wildlife that are normally found in interior Alaska forests inhabit the area. There are no known critical or important wildlife areas in or near the proposed sale or access routes. There is no harvest planned for any of the deciduous trees on the sale. All the mature balsam poplar trees will be protected for cavity nesting birds. Timber sale operators will be encouraged but not required to leave dead standing white spruce for cavity nesting birds.

    The timber sale harvest will afford more sunlight to the forest floor and will increase the production of browse species for moose. The increase in sunlight will also enhance the production of a variety of berries and seeds eaten by grouse and other animals.

23. USES OF FISH AND WILDLIFE: Trappers and moose hunters have used the proposed sale area. There is no known subsistence, recreational or commercial fishing in or near the sale area.

24. PERSONAL USE TIMBER: Personal use of timber will be allowed in the units after the close of the sale.

25. TOURISM: There is no known tourism in the proposed sale area.

26. ADJACENT LAND USES: There are no other known adjacent land uses in or near the proposed sale except for the private land noted in item 12 above.

27. AGRICULTURE: Agriculture tract 12A is adjacent to the proposed sale and shown on the attached maps. There is currently no known farming operations on the Tract and it is heavily overgrown with brush and trees. Very limited farming is occurring on the surrounding agriculture tracts.

28. TIMBER STAND COMPOSITION AND STRUCTURE: The unit is predominantly comprised of mature white spruce sawtimber. There is approximately 10-20% mixed species of aspen, birch, balsam poplar and black spruce in the unit.

29. STAND SILVICULTURE: The Delta Area goal for regenerating harvest areas that were predominantly mature white spruce is to establish a mixed species forest of hardwoods and white spruce, with white spruce being the predominate species. Old stands are to be rejuvenated to a fully stocked mixed stand of young healthy trees while retaining some residual trees resulting from partial harvest. Young forests provide future crop trees and food for wildlife. Residual trees provide seed sources, nesting sites, and other benefits which are explained in the paragraph below.

    A combination of environmental and economic factors has influenced the Delta Area to favor moderate to heavy partial harvests in combination with natural seeding. Partial harvests result in a wide range of the number of sapling to pole-sized trees per acre. The average harvest area has about 20 saplings and pole-sized mixed species trees left per acre. Some acres have no trees left and other sites have up to 100 saplings and pole-sized trees per acre left after harvest. The strong winds in the Delta Area combined with summer drought which typically occurs during the summer solstice period, cause a very high mortality of white spruce seedlings that germinated in May or early June. Partial harvesting allows some shading during the 20+ hour sunlight period and slows wind velocities to moderate the effect of desiccation of germinates and increases their survival rate.

This sale area will be partially harvested. The sale will allow the contractor to harvest spruce over 8 inches DBH. The mature sized balsam poplars will be protected from damage during the harvest to serve as cavity nesting trees and woody debris in the future. Mature white spruce will be left around the perimeters of the harvest units to provide seed sources for regeneration. Portions of the sale may be scarified to aid in warming the soil and improving regeneration of white spruce. Scarification can also improve the regeneration of woody shrubs and deciduous trees for wildlife browse and cover. The forester will make a final determination for the need to scarify any particular area within the sale after the harvest is completed. Any areas that are expected to be deficient in meeting the Alaska Forest Resources and Practices Act standard of 450 trees established by the 7th year will be planted with white spruce seedlings.

Sale areas with partial harvests are anticipated to have intermediate harvests of the residual white spruce pole timber. Intermediate harvests have occurred between 20 to 50 years after the initial harvest. Intermediate harvests provide opportunities to regenerate vegetation that is important to wildlife and will warm the soil to improve forest health.

30. SPECIFIC MANAGEMENT OBEJCTIVES FOR THE PROPOSED SALE AREA:

1. Harvest the commercial sawtimber before any significant loss occurs.
2. Return the site to a young productive mixed stand forest to include balsam poplar, birch, aspen, and white spruce.
3. Provide timber products for the industry and the State and local economy.

31. ALTERNATIVE ACTIONS:

There are four possible alternatives to consider for this sale area. A discussion of each of the four alternatives follows:

A. To continue the sale as proposed:

This alternate meets the objectives of DNR's constitutional mandate and is consistent with the land classification. Additional employment opportunities will occur associated with harvest operations, saw milling and value-added processing.

B. To modify the sale by making it smaller or larger:

The estimated volume and acreage of timber to be harvested as stated in this Forest Land Use Plan (FLUP) is designed to accommodate the existing and future markets in the vicinity of Delta Junction. The sale is of an adequate size to cover the costs to mobilize, access and harvest the sale. The sale boundaries are located in a manner to minimize the potential for wind-throw and meet the silvicultural objectives. Moving the boundaries inward would increase the risk of wind-throw to mature white spruce. Decreasing the size of the sale would make the sale less feasible to the State and the Purchaser.

C. Defer the sale to a later date:

Deferring harvest to a later date would fail to meet many of the objectives of the sale. In addition to the economic loss to the State and the local timber industry, there would be an extended risk to the timber in the sale from wildfire, insect infestations, windthrow and other natural processes associated with over-mature timber. The value of the timber will decline within the next 15 years for both the industry and the State.

D. Not offer this sale:

This alternative would result in not meeting any of the objectives outlined for this management action. Utilization of the forest resource would not be achieved. There would be no contribution to the State and local economies.

PRELIMINARY FINDING AND DECISION

The purpose of this decision is to determine if the Department of Natural Resources, Division of Forestry, will make available timber located in the proposed "Cliff Hanger" timber sale. After due consideration of all pertinent information and alternatives, the DNR has reached the following **Preliminary Decision: To offer the sale as propose in Alternative 1**. In addition, the DNR finds that this preliminary decision satisfies the objectives as stated in this document and it is in the best interest of the State to proceed with this action.

Signature on File
Al Edgren
Delta Area Forester

December 8, 2009
12-8-09
Date

UNITED STATES BANKRUPTCY COURT FOR THE DISTRICT OF ALASKA

Historic Courtroom
605 West Fourth Avenue
Anchorage, Alaska

CALENDAR OF BANKRUPTCY JUDGE GARY SPRAKER

TIME	CASE/ADVERSARY NUMBER, NAME, and CHAPTER TYPE OF PROCEEDING and COUNSEL
1:45 p.m.	Case No. A14-00065-GS, **In re DAVID M. DECKER and MARILYN L. DECKER, Debtors.** Ch 11. **TELEPHONIC** Scheduling Hearing on Disclosure Statement (DE# 93) and Chapter 11 Plan (DE# 92). Robert Crowther for the Debtors; Thomas Buford at **(206)553-2000 ext. 229** for the U.S. Trustee.
2:00 p.m.	Case No. A15-00279-GS, **In re SEWARD SHIP'S DRYDOCK, INC., Debtor.** Ch 11. Hearing on Debtor's Motion to Dismiss (DE# 43). David Bundy for the Debtor; Gary Sleeper for Alaska Marine Highway System; Thomas Buford for the U.S. Trustee.

Rep. Ken Calvert introduced a bill Thursday to allow drilling off the coast of California. Rep. Dana Rohrabacher this week put in a measure to exempt solar projects from environmental rules. Both Orange County lawmakers aren't expected to be able to get these bills through this year because o...

Rep. Ken Calvert introduced a bill Thursday to allow drilling off the coast of California. Rep. Dana Rohrabacher this week put in a measure to exempt solar projects from environmental rules.

Both Orange County lawmakers aren't expected to be able to get these bills through this year because of Democratic opposition. But both said such measures are needed to begin addressing the current pain at the pump.

House Speaker Nancy Pelosi said that offshore drilling is "off the table." And Democrats have been consistently unwilling to bend the kind of environmental rules Rohrabacher, R-Huntington Beach, wants to circumvent.

Pelosi made those comments as Republicans blocked a move by the Democrats to pass a bill that would have pushed drilling on federal lands already leased by oil companies.

Rohrabacher, Calvert and Reps. Ed Royce, R-Fullerton and **John Campbell**, Irvine, voted against the Democratic bill – called the Drill Act. Reps. Gary Miller, R-Diamond Bar and Loretta Sanchez, D-Garden Grove, had family emergencies and were not on Capitol Hill for the vote.

Although the Democrats' bill received a majority of votes, it didn't meet the two-thirds majority it needed because the bill was brought up outside of the regular procedures.

"All of us are frustrated," said Calvert. "I go home and people are absolutely beside themselves about what they're having to pay. They're looking for us to do something, not this charade that the democratic majority put on today."

Calvert said it's clear that there is oil to be had offshore and said "we can drill off the coast of California beyond the sight line" and provide enough revenues to the state to deal with its deficit.

Under Calvert's measure – called the MORE Act, Maximize Offshore Resource Exploration – would revoke the congressional moratorium on offshore drilling, the only thing standing in way of such efforts now that President Bush this week reversed an executive order banning such drilling. Rohrabacher is one of 13 original co-sponsors of Calvert's bill. No Democrats have signed on to it.

The bill also says that states would get 75 percent of the royalties the offshore drilling leases would provide. Drilling would only be allowed starting 25 miles from the shoreline. The first 25 miles belongs to the states.

If, the bill also says, states agree to drilling within 25 miles of their coastline, they share of the royalties would increase to 90 percent.

Calvert dismissed the Democrat's argument that there is already 68 million acres of federal lands leased to the oil companies that are not being used.

"The Democrats want to drill where there's no oil," Calvert said. But Pelosi said at a news conference Thursday that oil companies have told her they're not using those lands because either "it takes as long time" or "they don't have the equipment."

Rohrabacher said he is introducing a bill to waive environment impact statement requirements for solar projects in an effort to jump-start that technology.

"My bill simply says that in this time of crisis we should exempt solar energy projects from the need for the very complicated and drawn out EIR reports," Rohrabacher said.

"Are we going to do it?" Rohrabacher said." It depends on if the public – when they start filling up their cars with gas and seeing it's $80 or $90 – whether they scream and yell and demand that their government quit representing radical environmentalists."

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Article 02

The Lake Pend Oreille Aquatic Macrophyte Community and its Response to Higher Winter Water Levels

Tyler Wagner and C. Michael Falter

Final Report
Submitted to Idaho Department of Fish and Game
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January, 2001

Abstract

This study compares the species composition, biomass, and the influence of substrate composition on an aquatic macrophyte community in the meso-oligotrophic Lake Pend Oreille, Idaho under two winter drawdown regimes. Mean dry aquatic macrophyte biomass significantly increased in the drawdown zone (1.4 – 3.5 m) from 39.9 $g \cdot m^{-2}$ under a 3.5 m drawdown in 1990 to 99.2 $g \cdot m^{-2}$ and 103.7 $g \cdot m^{-2}$, respectively under 2.1 m drawdowns in 1998 and 1999. Mean aquatic macrophyte biomass deeper than 3.5 m did not significantly increase, suggesting the increased biomass in the drawdown zone can at least partially be attributed to decreased winter mortality. Myriophyllum sibiricum, Chara spp., and Potamogeton richardsonii dominated the aquatic macrophyte community under the 3.5 m winter drawdown, while Chara spp., P berchtoldii, and P. crispus dominated under higher winter water levels. The exotic Myriophyllum spicatum was present at one sample station and most prevalent in depths between 3.9 – 5.1 m. M. spicatum attained mean *maximum* densities in excess of 900 $g \cdot m^{-2}$ by August, 1999 (one year after it was first observed). Logistic regression indicated a higher probability of finding clay and cobble substrates in the drawdown zone. On these clay substrates, there were significantly lower densities of aquatic vegetation (17.9 $g \cdot m^{-2}$) than on sand (86.6 $g \cdot m^{-2}$) or silt (129.0 $g \cdot m^{-2}$) substrata and few plants were observed on cobble substrata.

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Introduction

Drawdowns can greatly influence the distribution, density, and species composition of aquatic macrophyte communities. Drawdowns may directly influence aquatic vegetation through exposure of both above-ground vegetation and beneath-ground root and rhizome systems to desiccation, under either freezing or hot conditions (Cooke 1980). Indirect effects of drawdowns include alteration of physical habitat through the formation of frost heaves on de-watered sediments and subsequent mechanical damage to root systems (Renman 1989) as well as de-watering and consolidation of exposed substrates (Cooke 1980). Water level fluctuations may also influence substrate particle size distribution (Gracia Prieto 1995). Sediment particle size is an important factor in determining the distribution of aquatic macrophytes (Unni 1977, Anderson 1978, Sand-Jensen and Sondergaars 1979) by controlling the availability of root attachment surfaces, intra-sediment chemistry, and nutrient dynamics (Anderson and Kalff 1988).

The response of aquatic macrophyte communities to seasonal de-watering (lake drawdown) has been the focus of many studies (Lantz et al. 1964, Hunt and Jones 1972, Nichols 1975a, Wilcox and Meeker1991). However, most studies have emphasized the use of drawdown as a lake management technique to control nuisance aquatic vegetation (Mathis 1965, Manning and Sanders 1975, Nichols 1975b, Goldsby et al. 1978, Cooke 1980, Tazik et al. 1982) and as a result, have taken place in meso-to eutrophic systems (Cooke and Gorman 1980, Siver et al. 1986). Fewer studies have taken place in meso-oligotrophic or oligotrophic water bodies (Rorslett 1985, Hellsten and Riihimaki 1996), or studied effects of higher winter water levels on an aquatic macrophyte community after exposure to multiple winter drawdowns.

The importance of aquatic macrophytes to the autotrophic community of freshwater lakes and rivers has been well-established (Hutchinson 1975, Horne and Goldman 1994). Aquatic macrophyte communities influence both physical and biogeochemical lake processes. Carpenter and Lodge (1986) provide a comprehensive review of the role of submersed macrophytes in lake ecosystems including; (1) physical processes, such as light extinction, water flow, substrate accretion and composition, and temperature; and (2) biogeochemical processes, such as oxygen production/consumption, dissolved inorganic and organic carbon cycling, and sediment-water nutrient dynamics. Aquatic macrophytes also serve as a food source and provide habitat for littoral fauna (Soszka 1975, Weaver et al. 1997). Aquatic macrophytes may reach nuisance densities as lake enrichment becomes more prevalent. These nuisance levels of aquatic vegetation may hinder water-based recreation and become aesthetically unpleasing (Tarver 1980, Falter and Burris 1996). Therefore, any anthropogenic changes to the lake littoral zone (*i.e.* lake level manipulations) and subsequently to the aquatic macrophyte community are of both ecological and economic importance.

The objectives of this study were to:

(1) Describe Lake Pend Oreille's littoral sediment and water column pysico-chemistry;

(2) Describe the aquatic macrophyte community in Lake Pend Oreille and its response to an experimental increase in winter lake elevation from 625 m

(typified by 1990 winter drawdown) to 626.7 m msl (typified by 1998-99 winter drawdown);

(3) Compare overall biomass of aquatic vegetation in the drawdown zone (the depths of the littoral zone from 0 m to 3.5 m) and in the permanently wetted depths of the littoral zone (depths greater then 3.5 m) in 1990 vs. 1998-99;

(4) Describe composition of the aquatic macrophyte community under both drawdown regimes (1990 and 1999); and

(5) Investigate relationships between substrate particle size, depth, and macrophytes in 1999.

Site Description

Lake Morphometry

The meso-oligotrophic Lake Pend Oreille lies in the glacially formed Purcell Trench in the panhandle of northern Idaho. Approximately 90% of the surface-water inflow and close to 90% of the total nitrogen and phosphorus loads to Lake Pend Oreille are from the Clark Fork River (Frenzel 1993), draining much of Montana west of the Continental Divide, into the northeast corner of the lake (Fig. 1). Lake Pend Oreille is divided into several basins: the deep relatively poorly flushed southern end with a mean hydraulic retention time greater than 10 years (Falter et al. 1992); the deep central basin with its steep shorelines; the shallow northern basin (mean hydraulic retention time less than 1 year; Hoelscher et al. 1993); and the lake's shallow outlet arm. Lake morphometry is an important factor influencing the spatial distribution of aquatic macrophytes in Lake Pend Oreille.

Lake Pend Oreille proper is a 383 km^2 (94641 acres) lake with mean and maximum depths of 164 m (538 ft) and 357 m (1171 ft), respectively (USGS 1996). It is Idaho's largest and deepest lake. Shoreline length of the lake proper is approximately 310 km with a maximum width of 10 km and low ratios of littoral area/lake volume to pelagic area/lake volume. The lake's outlet arm is the Pend Oreille River, exiting from the northwest corner of the lake. Mean and maximum depths of the outlet arm are 7.4 m and 48 m, respectively. Shoreline length of the outlet arm is about 152 km (USGS 1996). The outlet arm is impounded by Albeni Falls Dam on the Washington-Idaho border. Lake Pend Oreille is an important recreational and residential water body for the area, supporting moderate shoreline development on the northern half of the main lake and the outlet arm as well as seasonally heavy recreational use.

Lake Pend Oreille lies in a 59324 km^2 watershed. Major bedrock types in the watershed are Belt series and Kaniksu batholith (Savage 1965). Much of the watershed is forested (83% of the watershed) consisting mainly of coniferous tree species (Hoelscher et al. 1993). Developed lands (barren and impervious surfaces) in the early 1990's accounted for approximately five percent of the watershed, while agriculture and grazing comprised smaller percentages of total watershed use (EWU 1991). Population growth around Lake Pend Oreille is steadily increasing from about 15587 in the 1960's to 26622 in 1990 and a projected population of 35081 by 2010 (Hoelscher et al. 1993).

History of Winter Lake Drawdowns on Lake Pend Oreille

From 1966 to 1994, an annual winter drawdown controlled by the Albeni Falls outlet dam lowered lake water levels 3.0 m to 3.7 m (lake elevation of 625 m mean sea level (msl)) from mid-November through April, for spring flood control and winter power production. Maximum summer water level has been controlled at 628.6 m msl from 1952 to the present. The Idaho Department of Fish and Game (IDF&G) had concerns that winter drawdowns of 3.5 m were de-watering much of the preferred spawning substrate for winter lake-spawning kokanee (Onchorhynchus nerka). These concerns prompted experimental winter drawdowns of 2.1 m (higher winter lake levels of 626.3 m - 626.7 m msl rather than 625 m) in an effort to enhance kokanee spawning gravel and survival. The IDF&G also wanted to determine whether higher winter water levels would improve over-winter survival of warmwater fishes (*e.g.*, pumpkinseed (Lepomis gibbosus), black crappie (Pomoxis nigromaculatus), and largemouth bass (Micropterus salmoides)) in the outlet arm of Lake Pend Oreille by providing additional littoral habitat. These fishes prefer habitat of shallow waters with zero velocity, and dense vegetation. Over-winter fish habitat for these fishes had been consequently limited by winter drawdown (Dupont 1994). Any increase in aquatic macrophyte densities in these backwater areas as a result of higher winter water levels could increase available winter habitat and habitat complexity.

Materials and Methods

Sample Stations

Nineteen stations on the outlet arm and on Lake Pend Oreille proper were sampled for aquatic macrophytes in 1998 and 1999 (winter drawdown of 2.1 m). Six stations located on the outlet arm and the northern-most basin of the lake had earlier been sampled for aquatic macrophytes in 1990 (winter drawdown of 3.5 m). Drawdown regime analysis is restricted to the six stations with data in all three of these years (Fig. 1). The six sample stations were River Kilometer (RK) 0.8, 4.4, 18.5, and 26.6 on the outlet arm, and Kootenai and Sunnyside Bays. These sites are conducive to macrophyte growth (shallow depths and well-lit, fine substrate) and therefore most likely to respond to higher winter water levels.

Sediment and Water Physico-Chemistry

Sediment

To describe lake sediment chemistry, we sampled lake sediments at eight sample stations in July, 2000 in Lake Pend Oreille (LPO) proper and its outlet arm. LPO proper stations included Bottle, Ellisport, Idlewilde, and Scenic Bays. Outlet arm stations were RK 0.8, 4.4, 18.5, and 26.6. Three to nine replicate sediment samples were obtained at each site using a Petite Ponar Dredge (225 cm^2). Samples were cleaned of all vegetation, placed in storage containers, and stored in the dark on ice until processing. Analyses were performed at the Analytical Sciences Laboratory, University of Idaho. Analyses included the determination of sediment total phosphorus, percent nitrogen, percent organic carbon, percent carbon, and percent organic matter.

Water Column Physico-Chemistry

We measured selected physical and chemical water quality variables at all 19 stations in July-September, 1998 and July-October, 1999. A complete list of variables measured is in Tables 1 and 2. We also measured total phosphorus and nitrate-nitrogen at all 19 sample stations in July-October, 1999 as follows. Three replicate water samples were taken at each station using a 2-liter Kemmerer water sampler. Samples were placed in a 1-liter Cubitainer, fixed with 2 ml H_2SO_4 and stored in the dark on ice until processing. Quality Assessment/Quality Control (QA/QC) analyses included field and laboratory spikes. Field spikes were obtained by retrieving duplicate water samples from six randomly selected stations (three for nitrate-nitrogen and three for total phosphorus each month). One water sample was divided into two 1 l cubitainers. One cubitainer was spiked while the other was used as a control. Nitrate-nitrogen was determined according to Standard Methods Procedure 4500-N.B, and total phosphorus was determined according to Standard Methods Procedure 4500-P.C (APHA 1992).

Aquatic Macrophyte Collection and Laboratory Analysis

Aquatic macrophytes were sampled August 1990 and July through September in 1998 and 1999. Therefore, aquatic macrophyte data used in the drawdown regime analysis were restricted to samples collected in August (the period of maximum macrophyte biomass) in all three sampling years. Using a bathymetric map of Lake Pend Oreille and its outlet arm (USGS 1996), sample stations were established along the depth contours of the littoral zone. Depth zones were designated A through D as follows: A = 0 m (full summer level) – 1.4 m depth; B = 1.4 m – 3.5 m; C = 3.5 m – 7.0 m; and D = 7.0 m – 11.0 m depth. Samples were taken along a transect running perpendicular to the shoreline at increasing depths until all strata were sampled. We collected plants in 1990 with a Peterson Dredge (900 cm^2), taking four to eight replicate plant samples from each stratum per site. A Petite Ponar Dredge (225 cm^2) was used in 1998 and 1999 to obtain eight replicate plant samples from each stratum per site.

Plant samples obtained in 1990 and 1999 were carefully washed to remove any detritus, sediment, and epiphytic algae. Samples were then separated and identified to species. Plant identification followed the manual Flora of the Pacific Northwest (Hitchcock and Cronquist 1973). The Standard Methods Procedure (10400 D.3) for oven dry weight (ODW as $g{\cdot}m^{-2}$) or biomass, was used to obtain percent species composition by weight and total ODW per grab by depth to estimate areal biomass (APHA 1992). Total areal biomass per grab was determined for aquatic macrophytes sampled in 1990, 1998, and 1999. All mean biomass values include grabs in which no plants were collected (*e.g.*, if eight grabs were retrieved and 3 grabs contained no plants then 3 zero values were entered when computing mean biomass).

Substrate Composition Data Collection

Substrate particle size was visually determined for each plant grab using the modified Wentworth Scale (Hynes 1972). This scale classifies substrate ranging from clay-sized (< 0.004 mm) to boulder-sized (>256 mm) particles. Other qualitative physical properties such as sediment consolidation and color were also recorded.

Statistical Analysis

Sediment

We used analysis of variance (ANOVA) to evaluate overall between-site differences in measured sediment parameters. The Ryan-Einot-Gabriel-Welsch Multiple Range Test was used for multiple comparisons among sites. Sediment nutrient values were log-transformed prior to analysis to meet statistical assumptions (Kleinbaum et al. 1998).

Aquatic Macrophytes

Aquatic Macrophyte Community Dynamics. Mean aquatic macrophyte biomass values for the 19 selected sample stations are reported to describe temporal and spatial patterns of aquatic macrophyte biomass in Lake Pend Oreille proper and its outlet arm. Percent species dominance was calculated for 1999 sample stations. Statistical analyses of mean biomass values were not performed due to the inability to accommodate homogeneity of variance. Percent dominance was calculated by pooling the species data for each station as follows:

$$\text{Percent dominance} = \left(\frac{n}{N}\right) \times 100 \tag{1}$$

where 'n' is the total biomass of a given species and 'N' is the total biomass of all individual samples.

Drawdown Regime Analysis. To analyze the aquatic macrophyte community response to higher winter water levels we divided the littoral area into two zones, drawdown and permanently wetted. The drawdown zone was defined as the depths of the littoral zone that were previously de-watered during winter drawdowns of 3.5 m and now permanently wetted under higher winter water levels (winter drawdown of 2.1 m). The drawdown zone encompassed the depths between 1.4 m to 3.5 m.

Aquatic macrophyte biomass in the permanently wetted areas of the littoral zone (depths greater than 3.5 m) were analyzed to determine the temporal response of the aquatic macrophyte community in areas not de-watered during either drawdown regimes. This depth stratum had never been subjected to winter drawdown, and therefore served as a control to determine if an observed increase in biomass occurred over the entire littoral zone or only in the drawdown zone.

Between-year and among-site differences in mean aquatic macrophyte biomass in the drawdown zone and in the permanently wetted depths of the littoral were evaluated using analysis of variance (ANOVA). The Ryan-Einot-Gabriel-Welsch Multiple Range Test was used for multiple comparisons among years. Aquatic macrophyte biomass values were log-transformed prior to analysis to meet statistical assumptions (Kleinbaum et al. 1998). To take into account differences in sampling areas (dredge size of 900 cm^2 in 1990 and 225 cm^2

in 1998-99) between years, 1998 and 1999 biomass measurements were given 1/4 the weight (variance weighting) of the 1990 biomass measurements prior to the analysis. Sample stations were not randomly selected because of the need to ensure the areas analyzed were suitable macrophyte habitat; therefore, inferences based on statistical analyses cannot be made to the entire lake and pertain only to specific stations.

Community composition and diversity. Due to the inherent difficulty in analyzing multi-species community data (Smith et al. 1990), several methods were used to compare community composition in the drawdown zone in 1990 and 1999. Species percent dominance was calculated as described above. Percent frequency was calculated by pooling the species data for all six sites for 1990 and 1999 as follows:

$$\text{Percent frequency} = \left(f/F \right) \times 100 \tag{2}$$

where 'f' is the number of samples in which a given species was recorded and 'F' is the total number of samples. Percent dominance is based on abundance (biomass) whereas percent frequency is based on the number of samples in which a species was recorded.

Kulczynski's Index of Disimilarity (CAP 1999) was used to compute station dissimilarity values to define temporal variation in species composition and abundance between sample stations in 1990 and 1999. Rare species (frequency of occurrence less than 5% in both years) were deleted from the data matrix prior to analysis, as these occurrences can usually be attributed to chance rather than to an indication of ecological conditions (Gauch 1982). Aquatic macrophyte biomass for each species was averaged over replicate samples for each sample station to reduce variation (Gauch 1982) and later used as abundance values in the computation. Abundance data were double-square-root transformed (McRae et al. 1998) to allow less abundant species to contribute to between-site dissimilarities.

Dissimilarity values were calculated as follows:

Kulczynski's Index of Dissimilarity: $\mathrm{Djk} = 1 - \left(\frac{1}{2}\left(\frac{W}{A} + \frac{W}{B}\right)\right)$ (4)

where A is the sum of species abundance's at station j, B is the corresponding value at station k, and W is the sum of the minimum values for each species when comparing both stations. Computed values are on a scale from 0 to 1 where a dissimilarity value of 1 would indicate completely different community composition and abundance between stations j and k, and a dissimilarity value of 0 would indicate identical community composition and abundance between stations j and k.

The Kulczynski's Dissimilarity matrix was then used in cluster analysis using Ward's Minimum Variance method. Standard Euclidean distance measures were not used in the cluster analysis due to poor performances of these measures (Ludwig and Reynolds 1988). The hierarchical clustering method was used to produce a dendrogram showing any meaningful clustering of stations. For example, if 1990 sample stations clustered together but separately from 1999 stations, then community structure would be different between these years indicating different macrophyte communities between the two drawdown regimes.

Substrate Composition

To elucidate relationships between substrate composition, depth and aquatic macrophyte biomass we classified each plant grab's sediment content into one of five substrate categories. Each grab was classified as either (1) "clay "; (2) "silt"; (3) "sand"; (4) "gravel"; or (5) "cobble".

Binary logistic regression analysis was performed to determine if depth was a significant predictor of substrate. The probability of observing a substrate particle size class at a given depth can then be determined for any significant relationships as follows:

$$\mathrm{P}(substrate) = \exp^{(\hat{\beta}_o + \hat{\beta}_1 x)} \Big/ 1 + \exp^{(\hat{\beta}_o + \hat{\beta}_1 x)} \qquad (5)$$

where $\hat{\beta}_0$ and $\hat{\beta}_1 x$ are coefficients derived from logistic regression and 'exp' is e raised to the given power.

No aquatic macrophytes were found on "gravel" or "cobble" substrate classes. Therefore only mean aquatic macrophyte biomass on "clay", "silt", and "sand" substrate classes were compared using ANOVA and the Ryan-Einot-Gabriel-Welsch Multiple Range Test for pair-wise comparisons. Aquatic macrophyte biomass values were log-transformed prior to analysis to accommodate homogeneity of variance. All statistical analyses were performed using the SAS GLM and LOGISTIC procedures (SAS Institute Inc. 2000) and STATISTICA (Statistica for the Macintosh 1994) computing software.

Results

Sediment and Water Physico-Chemistry

Sediment

Lake sediment chemistry analyses determined that total sediment phosphorus ranged from 395.0 $\mu g \cdot g^{-1}$ - 1563.3 $\mu g \cdot g^{-1}$. Scenic Bay had significantly higher total phosphorus (1563.3 $\mu g \cdot g^{-1}$) than other stations (Table 3). Mean percent nitrogen ranged from 0.0 % at RK18.5 to 0.4 % at Bottle and Idlewilde Bays. Mean percent organic carbon ranged from 0.8 % at RK18.5 to 7.5 % at Scenic Bay; mean percent carbon ranged from 0.7 % at RK18.5 to 8.4 % at Scenic Bay; and mean percent organic matter ranged from 1.4 % to 12.9 % at RK18.5 and Scenic Bay, respectively.

Water Column Physico-Chemistry

Lake Pend Oreille is a meso-oligotrophic water body characterized by moderately high water clarity and low nutrient concentrations. Mean secchi depth ranged from 5.6 m - 12.0 m in August, 1998 and from 3.8 m - 8.9 m in August, 1999. Mean total phosphorus and nitrate-nitrogen concentrations at selected sample stations in August, 1999 ranged less than 7 $\mu g \cdot l^{-1}$ (detection limit) - 7 $\mu g \cdot l^{-1}$ and from 21.5 $\mu g \cdot l^{-1}$ - 40.25 $\mu g \cdot l^{-1}$, respectively (Tables 1 and 2).

Mean percent recovery (QA/QC) for total phosphorus and nitrate-nitrogen field spikes were 101.8% and 74.1%, respectively. Mean percent recovery for laboratory spikes of total phosphorus and nitrate-nitrogen were 90.8% and 94.5%, respectively.

Aquatic Macrophytes

Aquatic Macrophyte Community Dynamics

Mean aquatic macrophyte biomass from the 19 selected sample stations on Lake Pend Oreille proper and its outlet arm ranged from 0.0 $g \cdot m^{-2}$ at Warren Island to 276.0 $g \cdot m^{-2}$ at RK0.8 in 1998 and from 0.0 $g \cdot m^{-2}$ at Maiden Rock to 188.7 $g \cdot m^{-2}$ at RK16.1 in 1999 (Fig. 2 and 3). Mean aquatic macrophyte biomass declined from northern lake stations (*e.g.*, CFR and BOT) to southern lake stations (*e.g.*, IDL and SCE) in both years. No apparent trend in biomass was observed in the outlet arm.

Twenty-five macrophyte species from 14 families were present in Lake Pend Oreille proper and its outlet arm in 1999 (Table 4). Two dominant species in the outlet arm and Lake proper stations in July, 1999 were Potamogeton crispus (comprising 47% and 32% of the community in the outlet arm and Lake proper, respectively) and Elodea spp. (comprising 17% and 22% of the community in the outlet arm and Lake proper, respectively). In August, the two dominant species in the outlet arm were Elodea spp. and P. crispus (each comprising 26% of the macrophyte community). Myriophyllum sibiricum dominated (40%) the aquatic macrophyte community in the outelt arm stations in September. In August and September, the two dominant species in the Lake Pend Oreille proper stations were Chara spp. and P. berchtoldii (comprising 26% and 22% in August and 31% and 27% in September, respectively; Fig. 4).

Drawdown Regime Analysis

Mean dry aquatic macrophyte biomass, in the drawdown zone (1.4 m - 3.5 m), significantly increased ($p = 0.01$) from 39.9 $g{\cdot}m^{-2}$ in 1990 to 99.2 $g{\cdot}m^{-2}$ and 103.7 $g{\cdot}m^{-2}$ in 1998 and 1999, respectively (Fig. 5A). Mean aquatic macrophyte biomass among stations and stations×time interaction were not significant ($p = 0.23$ and 0.08, respectively); therefore, we investigated the effects of time on biomass independently of site. Mean aquatic macrophyte biomass in the permanently wetted littoral (depths greater than 3.5 m) were not significantly different ($p = 0.72$) in 1990 (70.3 $g{\cdot}m^{-2}$) when compared to 1998 and 1999 (185.0 $g{\cdot}m^{-2}$ and 157.1 $g{\cdot}m^{-2}$, respectively; Fig. 5B).

Community Composition and Diversity

Community composition changed in the drawdown zone in 1990 when compared to 1999 (Table 5). The four dominant aquatic macrophytes in 1990 were Myriophyllum sibiricum (30.1%), Chara spp. (29.3%), Potamogeton richardsonii (23.9%), and P. foliosus (6.3%). In 1999, Chara spp. (27.4%), P. berchtoldii (25.3%), P. crispus (23.6%), and Elodea spp. (12.7%) (E. canadensis and E. nutallii) dominantated the drawdown zone. Community composition in the described drawdown zone does not include the exotic Myriophyllum spicatum. This species was abundant at RK 0.8 in 1999 (maximum densities exceeded 900 $g{\cdot}m^{-2}$ oven dry weight) in depths between 3.9 – 5.1 m; however, it occurred less frequently and at lower densities in the 1.0 – 3.5 m depth range which includes the described drawdown zone (1.4 – 3.5 m).

The dominant species frequency of occurrence also changed between years. For example, in 1990, the three dominant aquatic macrophyte species also occurred most frequently. In 1999, however, Elodea spp. occurred more frequently (47.9%) than P. crispus (8.3%). All other macrophyte species comprised small proportions of the community. Potamogeton crispus, P. praelongus, and Drepanocladius were not found in 1990 in depths between 1.4 m and 3.5 m; however, they were present in depths below 3.5 m in 1990. These three species were present between 1.4 m and 3.5 m in 1999 after 3 years of higher winter water levels. Potamogeton zosteriformis was not found in 1990, but was present in the 1.4 – 3.5 m drawdown zone in 1999. Potamogeton robbinsii was present in the drawdown zone in 1990 and absent in 1999. Ceratophyllum demersum, Tillaea aquatica, and P. pectinatus were major species that showed no or little response to a change in winter water levels.

Cluster analysis of Kulczynski's dissimilarity values revealed two meaningful clusters (Fig. 6). Most stations within a year (stations under a similar drawdown regime) tended to cluster together. Shannon's H` Diversity Index was also calculated for each station in 1990 and 1999. Index calculations were based on the total number and biomass of species present at each station. Mean Shannon's H` Index did not significantly differ between 1990 and 1999 (*t*-test, $p = 0.64$).

Substrate Composition

Results of the binary logistic regression indicated that depth was a significant predictor of four of the five-substrate categories (Table 6). Silt was the only non-significant category ($p = 0.12$). The probability of observing "clay" and "cobble" increased as depth decreased; whereas, the probability of observing "gravel" and "sand" decreased as depth decreased (Fig. 7).

Mean aquatic macrophyte biomass was significantly lower ($p < 0.0001$) on "clay" substrate types (mean dry biomass = 17.9 $g \cdot m^{-2}$) compared to "silt" and "sand" substrate classes which had mean aquatic macrophyte biomass of 129.0 $g \cdot m^{-2}$ and 86.6 $g \cdot m^{-2}$, respectively (Fig. 8).

Discussion

Sediment and Water Physico-Chemistry

Sediment

Lake sediments play a large role in nutrient cycling and dynamics in many lakes and reservoirs (Horne and Goldman 1994). Heathwaite (1994) demonstrated that increased human development often leads to an increase in sediment and nutrient export from land to adjacent waterbodies and these changes are reflected in lake sediments. Lake Pend Oreille is phosphorus-limited (Woods 1993); therefore, any potential sources of phosphorus (*i.e.*, sediments) can potentially contribute to biological productivity. However, aerobic sediment conditions in Lake Pend Oreille retain sediment phosphorus in a biologically unavailable form (*i.e.,* as ferric phosphate). Total mean sediment phosphorus measured in Lake Pend Oreille ranged from 395 $\mu g \cdot g^{-1}$ at Idlewilde Bay to 1563.3 $\mu g \cdot g^{-1}$ at Scenic Bay, July, 2000. These values are likely influenced by the degree of human development at these two bays. Idlewilde Bay is located on a state park and as a result, has little human development. Scenic Bay however, is located on a town (Bayview, Idaho) and has a significant amount of housing development, house docks, and intense boating activity that may have contributed to the observed differences. Except for Scenic Bay, total phosphorus (TP) concentrations in Lake Pend Oreille are similar to those reported by Rattray et al. (1991) for the oligotrophic Lake Taupo, New Zealand (TP range = 234 – 700 $\mu g \cdot g^{-1}$). However, they are lower than the range reported by Ostrofsky (1987) for 66 lakes in the eastern U.S. representing a broad range of lake types from oligotrophic to eutrophic (TP range = 1329 – 9212 $\mu g \cdot g^{-1}$).

Water Column Physico-Chemistry

Due to its deep aerobic water column acting as a nutrient trap (Falter et al. 1992), Lake Pend Oreille is able to dilute much of the effects of the sizeable nutrient loading from the Clark Fork River. Nutrient concentrations (total phosphorus and nitrate-nitrogen) and water transparency (secchi depth) in Lake Pend Oreille proper appear not to have changed from 1990 through 1999. Mean total phosphorus and nitrate-nitrogen concentrations at selected sample stations in August, 1999 ranged less than 7 $\mu g \cdot l^{-1}$ (detection limit) to 7 $\mu g \cdot l^{-1}$ and 21.45 $\mu g \cdot l^{-1}$ - 40.25 $\mu g \cdot l^{-1}$, respectively. Mean concentrations of total phosphorus in Lake Pend Oreille proper in 1989-90 ranged from 5 $\mu g \cdot l^{-1}$ - 10 $\mu g \cdot l^{-1}$ (Woods 1993). Summer secchi depth readings in Lake Pend Oreille proper ranged from about 5.0 - 11.0 m in 1989-90 (Woods 1993). Mean summer secchi depth ranged from 5.6 - 12.0 m in August, 1998 and from 3.8 - 8.9 m in August, 1999. Low secchi depth readings observed by Woods (1993) were measured during spring runoff when turbid inflows entered the lake *via* the Clark Fork River and were not due to an increase in biological production.

Aquatic Macrophytes

Aquatic Macrophyte Community Dynamics

Mean aquatic macrophyte biomass (oven dry weight (ODW)) from the 19 selected sample stations on Lake Pend Oreille proper and its outlet arm ranged from 0.0 $g \cdot m^{-2}$ at Warren Island to 276.0 $g \cdot m^{-2}$ at RK0.8 in 1998 and from 0.0 $g \cdot m^{-2}$ at Maiden Rock to 188.7 $g \cdot m^{-2}$ at RK16.1 in 1999. The lack of aquatic plants at Warren Island and Maiden Rock are likely a function of lake morphometry (littoral slope) and substrate. Both stations were characterized by steep littoral slopes and a substratum dominated by medium to large cobble. The lack of root-attachment surface and low nutrient levels in coarse substrates (Barko and Smart 1986) likely limited macrophyte colonization at these sites.

Higher densities of aquatic macrophytes in sample stations located at the northern end of the lake were also influenced by lake morphometry and the Clark Fork River. The northern lake area has a shallower mean depth, a more gradual littoral slope, and receives an annual spring influx of fine sediments and nutrients from the Clark Fork River providing high quality aquatic macrophyte habitat compared to southern lake areas.

Common species in Lake Pend Oreille and its outlet arm included Potamogeton spp., Elodea, spp., Chara spp., and Myriophyllum spp. Falter and Olson (1990) found similar aquatic macrophyte species in Lake Pend Oreille proper and its outlet arm in 1989-90 which included M. sibiricum, Chara spp., Potamogeton spp., and Elodea canadensis.

Drawdown Regime Analysis

Mean aquatic macrophyte biomass (ODW) in the drawdown zone significantly ($p = 0.01$) increased from 39.9 $g \cdot m^{-2}$ in 1990 to 99.2 $g \cdot m^{-2}$ and 103.7 $g \cdot m^{-2}$ in 1998 and 1999, respectively. This overall increase in aquatic macrophyte biomass in the drawdown zone showed increased survival and spatial expansion of aquatic macrophytes into depth strata under the new regime of year-round submersion with higher winter water levels. We found no significant increase in aquatic macrophyte biomass in the permanently wetted littoral (deeper than 3.5 m) that supports this hypothesis. The lack of significant increase in biomass in the permanently wetted littoral suggests that the observed increase in aquatic macrophyte biomass in the drawdown zone was not due to site enrichment or any other physico-chemical changes that may have occurred between 1990 and 1998-99. Improvements in residential and commercial wastewater treatment systems surrounding the lake may have decreased potential site enrichment in higher density developments around the lake. For example, there has been a decrease in the number of shoreline residences with septic systems impacting the lake since 1977 (Lawlor 1993). And recently, a three-lagoon sewage collection and treatment system was developed for the north-east area of the lake that eliminated several more residential and commercial septic tank systems, thereby reducing potential nutrient leaching into the lake.

The increase in aquatic macrophyte biomass in the drawdown zone under higher winter water levels might be expected in relatively deep lakes with high transparency. Higher water levels increase the amount of available habitat and light does not rapidly become a limiting factor so a net increase of littoral volume ensues. Conversely, higher water levels may reduce the standing crop of aquatic macrophytes in shallower water bodies with low transparency. In these latter systems, high water levels can increase sedimentation, and decrease light penetration through wave re-suspension of sediments (Woltemade 1997), thereby reducing available habitat for aquatic vegetation. Lake Pend Oreille is clearly a lake in the former category.

Community Composition and Diversity

Higher winter water levels have a species-specific effect on aquatic macrophyte communities. Different species have different tolerances to de-watering and exposure to dry conditions (Hudon 1997). Different community composition would therefore be expected under different levels of winter drawdown. Three of the four dominant species present under higher winter water levels were either absent (P. crispus) or represented a very minor proportion of the macrophyte community (Elodea spp. and P. berchtoldii) in the 1.4 m - 3.5 m drawdown depth zone in 1990. Elodea spp. primarily spreads *via* stem fragmentation whereas P. crispus propagates primarily from dormant apices (turions; Nichols and Shaw 1986). Wave action and anthropogenic disturbances (*e.g.*, boat traffic) may lead to the dispersal of these vegetative structures into newly created habitat. The spatial expansion of these species from 1990 to 1998-99 into the new permanently wetted littoral zone may have been facilitated *via* the propagation of vegetative reproductive structures. Furthermore, these two species can overwinter as evergreen plants under ice cover, and grow quickly with spring warming (Nichols and Shaw 1986), thereby obtaining an advantage early in the growing season when competing for light. Hestand and Carter (1975) also documented shifts in dominant species under higher water levels following an overwinter drawdown. Hellsten and Riihimaki (1996) found different aquatic plant species composition in the regulated Lake Ontojarvi compared to the unregulated Lake Lentua. Average winter drawdown in Lake Ontojarvi was about 3.4 m. The aquatic macrophyte community in Lake Ontojarvi was comprised of species that had adapted to the level of disturbance caused by lake regulation.

Chara spp. was the only dominant member of the drawdown zone under both drawdown regimes in Lake Pend Oreille. Charophytes are often pioneering species and their oospores will remain viable after extended periods of dry and freezing conditions (Proctor 1967, Bates and Smith 1994). These characteristics may account for its dominance both in the exposed area of the littoral zone after overwinter drawdown (1990) and its continued dominance with higher winter water levels in Lake Pend Oreille (1999). The movement of P. crispus, P. praelongus, and Drepanocladius from the permanently wetted littoral (depths > 3.5 m) into the drawdown zone with higher winter water levels, suggests that the earlier 3.5 m winter drawdown limited the shoreward distribution of these taxa. In 1999, P. crispus occurred less frequently than Elodea spp. although the former was a more dominant species (occurred in higher densities) in the community. This is likely because P. crispus was found in dense monospecific stands, while, Elodea spp. occurred in more samples, but at lower densities.

Some species showed no response to higher winter water levels. C. demersum represented a small (0.4%) but constant proportion of the community under both drawdown regimes. Since C. demersum lacks true roots, currents and wave action can move it between depth zones and as a result, it will be relatively unaffected by winter drawdowns and subsequent increases in winter water levels. Nichols (1975a) also found C. demersum show no response to overwinter drawdown and no preference to water level in the Chippewa Flowage, Wisconsin. However, Hestand and Carter (1975) found a disappearance of C. demersum upon refilling of shallow Lake Ocklawaha following a 1.5 m overwinter drawdown from September to February. Lake morphometry, winter conditions, and species mix likely influence the response of individual species to higher water levels. For example, the Chippewa Flowage is a large reservoir with interconnected bays. Isolated areas of the reservoir experience different water level changes as surface water connection with the flowage is cut off. As a result, some areas experience less than a 2 m drawdown while other areas experience up to a 9 m drawdown. The areas that experience relatively stable water levels apparently provide refugia for populations of aquatic plants. Whereas Lake Ocklawaha, a shallow reservoir in central Florida, has the entire lake littoral area affected by water level fluctuations, thereby reducing the chance of shallow water refugia. Hestand and Carter (1975) further noted that plant cover of Hydrilla verticillata increased following winter drawdown. Hydrilla may have acted synergistically, through competition for resources, with winter drawdown to reduce densities of C. demersum.

Cluster analysis indicated that different aquatic macrophyte communities were present in the drawdown zone in 1990 compared to 1999. These communities differed in community composition and overall biomass (as described above). I believe that biomass of species present (overall increase in biomass in the drawdown zone) and species composition (spatial expansion of species into the new permanently wetted littoral under higher winter water levels) both contributed to the dichotomy of the two communities. However, with such extreme spatial heterogeneity of aquatic plant communities (France 1988), I do expect that a few sample stations would cluster with stations under a different drawdown regime.

Substrate Composition

Logistic regression showed the probability of observing "clay" and "cobble" decreased as depth increased and the probability of observing "gravel" and "sand" increased as depth increased. With water level fluctuation, finer particles will be transported before large particles (Horne and Goldman 1994), therefore increasing the probability of leaving cobble-sized particles in the drawdown zone. The higher probability of finding cobble substrates in shallow water in this study reduced the amount of available plant habitat in the drawdown zone.

Substrate composition was influenced by both overwinter drawdown and by the dominant bottom morphology of sample stations in this study. The increased probability of observing clay and cobble substrate types in shallow depths are likely a direct result of years (since 1966) of exposing littoral sediments to drying and desiccation.

Four of the six sample stations were located in the outlet arm of Lake Pend Oreille. The outlet arm has some lotic characteristics, having unidirectional flow (velocities up to 8 $cm \cdot s^{-1}$; Dupont 1994) and the presence of an old river channel as the deepest area (thalweg). As depth, current velocity, and slope increase in the thalweg, the substrate shifts to a sand and gravel composition because these larger substrate particles are less likely to be moved by the current. Falter et al. (1991) also cited the direct effects of morphometry and velocity on substrate deposition and accumulation as limiting factors of aquatic macrophyte colonization in the Pend Oreille River, Washington immediately downstream of Lake Pend Oreille. Carlson (1995) compared aquatic macrophyte densities in two sloughs in the Pend Oreille

River, Washington and concluded that lower aquatic macrophyte densities in one slough was primarily a function of morphometry (*i.e.*, steeper littoral slope).

Highest biomass was found on silt and sand substrates for two likely reasons (1) the probability of observing sand increased as depth increased; therefore, plants on this substrate were removed from effects of wave action and winter drawdown; and (2) low nutrient levels and limited nutrient diffusion rates in coarse substrates such as gravel (Barko and Smart 1986). Anderson and Kalff (1988) found that silt substrate supported significantly higher biomass than did sand or organic sediments and that these three categories all supported higher biomass than gravel. Madsen and Adams (1989) found maximal aquatic macrophyte biomass on silt substrata in a eutrophic stream (Badfish Creek, Wisconsin). Aquatic macrophyte densities were low on gravel and lowest on sand. Badfish Creek was dominated by P. pectinatus, a species also found in Lake Pend Oreille.

Ecological and Management Implications

Years of winter drawdown have altered the physical habitat for aquatic macrophytes in many areas of Lake Pend Oreille through sediment alterations such as consolidation, erosion, and depositional processes. Sediment consolidation occurs as exposed flocculent sediments dry out and compact. For example, Plotkin (1979) conducted a series of artificial lake drawdowns on experimental lakes. After 6 weeks desiccation, exposed sediment in all test lakes were consolidated and sediment depth decreased by 50%. The sediments in the test lakes remained firm 6 months after refilling. This consolidation can influence aquatic plant growth. For instance Plotkin (1979) noticed slower growth rates of Elodea densa in the compacted sediments compared to flocculent sediment. Our study did not directly measure sediment consolidation; however, consolidated clay sediments were common in shallower depths (*i.e.*, the drawdown zone) and these sediments provided relatively poor aquatic plant habitat.

Increasing the permanently wetted littoral area through higher winter water levels has led to an overall increase in aquatic macrophyte density and resulted in the spatial expansion of species from deep-water communities to shallow-water communities in Lake Pend Oreille. The spatial complexity and abundance of the resulting plant community will benefit aquatic and semi-aquatic biota which utilize these vegetated littoral areas. For example, yellow perch (Perca flavescens) are often more dominant in dense, species-rich vegetation beds that are structurally complex (Weaver et al. 1997). Liter (1991) collected fish densities up to 5.2 fish$\cdot$m^{-2} in heavily vegetated areas while sampling with pop nets in the Pend Oreille River, Washington, and concluded that heavily vegetated areas were important fish habitats, especially for juvenile centrarchids. Aquatic macrophyte communitites in the Pend Oreille River, Washington also contained higher density and diversity of zooplankton species than in adjacent open waters (Carlson 1995). For example, Carlson (1995) determined mean zooplankton densities measured in aquatic macrophyte beds to be 43 organisms$\cdot l^{-1}$ in late August compared to 3 organisms$\cdot l^{-1}$ in adjacent open water.

These backwater areas also represent important fish habitat in the outlet arm of Lake Pend Oreille (Dupont and Bennett 1991). Dupont (1994) concluded that many warmwater fishes in the outlet arm of Lake Pend Oreille are limited by overwintering habitat, primarily vegetated areas of low velocity. The observed increase in aquatic plant densities may increase the amount of overwintering habitat and possibly increase winter survival of the warmwater fish community. Furthermore, aquatic macrophytes provide an important substrate for aquatic invertebrates (Soszka 1975) and therefore can increase the food supply for species that forage in these areas. The dominant macrophyte species found under higher winter water levels in Lake Pend Oreille represent important habitat and food sources for migratory waterfowl. For example, turions and seeds produced by P. crispus and E. canadensis are important food for many waterfowl species (Rogers and Breen 1980, Nichols and Shaw 1986).

In managing Lake Pend Oreille, a balance must be attained between improving littoral habitat (providing a diverse aquatic macrophyte community) versus the possibility of nuisance aquatic plant growth (dense monospecific stands) as a result of high winter water levels. Extremely dense aquatic plant growth not only impedes recreation (Hestand and Carter 1975), but also decreases bass (Micropterus salmoides) growth rates as a result of decreased forage efficiency (Engel 1987).

Development of the Exotic Myriophyllum spicatum (Eurasian watermilfoil)

The invasive, nonindigenous species (Myriophyllum spicatum L.) was first observed in Albeni Cove on the outlet arm of Lake Pend Oreille in the summer of 1998. The patchy distribution of M. spicatum in the 1.0 – 3.5 m depth range and subsequent exclusion from the drawdown regime analysis should not minimize the effects this species can have on surrounding littoral habitats. For example, mean *maximum* densities within monospecific plant beds exceeded 900 $g \cdot m^{-2}$ oven dry weight by August, 1999. These densities are higher than values reported for milfoil in the Pend Oreille River, Washington, which reached densities near 600 $g \cdot m^{-2}$ (Getsinger et al. 1997). This species has the potential to spread rapidly throughout this system. For instance Eurasian watermilfoil spread at a rate of 3.7 ha·yr in the Pend Oreille River, Washington immediately downstream of Albeni Falls Dam and has become a severe nuisance throughout this 55 km river reach (Gibbons et al. 1983, Falter et al. 1991). Winter drawdown has been used successfully to control this species (Goldsby and Bates 1978, Siver et al 1986) in some systems; however M. spicatum occurs deeper than 5 m in the outlet arm of Lake Pend Oreille reducing much of the benefit of a 3.5 m winter drawdown as a control method. Possible management of this system could include utilizing a winter drawdown of 3.5 m every few years (since consecutive winter drawdowns have shown to provide little additional macrophyte control compared to the initial drawdown; Nichols 1975b) to control nuisance aquatic vegetation and maximize the available wetted littoral for aquatic biota.

Summary

- Highest mean densities of aquatic macrophytes were found in northern lake stations and declined at mid- and southern lake stations. Aquatic macrophytes most commonly found in Lake Pend Oreille proper and its outlet arm were P. crispus, Elodea spp., M. sibiricum, and Chara spp.
- Mean aquatic macrophyte biomass (oven dry weight) significantly increased in the drawdown zone from 39.9 $g \cdot m^{-2}$ in 1990 (winter drawdown of 3.5 m) to 99.2 $g \cdot m^{-2}$ and 103.7 $g \cdot m^{-2}$ in 1998 and 1999, respectively (winter drawdown of 2.1 m).
- Mean aquatic macrophyte biomass (oven dry weight) in the permanently wetted littoral did not significantly increase from 70.3 $g \cdot m^{-2}$ in 1990 when compared to 1998 and 1999 (mean aquatic macrophyte biomass of 185.0 $g \cdot m^{-2}$ and 157.1 $g \cdot m^{-2}$, respectively). This suggests the observed increased biomass in the drawdown zone can at least partially be attributed to decreased winter mortality from freezing and desiccation under higher winter water levels.
- Two distinct aquatic macrophyte communities existed in the drawdown zone under the two drawdown regimes. Myriophyllum sibiricum, Chara spp., Potamogeton richardsonii, and P. foliosus dominated the aquatic macrophyte community under the 3.5 m winter drawdown, while Chara spp., P berchtoldii, P. crispus, and Elodea spp. dominated under higher winter water levels (winter drawdown of 2.1 m). The spatial expansion of species previously restricted to depths below 3.5 m in 1990 to areas shallower than 3.5 m in 1998 and 1999 contributed to the observed differences in community structure.

- The patchy distribution of M. spicatum in the 1.0 – 3.5 m depth range and subsequent exclusion from the drawdown regime analysis should not minimize the potential effects this species can have on surrounding littoral habitats. Illustrated by the production of large monospecific beds, which attained mean *maximum* densities in excess of 900 $g \cdot m^{-2}$ one year after it was first observed in 1998.
- A higher probability of observing clay and cobble substrate types existed in the drawdown zone than in the permanently wetted littoral. These two substrate types provided relatively poor habitat for aquatic macrophytes. For example, significantly lower densities of aquatic vegetation was observed on clay (17.9 $g \cdot m^{-2}$) substrate types than on silt or sand substrates (mean macrophyte biomass of 129.0 $g \cdot m^{-2}$ and 86.6 $g \cdot m^{-2}$, respectively), and few plants were observed on cobble substrates.
- A 40 % increase in macrophyte biomass in the drawdown zone increased littoral habitat heterogeneity and therefore available overwintering habitat for littoral fishes that utilize these areas.
- Possible management of this system could include utilizing a winter drawdown of 3.5 m every few years to control nuisance aquatic vegetation and maximize the available wetted littoral zone for aquatic biota.

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Figures

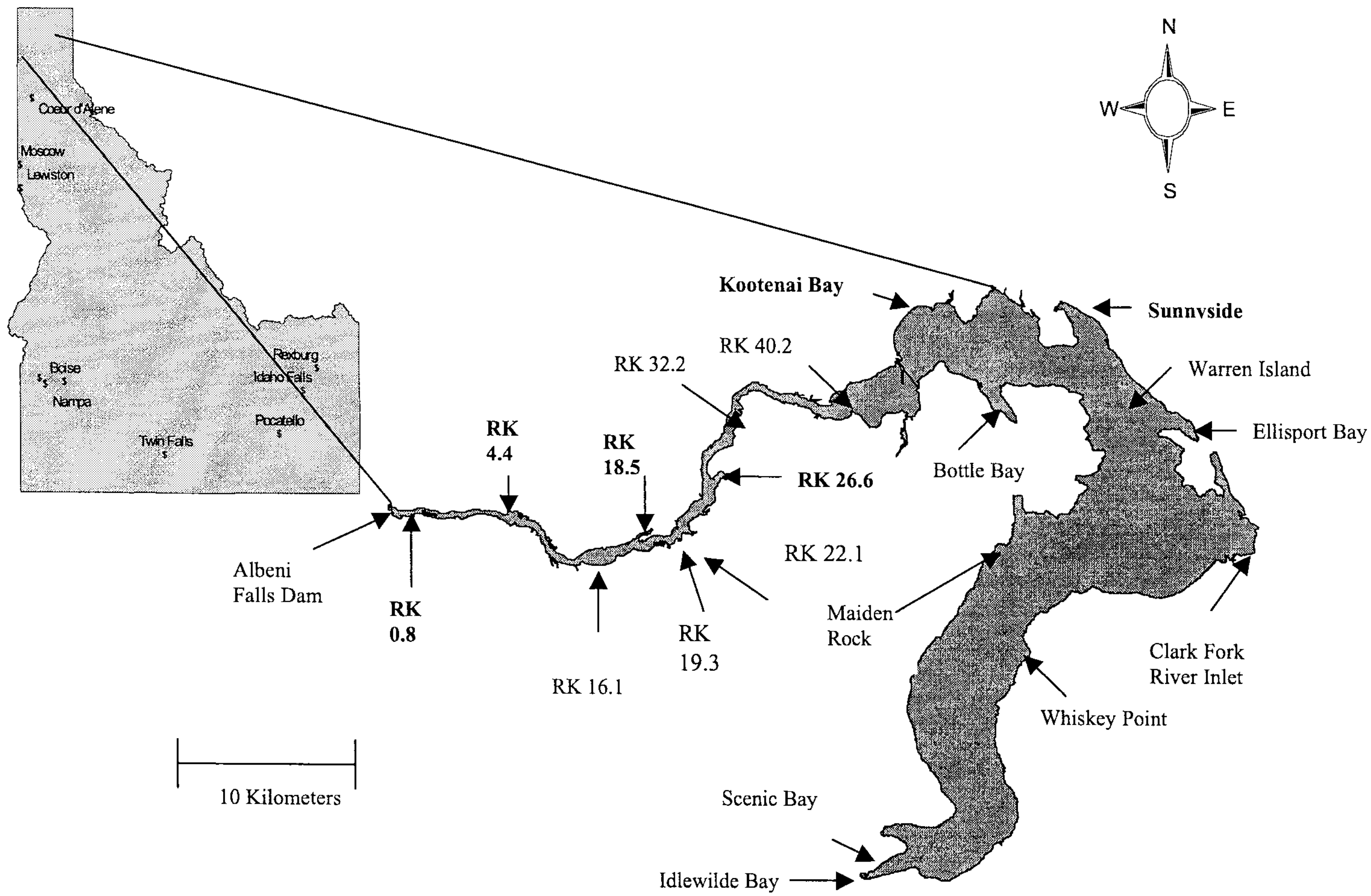

Figure 1.-Aquatic macrophyte sampling stations located on the outlet arm of Lake Pend Oreille and Lake Pend Oreille proper. Stations used in drawdown regime analysis are in bold.

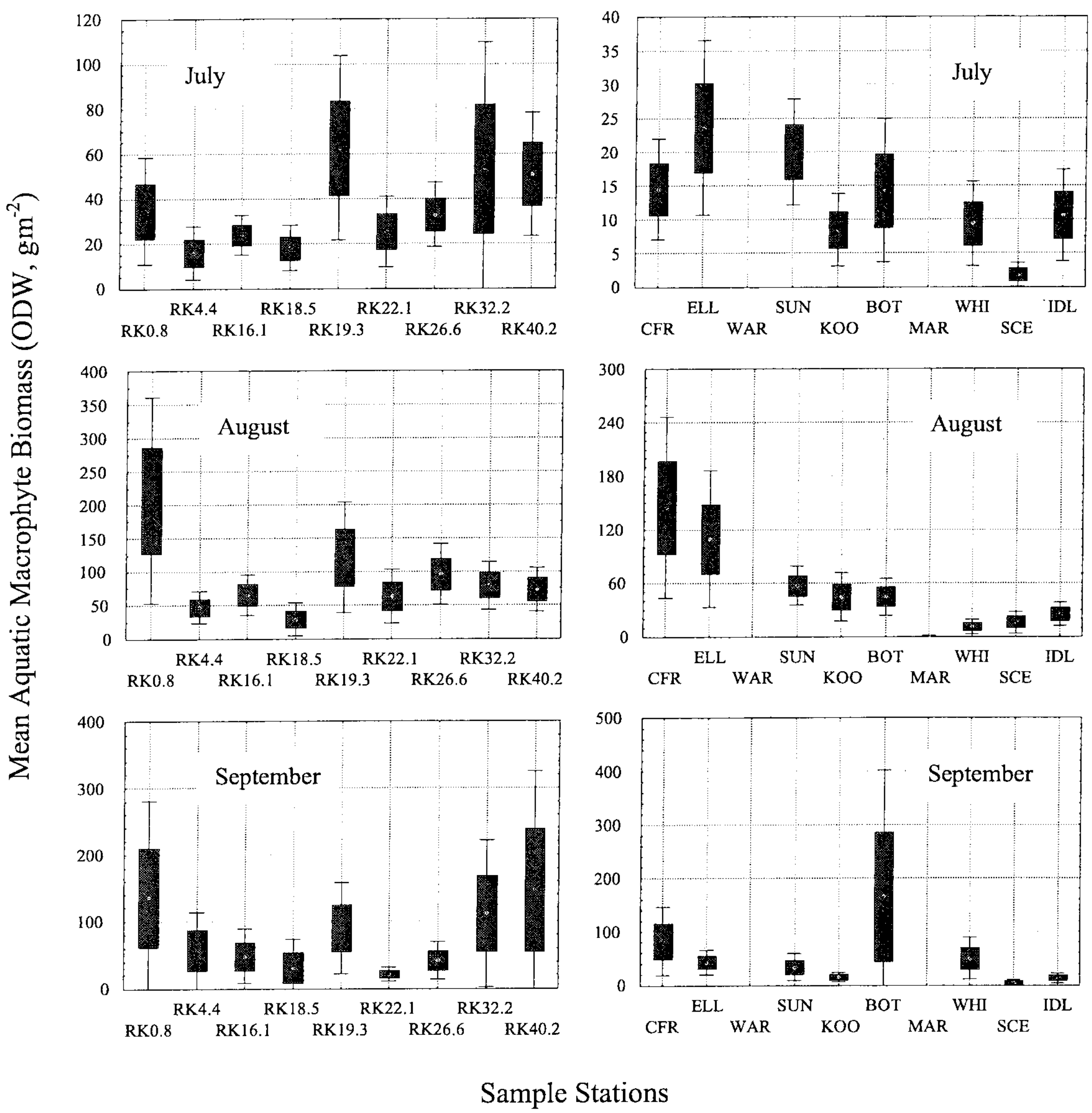

Figure 2.-Mean aquatic macrophyte biomass (oven dry weight (g·m^{-2})) at the 19 selected sample stations on Lake Pend Oreille proper and its outlet arm July, August, September, 1998. The box represents mean ± 1 standard error and the bars represent mean ± 1.96* standard error. CFR = Clark Fork River inlet, ELL = Ellisport Bay, WAR = Warren Island, SUN = Sunnyside, KOO = Kootenai Bay, BOT = Bottle Bay, MAR = Maiden Rock, WHI = Whiskey Point, SCE = Scenic Bay, and IDL = Idlewilde Bay.

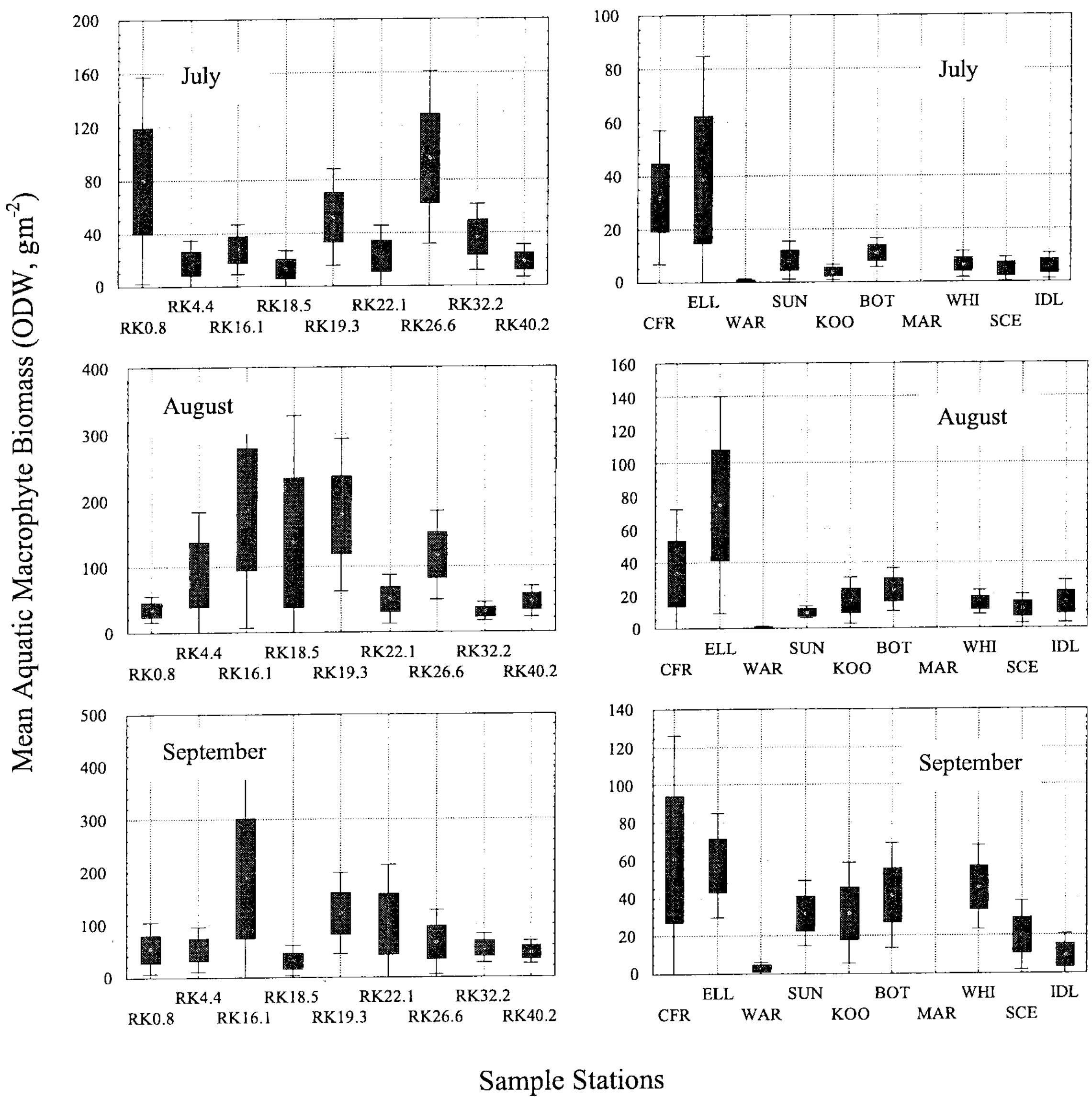

Figure 3.- Mean aquatic macrophyte biomass (oven dry weight (g·m^{-2})) at the 19 selected sample stations on Lake Pend Oreille proper and its outlet arm July, August, September, 1999. The box represents mean ± 1 standard error and the bars represent mean ± 1.96* standard error. CFR = Clark Fork River inlet, ELL = Ellisport Bay, WAR = Warren Island, SUN = Sunnyside, KOO = Kootenai Bay, BOT = Bottle Bay, MAR = Maiden Rock, WHI = Whiskey Point, SCE = Scenic Bay, and IDL = Idlewilde Bay.

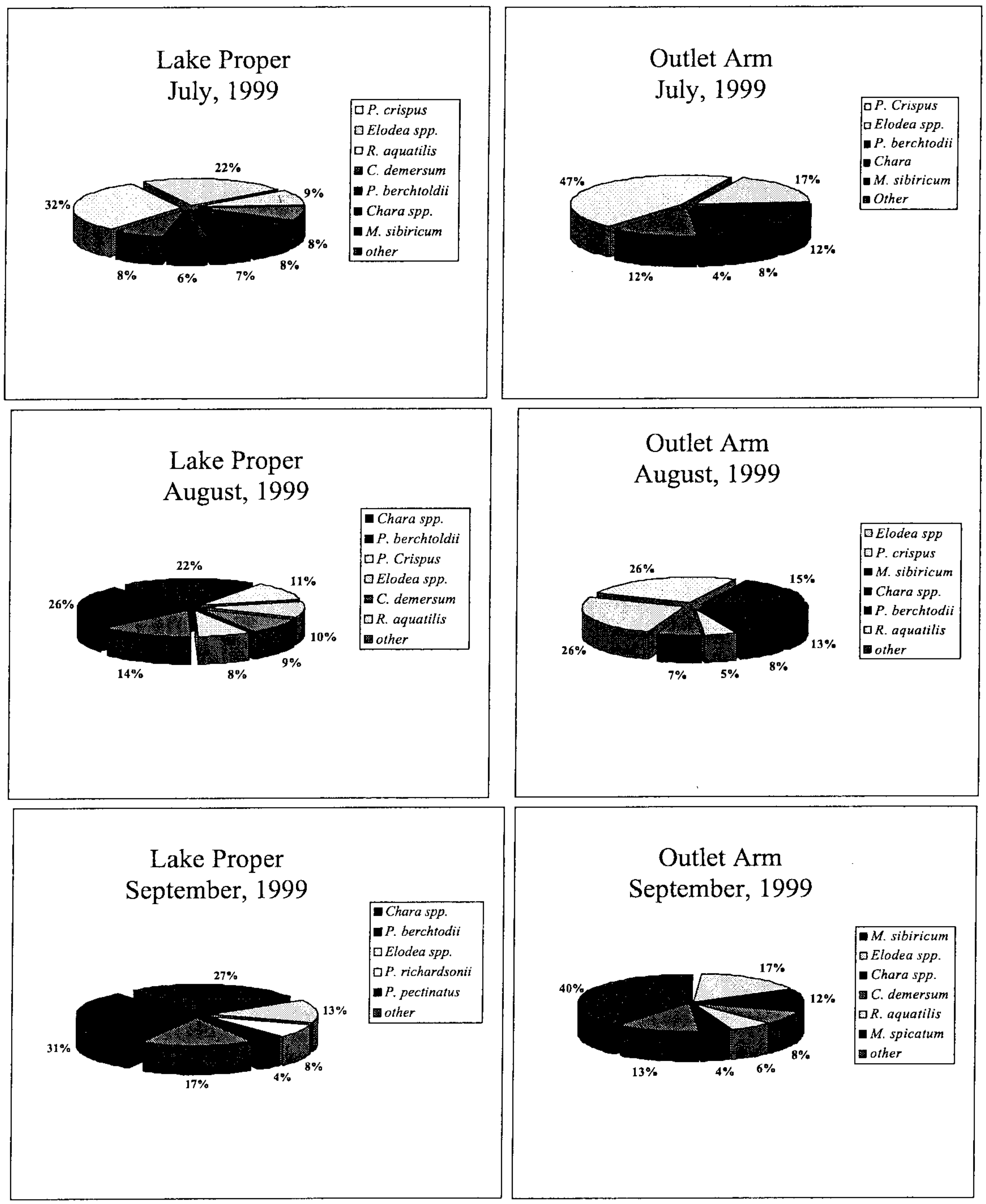

Figure 4.-Dominant aquatic macrophyte species from the 19 selected sample stations in Lake Pend Oreille proper and its outlet arm, July, August, September, 1999.

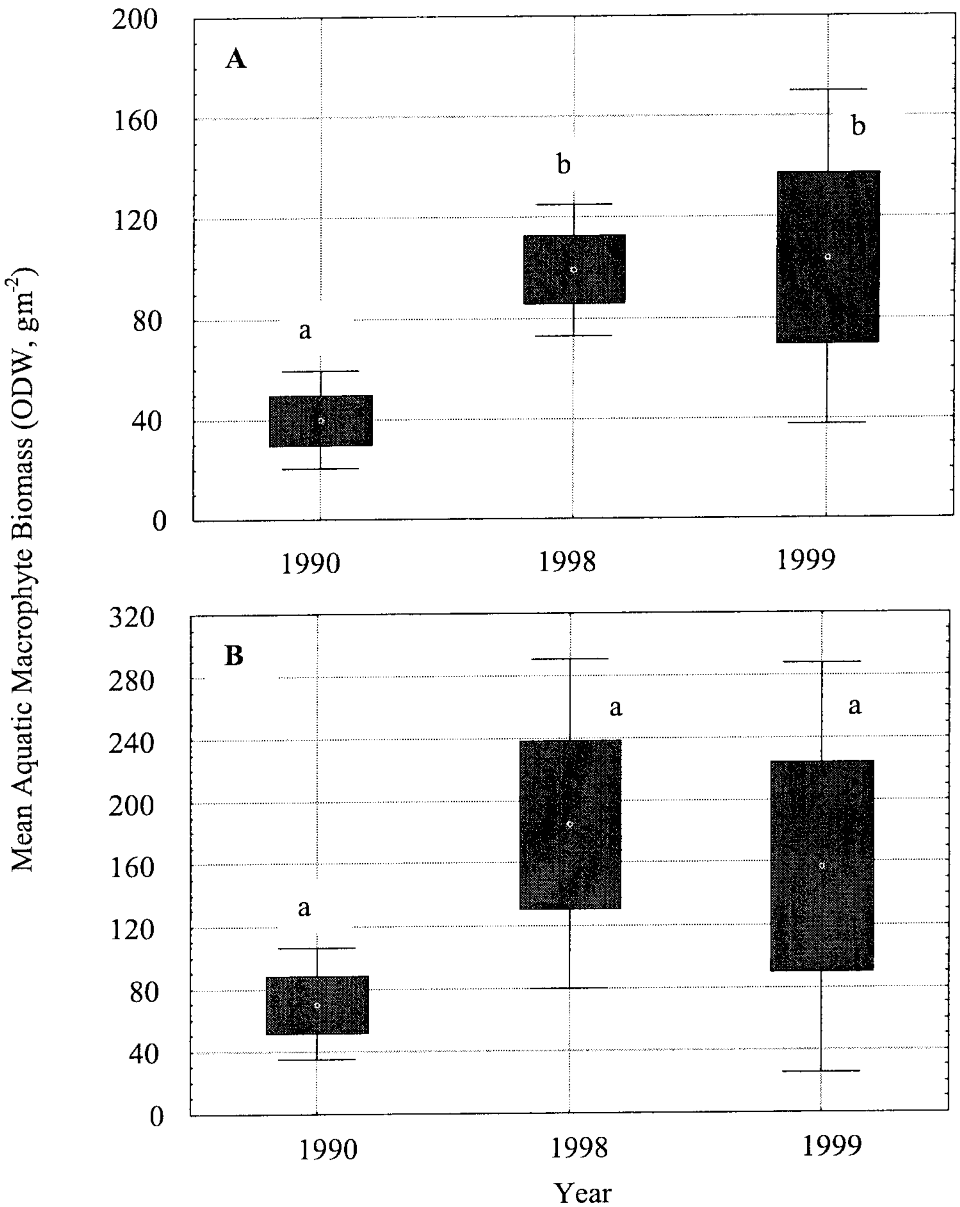

Figure 5.-Mean aquatic macrophyte biomass (oven dry weight (g·m^{-2})) in Lake Pend Oreille, Idaho, August 1990, 1998, and 1999 in (**A**) the winter drawdown zone (1.4 m - 3.5 m) and (**B**) the permanently wetted littoral (3.5 m - 7.0 m). The box represents mean ± 1 standard error and the bars represent mean ± 1.96* standard error. Different letters designate significant difference ($p < 0.05$) between mean aquatic macrophyte biomass.

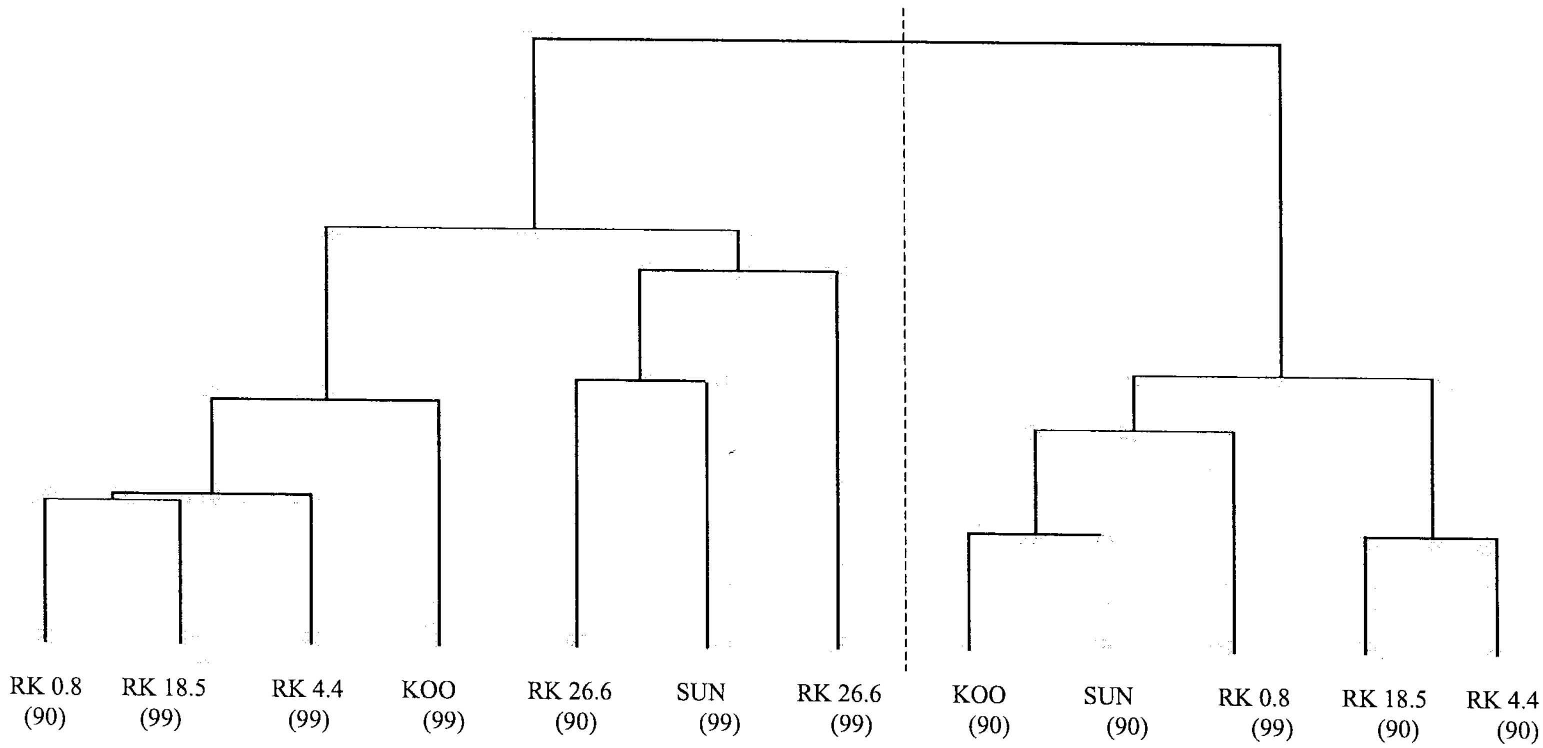

Figure 6.-Dendrogram of sample stations from Kulczynski's dissimilarity distance matrix based on aquatic macrophyte species composition and abundances in the drawdown zone (1.5 m – 3.5 m) for sample stations on the outlet arm of Lake Pend Oreille and Lake Pend Oreille proper, Idaho, August 1990 and 1999. Winter lake drawdown of 3.5 m occurred in 1990 compared to 2.1 m drawdown in 1999. Site code is followed by sample year in parenthesis (RK = River Kilometer, KOO = Kootenai Bay, SUN = Sunnyside). Dashed line represents delineation of clusters.

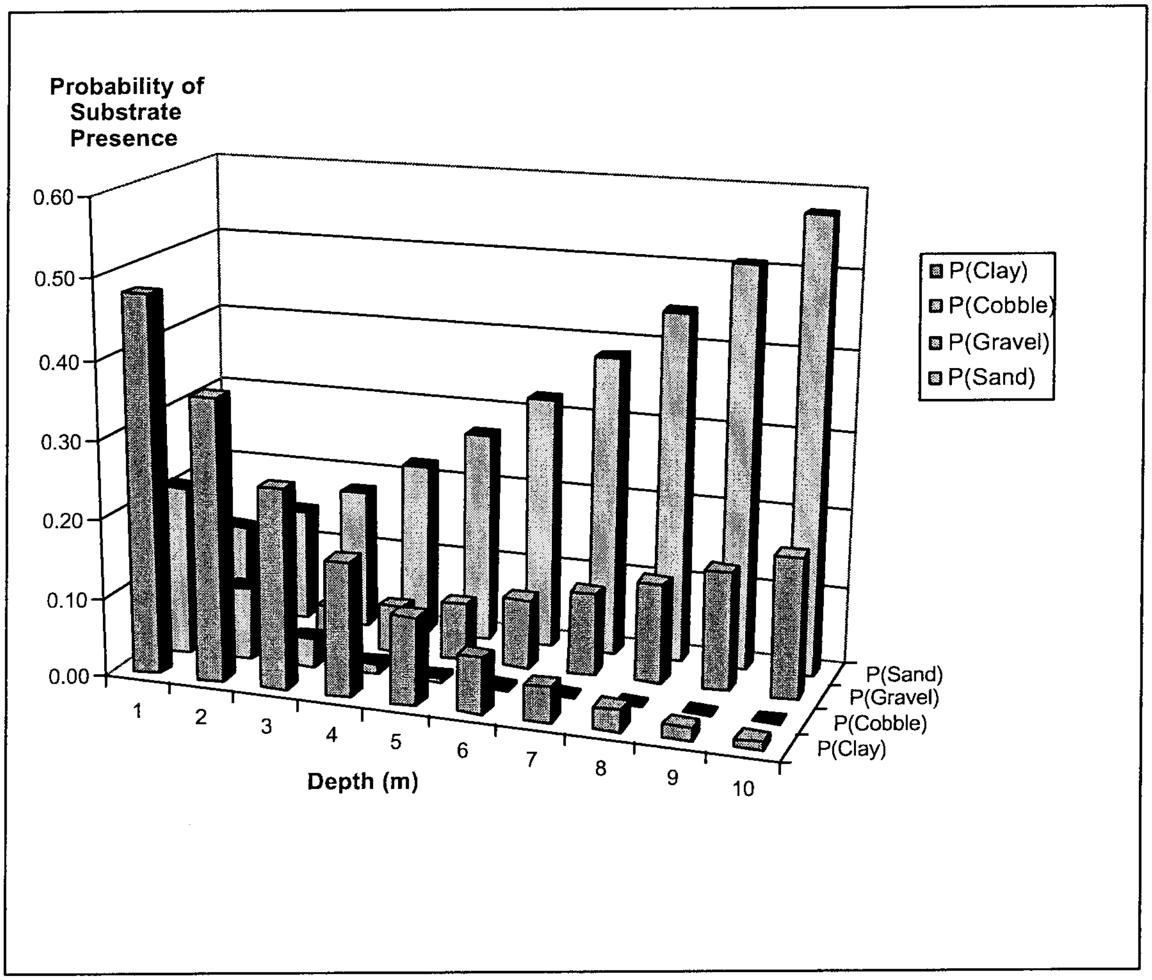

Figure 7.-Probabilities of observing four substrate classes (clay, cobble, gravel, and sand) at various increasing depths from full summer pool for selected sample station on Lake Pend Oreille, Idaho, August 1999.

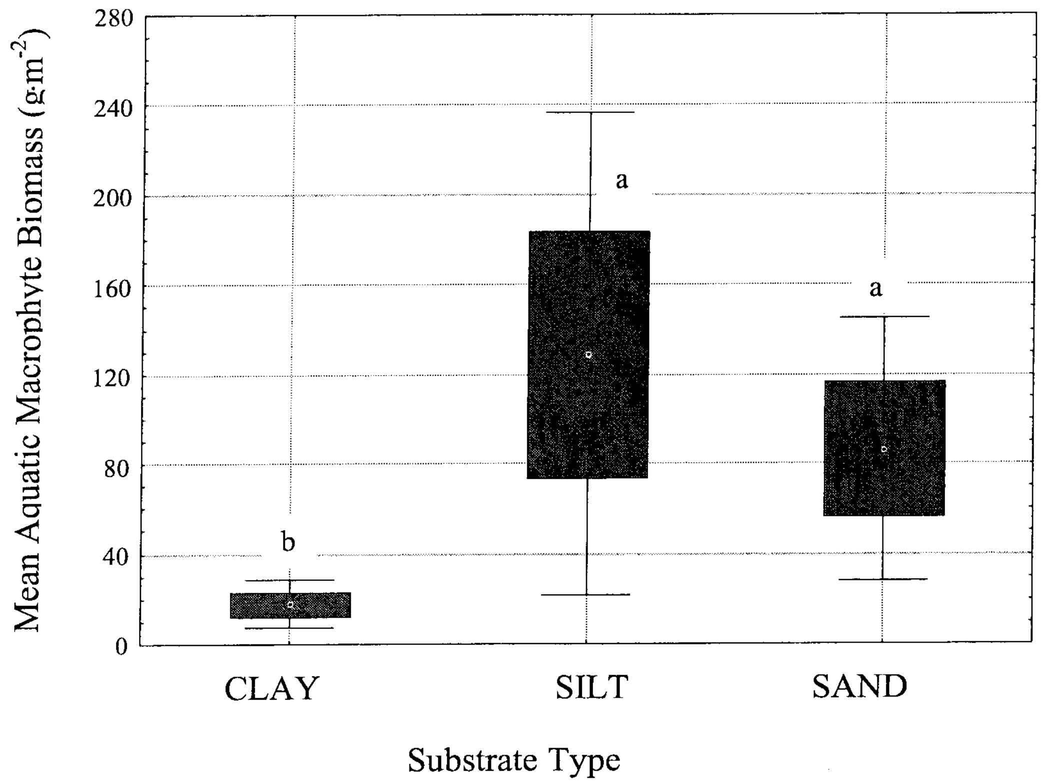

Figure 8.-Mean aquatic macrophyte biomass (oven dry weight (g·m^{-2})) on three substrate classes in Lake Pend Oreille, Idaho, August 1999. The box represents mean ± 1 standard error and the bars represent mean ± 1.96* standard error. Different letters designate significant difference ($p < 0.05$) between mean aquatic macrophyte biomass.

Tables

Table 1.- Selected physico-chemical water quality variables from Lake Pend Oreille proper and its outlet arm July – September, 1998.

Site	Date	Secchi Depth (m)	Mean Temperature (C)	Mean Conductivity (u siemens)	Alkalinity (mgl^{-1} $CaCO_3$)	Site	Date	Secchi Depth (m)	Mean Temperature (C)	Mean Conductivity (u siemens)	Alkalinity (mgl^{-1} $CaCO_3$)
Clark Fork	JUL	3.4	20.6	*	*	**RK 40.2**	JUL	2.7	20.6	*	*
	AUG	10.1	23.4	*	*		AUG	8.4	24.1	*	*
	SEP	8.5	22.0	175.0	79.0		SEP	7.9	23.1	186.0	78.0
Site Mean		**7.3**	**22.0**	*	*	**Site Mean**		**6.3**	**22.6**	*	*
Ellisport Bay	JUL	4.1	21.1	*	*	**RK 32.2**	JUL	3.4	20.4	*	*
	AUG	10.8	24.0	*	*		AUG	8.6	23.9	*	*
	SEP	7.8	22.1	175.0	79.0		SEP	7.0	22.6	186.0	76.0
Site Mean		**7.5**	**22.4**	*	*	**Site Mean**		**6.3**	**22.3**	*	*
Warren Island	JUL	5.6	19.8	*	*	**RK 26.6**	JUL	4.0	20.9	*	*
	AUG	11.3	23.8	*	*		AUG	8.5	24.5	*	*
	SEP	11.3	22.1	188.0	80.0		SEP	4.1	22.4	181.0	78.0
Site Mean		**9.4**		*	*	**Site Mean**		**5.5**	**22.6**	*	*
Sunnyside Bay	JUL	3.8	20.0	*	*	**RK 22.1**	JUL	3.0	21.3	*	*
	AUG	11.5	23.5	*	*		AUG	7.3	24.1	*	*
	SEP	9.5	21.9	181.0	79.0		SEP	4.6	22.3	179.0	78.0
Site Mean		**8.3**	**21.8**	*	*	**Site Mean**		**5.0**	**22.6**	*	*
Bottle Bay	JUL	4.3	20.5	*	*	**RK 19.3**	JUL	3.6	21.6	*	*
	AUG	8.8	23.5	*	*		AUG	8.3	23.8	*	*
	SEP	9.0	22.3	178.0	71.0		SEP	4.8	22.3	179.0	79.0
Site Mean		**7.3**	**22.1**	*	*	**Site Mean**		**5.6**	**22.6**	*	*
Kootenai Bay	JUL	3.4	20.5	*	*	**RK 18.5**	JUL	3.9	22.3	*	*
	AUG	10.6	23.2	*	*		AUG	8.5	23.7	*	*
	SEP	9.3	22.2	184.0	81.0		SEP	4.9	22.4	287.0	78.0
Site Mean		**7.8**	**22.0**	*	*	**Site Mean**		**5.8**	**22.8**	*	*
Maiden Rock	JUL	4.9	15.1	*	*	**RK 16.1**	JUL	3.6	20.8	*	*
	AUG	13.5	23.6	*	*		AUG	8.5	23.8	*	*
	SEP	11.3	21.7	191.0	79.0		SEP	4.5	22.4	183.0	77.0
Site Mean		**9.9**	**20.1**	*	*	**Site Mean**		**5.5**	**22.3**	*	*
Whiskey Point	JUL	6.4	19.8	*	*	**RK 4.4**	JUL	3.9	21.1	*	*
	AUG	12.0	22.9	*	*		AUG	5.6	23.4	*	*
	SEP	13.3	21.5	181.0	79.0		SEP	4.6	22.2	200.0	79.0
Site Mean		**10.6**	**21.4**	*	*	**Site Mean**		**4.7**	**22.2**	*	*
Scenic Bay	JUL	6.0	13.7	*	*	**RK 0.8**	JUL	3.6	21.4	*	*
	AUG	11.5	23.6	*	*		AUG	7.0	23.2	*	*
	SEP	12.4	21.6	181.0	79.0		SEP	4.6	21.9	232.0	75.0
Site Mean		**10.0**	**19.6**	*	*	**Site Mean**		5.1	22.2	*	*
Idlewilde Bay	JUL	5.0	13.2	*	*						
	AUG	7.8	22.7	*	*						
	SEP	11.8	22.1	190.0	78.0						
Site Mean		**8.2**	**19.3**	*	*						

Table 2.- Selected physico-chemical water quality variables, total phosphorus, and nitrate-nitrogen concentrations from Lake Pend Oreille proper and its outlet arm July – October, 1999. One standard deviation is shown in parenthesis for total phosphorus and nitrate-nitrogen where applicable.

Site	Date	Secchi Depth (m)	Mean Temperature (C)	Mean Dissolved Oxygen ($mg l^{-1}$)	Mean Conductivity (u siemens)	Alkalinity ($mg l^{-1}$	pH	Mean Total Phosphorus ($ug l^{-1}$)	Mean Nitrate-Nitrogen ($ug l^{-1}$)
Clark Fork	JUL	2.5	14.6	9.8	168.9	69.0	7.9	<7	69.9 (45.0)
	AUG	6.1	18.5	9.5	168.0	80.0	7.9	<7	25.2 (3.2)
	SEP	7.1	17.4	9.3	170.0	77.5	6.6	<7	27.9 (1.1)
	OCT	6.0	11.9	9.9	170.0	83.0	*	8.31 (3.3)	26.2 (4.5)
Site Mean		**5.4**	**15.6**	**9.6**	**163.7**	**77.4**	**7.7**	**<7**	**37.3**
Ellisport Bay	JUL	3.3	15.7	10.0	167.9	72.0	8.0	<7	38.8 (47.1)
	AUG	7.0	20.1	9.8	169.4	76.0	8.0	<7	39.7 (19.5)
	SEP	8.0	18.9	9.1	211.0	77.0	7.0	<7	23.3 (3.9)
	OCT	7.9	12.2	9.8	149.0	81.0	*	<7	27.1 (2.5)
Site Mean		**6.5**	**16.7**	**9.7**	**174.3**	**76.5**	**7.8**	**<7**	**32.2**
Warren Island	JUL	3.5	14.9	10.0	171.0	68.0	7.9	<7	16.4 (1.7)
	AUG	7.7	18.6	9.3	169.8	76.0	7.9	<7	21.4 (7.7)
	SEP	9.8	19.2	9.0	176.0	79.0	6.9	<7	25.5 (3.0)
	OCT	8.1	12.3	9.9	150.5	84.0	*	<7	19.9 (4.5)
Site Mean		**7.3**	**16.2**	**9.5**	**166.8**	**76.8**	**7.7**	**<7**	**20.8**
Sunnyside Bay	JUL	3.5	15.7	9.6	222.8	43.0	7.1	<7	24.1 (6.1)
	AUG	5.6	17.9	9.9	153.4	74.0	7.2	<7	23.2 (4.0)
	SEP	8.8	18.7	8.8	171.3	73.0	6.7	<7	26.9 (1.3)
	OCT	7.9	12.2	9.8	147.0	81.0	*	<7	22.5 (4.9)
Site Mean		**6.5**	**16.1**	**9.5**	**173.6**	**61.8**	**7.0**	**<7**	**24.2**
Bottle Bay	JUL	3.9	15.3	9.9	162.2	67.0	7.5	<7	70.0 (45.2)
	AUG	6.6	18.1	9.5	198.1	77.0	7.3	<7	22.8 (2.4)
	SEP	6.0	18.8	8.9	171.5	82.0	7.0	<7	29.5 (5.3)
	OCT	7.8	11.9	9.8	147.5	81.5	*	<7	18.9 (3.2)
Site Mean		**6.1**	**16.0**	**9.5**	**169.5**	**76.9**	**7.3**	**<7**	**35.3**
Kootenai Bay	JUL	3.6	16.2	10.0	192.2	72.0	7.9	<7	25.4 (8.3)
	AUG	6.3	20.1	9.4	163.9	75.0	7.6	<7	22.4 (11.0)
	SEP	8.7	19.0	9.0	176.9	75.0	6.8	<7	24.8 (2.7)
	OCT	5.9	11.8	10.2	139.4	80.0	*	<7	28.2 (1.7)
Site Mean		**6.1**	**16.8**	**9.6**	**168.1**	**75.5**	**7.6**	**<7**	**25.2**
Maiden Rock	JUL	5.6	15.8	9.9	142.2	59.0	6.8	<7	43.0 (48.6)
	AUG	8.9	20.3	9.3	171.8	80.0	7.2	<7	25.1 (12.6)
	SEP	*	17.5	9.4	170.0	76.0	6.5	<7	24.2 (2.0)
	OCT	10.1	12.3	10.0	145.5	80.5	*	<7	26.5 (3.5)
Site Mean		**8.2**	**16.5**	**9.6**	**157.4**	**73.9**	**6.9**	**<7**	**29.7**
Whiskey Point	JUL	4.4	14.2	10.1	159.7	76.0	8.0	7.2 (1.6)	47.6 (42.4)
	AUG	8.6	18.7	10.1	165.8	79.0	7.9	<7	30.0 (6.7)
	SEP	8.1	17.6	9.3	172.5	75.0	6.7	<7	27.1 (2.2)
	OCT	10.4	12.2	9.8	148.0	80.5	*	8.2 (2.2)	22.4 (1.7)
Site Mean		**7.9**	**15.7**	**9.8**	**161.5**	**77.6**	**7.8**	**<7**	**31.8**
Scenic Bay	JUL	4.5	15.7	9.9	169.1	76.0	8.0	<7	47.3 (41.0)
	AUG	8.6	20.7	9.1	175.7	82.0	7.9	<7	20.0 (2.9)
	SEP	8.5	17.0	9.5	168.0	75.0	6.7	<7	21.0 (5.9)
	OCT	8.9	12.1	9.9	142.0	82.0	*	<7	25.0 (7.5)
Site Mean		**7.6**	**16.4**	**9.6**	**163.7**	**78.8**	**7.8**	**<7**	**29.2**
Idlewilde Bay	JUL	5.1	14.7	10.1	144.2	78.0	7.2	<7	70.9 (53.4)
	AUG	7.9	20.8	9.2	177.6	78.0	7.9	<7	40.3 (14.8)
	SEP	7.1	16.6	9.5	170.0	74.5	6.8	<7	43.5 (36.3)
	OCT	10.2	11.9	9.9	142.5	80.0	*	<7	23.8 (1.5)
Site Mean		**7.6**	**16.0**	**9.7**	**158.6**	**77.6**	**7.5**	**<7**	**44.6**

Table 2 con't.- Selected physico-chemical water quality variables, total phosphorus and, nitrate-nitrogen concentrations from Lake Pend Oreille proper and its outlet arm July – October, 1999. One standard deviation is shown in parenthesis for total phosphorus and nitrate-nitrogen where applicable.

Site	Date	Secchi Depth (m)	Mean Temperature (C)	Mean Dissolved Oxygen ($mg l^{-1}$)	Mean Conductivity (u siemens)	Alkalinity ($mg l^{-1}$ $CaCO_3$)	pH	Mean Total Phosphorus ($ug l^{-1}$)	Mean Nitrate-Nitrogen ($ug l^{-1}$)
RK 40.2	JUL	3.4	16.5	9.7	188.0	69.0	8.0	<7	14.9 (6.0)
	AUG	4.1	20.5	9.1	166.9	75.0	7.7	<7	32.3 (4.5)
	SEP	6.1	18.7	9.3	175.6	73.5	6.7	<7	26.1 (2.4)
	OCT	7.4	11.1	10.1	146.5	81.0	*	<7	24.5 (0.6)
Site Mean		**5.3**	**16.7**	**9.5**	**169.3**	**74.6**	**7.7**	**<7**	**24.5**
RK 32.2	JUL	2.8	16.2	9.6	180.0	67.0	8.0	<7	22.2 (10.4)
	AUG	4.1	20.5	9.1	166.9	74.0	7.9	<7	26.2 (1.2)
	SEP	5.8	18.7	9.1	172.9	75.5	6.7	<7	28.7 (2.3)
	OCT	7.1	11.2	10.1	143.0	82.0	*	<7	25.7 (0.9)
Site Mean		**4.9**	**16.7**	**9.5**	**165.7**	**74.6**	**7.1**	**<7**	**25.7**
RK 26.6	JUL	3.3	14.9	9.6	168.9	69.0	7.3	<7	73.5 (45.1)
	AUG	3.8	20.2	9.2	163.7	72.5	7.0	<7	30.9 (3.3)
	SEP	7.1	18.5	8.7	170.5	73.0	6.6	7.7 (2.7)	24.8 (15.4)
	OCT	6.4	11.2	10.3	148.3	81.0	*	7.1 (2.2)	23.7 (0.8)
Site Mean		**5.1**	**16.2**	**9.5**	**162.9**	**73.9**	**7.1**		**38.2**
RK 22.1	JUL	3.3	15.2	9.5	172.6	67.0	7.6	<7	43.5 (46.4)
	AUG	3.9	20.7	9.3	163.7	76.0	7.6	<7	29.2 (2.6)
	SEP	5.9	19.0	8.7	169.0	73.0	6.7	<7	26.2 (3.3)
	OCT	6.7	11.1	10.4	144.0	79.0	*	<7	21.8 (0.9)
Site Mean		**4.9**	**15.6**	**9.5**	**162.3**	**73.8**	**7.5**	**<7**	**30.2**
RK 19.3	JUL	3.1	15.8	9.4	248.9	66.0	7.8	7.5 (1.6)	20.5 (1.8)
	AUG	4.3	20.8	9.2	170.8	72.0	7.9	<7	29.7 (6.7)
	SEP	5.9	19.8	8.7	177.5	74.0	6.9	9.8 (1.1)	27.8 (2.8)
	OCT	6.4	11.1	10.3	142.0	80.0	*	9.3 (4.2)	29.9 (12.4)
Site Mean		**4.9**	**16.9**	**9.4**	**184.8**	**73.0**	**7.7**	**7.5**	**27.0**
RK 18.5	JUL	3.4	15.8	9.4	176.6	70.0	7.7	<7	66.3 (46.4)
	AUG	4.0	21.1	9.3	171.8	70.0	7.8	<7	29.4 (2.3)
	SEP	6.9	20.0	8.8	173.5	74.0	6.2	<7	34.8 (13.4)
	OCT	6.2	11.3	10.5	144.0	78.0	*	<7	17.8 (3.1)
Site Mean		**5.1**	**17.1**	**9.5**	**166.5**	**73.0**	**7.6**	**<7**	**37.1**
RK 16.1	JUL	3.0	15.7	9.5	167.4	70.0	7.6	7.1 (4.9)	45.1 (43.5)
	AUG	3.8	21.1	9.2	171.2	74.0	7.6	<7	26.9 (0.3)
	SEP	4.6	20.2	8.8	177.0	73.0	6.9	<7	26.9 (6.6)
	OCT	5.8	11.3	10.4	140.5	79.5	*	<7	23.8 (2.5)
Site Mean		**4.3**	**17.1**	**9.5**	**164.0**	**74.1**	**7.5**	**<7**	**30.7**
RK 4.4	JUL	3.4	16.7	9.5	402.5	70.0	7.5	7.3 (3.3)	44.9 (38.8)
	AUG	3.9	20.5	9.0	165.2	72.0	7.5	7.0 (4.6)	27.8 (8.4)
	SEP	4.0	20.0	8.7	176.5	73.0	7.0	<7	35.2 (1.5)
	OCT	5.6	11.5	10.4	142.3	79.0	*	11.4 (5.1)	30.4 (16.2)
Site Mean		**4.2**	**17.2**	**9.4**	**221.3**	**73.5**	**7.4**	**7.3**	**34.6**
RK 0.8	JUL	3.4	16.0	9.3	230.6	67.0	7.2	<7	42.8 (44.3)
	AUG	3.9	20.5	9.3	173.3	72.0	7.5	<7	26.8 (0.4)
	SEP	5.2	19.6	8.1	168.5	72.0	7.5	<7	33.9 (1.1)
	OCT	6.2	11.1	10.1	131.4	76.0	*	<7	18.3 (1.5)
Site Mean		**4.7**	**16.8**	**9.2**	**176.0**	**71.8**	**7.4**	**<7**	**30.5**

Table 3.-Mean selected sediment chemical values for eight sample stations on Lake Pend Oreille proper and its outlet arm, July, 2000. One standard deviation is shown in parentheses. Mean values with the same superscripted letter within a given column are not significantly different ($p > 0.05$).

Sample Station	Mean Total Phosphorus ($\mu g \cdot g^{-1}$)	Mean Percent Nitrogen (%)	Mean Percent Organic Carbon (%)	Mean Percent Carbon (%)	Mean Percent Organic Matter (%)
Bottle Bay	577.8 (56.5) ^{bc}	0.4 (0.1) ^{a}	5.6 (1.0) ^{a}	5.6 (1.5) ^{a}	9.6 (1.7) ^{a}
Ellisport Bay	546.7 (90.3) ^{bc}	0.3 (0.1) ^{abc}	3.8 (1.9) ^{ab}	3.6 (1.9) ^{ab}	6.5 (3.2) ^{ab}
Scenic Bay	1563.3 (1422.9) ^{a}	0.2 (0.2) ^{abc}	7.5 (6.0) ^{a}	8.4 (7.1) ^{a}	12.9 (10.3) ^{a}
Idlewilde Bay	395.0 (27.4) ^{c}	0.4 (0.2) ^{ab}	5.8 (1.8) ^{a}	6.1 (2.8) ^{a}	9.9 (3.2) ^{a}
RK 0.8	611.1 (113.4) ^{bc}	0.1 (0.1) ^{dc}	1.8 (1.9) ^{bc}	1.9 (2.6) ^{bc}	3.1 (3.2) ^{bc}
RK 4.4	790.0 (88.8) ^{b}	0.1 (0.1) ^{bcd}	1.9 (1.2) ^{bc}	1.7 (1.1) ^{bc}	3.3 (2.1) ^{bc}
RK 18.5	483.3 (192.4) ^{c}	0.0 (0.0) ^{d}	0.8 (0.5) ^{c}	0.7 (0.6) ^{c}	1.4 (0.9) ^{c}
RK2 6.6	545.0 (97.1) ^{bc}	0.2 (0.1) ^{abc}	2.9 (1.3) ^{ab}	2.7 (1.2) ^{ab}	5.0 (2.3) ^{ab}

Table 4.-Aquatic macrophyte species collected from the 19 selected sample stations on Lake Pend Oreille proper, Idaho and its outlet arm, 1998 and 1999. Mean percent organic content of oven dry weight biomass is included for July, August, and September, 1999. One standard deviation is shown in parentheses where applicable.

Species	Mean Percent Organics (July)	Mean Percent Organics (August)	Mean Percent Organics (September)	July-September Mean
Callitrichaceae (Water-starwort Family)				
Callitriche marginata Torr.	93.2 (--)	95.8 (--)	87.2 (5.9)	92.1
Ceratophyllaceae (Hornwort Family)				
Ceratophyllum demersum L.	84.3 (4.9)	87.1 (3.3)	83.6 (5.0)	85.0
Characeae (Stoneworts)				
Chara spp.	58.8 (14.6)	56.8 (19.9)	44.5 (11.8)	53.4
Nitella spp.	56.5 (1.3)	59.4 (16.1)	47.9 (8.8)	54.6
Crassulaceae (Stonecrop Family)				
Tillaea aquatica L.	86.1 (4.2)	87.6 (3.9)	81.2 (8.2)	85.0
Elatinaceae (Waterwort Family)				
Elatine triandra	92.9 (4.1)	Not found	Not found	--
Hippurisaceae (Mare's-tail family)				
Hippuris montana Ledeb.	78.4 (7.0)	Not found	82.7 (5.2)	80.55
Hydrocharitaceae (Frog's-bit Family)				
Elodea canadenis Rich. in Michx.	82.6 (6.1)	82.1 (2.1)	80.7 (4.8)	81.8
E. Nuttallii (Planch.) St. John	81.2 (4.9)	83.3 (2.6)	73.9 (--)	79.5
Haloragaceae (Water-milfoil Family)				
M. sibiricum (Fern.) Jeps.	83.2 (3.2)	84.2 (2.8)	87.0 (6.2)	84.8
Myriophyllum spicatum L.	80.8 (--)	85.2 (3.3)	86.4 (3.5)	84.1
Isoetaceae (Quillwort Family)				
Isoetes spp.	74.0 (9.0)	73.3 (12.4)	70.2 (8.6)	72.5
Najadaceae (Water-nymph Family)				
Najas flexilis (Willd.) Rost. & Schmidt	85.9 (7.9)	84.0 (6.6)	81.1 (4.8)	83.7
Potamogetonaceae (Pond Weed Family)				
Potamogeton berchtoldii Fieb.	85.0 (4.8)	86.0 (5.3)	84.6 (7.1)	85.2
P. crispus L.	86.7 (3.4)	86.2 (2.6)	93.7 (3.8)	88.9
P. foliosus Raf.	81.3 (--)	Not found	Not found	--
P. gramineus L.	86.0 (5.7)	83.6 (6.5)	83.9 (7.3)	84.5
P. pectinatus L.	84.7 (4.5)	86.6 (3.5)	85.3 (4.1)	85.5
P. praelongus Wulf.	89.7 (1.8)	84.6 (2.9)	77.2 (--)	83.8
P. richardsonii (Bennett) Rydb.	85.6 (4.9)	88.2 (3.6)	85.1 (3.9)	86.3
P. robbinsii Oakes	81.9 (5.6)	85.1 (2.5)	88.2 (16.7)	85.1
P. zosteriformis Fern.	86.6 (7.2)	89.6 (2.4)	92.5 (2.4)	89.6
Ranunculaceae (Buttercup Family)				
Ranunculus aquatilis L.	86.6 (3.1)	84.2 (2.6)	85.5 (4.3)	85.4
Zannichelliacaea (Horned Pondweed Family)	87.8 (5.3)	75.8 (--)	84.9 (7.2)	82.8
Zannichellia palustris L.				
Bryophytes				
Drepanocladius spp.	62.4 (13.3)	46.8 (7.9)	56.4 (9.4)	55.2

Table 5.-Percent dominance and percent frequency of aquatic macrophyte species in the drawdown zone (1.4 m – 3.5 m depth) from the six selected sample stations on the outlet arm of Lake Pend Oreille and Lake Pend Oreille proper, Idaho.

Species	1990 Percent Dominance	1990 Percent Frequency	1999 Percent Dominance	1999 Percent Frequency
Ceratophyllaceae (Hornwort Family)				
Ceratophyllum demersum L.	0.4	8.7	0.4	4.2
Characeae (Stoneworts)				
Chara spp.	29.3	60.9	27.4	54.2
Crassulaceae (Stonecrop Family)				
Tillaea aquatica L.	0.0	4.4	0.0	2.1
Hydrocharitaceae (Frog's-bit Family)				
Elodea canadenis Rich. in Michx.	1.8	17.4	12.7	47.9
E. Nuttallii (Planch.) St. John				
Haloragaceae (Water-milfoil Family)				
Myriophyllum sibiricum (Fern.) Jeps.	30.1	26.1	1.7	8.3
**M. spicatum* L.				
Isoetaceae (Quillwort Family)	2.0	8.7	0.2	14.6
Isoetes spp.				
Najadaceae (Water-nymph Family)				
Najas flexilis (Willd.) Rost. & Schmidt	0.1	13.0	0.0	4.2
Potamogetonaceae (Pond Weed Family)				
Potamogeton robbinsii Oakes	0.3	4.6	0.0	0.0
P. pectinatus L.	2.0	4.4	2.1	14.6
P. crispus L.	0.0	0.0	23.6	8.3
P. zosteriformis Fern.	0.0	0.0	0.3	4.2
P. praelongus Wulf.	0.0	0.0	0.0	2.1
P. richardsonii (Bennett) Rydb.	23.9	30.4	0.5	6.3
P. pusillus L.	0.0	8.7	0.0	0.0
P. berchtoldii Fieb.	0.5	8.7	25.3	58.3
P. gramimeus L.	1.4	8.7	0.1	8.3
P. foliosus Raf	6.3	4.4	0.0	0.0
Ranunculaceae (Buttercup Family)				
Ranunculus aquatilis L.	1.9	13.0	5.6	16.7
Bryophytes				
Drepanocladius spp.	0.0	0.0	0.0	4.2
Others	0.0	0.0	0.0	2.1

* M. spicatum did not occur frequently in the 1.0 – 3.5 m depth range and therefore was not represented in samples between 1.4 - 3.5 m depths (drawdown zone) in 1999. However this species was present at sample station RK0.8, first having appeared in Lake Pend Oreille in July, 1998.

Table 6.- Depth (m) as a predictor of substrate particle size class ($\hat{\beta}_0$ and $\hat{\beta}_1 x$ are coefficients derived from binary logistic regression; α = 0.05).

Substrate Class	$\hat{\beta}_0$	$\hat{\beta}_1$	**p-value**
Clay	0.4225	- 0.4984	< 0.0001
Silt	-0.8984	0.0797	0.12
Sand	- 2.936	0.2594	< 0.0001
Gravel	- 3.5624	0.2045	.03
Cobble	- 0.2986	- 0.9881	0.004

Prediction of Potential Eurasian Watermilfoil Habitat in Lake Pend Oreille, Idaho

Abstract

The exotic aquatic macrophyte Eurasian watermilfoil was first observed in Albeni Cove on the outlet arm of Lake Pend Oreille, in August, 1998. We conducted a systematic random sampling of Eurasian watermilfoil throughout the cove to describe relationships between milfoil biomass and depth. These data, along with substrate composition, were used in a geographic information system (GIS) to predict the amount of potential Eurasian watermilfoil habitat in this system. This information was then used to suggest management options for future milfoil control programs. We also conducted physico-chemical measurements in the water column (light and dissolved oxygen profiles, pH, and total alkalinity) in and adjacent to the Eurasian watermilfoil bed to assess effects of this species on the surrounding physical and chemical environment. Light attenuated rapidly beneath the canopy reaching levels below 1 % incident at about 1.5 m that likely contributed to the formation of monospecific stands of milfoil in Albeni Cove. A significant relationship was found between milfoil density and depth. A model describing the relationship between milfoil biomass and depth along with a substrate grid was used in a GIS to quantify possible habitat. Approximately 39% (1438 ha) of the outlet arm area is likely Eurasian watermilfoil habitat. Management of milfoil in this system could include the use of herbicides, hand harvesting, and mechanical harvesting. Contact herbicides may be effective in backwater areas of zero current velocity, hand harvesting can be used to remove isolated, low density colonies. Systemic compounds or mechanical harvesting may be utilized in areas where current is present and densities are high.

Introduction

In 1998, Eurasian watermilfoil (Myriophyllum spicatum L.) was discovered in Lake Pend Oreille, Idaho at Albeni Cove (River Kilometer 0.8), just upstream of Albeni Falls Dam (Fig. 9). Milfoil has been present in the Pend Oreille River immediately downstream of Albeni Falls Dam since 1976, and this area was a possible source of fragments. Eurasian watermilfoil has the potential to spread rapidly in clear, lentic waters of the Pend Oreille system. For example, Eurasian watermilfoil spread at a rate of 3.7 ha·yr in the Pend Oreille River and has become a severe nuisance throughout the river (Gibbons et al. 1983a, Falter et al. 1991, WDE 1993).

Lake Pend Oreille proper is a 383 km^2 (94640 acres) meso-oligotrohic lake with mean and maximum depths of 164 m (538 ft) and 357 m (1171 ft), respectively (USGS 1996). The lake's outlet arm is the Pend Oreille River, exiting from the northwest corner of Lake Pend Oreille. Mean and maximum depths of the outlet arm are 7.4 m (24 ft) and 48 m (157 ft), respectively with a shoreline length of 152 km (94 mi.; USGS 1996). The outlet arm is impounded by Albeni Falls Dam on the Washington-Idaho border and controls water levels of the entire lake. An annual winter drawdown from mid-November through May of 2.3 m (7.5 ft) to 3.5 m (11.5 ft) is implemented primarily for spring flood control and winter power production.

The objectives of this study were to:

(1) Identify likely habitat for milfoil colonization on the outlet arm of Lake Pend Oreille using a GIS to integrate Eurasian watermilfoil biomass, water depth, and substrate composition;

(2) Describe apparent physico-chemical effects of Eurasian watermilfoil on the surrounding environment; and

(3) Develop and recommend management options to control the spread of milfoil in this system.

Ecology of Eurasian Watermilfoil

Eurasian Watermilfoil Distribution and Growth Forms

Eurasian watermilfoil is a submersed, perennial, aquatic angiosperm that was introduced into the United States near Chesapeake Bay in the late 1880's. Since its introduction, Eurasian watermilfoil has spread across the United States and become one of the most troublesome submersed aquatic plants in North America (Smith and Barko 1990). Nuisance growths of Eurasian watermilfoil (hereafter also referred to as milfoil) restrict water-based recreation through the development of dense surface canopies (Nichols 1975, Wile 1978) and create aesthetically displeasing lake littoral zones.

Biology of Eurasian Watermilfoil

Eurasian watermilfoil is a member of the Haloragaceae (watermilfoil family). This submersed perennial aquatic herb is essentially evergreen which overwinters as root-stocks forming no specialized overwinter structures such as turions (Smith and Barko 1990). Milfoil has a pillar-like growth form (vertical clumpings of 10-40 stems per clump) early in the growing season (Budd et al. 1995), but as water temperature and photoperiod increase, long stems are produced that can exceed 10 m in length. These stems are covered with finely dissected leaves arranged in whorls of 3 to 6, usually 4 per node (Hitchcock and Cronquist 1973, Aiken et al. 1979). Leaf outline is feather-like with 14 – 24 pairs of leaflets (Aiken et al. 1979). Stems branch once reaching the water surface form dense surface canopies. The formation of these dense surface canopies interferes with water-based recreation and can decrease the diversity of littoral vegetation (Madsen et al. 1991). Once canopy formation begins, leaves low on the stem senesce leaving only the surface canopy foliated.

Milfoil possesses several structural and physiological adaptations that allow it to be a superior competitor:

(1) The location of photosynthetic tissue near the water surface;

(2) C_4- fixation similarities (*i.e.*, a bicarbonate (HCO^{-3}) uptake mechanism analogous to the C_4-dicarboxylic acid pathway where CO_2 is actively transported to the site of the Calvin Cycle with a subsequent decarboxylation) (Hutchinson 1975);

(3) The ability to survive under low light (1-2% of surface light);

(4) An opportunistic use of nutrients (nutrient uptake from the most available source, whether sediments or the water column); and

(5) A life history that tolerates cool weather (the ability to overwinter as the entire plant and grow under ice; Nichols and Shaw 1986), and very rapid growth throughout the growing season out-competing native vegetation (Gibbons et al. 1983a).

Nutrient Dynamics

Milfoil communities are affected by surrounding sediment and water column nutrient concentrations (Nichols and Keeney 1976, Rattray et al. 1991). The addition of nitrogen to sediments has been shown to result in a 30-40% increase in milfoil biomass (Anderson and Kalff 1986). Eurasian watermilfoil colonies also affect surrounding nutrient dynamics *via* nutrient uptake, translocation, and release upon senescence and decomposition (Smith and Barko 1990, Nichols and Keeney 1973, Carignan 1985). DeMarte and Hartman (1974) concluded that ^{32}P was actively translocated from the roots of M. sibiricum to the shoot system and subsequently released to the surrounding water. Smith and Adams (1986) also demonstrated the importance of roots in transferring phosphorus from lake sediments into plants and concluded that roots accounted for 73% of total plant phosphorus uptake (shoot uptake accounted for 27%). During their experiment, phosphorus efflux from live milfoil shoots to the water was low. However, high efflux occurred during decay, illustrating the importance of phosphorus release upon senescence. Bristow and Whitcombe (1971) reported that most (59%) of the phosphate measured in stems of milfoil was derived from sediment, demonstrating the importance of sediment composition to growth of rooted aquatic macrophytes that derive nutrients primarily from lake sediments. Nutrient release may be an important component influencing pelagic phytoplankton community composition and abundance in fall (Brooker and Edwards 1975, Malthus et al. 1990). Landers (1982) reported that senescing mifoil beds produced about 18% of the annual total phosphorus load and a significant amount of nitrogen to an Indiana reservoir. Additionally, significant increases in phytoplankton and periphyton biomass (indicated by Chl *a*) were measured in response to the pulses of nutrient release from milfoil decay.

Effects on Benthic Macro Invertebrates and Fishes

Ecological effects of nuisance growths include the decline of native aquatic vegetation under dense milfoil canopies (Madsen et al. 1991) and lower aquatic invertebrate densities (essential food for many fishes and semi-aquatic organisms) within milfoil beds (Sloey et al. 1997). For example, Keast (1984) found five important taxa of fish prey invertebrates to be three to seven times more abundant in a <u>Potamogeton</u>-dominated community than in a milfoil-dominated community. In the same study, three to four times as many fish were found feeding in the benthos beneath the indigenous macrophyte bed when compared to beneath the milfoil plant community. However, Liter (1991) found higher fish densities in vegetated sloughs when compared to the main reservoir while sampling with pop nets in Box Canyon Reservoir on the Pend Oreille River, Washington. These vegetated sloughs in Box Canyon Reservoir are largely composed of milfoil (Falter et al. 1991) and contained fish densities of up to 5.2 fish $\cdot m^{-2}$ (Liter 1991). Lyons (1989) speculates that environmental degradation caused by the invasion of milfoil into Lake Mendota, Wisconsin, contributed to the extinction of eight species of small littoral fishes and consequently a reduction in prey abundance for larger fishes. Other effects include a possible decrease in foraging efficiency of littoral fishes through an increase in habitat complexity (difficulty of piscivorous fishes locating prey) and light reduction (Diehl 1988) as well as altering fish spawning site distribution (Keast 1984). Engel (1987) documented a shift in prey item occurrence in largemouth bass as the density of aquatic macrophytes (Potamogeton spp., Ceratophyllum demersum, Spirogyra, and others) increased. For example, bass and bluegill (Lepomis macrochirus) under age III utilized aquatic plant beds early in the year (low plant densities) while feeding on aquatic invertebrate larvae. As aquatic plant densities increased, bluegill in those areas shifted to feed on zooplankton and finally to aquatic plant tissue at maximum plant densities. Largemouth bass, however, began feeding on fish prey as plant densities increased, but encountered difficulties penetrating dense macrophyte beds in search for prey. Dibble and Harrel (1997) also found piscivory to be more prevalent in largemouth bass contained in milfoil enclosures than those contained in common pondweed-dominated enclosures. Diets of largemouth bass contained in the pondweed enclosures consisted primarily of macroinvertebrates. Dibble and Harrel (1997) hypothesized that differences in plant architecture were responsible for these differences in diet. For example, the frequency of vertical and horizontal interstices was higher in the pondweed communities (increased frequency of microhabitat for aquatic invertebrates) relative to milfoil communities (Dibble and Harrel 1997). This enhanced spatial complexity in the pondweed communities may increase the abundance of prey items and therefore benefit the foraging efficiency of littoral fishes.

Controlling Factors

The mechanisms of colonization and factors that affect the dispersal of milfoil have received a great deal of attention due to the profound impact milfoil invasion can have on a waterbody and surrounding ecosystems. Factors influencing the distribution of Eurasian watermilfoil on a large spatial scale include water column total phosphorus and Carlson's Index (Madsen 1998). Milfoil dominance increases as water column total phosphorus levels increase from oligotrophic (< 10 $ug \cdot l^{-1}$) to mesotrophic (< 30 $ug \cdot l^{-1}$) and then declines as total phosphorus levels exceed 50 $ug \cdot l^{-1}$. Carlson's Index (1977; TSI) is based on Secchi depth, chlorophyll *a* ($ug \cdot l^{-1}$), and total phosphorus concentrations. Lakes are then classified on a scale ranging from 0 to 100 based on these parameters. According to Carlson's Index, milfoil dominates in oligo-mesotrophic to moderately eutrophic waterbodies (TSI 35-70) (Madsen 1998).

Factors affecting milfoil within-lake distribution include water depth and substrate composition (Peltier and Welch 1969, Spence and Chrystal 1970, Anderson 1978, Spence 1982, Chambers and Kalff 1985, Duarte et al. 1986, Sheldon 1994, Middelboe and Markager 1997). The low nutrient concentrations and limited rates of nutrient diffusion found in coarse substrates provide poor habitat for macrophyte growth (Barko and Smart 1986, Aiken and

Picard 1980). Milfoil prefers substrates that range from 6 to 18% organic matter and sediment textures from 12 to 36% fine particles (< 0.5 mm diameter). However, it can be found on substrates from 0 to 32% organic matter and on sediment textures from 0 to 40% fine particles (Nichols 1994).

Higher levels of organic matter in sediments seem to retard milfoil growth (Barko 1983), largely as a result of changes in pH, redox potential, and the evolution of growth inhibiting gases (*e.g.*, hydrogen sulfide and ammonia) from eutrophic sediments (Horne and Goldman 1994). Depth also limits within-lake distribution of milfoil. Milfoil is most commonly found in depths of 1-3 m, but is commonly found in depths greater than 6 m and in depths of up to 10 m in waterbodies with high transparency (Boylen et al. 1996, Aiken et al. 1979). Poor light penetration can limit the distribution of milfoil to shallower waters (Nichols and Rogers 1997). Freezing and desiccation of milfoil plants on dewatered sediments in regulated lakes and rivers also limit the littoral distribution of milfoil colonies (Stanley 1976).

Eurasian Watermilfoil Propagation

Eurasian watermilfoil can spread rapidly within and between water bodies. Intra-lake colonization is primarily achieved through fragment production (both auto and allofragmentation) and/or clonal expansion which is mostly accomplished *via* stolon growth (Madsen and Smith 1997, Kimbel 1982). Fragment production and dispersal are likely responsible for the spread of milfoil across North America (Smith and Barko 1990). Boat movements between infested and non-infested water bodies facilitate inter-lake fragment dispersal (Williams 1993). Johnstone et al. (1985) found the plant distribution of five nonindigenous aquatic plants that spread vegetatively to be significantly associated with boating and fishing activities. Seed production does occur; however, it is less important than vegetative reproduction (Aiken et al. 1979).

Eurasian Watermilfoil Management

Management of milfoil has become a top priority for many agencies across the United States. To manage aquatic systems, several tools have been developed to study the spatial distribution of organisms and analyze relationships between environmental variables and biotic systems. Geographic information systems (GIS) are becoming increasingly popular in many biophysical sciences, including the aquatic sciences for this purpose (Lehmann and Lachavanne 1997). For example, Jensen et al. (1992) used GIS to develop a model for predicting the potential spatial distribution of cattail (Typha latifolia) and waterlilies (Nymphaea odorata) based on five biophysical criteria. Welch and Remillard (1988) used remote sensing in conjunction with GIS to monitor water quality and distribution of aquatic macrophytes in a South Carolina lake. Narumalani et al. (1997) used logistic multiple regression and GIS to determine the probability of macrophytes occurring at various water levels in a cooling reservoir in South Carolina. Many other studies (Koutnik and Padilla 1994, Janauer 1997, Williams and Lyons 1997, Gottens et al. 1998) pertaining to the management of aquatic ecosystems have also used GIS to assist in the analysis, modeling, and mapping of the spatial distributions of aquatic systems and their communities. GIS also facilitates the transfer of information between organizations and between organizations and the public and therefore represents a powerful tool in aquatic resource management.

Control techniques include the use of herbicides (both contact and systemic herbicides), rotovation, benthic barriers, benthic dredging, biological control agents (*e.g.*, the weevil Euhrychiopsis lecontei), and microbial control agents (*e.g.*, the fungus Mycoleptodiscus terrestris) (Richardson 1975, Wile 1978, Cooke and Gorman 1980, Nichols 1984, Sneh and Stack 1990, Verma and Charudattan 1993, Nelson 1996, Getsinger et al. 1997, Newman et al. 1997, Sutter and Newman 1997). Analysis of a water body with respect to potential areas of colonization and system-specific characteristics that may influence the effectiveness of control measures should be carried out prior to implementation of such control measures (Van Vierssen 1993) due to the wide variety of techniques available.

Eurasian watermilfoil was first observed in the outlet arm of Lake Pend Oreille in August, 1998. Milfoil beds in Albeni Cove were chemically treated in late August, 1998 in an attempt to reduce densities and prevent the spread of this species up the outlet arm and into Lake Pend Oreille proper. Chemical treatment consisted of applying two contact herbicides Aquathol ® (endothall (7-oxabicyclo (2,2,1) heptane-2, 3-dicarboxylic acid) and Reward ® (diquat (6,7-dihydrodipyrido[1,2-a:2',1'-c] pyrazinediium ion)) to 34 acres of water. The Bonner County (Idaho) Weed Control and Waterways Department performed the application.

Materials and Methods

Eurasian Watermilfoil Sampling and Laboratory Analysis

We used systematic random sampling design to describe milfoil densities in Albeni Cove in relation to depth. Thirty transects, 27.5 m apart, beginning at the west end of the cove and extending to the eastern-most point of the cove. The first transect sampled was randomly selected. Every third transect was sampled from that point until the entire bay was sampled. Five samples were obtained between 0 – 10 m depths on each sampled transect. Samples were labeled, stored on ice, and frozen upon returning from the field. Biomass (oven dry weight (ODW, $g{\cdot}m^{-2}$)) and species composition were determined for each sample following Standard Methods Procedure 10400 D.3 (APHA 1992).

The watermilfoil bed in Albeni Cove was also sampled in August, 1998 (pre-chemical treatment) and again in August, 1999 (post-chemical treatment) to obtain *maximum* biomass estimates. A Petite Ponar dredge (225 cm^2) was used to obtain four replicate plant grabs from the entire bed in 1998 and three in 1999. The dredge was positioned towards the center of the milfoil bed to ensure the edge of the bed was not sampled. Depth (m) and substrate type (clay, silt, sand, gravel, and cobble) were recorded for each grab. Biomass (oven dry weight (ODW, $g{\cdot}m^{-2}$)) was determined for each sample following Standard Methods Procedure 10400 D.3 (APHA 1992).

Eurasian Watermilfoil Site Limnology

Solar radiation extinction was measured with a LI-COR LI-250 (LI-COR ®,Lincoln NE) light meter in or near the center of the milfoil bed and outside of the milfoil bed from the water surface to lake bottom. A dissolved oxygen profile was obtained using a YSI model 55/25 (YSI Inc., Yellow Springs, OH) dissolved oxygen meter both within and adjacent to the milfoil bed. Electrical conductivity was taken using a YSI model 33 S-C-T. Alkalinity and pH were measured as follows: (1) water samples were taken using a 2-liter Kemmerer water sampler; (2) samples were retrieved at mid-depth near the center of the milfoil bed and; (3) three replicate water samples for the determination of pH and total alkalinity (mg $CaCO_3 \cdot l^{-1}$) were stored in full BOD bottles, and placed on ice until processing that evening (replicates were not obtained from outside the milfoil bed). Alkalinity was determined by the titration method according to Standard Methods procedure 2320.B (APHA 1992). Mean percent species composition by weight was also determined using data obtained from the *maximum* biomass samples. Together, those data were used to determine apparent effects milfoil has on the surrounding aquatic macrophyte community.

GIS Database Development

Bathymetry

A digitized bathymetric map of the outlet arm was obtained from the U. S. Geological Survey (USGS). To generate this map, the USGS measured depths at 62 bathymetric sections on the outlet arm using a calibrated video depth sounder. Depth and locations were digitized onto a base map of the shoreline that had been generated from 7.5-minute USGS topographic maps (USGS 1996).

Substrate Composition

A polygon coverage containing the dominant substrate types in the outlet arm of Lake Pend Oreille was obtained from Dupont (1994, Fig. 10). The substrate coverage was converted into a 10-m raster grid. The assumption was made that substrate particle size distribution had not changed significantly over time from that identifies in 1994.

Statistical Analysis

Eurasian Watermilfoil Biomass and Depth

Regression analysis was used to determine the relationship between water depth (m) and biomass of milfoil (ODW, $g{\cdot}m^{-2}$). Biomass values were log-transformed prior to analysis to accommodate homogeneity of variance (Kleinbaum et al. 1998). Substrate composition was not included in the regression analysis due to insufficient replication on the various substrate types; however, substrate composition was used in the GIS modeling process. All statistical analyses were performed using SAS GLM (SAS Institute Inc. 2000) or STATISTICA® (Statistica for the Macintosh 1994) computing software.

GIS Analysis

The bathymetric map contained discrete depth values (*i.e.*, every contour line had a measured depth value, but the area between contour lines did not have depth values). In order to generate a map consisting of continuous depth values, we converted the bathymetric coverage into a TIN (Triangulated Irregular Network) model. The TIN was then converted into a 10 m cell-sized raster grid. All coverage and grid manipulations were performed using various commands and modules in ArcInfo v. 7.2.1 and ArcView v. 3.2 (ESRI, Environmental Systems Research Institute).

The model describing the relationship between milfoil biomass and depth in Albeni Cove was applied to the depth grid to generate predicted densities of milfoil for each cell in the grid based on its depth value (Fig. 11). Substrate and biomass grids were then combined using the CON statement in ArcInfo. The CON function is a conditional statement that is evaluated on a cell-by-cell basis. For example, substrate cells were given the value from the predicted biomass grid if the substrate was "clay," "silt," or "sand" and given a value of "zero" if the substrate was "gravel" or "cobble," since milfoil was absent from all gravel and cobble substrate types sampled. This allowed a final estimation of likely available habitat taking into account substrate composition and depth. These predicted biomass values were then used as indicators of suitable milfoil habitat. We assumed that a higher predicted biomass was indicative of more suitable habitat since aquatic macrophytes can be used as bioindicators of suitable habitat (Nichols and Buchan 1997, Nichols 1994).

Results

Eurasian Watermilfoil Site Limnology

Light rapidly attenuated under the dense milfoil canopy from 17, 000 LUX at the surface to 40 LUX at 3.25 m (outlet arm bottom, Fig. 12). Only 0.59% of surface solar radiation was present at 2 m depth. Light attenuated from 16,000 LUX to 4,300 LUX at 3.25 m in open water adjacent to the milfoil canopy.

Daytime dissolved oxygen in the milfoil bed was at 115% saturation (9.8 $mg \cdot l^{-1}$) at the surface and declined to 80% saturation (6.8 $mg \cdot l^{-1}$) at the sediment-water interface (Fig. 13). Dissolved oxygen adjacent to the milfoil bed was at 90% saturation (8.1 $mg \cdot l^{-1}$) at the surface and 91% saturated (8.2 $mg \cdot l^{-1}$) at 3.25 m. Mean water-column temperature (°C) and conductivity (µsiemens) inside the milfoil bed were 19.8 and 147, respectively. Water-column temperature (°C) and conductivity (µsiemens) outside the milfoil bed were 20.5 and 173.3, respectively. Mean alkalinity inside the milfoil bed was 73.0 mg $CaCO_3 \cdot l^{-1}$ and mean pH was 7.3. Alkalinity outside the bed was 72.0 mg $CaCO_3 \cdot l^{-1}$ and pH was 7.5 (Table 10).

Milfoil was the dominant species present in the *maximum* biomass samples comprising 84% mean species composition by weight. Elodea canadensis, Ceratophyllum demersum, and Ranunculus aquatilis comprised a minor proportion of the most dense milfoil beds with 10%, 5%, and 1% mean species composition, respectively.

GIS: Predicted Available Habitat

The relationship between milfoil biomass and depth predicted that approximately 52% (2098 ha) of the outlet arm area was suitable habitat. Suitable habitat was defined as any area predicted to contain any densities of milfoil. This definition is broad, but given the coarse resolution of the analysis and the limited number of predictor variables it allows for a liberal estimation of available habitat. Using the relative predicted densities as indicators of habitat quality, approximately 33% (1346 ha) of the predicted milfoil habitat was "low" quality habitat (predicted biomass between 1 – 25 $g{\cdot}m^{-2}$, ODW), 5% (194 ha) was "moderate" quality habitat (predicted biomass between 26 – 210 $g{\cdot}m^{-2}$, ODW), and 14% (558 ha) was "high" quality habitat (predicted biomass > 210 $g{\cdot}m^{-2}$, ODW) (Fig. 11).

Eurasian Watermilfoil Biomass and Depth

Depth was a significant predictor of milfoil density ($p < 0.0001$, $r^2 = 0.57$). We found that a parabola described the relationship between milfoil biomass and depth (Fig. 14).

$$\mathrm{LOG(biomass)} = -2.257 + 2.482(\mathrm{depth}) - 0.330(\mathrm{depth})^2 \qquad (1)$$

Once the model took into account both substrate composition and depth, approximately 39% (1438 ha) of the outlet arm area was predicted as suitable habitat (*i.e.*, was in the depth range of 0 m to 7 m and was not on gravel or cobble substrates).

Approximately 24% (871 ha) was "low" quality habitat, 4% (147 ha) of "moderate" quality, and 11% (420 ha) was "high" quality habitat (Figs. 15 and 16).

Discussion

Eurasian Watermilfoil Biomass and Depth Modeling

The relationship between depth and milfoil biomass in Lake Pend Oreille was approximated by a parabolic curve with a maximum biomass attained near 4 m depth. Lehmann et al. (1994) also found this parabolic relationship between biomass and depth with three pondweed species in Lake Geneva, Switzerland, and used the relationships in modeling submerged macrophyte biomass using GIS. Low biomass in the shallow depths is partially due to the effects of winter drawdown and in many cases may be attributed to disturbance caused by wave action (Schiemer and Prosser 1976, Chambers 1987). The decrease in milfoil biomass deeper than 4 m is related to an increase in littoral slope. As depths approach 6 m, slope increases to the thalweg. Higher slope decreases physical stability of the finer sediments resulting in poor plant habitat (Duarte and Kalff 1986). Low light is often cited (Spence and Chrystal 1970, Duarte et al. 1986) as a limiting factor to the maximum depth of colonization of aquatic macrophytes. However, in this study the light compensation point for photosynthesis (1% of surface light) was deeper (8 m in Albeni cove) than the deepest milfoil communities suggesting that other factors, such as littoral slope and substrate, are controlling the maximum depth of milfoil colonization in this system. Carlson (1995) also concluded that slope and substrate were likely limiting the Eurasian watermilfoil-dominated community in the Pend Orielle River, Washington. Ballesteros et al. (1989) speculated that sediment features were responsible for the lower boundaries of aquatic macrophyte colonization in an oligotrophic lake when irradiance failed to explain the maximum depth of colonization. Irradiance was about 50% well above the compensation point (1%).

Reward ® (diquat) and Aquathol ® (endothall) application in 1998 failed to significantly reduce the *maximum* biomass of Eurasian watermilfoil in Albeni Cove from 1999 maxima (1998 mean maxima = 1119.7 $g \cdot m^{-2}$, 1999 mean maxima = 905.3 $g \cdot m^{-2}$, *t*-test, $p = 0.35$). The ineffectiveness of this application may be due to several factors. The chemical application occurred late in the growing season. Diquat is most effective early in the growing season when plants are actively photosynthesizing (Murphy and Barrett 1993). Furthermore, water velocities in the outlet arm likely limited the contact time of the chemicals in the areas of higher velocity. For example, Newroth (1979) concluded that diquat was ineffective and expensive in large spread treatments of milfoil, especially in lotic systems. Reinert et al. (1985) determined over 90% of granular endothall entered solution 24 h after application. This rapid release rate may reduce its effectiveness in lotic systems (Reinert et al. 1985).

Future management options may include different herbicides and/or mechanical control methods. For example, in the Pend Oreille River, Washington, just west of Albeni Falls Dam, mechanical rotovation was successful in reducing milfoil stem densities. Milfoil stem densities were reduced 63 - 90% immediately following rotovation and remained reduced 25 - 70% the following growing season (Gibbons and Gibbons 1988). Wile (1978) also reduced milfoil stem densities with multiple harvests by a mechanical harvester, and concluded that fish populations were unaffected by harvest activities. Population estimates of warmwater fish species (pumpkinseed Lepomis gibbosus) remained level over the duration of their study in both harvested and nonharvested control areas. However, Wile (1978) did record a direct loss of fish that were trapped in the vegetation upon removal. A loss of approximately 8.9 kg fish per ha lake area harvested. Small (12 to 190 mm) yellow perch (Perca flavescens) were the most numerous species removed accounting for 56% of the total number of fish harvested (Wile 1978). Winter drawdowns also have been successfully implemented to control milfoil populations (Goldsby et al. 1978, Tarver et al. 1978, Cooke 1980, Tarver 1980, Siver et al 1986). However, these studies occurred in enriched water bodies where milfoil is limited to shallow depths and therefore fully exposed during drawdown. Winter drawdown to 3.5 m will not be as successful in the outlet arm of Lake Pend Oreille due to high transparency and the resulting deeper milfoil colonization (depths greater than 5 m). A winter drawdown to 3.5 m would only reduce densities in the shallowest areas of the littoral zone.

Other chemicals that may be considered include systemic compounds such as triclopyr (3,5,6-trichloro-2-pyridinyl-oxyacetic acid) and 2,4-D (2,4-dichlorophenoxy acetic acid). Triclopyr is a selective herbicide that has the potential to remove the nonindigenous dicot milfoil while not affecting native monocots such as Elodea spp. (Sprecher and Stewart 1995). Getsinger et al. (1997) reduced milfoil biomass by 99% (4 weeks after treatment) using triclopyr in a portion of the Pend Oreille River, Washington, between Albeni Falls Dam and Box Canyon dams. Milfoil plants have also been shown to be highly susceptible to 2,4-D. Westerdahl and Hall (1983) determined the threshold concentration required to control milfoil was 0.10 - 0.25 $mg{\cdot}l^{-1}$. Diver-operated suction dredging and hand harvesting have been used for milfoil removal in the outlet arm of Lake Pend Oreille in September, 2000. Divers up-rooted the entire plant and placed it into a bag or suction dredge. This procedure effectively removed milfoil shoots and roots; however, long-term effectiveness of this procedure has not yet been determined. Suction harvesting substantially reduced the biomass and percent coverage of milfoil in Lake George, New York, while increasing species richness in the harvested areas a year later (Eichler et al. 1993). Hand harvesting has also been used effectively to reduce densities on small patches of milfoil (Titus 1994).

Eurasian Watermilfoil Site Lminology

The light attenuation under the milfoil canopy illustrates the competitive nature of this species and its ability to shade out native vegetation (Aiken et al. 1979, Madsen 1994). We found that light was reduced below the compensation point below about 1.5 m under the milfoil canopy limiting photosynthesis of indigenous plants and resulting in a monospecific milfoil stand. Milfoil becomes dominant partially as a result of its growth form and its competitive abilities. Falter et al. (1991) reported similar effects of milfoil beds on light penetration in the Pend Oreille River, Washington. Madsen et al. (1991) recorded a decline in the number of native plant species under a dense milfoil canopy. The number of plant species dropped from 20 (under low densities of milfoil) to 9 under a dense milfoil canopy cover. Falter et al. (1991) also reported that milfoil communities dominated some littoral areas in the Pend Oreille River, Washington, accounting for up to 97% of the littoral aquatic macrophyte community. All mechanisms by which milfoil out-competes native species are in need of further investigation.

The dissolved oxygen profile of the Lake Pend Oreille milfoil bed is typical of many aquatic plant communities (Carpenter and Lodge 1986). During daylight hours, photosynthesis near the surface creates supersaturated dissolved oxygen (DO) conditions, while respiration of macrophyte tissue consumes oxygen in deeper waters, especially near the sediment-water interface (Jensen 1989). Frodge et al. (1990) found elevated DO concentrations in the surface canopies of submerged species and lower DO concentrations near the sediments in Keevies Lake and Bull Lake, Washington, and concluded that canopy formation was probably more important than species composition with respect to effects on water chemistry. In our study on the outlet arm of Lake Pend Oreille, water temperature, electrical conductivity, total alkalinity, and pH in the milfoil bed were all similar to those values found in the pelagic zone of the outlet arm. However, Carter et al. (1991) observed pH to be stratified by depth in aquatic macrophyte comunities in the Potomac River with pH associated with decompositional processes in anaerobic benthos. Effects of macrophyte communities on the surrounding water chemistry, however, depends upon the type of waterbody and the size and depth of the system and can be expected to differ between and within lakes and rivers (Carter et al. 1991).

GIS: Predicted Available Habitat and Management

The GIS illustrated the potential spatial extent of milfoil in Lake Pend Oreille using two habitat variables. According to the model, a large proportion (39%) of the littoral area on the outlet arm of Lake Pend Oreille is suitable milfoil habitat (Fig 16.). The amount of potential habitat is likely overestimated due to the spatial scale of the analysis and the limited number of predictors involved in the model. At this scale, the analysis does not take into account the within-bed spatial complexity and patchiness (France 1988). Milfoil populations in oligo to meso-oligotrophic waterbodies often form patches of varying densities and sizes that may be attributed to patchy areas of habitat in these systems and/or the intrinsic growth patterns seen in nutrient-poor environments (Madsen 1994). However, the model gives an indication to the potential impacts this species can have on the outlet arm and potentially on Lake Pend Oreille proper. Future modeling efforts should include more predictor variables such as littoral slope and fetch (as a determinant of wave action). A logistic model could then be developed to determine the probability of milfoil colonization at a given location. Such a model would be valuable for management agencies when they prioritize control efforts to certain areas of a water body. This model also illustrates the need for agencies to develop an effective management plan and to inform the public of the potential effects of this species and the ease with which it is dispersed.

Based on this research, areas on Lake Pend Oreille proper that represent potential habitat for Eurasian watermilfoil (*i.e.*, have suitable depth and substrate) include Scenic and Bottle Bays, the Pack River Delta, and the Clark Fork River Inlet. Another northern lake area is the littoral zone surrounding the Sandpoint public beach. There are fine sediments and shallow depths near the public beach and the presence of public boat ramps provides a vector for its introduction. Middle and southern lake areas contain less potential milfoil habitat due to steep littoral zones and coarse substrates.

Results from literature demonstrate the profound impact Eurasian watermilfoil can have on littoral communities and human recreation. Site-specific management techniques need to be developed to maximize effectiveness and minimize costs. The use of herbicides in conjunction with mechanical harvesting in areas of high use (*e.g.*, boat ramps) may represent an effective means for reducing the rate of milfoil colonization compatible with water-based recreation. However, the elimination of this species by these methods, or any others, is unlikely if not impossible (Gibbons et al. 1983b). Eventually, the milfoil community will naturally decline in abundance (Trebitz et al. 1993). The duration of peak biomass is approximately 10 years; however, the mechanisms responsible for its decline are varied and seem to be a result of multiple interacting factors (Carpenter 1980). Trebitz et al. (1993) also noted an invasion cycle of milfoil dominance in Lake Wingra, Wisconsin. Milfoil dominated Lake Wingra in the 1960's and then declined in the 1970's. While total plant biomass remained similar between those years (between 300 – 400 $g \cdot m^{-2}$), species diversity increased with milfoil persisting at lower densities. Creed (1998) suggested that the native herbivorous weevil (Euhrychiopsis lecontei (Dietz)), whose normal host is northern milfoil (M. sibiricum), may be partly responsible for the decline of Eurasian watermilfoil in many northern states and Canada.

In summary, Eurasian watermilfoil control programs in the outlet arm of Lake Pend Oreille should be developed to take into account the physical and biological limitations present at a given point of infestation. The use of herbicides, hand harvesting, and, mechanical harvesting if necessary, represent viable control options for this system. Contact herbicides may be effective in backwater areas of zero current velocity; whereas, hand harvesting can be used to remove isolated low-density colonies. Systemic herbicides or mechanical harvesting may be utilized in areas where milfoil densities are high and current is present. Since milfoil is now a part of the littoral community in this system, fisheries managers should manage these communities to maximize the use of this new habitat. For example, in some areas channels can be cut through the vegetation to increase the forage efficiency and cover for piscivores by increasing edge effect. More diverse colonies of other aquatic macrophyte species could grow to protect emerging year classes and nursery areas of fish (Engel 1995).

Summary

- A significant relationship was found between Eurasian watermilfoil biomass and depth in the outlet arm of Lake Pend Oreille with a maximum biomass attained near 4 m.
- Approximately 52% (2098 ha) of the outlet arm area was likely Eurasian watermilfoil habitat based on depth alone. Once the GIS accounted for areas consisting of gravel and cobble substrate, approximately 39% (1438 ha) of the outlet arm area was predicted as likely habitat (*i.e.*, was in the depth range of 0 m to 7 m and was not on gravel or cobble substrates).
- Reward ® (diquat) and Aquathol ® (endothall) application failed to significantly reduce the mean *maximum* biomass in 1999 (905.3 $g{\cdot}m^{-2}$) from1998 maxima (1119.7 $g{\cdot}m^{-2}$). The ineffectiveness of this treatment may be associated with a single application late in the growing season.
- Eurasian watermilfoil management should be site-specific, allow for the degree of infestation, and take into account the surrounding physical environment.
- Future modeling efforts could include more predictor variables such as littoral slope and fetch (as a determinant of wave action). A logistic model could then be developed to determine the probability of milfoil colonization at a given location.

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Figures

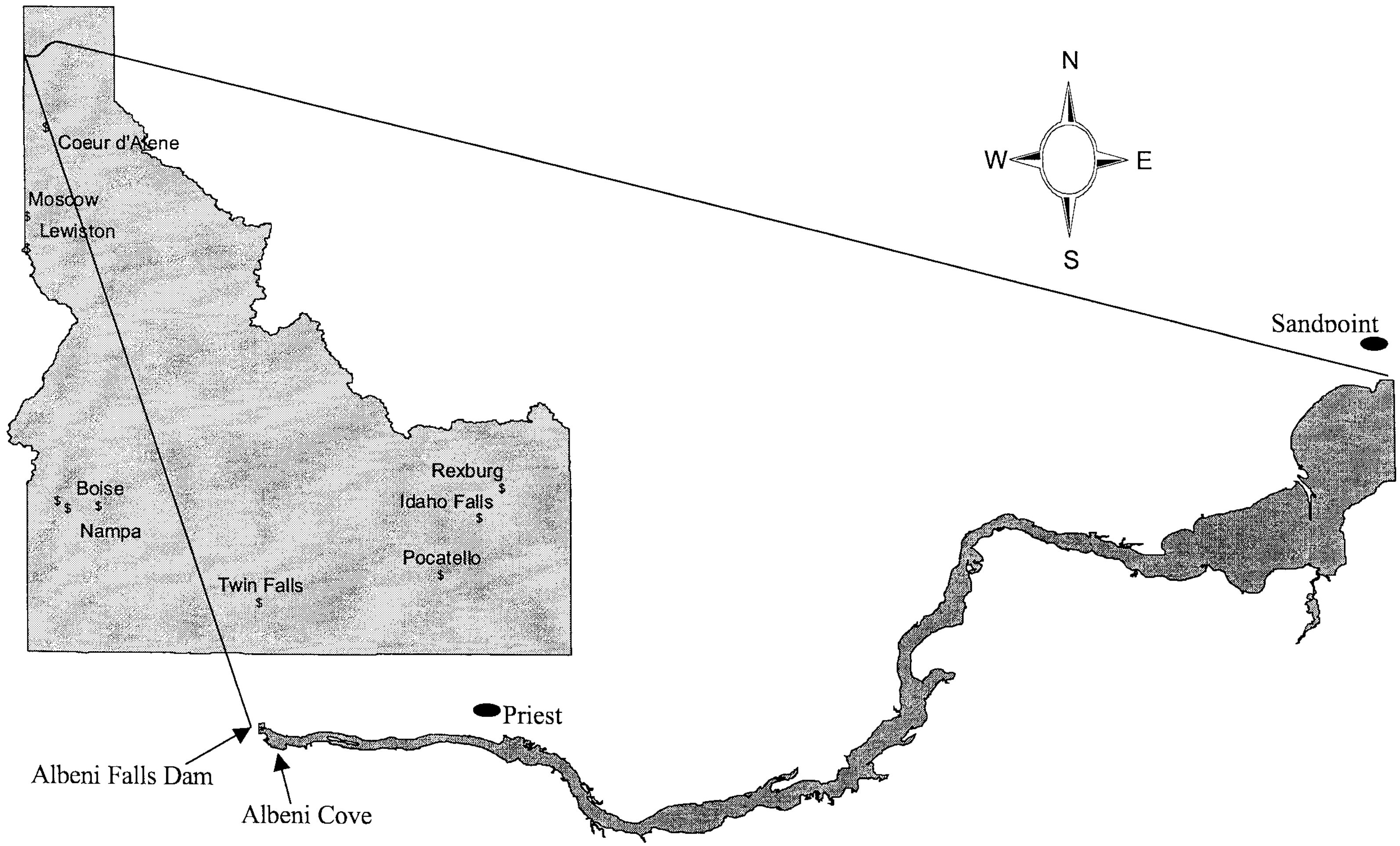


Figure 9.-The outlet arm of Lake Pend Oreille, Idaho. Albeni Falls Dam impounds the outlet arm at the Idaho-Washington border. Eurasian water was discovered in Albeni Cove in August, 1998.

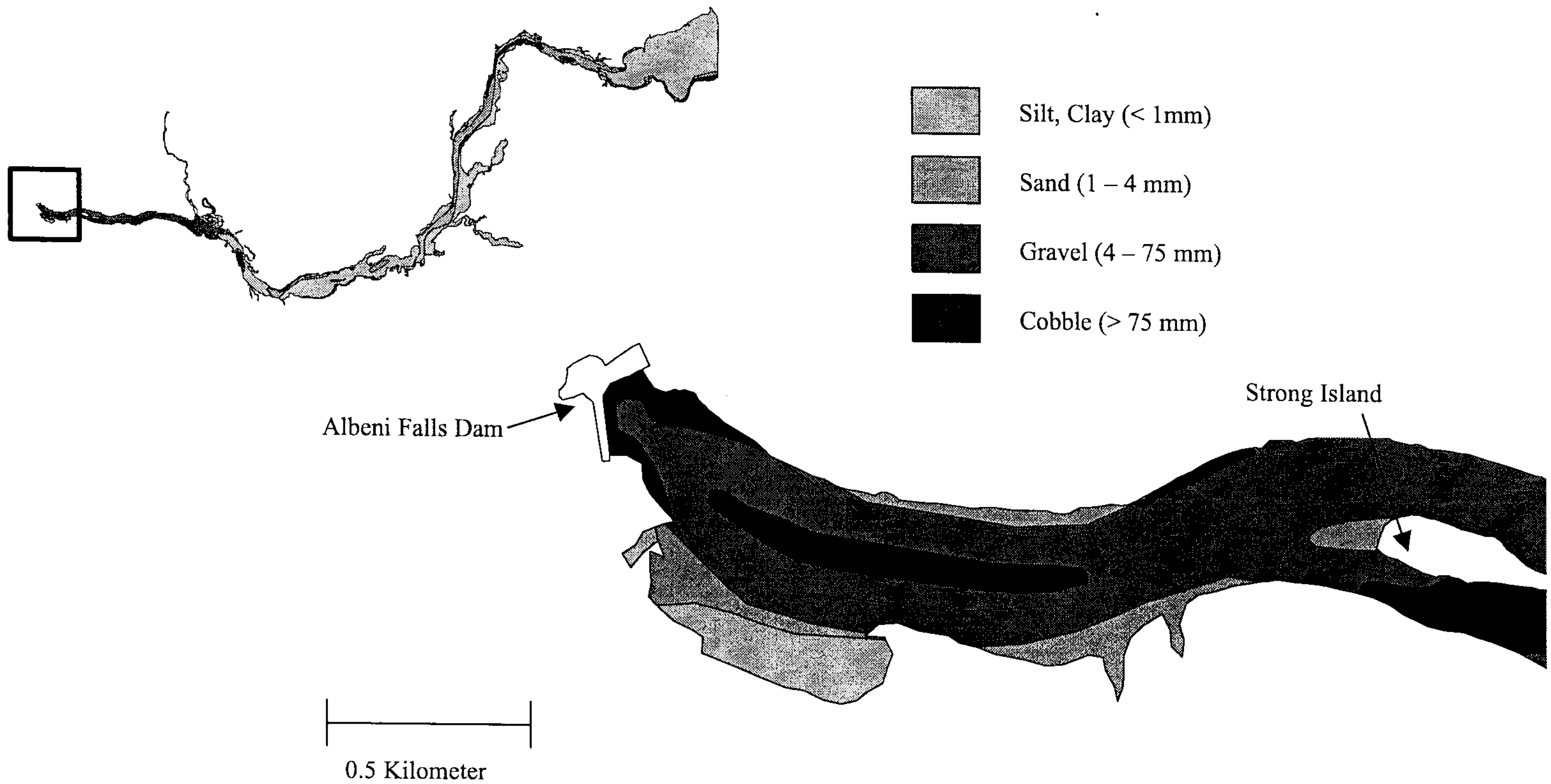


Figure 10.-Substrate composition grid of the outlet arm of Lake Pend Oreille, Idaho. Substrate size classes ranged from clay to boulder-sized substrates (Dupont 1994).

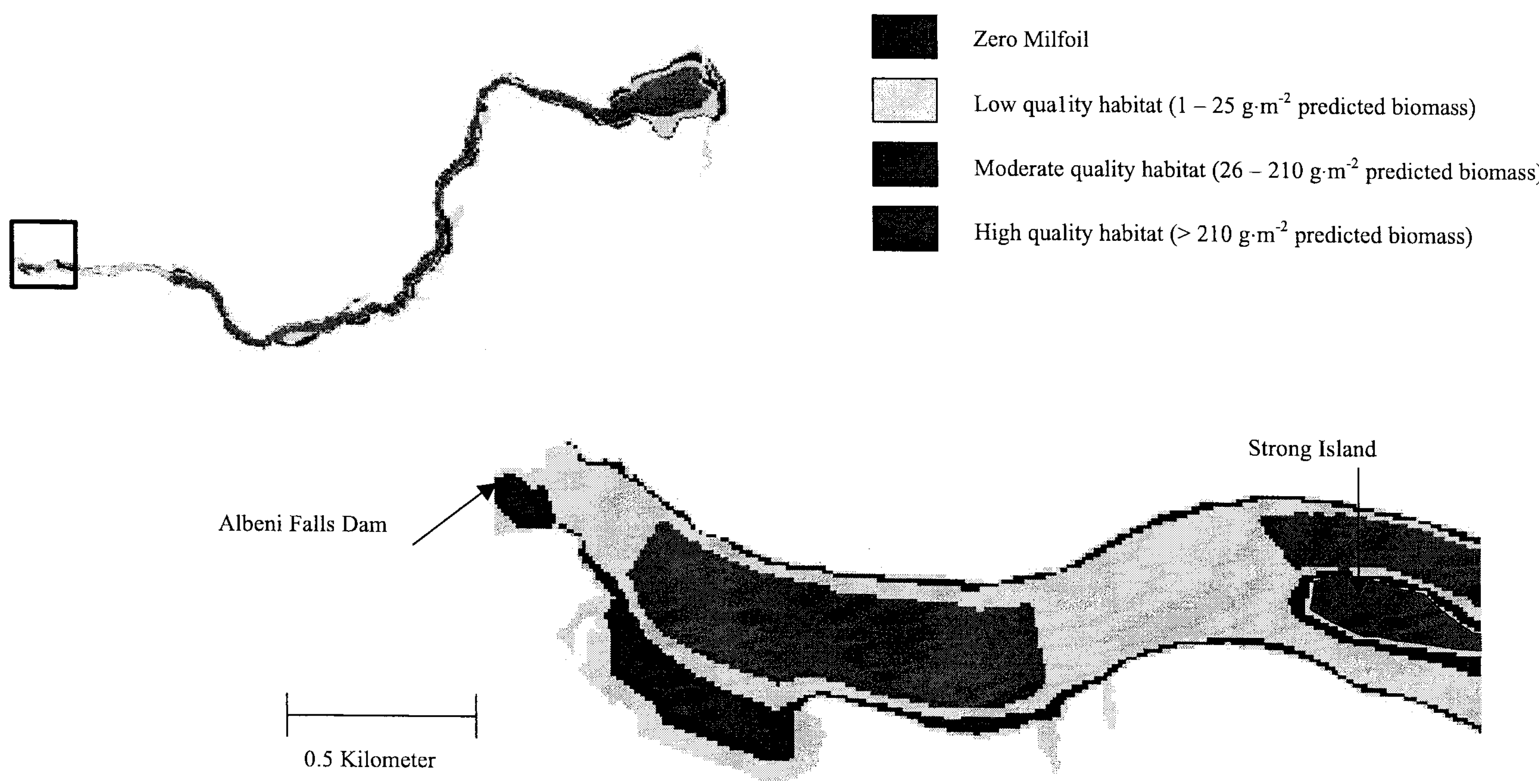


Figure 11.-Predicted milfoil densities based on the depth-density relationship in the outlet arm of Lake Pend Oreille, Idaho, 1999.

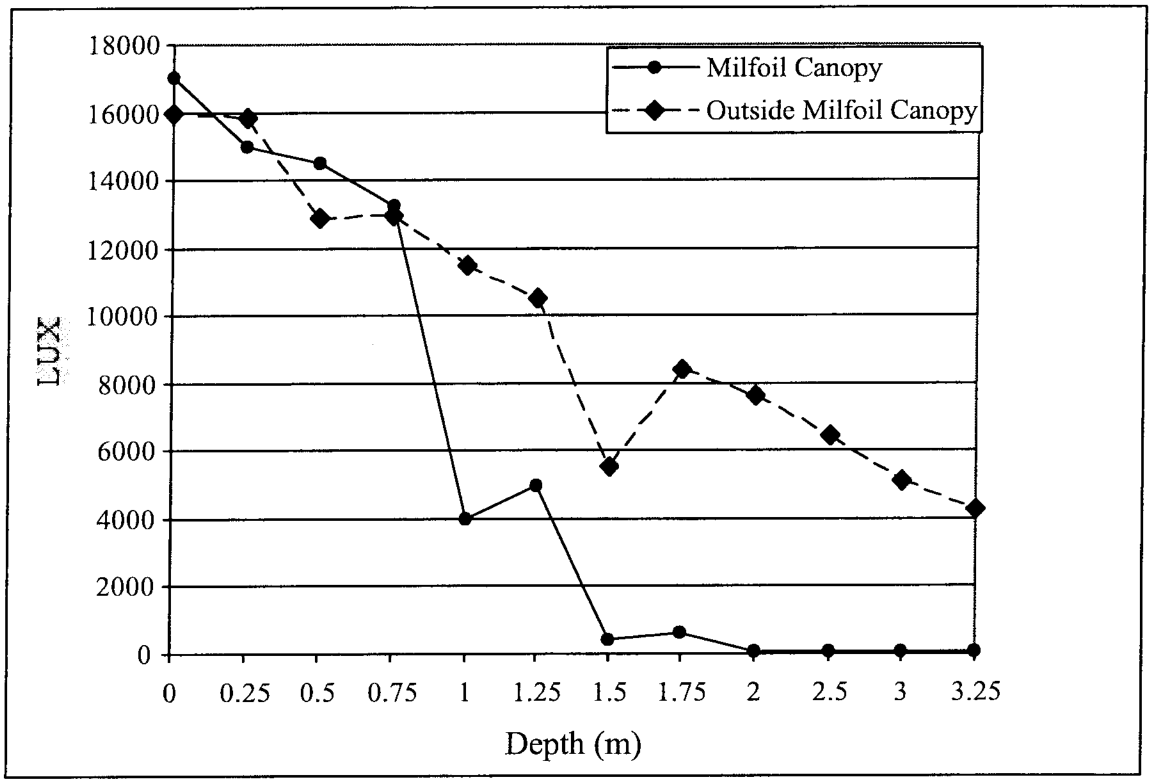


Figure 12.-Light profiles of Eurasian watermilfoil bed (maximum densty of 905.3 g·m^{-2}) compared to open water adjacent to the milfoil bed in Albeni Cove, outlet arm of Lake Pend Oreille, Idaho, 1999.

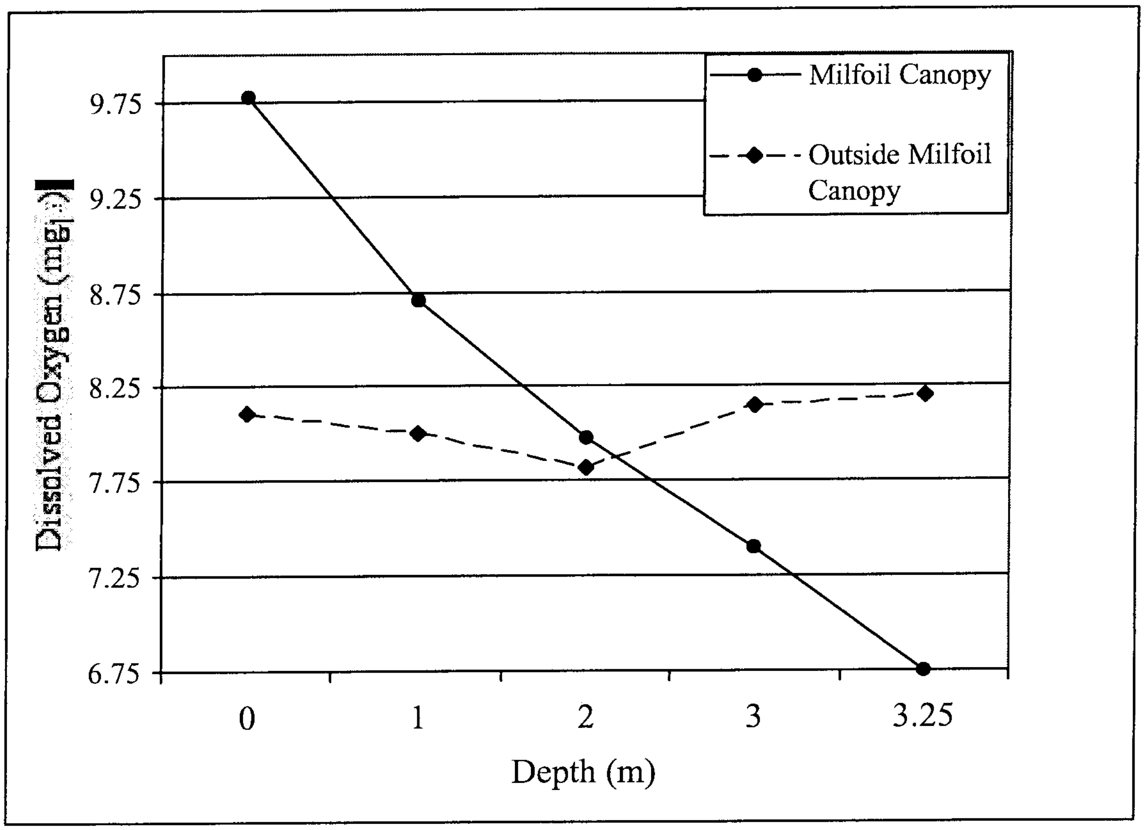


Figure 13.-Dissolved oxygen profiles of of Eurasian watermilfoil bed (maximum densty of 905.3 g·m^{-2}) compared to open water adjacent to the milfoil bed in Albeni Cove, outlet arm of Lake Pend Oreille, Idaho, 1999.

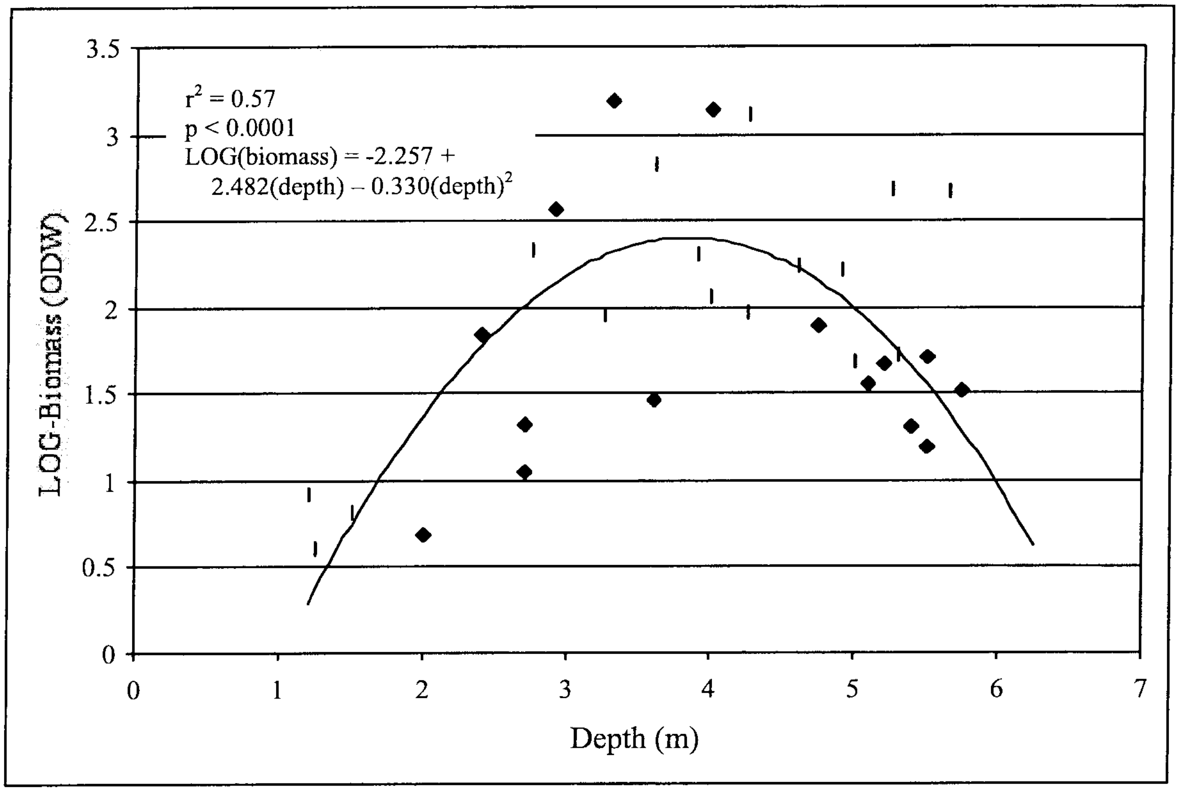


Figure.-14. Log Eurasian watermilfoil biomass (oven dry weight, $g \cdot m^{-2}$) in relation to depth (m) in Albeni Cove, outlet arm of Lake Pend Oreille, Idaho.

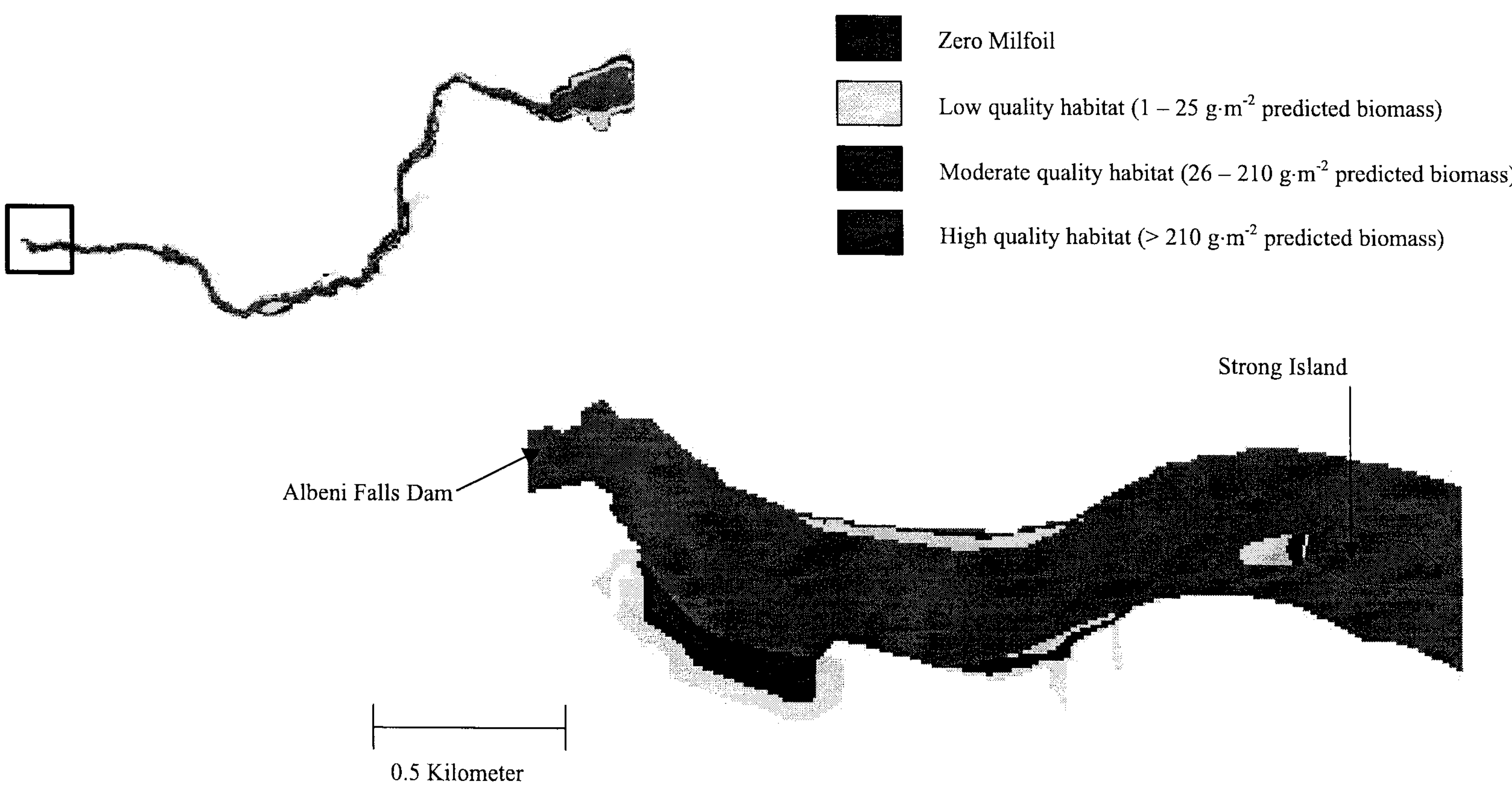
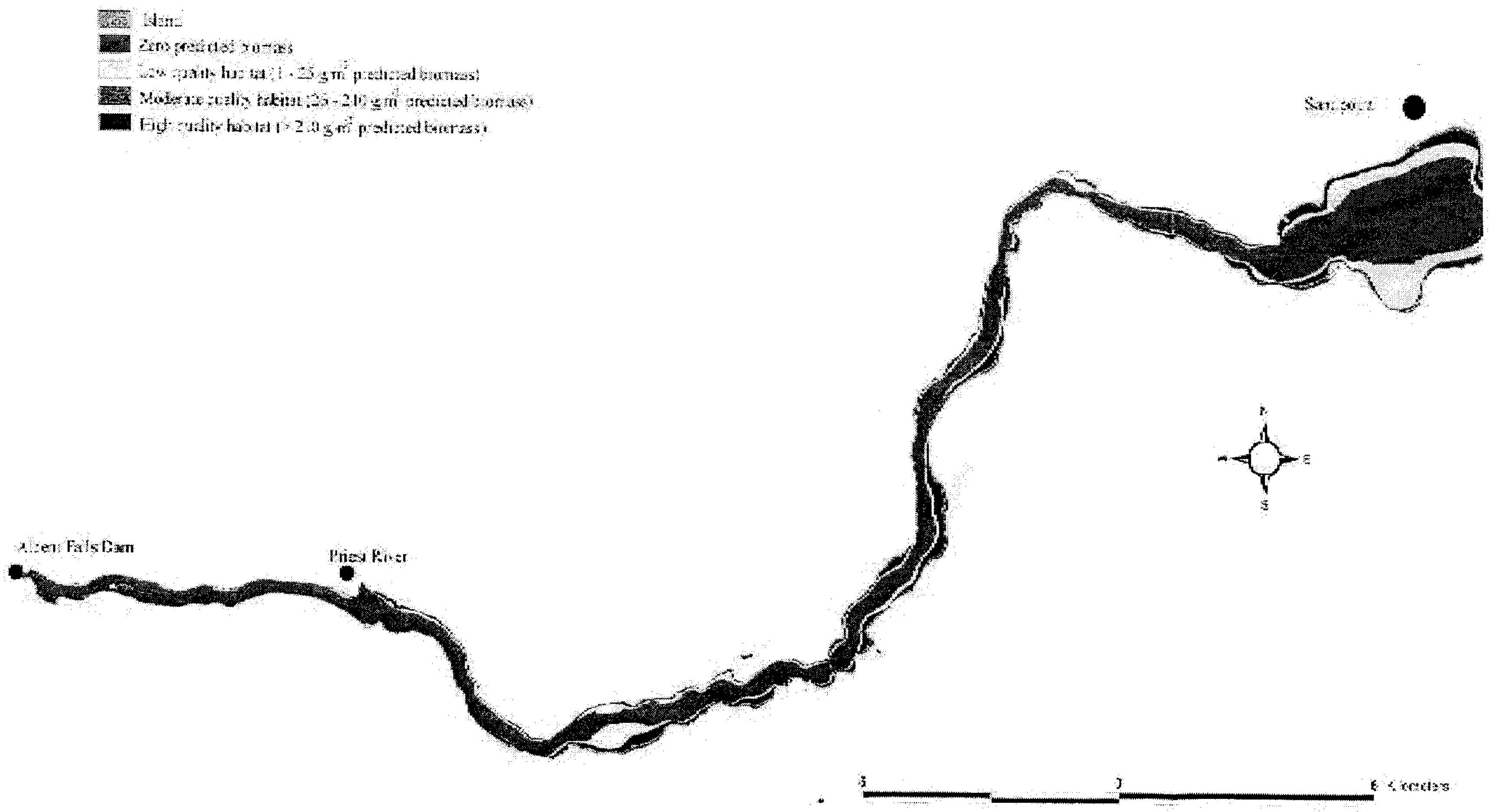


Figure 15.-Predicted densities of Eurasian watermilfoil based on depth and substrate type in the outlet arm of Lake Pend Oreille, Idaho, 1999.


Island
Zero predicted biomass
Albeni Falls Dam
Priest River
Sandpoint
Kilometers

Tables

Table 7.- Water chemistry parameters measured from in a Eurasian watermilfoil bed and in open water adjacent to the milfoil bed in Albeni Cove on the outlet arm of Lake Pend Oreille, Idaho, 1999.

	Temperature (°C)	Electrical Conductivity (μmhos)	Total Alkalinity (mg $CaCO3 \cdot l^{-1}$)	pH
Within milfoil bed	19.8	147.0	73.0	7.3
Open water	20.5	173.3	72.0	7.5


Hugh Hammond Bennett (right), first Chief of the Soil Conservation Service.

natural resources REPORTER

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NRCS Responds to Drought in New Mexico

Farm Bill EQIP Funds Devoted to Drought Related Practices

NRCS has championed conservation in New Mexico by devoting more than 80 percent of its Farm Bill Environmental Quality Incentive Program (EQIP) funds since 1996 to drought related practices. Since that time, NRCS has received \$30,883,345 for its EQIP program, and entered into 2,225 contracts with New Mexico farmers and ranchers for conservation improvements.

Some 7,625,990 acres of New Mexico farm and ranch land has benefited from these conservation practices, or 13 percent of all private land in the state.

Of critical importance, in a state where water and irrigation are so essential, over 300,000 of irrigation improvements have been made through EQIP since 1996. Viewed another way, NRCS has invested \$12,389,799 to improve irrigation systems, accounting for 40 percent of all EQIP funds. This investment has resulted in installation of 364 sprinkler systems, 600 miles of pipeline and concrete ditches, and land leveling on 571 projects. All of this investment has helped New Mexicans save precious water while raising the agriculture products upon which this nation depends.

Seventeen percent of the Farm Bill funds in New Mexico have gone to livestock water development, amounting to an investment of \$5,098,856. With these funds, ranchers have installed 450 wells, 1,179 miles of pipeline, and 1,314 watering tanks.

Another \$6,632,204 has been expended to alleviate brush that sucks water from the state's rangelands. Ranchers have treated 363,996 acres for brush, and accounted for 21 percent of the state's total EQIP funds to do this.

Polls have shown that water is one of New Mexico's top issues. It continues to garner much attention throughout the state. NRCS's response to the drought in New Mexico has been multifaceted and extensive. From irrigated crop lands to range lands, the NRCS response has been felt.


Drought in Las Vegas, New Mexico - Spring 2003

NRCS Natural Resources Conservation Service

2002 Farm Bill Celebrates First Anniversary
Much More Is To Come

Rosendo Trevino III
State Conservationist

May 13, 2003 marked the first anniversary of the 2002 Farm Bill. The 2002 Farm Bill has already invested $6,267,457 in 151 projects in New Mexico, and much more is to come.

As NRCS Chief Bruce I. Knight said, "This is ... a great time to thank the landowners who have and will participate, to thank NRCS personnel, conservation districts, agricultural organizations, wildlife organizations, environmental organizations and all others who are all working to optimize the opportunities before us."

Chief Knight said another thing that gets to the core of the magnitude of this legislation.

He said, "Most agricultural producers can't quote the 600-page 2002 Farm Bill by line and verse. But they know one thing: It's helping them become better stewards. By this time next year, tens of thousands of additional farmers and ranchers will be receiving the assistance they need to conserve, maintain and improve our soil, air, water, and plant resources. That's because the Farm Bill provides an unprecedented investment in conservation - ranging from the Wetlands Reserve Program, to the Environmental Quality Improvement Program, to the Wildlife Habitat Incentives Program, all of which build upon our base Conservation Technical Assistance programs."

The 2002 Farm Bill is a very positive step in the stewardship of our treasured New Mexican land, water, wildlife, and other natural resources. It is always encouraging to me as I travel this state to meet and know New Mexicans who can envision the positive, even during tough times. In my experience it is those who see the positive and strive for it that really help us progress in the field of natural resources.

While NRCS is making great strides with the Farm Bill, our partners are setting precedents that other states are watching. Conservation Districts are realizing major accomplishments with their salt cedar projects. In addition, the New Mexico State Legislature appropriated significant funding for technical assistance through the Soil and Water Conservation Commission.

I, also, want to take this opportunity to recognize some personal achievements of our partners. Debbie Hughes, executive director of the New Mexico Association of Conservation Districts, was recently honored by Congresswoman Heather Wilson as an outstanding leader at Women's History Month Recognition in Albuquerque. And Levi Newkirk, New Mexico's High School Youth Forum winner, placed second at the International High School Forum sponsored by the Society for Range Management. The High School Youth Forum judges student papers that address any aspect of range management.

It is with deep appreciation that I live and work in a state with such doers. Thank you, New Mexico, for a good year and the opportunity to be of service to you.

Natural Resources Reporter
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Barbara Garrett, Editor - Albuquerque (505)761-4406

Teams work to Improve Forest Health

by Duston L. Hunt Jr.

Recently the smoke from five controlled burns could be seen near Silver City. These burns were conducted to reduce the threat of dangerous wild fire, improve wildlife habitat, and improve watershed conditions. Though the reason for these burns was the same, the process required to conduct them was different.

Usually the Forest Service addresses forest health issues on forest land with their own dollars and their own personnel. Two of the recent burns, however, were collaborative efforts made possible by a Memorandum of Understanding between Grant Soil & Water Conservation District and the Gila National Forest.

Grant SWCD recognizes that the hazards created by 80 years of fire control are just as real on private and state land as they are on the National Forest. Roughly 50 percent of the land in Grant County is private or state owned, and 50 percent is federal. These different lands are randomly intermingled. It doesn't make much sense to address the wildlife and watershed problems on one side of the fence if you can't fix them on the other side. Thanks to the MOU and a grant from the Environmental Protection Agency the forest health of the Mangas Creek watershed is being addressed in a comprehensive manner.

First efforts to implement what is known as the Mangas Water Quality Project were represented by the Schoolhouse and Cain prescribed burns. The 5,000-acre Schoolhouse burn was conducted by Forest Service fire managers on Forest Service land with the Grant SWCD constructing numerous erosion control structures within the burn area. These structures will begin the process of healing gullies. The 500-acre Cain burn was conducted entirely on private land and truly represents a cooperative effort. The Natural Resources Conservation Service did the initial studies and wrote the burn plan, while the work of conducting the burn was accomplished by the Cliff-Gila Volunteer Fire Department and New Mexico State Forestry. The effort was directed by Ricky Sedillo and Mike Head, both experienced USDA Forest Service fire managers.

These two burns, represent the first steps of the Mangas Water Quality Project, and as a result, the waters of Mangas Creek and the Gila River will eventually run clearer. The habitat of wildlife such as mule deer will be greatly enhanced. It is also important to consider that collaborative efforts like the Mangas Water Quality Project provide local property owners a certain amount ownership in the success or failure of forest restoration efforts.

A long-term goal of the Mangas Water Quality Project is to heal the deep erosion channel that runs the length of Mangas Valley. Not much can be done with the channel until the overgrown forest condition in the uplands is addressed. Grant SWCD sees this as a long-term project, which must include the needs of Mangas Valley residents without threatening those who depend on this land for their livelihood. These residents know they will be the ones to gain the most from a successful watershed restoration project or have the most to lose if no management is undertaken.

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NRCS Natural Resources Conservation Service

Natural Resources Reporter

Holistic Irrigation Technology Provides Answers

Drought Response Heralded As Hard Work But Doable

These efficient irrigation systems reduce evaporation of water.

At a time when New Mexico farmers, cities, and other interests face extreme water shortages and the press anticipates water wars, calmer heads in agriculture are quietly advancing solutions that will require hard work but are doable.

Mike Sporcic, NRCS agronomist, is one of these conservation advocates with ideas.

"Some of the solutions require a huge commitment to management, but the effort is worth it," Sporcic said.

The program that Sporcic sees as a solution for drought beleaguered New Mexicans is the Holistic Irrigation Technology (HIT) program first prepared by Rudy Garcia, Linda Scheffe, John Allen, and R. David Fischer, all of the New Mexico Natural Resources Conservation Service.

The Holistic Irrigation Technology has some 22 points that can guide irrigation districts and producers to the benefits of irrigation water management.

First, the program notes the installation of high flow structures can help improve irrigation efficiency from less than 25% to over 60% due to greater uniformity of application with less water. High flow structures take less time to put water to the end of the check, thus avoiding excessive soaking of water into the ground. Because high flow structures take less time to irrigate there is also a savings in labor. The time to irrigate a field can be cut in half.

Laser leveling increases irrigation application uniformity and overall irrigation efficiency. It is possible to apply 2 - 3 inches of water when the producer has access to a large head of water and fields are laser leveled and irrigated with high flow turnouts.

Water metering devices enable producers to evaluate and implement alternative practices which will increase his/her irrigation efficiency. This amounts to a significant saving in irrigation water. For example, water metered on fields that are laser leveled and which also have high flow turnouts and lined ditches, has resulted in farmers being charged as much as 40% less per irrigation.

"Putting all the hardware and management into place can realize this kind of savings," Sporcic said. "The Elephant Butte Irrigation District does a good job and is showing the benefits of all their work. We have others that are learning and working on this."

"There is still tons of work out there to do. I just can't emphasize that enough."

In addition to high flow turnouts, laser leveling, and metering - measuring soil moisture can help identify appropriate times to irrigate thus preventing plant stress conditions. The result is higher crop yields and better quality products that translate into a better profit margin for the producer. Tensiometers, probes, or the feel method can be used.

Tensiometer are filled with water

and measure the suction of the soil on that water. Coupled with a gauge, the tensiometer can show when the moisture in the soil has reached such a level that it is time to water again. Soil texture, porosity, and crop type can determine the total amount of water that is needed. Lettuce, for example, uses a soil zone of one foot while alfalfa uses four feet of soil.

The Natural Resources Conservation Service (NRCS) has developed a spread sheet that can determine the amount of water needed for any field. Farmers interested in this kind of assistance should contact their local NRCS office.

"This kind of assessment can be tailored to the conditions of any given farm," Sporcic said. "It should go in every conservation plan in New Mexico. There just is no need to do without this valuable tool."

Using a probe for a soil moisture measurement entails a device that has electrodes and measures conductivity across two rods. The more moisture in the soil, the greater conductivity.

Finally, the simplest method of checking soil moisture is by feel. This can be a learned skill.

All of these soil moisture testing systems inherently rely on an "on-demand" irrigation system where the farmer can call up the ditch rider and get irrigation water when needed, rather than on a rotational system.

Installation of pipelines, where appropriate, can be used to both conserve and convey water very efficiently. Use of pipelines depends upon the objectives of the farmer and the irrigation district. If the main objective is to get water to the farm, pipelines are effective. If an objective is to recharge the aquifer in the process, the alternative transport systems are used.

Another important component of a well managed operation is properly maintaining drains to keep the root zone dewatered and provides for a health growing environment. Roots do not grow in water saturated soil. They need air to grow. Farmers need five to six feet of soil to grow crops.

Record keeping has proven to be an invaluable decision making tool for farmers in their efforts to irrigate more efficiently and effectively. NRCS has created the 449 Irrigation Management Job Sheet for this task. This is available at your local NRCS office.

Reduced tillage in orchards shows an improvement of the soil surface structure and tilth (organic matter content) which translates into water conservation.

The development of nutrient budgets has resulted in significant reductions in inputs of fertilizers, soil amendments, and other chemicals. Nutrient management is a part of Holistic Irrigation Technology that integrates all aspects of farm operations. NRCS staff can develop a nutrient budget for cropland and uses New Mexico State University fertilizer recommendations which can be used alone or in conjunction with dealer recommendations.

There is a need to check preplant nitrates in the spring because nitrates move with water and a farmer does not want to get nitrates into shallow wells. The goal is to keep nitrate reserves to a minimum for this reason, and the cropland may not need more. This is an inexpensive test, $30 per field plus time, and could cut fertilizer costs by 20 percent.

Finally, there are a variety of drip irrigation systems on the market today that allow for the application of very small amounts of water which is particularly important during early growth stages. Such systems enable a grower to maintain optimum moisture conditions for best production, apply precise amounts of nutrients, and increase yields. They are 95 percent efficient.

"They require a huge commitment of resources and management," Sporcic said, "but the effort is worth it. Yields are up and diseases down."

"If you want to know what you can do in drought, the Holistic Irrigation Technology Program is it. It calls for some tough decisions, but it could drop our water use in this state by 30 percent."

For further information contact Mike Sporcic at 761-4424.

Plant Materials Center Important to Park Service

Mutton Grass and San Juan Pestemon Mark Spring

Mutton grass seed, falling to the blades of the harvester, recently marked springtime at the Los Lunas Plant Materials Center. Dan Goodson, agronomist, was harvesting the seed for National Parks throughout the southwest.

The National Park Service relies on the Los Lunas Plant Materials Center for the production of plant species in which they are particularly interested. The seed the National Park Service uses must meet extremely rigorous standards to prevent contamination.

" The Park Service requires seeds that are descendant from ecosystems in their parks," said Greg Fenchel, Plant Materials Center manager. "By being so exacting, these land managers can assure that the plants grown from these seeds can, in the long run, tolerate the climate extremes of the sites where they are sown."

Mutton grass is important to the National Park Service and others because it is very palatable to elk and other grazing animals. It is the dominate grass component under Ponderosa pine. Like the Ponderosa pine it requires significant water, 16 - 20 inches per annum. In New Mexico it is typically found in 7000 - 9000 foot altitude areas. There is some debate about its use after fires, and there are arguments why mutton grass should be used and why small grains are preferred. Regardless of the debate, mutton grass is important in our National Parks and forestlands throughout the southwest.

Like the harvesting of mutton grass, the blooming of the San Juan pestemon recently signaled the return of warm weather at the Plant Materials Center. The pestemon is a wildflower, great for xerioscaping in yards, along highways, and anywhere where drought resistant flowers are needed.

"In the Albuquerque area, pestemon will thrive without any irrigation, and at the Plant Material Center in Los Lunas is grown without irrigation," said Fenchel. "It typically requires only 7 - 8 inches of water a year."

It is a busy time for the Plant Material Center as it enters its production season. If you wish additional information about mutton grass, San Juan pestemon, or the Plant Material Center contact Greg Fenchel at (505)865-4684.

Top: Dan Goodson harvesting mutton grass. Bottom: San Juan pestemon colors field in purple at the Los Lunas Plant Materials Center

Brooks Responds to Challenges of Urban Office

Complex Mosaic Thrives in Albuquerque Area

Drought management in New Mexico is a long term responsibility, not just an emergency situation, according to Corinne Brooks, Albuquerque Field Office District Conservationist. Brook's perspective results from managing a field office for the state's most urbanized conservation district.

"In general the healing or improving of land does not happen overnight, Brooks said. "Most of our traditional agriculture producers know this. The land is their livelihood and they know how to care for the land, and have the foresight to do the proper planning."

The urbanized Albuquerque district has many non-traditional agriculture producers however, including hobby farmers, first time irrigators, and small acreage landowners. Many of these individuals may be on the learning curve, and want instant results or are reacting to the dry conditions rather than anticipating them.

This complex mosaic of producers and land management skill levels make Brooks' job both challenging and rewarding as she helps individuals with varied backgrounds bring conservation to the land.

"I am not saying that other district conservationists don't also have challenging jobs. It is just that the variety of situations in an area bordering the largest urban center in the state keeps you on your toes," said Brooks.

Brooks also shared a perspective about the drought.

"This period of drier conditions may not really be a drought. Climate experts point to recent wet years as being above normal and what we have now may be closer to the norm."

Weather forecasters agree that this dry period for New Mexico may be extended. Planners and politicians alike are calling for the need for planning for extensive dry periods in New Mexico, and conservation and development of available water sources.

Brooks says she does have producers who are adjusting to the dry conditions.

"We do have producers who are adjusting crop rotations. By this I mean they may turn alfalfa into a crop that uses less water on the fifth year of the crop rather than let the alfalfa go another two or three years."

Land leveling and irrigation are among other measures Albuquerque producers are taking. Irrigation improvements concentrate on improvements such as pipelines instead of earthen ditches, ditch lining, and new turnouts.

"These are by far the majority of practices we are dealing with," Brooks said.

"Finally a concern of ours is the number of animals on the land whether it be irrigated pasture or rangeland."

Corinne Brooks, Albuquerque District Conservationist

In drought livestock producers cannot produce the forage for the animals they can during wet years.

"The same principles apply for the small producer on five acres with only three or four cows. That producer may need to get rid of one cow during dry spells, while the large rancher may need to get rid of a hundred. They still have to cut back on the number of animals they are carrying on the land."

For more information about an urbanized field office, contact Corinne Brooks at (505)761-5444.

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