DEPARTMENTS

Technological Tools

Note: Dr. David Inouye is the editor of the **Technological Tools** section. Anyone wishing to contribute articles or reviews to this section should contact him at the Department of Zoology, University of Maryland, College Park, MD 20742, E-mail: di5@umail.umd.edu.

THE USE OF DATA LOGGERS TO MONITOR ENVIRONMENTAL STATE CHANGES: SNOW MELT AND LOSS OF SURFACE WATER

HOBO Temperature Data Logger, H01-001-01 (list price $49.00);
HOBO Cases: white, SUBC2-WH (list $25.00); clear, SUBCASE-CLR (list $35.00).
Onset Computer Corporation,
P.O. Box 3450, Pocasset, MA 02559-3450
1-800-564-4377; (508) 759-9500;
Fax: (508) 759-9100
<http://www.onsetcomp.com>

The arrival or departure of standing water or snow cover can have profound affects on the distribution and activity of organisms. The loss of standing water in ephemeral streams triggers changes in nutrient cycling (Grimm 1988, Grimm and Petrone 1997, Mitsch and Gosselink 2001) and activity of aquatic invertebrates or amphibians (Stanley et al. 1994, Morey 1998), and the extent and duration of inundation in temporary wetlands or vernal pools dictate vegetative structure (Bliss and Zedler 1997, Casanova and Brock 2000). It is well established that the distribution of snow influences plant communities in alpine areas (for example, Gjaerevoll 1956, Friedel 1961) and subalpine forests (Billings and Bliss 1959). Snow cover protects dormant and growing plant tissues from solar radiation (Billings and Mooney 1968) and protects winter-active mammals such as pikas and weasels from cold temperatures (Chappell 1980, Smith and Weston 1990). Snow can have negative effects as well. Perhaps the most obvious is in shortening the length of the growing season for both plants and animals. Less clear are its effects on plant respiration (due to elevated soil temperatures), microbial and pathogen activity, and nutrient cycling (Körner 1999).

Detecting changes in the presence of standing water or snow cover can be of profound importance to studies of ephemeral aquatic and alpine environments. We report a simple technique that takes advantage of the insulative properties of water and snow to identify when transitions in water and snow cover take place.

Because many field sites are in remote locations, it is not always possible to make direct observations of the presence of snow or water. Instead, we suggest the use of temperature data loggers to record temperature at regular intervals. Although air temperatures may vary considerably, temperatures remain relatively constant under adequate water or snowpack, due to the low thermal conductivity of water relative to air. Variation in temperatures can be used to infer the date and even the time at which the insulative properties of the snow or water disappear.

Although this technique can be used with any portable data loggers, we used HOBO temperature data loggers (Onset Computer Corporation, Bourne, Massachusetts, USA [URL: <http://www.onsetcomp.com/>]). Most data loggers are not waterproof, but waterproof cases are available. These cases come in two styles, clear and solid. Therefore, our experimental design included two factors: environmental medium (three levels; snow, water, or air) and case type (two levels; clear or solid).

To demonstrate the validity of this technique, we conducted a simple experiment to determine if an increase in temperature variation coinciding with the loss of snow or water cover can be detected by data loggers. The experiment was conducted from 12 to 19 November 2001. At the start of the experiment, four data loggers (two of each case type) were placed in each of six circular tubs with a diameter of ~1 m. Two of the tubs were filled to a depth of 30 cm with water, and two were covered to a similar depth with finely crushed ice (to simulate snow). The data loggers in the final two tubs were left exposed to the air. Ice was added daily to the snow treatment to maintain a constant depth. After 5 days, the snow was allowed to melt, and we drilled small holes in the bottom of the water-filled tubs to allow the water to drain. Data loggers were no longer covered by either snow or

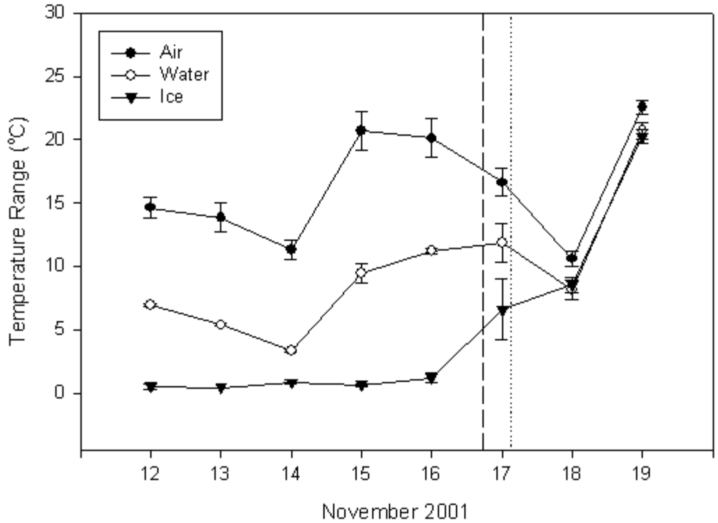

Fig. 1. Daily range in temperature for each of the three environmental conditions (air, water, and ice), for data loggers in solid cases. The dashed vertical line indicates the time at which water was completely gone from the tubs. The dotted vertical line indicates the time at which ice had completely melted.

ice by 17 November 2001. We compared the maximum daily range in temperatures among treatments using a two-way ANOVA.

We also made field measurements under snow and under water. Field observations using snow cover were made in the Beartooth Mountains of northwest Wyoming. Field observations using this technique in a lotic system were made on the Big Lost River in Central Idaho.

Fig. 1 shows the results of our controlled experiment for data loggers in solid cases. During our experiment, the range in daily temperature (24-hour maximum–24-hour minimum) was greatest in the air and smallest under crushed ice, and the air treatment was significantly different from the other two treatments during the period when data loggers were covered ($P< 0.001$). There was no difference in daily temperature range for clear vs. solid waterproof cases under water or ice. There was a significant effect of case type on daily temperature range for loggers exposed to air ($P< 0.001$): daily temperature range was greater in clear cases. There was a significant interaction ($P = 0.005$) between environmental medium and waterproof case type, the result of the significant effect of case type in air.

For data loggers under water or ice, daily temperature range increased when the ice melted or the water was drained (Fig. 1). This demonstrates that the use of temperature variation as recorded by the data loggers is a reasonable way to detect initial presence of standing water or snowpack and the date on which the water or snow is completely gone.

The significant effect of housing type in loggers exposed to air is potentially useful. If the goal is simply to determine if snow or water is present, rather than to determine the actual temperatures, a clear housing may be more useful. These waterproof cases act as small greenhouses under direct insolation and can greatly increase the temperature range, providing greater resolution of areas under water or snow vs. those exposed. This is most clearly shown by the fact that the minimum temperature of data loggers exposed to air was not significantly different between clear or solid cases ($P = 0.504$), but the maximum temperature was much higher in clear than in solid cases ($P = 0.003$).

We have successfully used this technique to determine presence of snowpack in an alpine environment and presence of water in a river that undergoes annual drawdown (Figs. 2 and 3). In the Beartooth Mountains, we were interested in determining when snow melts from different habitats because we suspected that successful breeding of pikas was being inhibited by late-lying snow (Kreuzer and Huntly 2002). Fig. 2 shows the average daily variation for two data loggers, one exposed to air for the entire winter, and one that was covered for most of the winter. We were able to determine the time of snow melt in different parts of the study area by placing several data loggers within each sampling plot. Among the

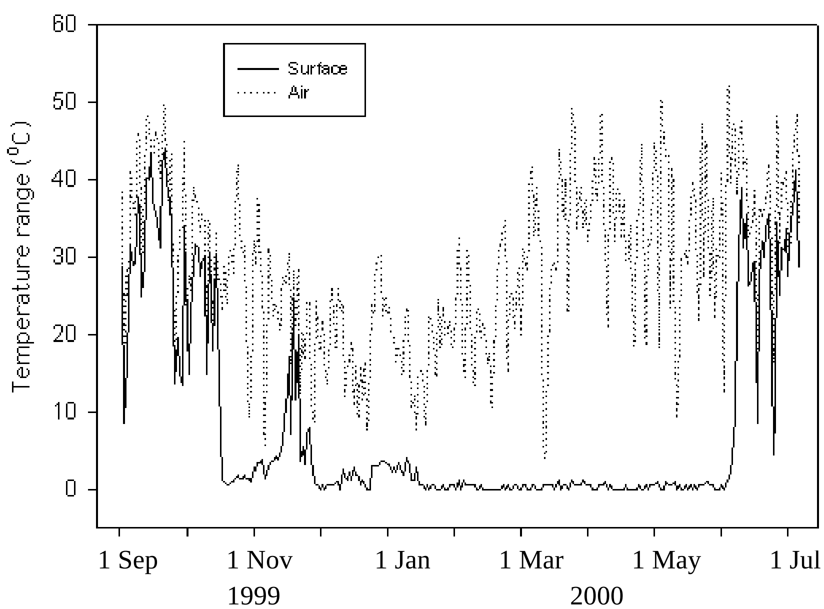

Fig. 2. Daily temperature ranges from two data loggers in the Beartooth Mountains. One data logger was placed on the ground and was subjected to snow cover and the other was on a windswept ridge where it was exposed to air for the entire period.

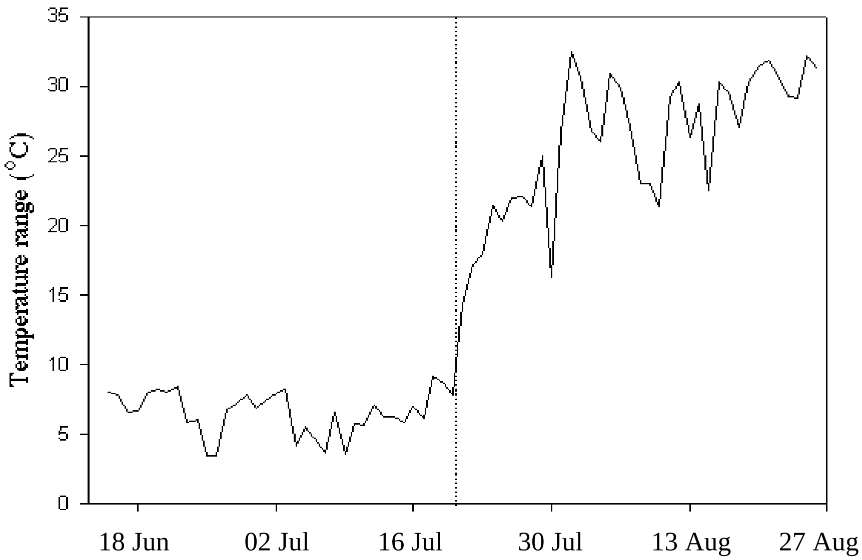

Fig. 3. Daily temperature ranges from a single data logger in the Big Lost River near Mackay, Idaho. The data logger was secured to the river bottom and was in place during periods when water was present (before 21 July 2001) and following the day of drawdown, shown by a dotted vertical line (post 21 July 2001) in this stretch of the river.

data loggers within each plot, we used the average date at which temperatures varied by >10˚C as the melt date for that plot (Kreuzer and Huntly 2002).

Our work on the Lost Rivers in central Idaho examines how the removal of water for irrigation purposes alters the structure and function of river ecosystems, as well as how current management practices affect the sustainability of these resources. We successfully used data loggers to detect the date when drawdown occurred in different sections of the river, enabling us to determine the period of time that each reach was without water. Fig. 3 shows the daily variations in temperature before and after dewatering and provides an example of the strength of the signal provided from a data logger upon exposure.

Although the benefits of this approach are apparent, there are limitations to this type of indirect measurement of snow cover or the presence of water. The size of the data logging instruments and casing used dictate the level of temporal resolution. Our cases were ~7.0 cm in diameter and, as a result, exposure of the casing (and instrument) precedes the actual date of snow melt or water loss. If better temporal resolution is necessary, smaller dataloggers such as the StowAway Tidbit (Onset Computer Corporation), which have a height of <2.5 cm, are available.

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Features of HOBO Temperature Data Logger H01-001-01

- Standard temperature range: -20°C to +70°C
- Operating temperature range (logger) -20°C to +70°C, noncondensing
- Operating temperature range (sensor) -40°C to +120°C
- Temperature sensor on 4" wire extends from case for external measurement
- Sampling intervals from 0.5 s to 9.0 h
- Response time 15 minutes in air (1-min response time with sensor outside case)
- Small size: 2.4" tall x 1.9" wide x 0.8" thick and 1 oz.
- Optional submersible case rated to 400' depth
- One-year battery life (user replaceable)
- Blinking LED light confirms operation
- Stores up to 1800 measurements
- Nonvolatile EEPROM memory retains data even when battery has been removed
- Data readout in <30 s
- Data exportable to spreadsheet programs (Lotus, Excel, etc.)
- Compliance Certificate available
- NIST-traceable Certification available

OPEN-SOURCE SOFTWARE FOR ECOLOGISTS: A QUICK INTRODUCTION TO OPEN-SOURCE SOFTWARE

Nonprogrammers may be surprised to discover that we are in the middle of a revolutionary time in software development. Commercial software companies traditionally have treated the basic building blocks of their programs (the “source code,” written in programming languages such as C, Pascal, BASIC, etc.) as trade secrets, and released only the executable “binaries” (the “.exe” files in Windows) of their programs to customers. Although most of us treat the software that we pay for as our own property, in most cases we in fact only license software, and users generally do not have the right to sell or redistribute proprietary, commercial software.

In the early 1990s, a group of programmers recognized that as software gained an increasingly central position in every aspect of modern life, the restrictions placed on the use and distribution of software had the potential to cause serious social problems, such as widening the “digital divide” between those who could afford software and those who could not. This awareness led to the Free Software Movement, which developed an unusual software license called the GPL (the General Public License). Software that is published under the GPL can be distributed in binary, executable form, but it differs from proprietary software in that the source code must also be made available. The license allows the software to be redistributed, and even sold, as long as the source code is always available. Furthermore, anyone is free to modify the source code, to fix bugs, to add features that they feel are lacking, or to make the software run on a different operating system or on different hardware; however, if they distribute the modified software, they must also distribute their modifications to the source code. This “share and share alike” provision of the license ensured that nobody who contributed to a GPL’d project would have their efforts used in products that they had no right to use themselves.

At first glance there is nothing in the GPL that would interest commercial software companies, since source code that is given away for free can be converted into a binary executable, depriving the company of sales. However, as GPL’d software began to appear, it became clear that the availability of source code allowed programmers to use an extremely effective, collaborative method of software development. Programmers from anywhere in the world could work effectively on programs that were too large and complicated for single individuals. Early successes by projects like the Apache web browser and the Linux operating system made it clear that rapid progress on complex projects was possible when source code is freely available.

These projects also demonstrated that users who had programming skills, when given the opportunity and when protected from exploitation by an appropriate software license, would not only report bugs in the software, but also would voluntarily review source code and contribute fixes to problems. This, in effect, tremendously expanded the number of programmers who could participate in a project, and provided a form of peer review for the source code. The ability of these projects to produce high-quality software on very limited budgets with the help of small armies of volunteers caught the attention of some large software companies (including Sun Microsystems, Apple Computer, Netscape, IBM, and others), who published source code for some of their most valuable commercial software under the GPL or similar licenses as a means of benefiting from the efforts of their users. Additional open-source licenses have been created to be more or less restrictive in their provisions than the GPL, to allow programmers (and corporations) greater flexibility in using their source code in both commercial and noncommercial projects. Collectively, these projects are called "open-source software" (OSS), which refers to the collaborative method of software development, whereas "free software" applies specifically to software under licenses (such as the GPL) that emphasize the rights of users to have access to source code.

General benefits of open-source software

This description of the open-source movement provides a necessary context for understanding the benefits of OSS to users. It is common, for example, to confuse OSS with shareware. In fact, shareware is usually proprietary, commercial software that is developed by individuals or small groups. Although there are exceptions, shareware does not benefit from commercial backing (as large, proprietary, commercial projects do), nor can it benefit from the contributions from the user community that occur in OSS development. The remainder of this article will review these benefits to users of OSS, and four open-source packages that should be of interest to a wide range of scientists and educators: the OpenOffice office suite, the R statistical package, the GRASS geographic information system, and the GNU Image Manipulation Program (GIMP) image editing package. I chose these packages as examples because I use them and, I hope, can do justice to presenting their strengths and weaknesses. In fact, there are thousands of open-source packages available today, and I hope this article will stimulate interest in open-source software in general. At the end of the article, I have included links to web sites that index large numbers of packages.

The immediately obvious benefit to the nonprogrammer of using OSS is that it is free of charge and can be freely redistributed. Some open-source packages are used as the basis for commercial software (e.g., OpenOffice), and some open-source projects offer additional materials (such as printed documentation, technical support, etc.) for a fee. All of the software that I describe here, however, can be downloaded from the Internet for free as binary executables. This makes it relatively easy for instructors to distribute copies of all of these packages to their students for use on their own computers. This opportunity has the potential to release students from reliance on access to student computer labs or, alternatively, to save them the cost of expensive software to do class assignments. Savings in software license costs could have positive effects on research budgets.

Redistribution is not only allowed by open-source software licenses, but also is encouraged. It is true that there are strict regulations, backed by copyright law, on how programmers can use the source code in derived works. For example, it is strictly forbidden to take GPL'd source code, add it to your own project, and then sell the binary executable without making the source code available. Readers who are interested in writing or contributing to OSS are advised to read about the various licenses that are available (a good starting place is <http://www.gnu.org>). However, it is impossible to violate an open-source license by installing and using the software (which cannot be said for most proprietary, commercial packages). This means that since switching to these packages, I can safely say that I am complying with the licensing terms of all of the software that I use.

Open-source software uses well-documented, nonproprietary file formats. This derives, in part, from the source code, which contains within it the structure of any files the program produces. Open-file formats are also consistent with the motivations of OSS programmers, who have no incentive to use proprietary file formats to make switching to other software difficult. This means that it will always be possible to extract a user's documents and data from the files of one of these programs (perhaps with the help of a friendly computer science student), even if the program is no longer being actively developed. For example, it is increasingly common for open-source projects to use XML (the eXtensible Markup Language) as a file format, because it can be opened in a text editor, is self-describing, and is designed to be easily converted to other formats. Thus, using OSS greatly reduces the risk that you will be unable to open old, archived data files or other documents a decade from now.

OSS is generally not limited by commercial constraints. An example of the benefits provided is that the packages that I will describe next are all available on a variety of operating systems and hardware platforms. I am writing this article using OpenOffice on a bizarre combination of Apple Macintosh hardware running the Linux operating system. There is virtually no commercial software for this platform, yet a small group of volunteers ported the office suite to Linux on PowerPC hardware, and I am enjoying the benefits of their efforts. Whereas commercial companies only produce software for platforms on which they can make profits, open-source developers produce software for whatever platform they want to use, and like-minded users benefit.

Evaluations of OpenOffice, R, GRASS, and GIMP packages follow.

OpenOffice

OpenOffice is a full-featured office suite that compares favorably to suites sold by Microsoft, Corel, and others. The source code for OpenOffice is owned by Sun Microsystems, who published it under an open-source license in 1999. Sun uses the source code as the basis for their commercial Star Office suite, which includes some additional tools, resources, and technical support that are not available with OpenOffice. OpenOffice is available for Windows, Sun's Solaris operating system, FreeBSD, and Linux on both Intel Pentium compatible and PowerPC (primarily Macintosh) hardware. A port to the Macintosh OS X is underway.

OpenOffice includes a word processor, spreadsheet, presentation package, and vector drawing package. Basic image editing, charting, and equation editing tools are integrated into these base packages. The word-processing package has the expected features, such as on-the-fly spell checking, tables, styles, change tracking, and object embedding (i.e., embedding graphics, bits of spreadsheets, etc.). The spreadsheet contains a comprehensive set of functions, supports array operations, conditional expressions, iterative goal seeking, and has a cross-tabulation tool. Each sheet is currently limited to 32,000 rows, but access to data in database programs (such as MS Access, Oracle, etc.) is supported through ODBC and JDBC. The presentation package includes the expected basic formatting and layout functions, as well as animated transitions. Import and export of other file formats is good, particularly for MS Office files (a WordPerfect filter is included in StarOffice, and one is under development for OpenOffice as well). File exchange is a small issue for most teaching tasks, but presently it might be necessary to save documents in more common file formats for electronic submission of manuscripts. This package has suited my requirements very well, but has the greatest room for improvement in its charting and database access tools, areas that may be more critical for some users than they are for me. The package can be downloaded from <http://www.openoffice.org>.

R

Not to be confused with the R package, which is an ecological analysis package developed by Casgrain and Lebreton, R is an open-source clone of the proprietary, commercial S+ package. It is an extremely capable data analysis package in its own right, with strengths in general linear modeling, statistical graphics, and interactive model building (including likelihood-based methods). It has also attracted a large and growing number of contributed add-on packages of interest to ecologists, including a variety of spatial analysis packages, phylogenetic comparative analysis, structural equation modeling, MARS, general bootstrap and randomization testing, and ordination methods (i.e., DECORANA, canonical correspondence analysis). Data import and export is good, with support for SAS transport files and SPSS files, as well as fixed-field and delimited text files. Database access is also supported through a variety of native database drivers and ODBC support.

The greatest drawback of the R package for new users is that it has a command-line interface (although whether this is a drawback or a feature depends on your preferences). The Windows and Macintosh versions include a graphical user interface for a few tasks such as exporting graphics for use in other packages, but most statistical functions are accessed through the command line. Consequently, although S+ users should feel right at home, there is a steep learning curve for users of other packages. Once learned, though, R provides a sufficiently broad coverage of statistical procedures that you may find it possible to use R exclusively, rather than relying on specialized packages for different types of analysis. This package is available from <http://cran.r-project.org> for Windows, Mac OS 9 and OS X, and several flavors of Unix.

GRASS

The Geographic Resources Analysis Support System (GRASS) was originally developed by a division of the U.S. Army Corps of Engineers. The source code is now published under the GPL, and is actively developed by an international team. The strength of GRASS is in raster GIS, but it also has limited support for vector data. GRASS 5.0 was recently released, and includes many improvements and new features not found in the previous release, GRASS 4.3.

GRASS includes a fairly primitive graphical user interface that will frustrate experienced GIS users, but it is helpful for beginners who want to get started quickly. Not all of GRASS's functions are available through the graphical interface, though, and to access all of this package's abilities, one should learn to use its command line interface. Like R, GRASS has a steep learning curve, but it rewards your devotion.

GRASS is available for Windows, Mac OS X, and several flavors of Unix at <http://www3.baylor.edu/grass>. The Windows version requires installation of some additional free software (the Cygwin tools) that enables Unix software to run on Windows. Links to the necessary software can be found at the Baylor website.

GIMP

Whimsical names are common in software that is unfettered by concerns about corporate image. GIMP (Gnu Image Manipulation Program) is exemplary. This package is meant to compete with image-editing software such as Adobe Photoshop and Corel PhotoPaint, and although I have not used either of these packages extensively, I have yet to find something that I want to do with an image that GIMP cannot do. It can import and export a variety of common and exotic image file formats, and supports masks, channels, alpha transparency, and a variety of image-filtering operations. It is also possible to import postscript and pdf files, which are converted to bitmaps, for editing.

The learning curve is less severe for this package than for the two command-line packages that I have described, but much of the functionality is contained in "context menus" that appear only by right-clicking on an image. This tip should be enough to make a test drive productive, as the menus are comprehensive and self-explanatory once you find them. The GIMP is developed primarily for Linux, but has also been ported to Windows. It can be downloaded at <http://www.gimp.org>.

Concluding remarks

Open-source software development has already produced an impressive number of packages that are useful to ecologists, both as teachers and as scientists. I have only scratched the surface in this article, describing only the small selection of packages I believe will be the most useful to a large number of readers. I encourage you to download and test one or more of them.

I was motivated to write this article both out of altruism and out of enlightened self-interest. I have found that each of these packages satisfies my needs, and I believe they should do the same for many of you. Additionally, because of the way it is developed, open-source software improves the more it is supported by a community of users. The programmers who donate their time to these projects are well aware of this; many open-source projects begin as a way of using the collective labor and talent from many contributors to fulfill a programmer's own need for software that they could not write by themselves. Thus, as good and useful as these packages are now, they only stand to improve with use.

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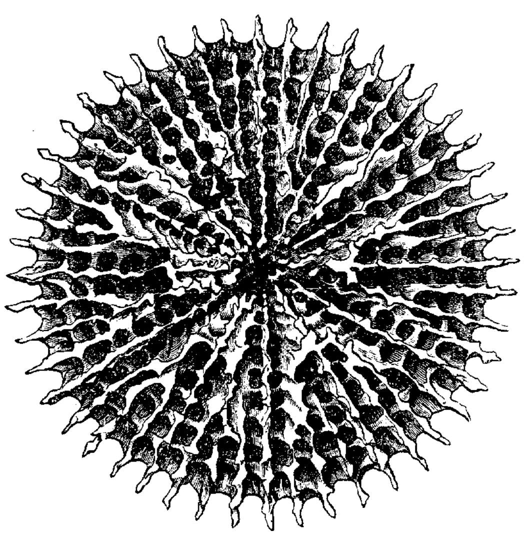
Links to additional software

- *Sourceforge*, a site for OSS project development <http://www.sourceforge.net>
- *Freshmeat,* listings of primarily OSS projects <http://www.freshmeat.net>

Inadvertently amusing excerpt spotted by the ESA Publications Office:

" ... urchins sometimes lose their grip ..."



— Dill et al. (2003), *Ecology* 84

Section and Chapter News

SOUTHEASTERN CHAPTER NEWSLETTER

ISSUE 2002-3

Chapter Officers

Chair: Paul Schmalzer (2002–2004) <schmapa@kscems.ksc.nasa.gov>
Vice-Chair: Pat Parr (2001–2003) <parrpd@ornl.gov>
Secretary/Treasurer: Yetta Jager (2002–2004) <jagerhi@ornl.gov>
Web-Master: Mark Mackenzie <mackenzi@forestry.auburn.edu>
Chapter Home Page: <http://www.auburn.edu/seesa/>

Message from the Chair

I hope that many of you are planning on attending the ASB meeting in Washington, D.C., in April 2003. Our Chapter will be sponsoring a symposium, holding our annual business meeting, electing a vice-chair for 2003–2005, and sponsoring the Odum Award for the best ecological paper presented by a student.

Spring 2003 Chapter Meeting in Washington, D.C.

The chapter will meet with the Association of Southeastern Biologists (ASB), 10–13 April 2003 at Howard University in Washington, D.C. Our section will sponsor a symposium, "Forest fragmentation and biodiversity in the Southeastern United States," coordinated by Scott Franklin, University of Memphis. Do you have an idea for a Chapter-sponsored workshop or symposium for 2004? Contact Pat Parr <parrpd@ornl.gov>.

2003 Elections

Elections for vice-chair will be held at the Spring 2003 meeting, with the term beginning in August. Persons interested in being candidates for this position should contact Pat Parr by January. Early nominations for chair and secretary/treasurer for 2004 elections are also welcome.

2003 Odum Award

The Chapter sponsors the Eugene P. Odum Award for the best ecological paper presented by a student at the ASB meeting. Students are encouraged to submit their papers for consideration. For more details, check the ASB web site <http://www.asb.appstate.edu/future.htm>.

Membership Renewal

Please remember to renew your membership in the Southeastern Chapter when you renew your ESA membership. Also, check that ESA has your correct e-mail address. Your donations to the Eugene P. Odum Fund support the 2003 Best Student Paper Award.

Upcoming Meetings and Symposia

The 2003 ESA Annual Meeting will be on 3–8 August in Savannah, Georgia (see <http://www.esa.org/savannah/>). The Southeastern Chapter will have an informal brown-bag lunch at this meeting. Other meetings of interest to ecologists in the Southeast: The Society of Wetland Scientists will hold their 24th Annual Meeting, 8–13 June 2003, in New Orleans, Louisiana. The USDA Symposium on Natural Resource Management to Offset Greenhouse Gas Emissions will be held in Raleigh, North Carolina, 19–21 November 2002. The Coastal Plains Chapter of the Society for Ecological Restoration seeks abstracts for presentation at the Annual Symposium and Membership Meeting to be held 27–28 February 2003 at the University of Georgia in Athens. The Second International Wildland Fire Ecology and Fire Management Congress will be held 16–20 November 2003 at the Colorado Springs Resort in Orlando, Florida.

Job Announcements

The University of Southern Mississippi Gulf Coast Research Laboratory is looking for a qualified Ph.D to teach a 5-week class in Marine Ecology in the summer of 2003. Potential applicants may contact Chet Rakocinski (e-mail: chet.rakocinski@usm.edu).

Keeping in Touch

Join the Southeastern Chapter of the ESA LISTSERVER: To join this ListServer, please send a message to <majordomo@mail.auburn.edu> with the following command in the body of your e-mail message: subscribe scesa. If you use a signature file, it is best to turn it off. If you have any news or announcements for the Southeastern Chapter's home page, please send them to Mark Mackenzie at <mackenzi@forestry.auburn.edu>.

Yetta Jager
Newsletter Editor