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ISSUES – FIGURE SET

Ecology of Disturbance

Charlene D'Avanzo, School of Natural Sciences
Hampshire College, Amherst, MA, 01002
cdavanzo@hampshire.edu

Controlled fire, © Konza Prairie LTER, Manhattan, KS {www.konza.ksu.edu/gallery/hulbert.jpg}

Figure Set 3: Ecology of Fire

Purpose: To introduce students to the ecology of fire under natural and "controlled" conditions.
Teaching Approach: "Citizen's argument"
Cognitive Skills: (see Bloom's Taxonomy) — comprehension, interpretation, application
Student Assessment: Oral presentation

BACKGROUND

Fire — natural and human caused — is an important and controversial disturbance worldwide and is particularly interesting to many students. U.S. regions characterized by fire vegetation include coniferous forests in the west, the southern pine barrens, grasslands in the midwest, and mediterranean shrubland and chaparral in the southwest. Fires typically occur in locales where plants grow in seasons with rain followed by dry season and dry lightening storms, although these conditions are not always necessary.

Controversies related to fire include: setting fires for agriculture and grazing, control burns in national parks that affect bordering populated areas, the problem of accumulated fuel from decades of fire suppression, encroaching development in fire communities, and control of natural fires in parks and other public lands.
Ecological topics related to fire are types of fire (surface, crown, ground) and adaptations and tolerance of plants to fire, including serotiny (seed release in cones heated by fire). See the resource section on the first page of this issue for links giving more background about these subjects and also controversies and debates.
Numerous more recent studies have shown the response to fire by some species is less direct than the example of serotiny. For example, some plants that are seemingly destroyed during a fire, quickly re-sprout from intact underground stems and roots. These new sprouts benefit from the reduced cover of competing species. Briggs and Knapp (1995) have shown that fire increases production of grasses on the Konza LTER prairie. In addition, annual fires limit spread of woody plants but fire rotations of 4 years or more actually increases their growth (Briggs et al. 2002).

Bormann and Likens Study

The data in Figure 3A are fire statistics in two parts of the U.S. where fire is (Great Lakes region) and is not (northeast) an important ecological phenomenon.

In the Great Lakes region several pollen studies of lake cores indicate that catastrophic fires have been frequent in the northern hardwood forest. Heinselman's (1973) core data from the Boundary Waters Canoe Area in Minnesota show a natural fire rotation of about 100 years in the presettlement period. Interestingly, this is the region that Clements studied as he developed his climax hypothesis. As a result of widespread, fires old and even-aged stands of white pine are common in the Great Lakes area.

In contrast, in their book Pattern and Process in a Forested Ecosystem Bormann and Likens (1979) argue that fire has not historically been an important disturbance in northern parts of the northeast U.S. — and that this remains the situation today. They present evidence that Native Americans did not set fires to forests in northern New England. This is in contrast to southern/central New England, Pennsylvania, and New York, in addition to the Great Lakes forests. Bormann and Likens argue that Native American populations in the Hubbard Brook area in northern New Hampshire, for example, were small and migratory. While Native Americans in other regions apparently set fire for agriculture, summer travel over land, and driving herds of deer, those of the northern New England region farmed little, traveled by canoe in summer, and killed deer by stalking.

Controversy About Native Americans and Fire in New England.

The data in Figure 3A clearly show that human-induced fires are much more common than fires caused by lightening. In addition, fires in Vermont and New Hampshire (Green and White Mountains) are quite rare compared to the those in national forests in Pennsylvania, Wisconsin, Minnesota, and Michigan. Northern New England forests have been called "asbestos forests" because fires are so relatively uncommon. Hurricanes and other wind events are much more important vectors of disturbance here (see Foster 1997). Factors limiting fire in northern New England include: precipitation throughout the year, resistance of dominant trees to fire, limited litter accumulation, and many sites (e.g. valleys) protected from high winds. Students from western states in particular may be surprised that fires are uncommon in some locales; the New England example helps us better understand variables determining fire as an important ecological consideration.

The degree to which Native Americans changed the landscape with fires continues to be a controversial topic in the ecological literature. In her paper on forest fires set by Native Americans Russell (1983) concludes that no strong evidence supports their large scale burning of New England forests in precolonial times. She proposes instead that these peoples did increase the numbers of naturally occurring fires in areas around their habitation sites. Russell analyzed documents written before 1700 and includes several interesting quotes such as this one written by Adriaen Van der Donck who lived on an island in the Hudson River:

> *"the Indians have a yearly custom (which some of our Christians have also adopted) of burning the woods, plains and meadows in the fall of the year... for several reasons: First to render hunting easier... Secondly to thin out and clear the woods of all dean substances and grass, which grow better in the early spring... and Thirdly to circumscribe and close the game within the lines of the fire... Notwithstanding the apparent danger of the entire destruction of the woodlands by the burning, still the green trees do not suffer. The outside bark is scorched three to four feet high, which does them no injury, for the trees are not killed."*

In addition to giving these first-hand accounts Russel's paper is illuminating because it nicely outlines the controversy as to whether Native Americans were "aboriginal pyromaniacs" (Raup 1937). Faculty especially interested in this topic could lead a stimulating class discussion about the types of evidence ecologists can use to address this question.

Literature Cited

Heinselman, M. L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Quaternary Research 3: 329-382.

Russell, E. W. B. 1983. Indian-set fires in the forests of the northeastern United States. Ecology 64: 78-88.

Minnich Study

Minnich studied fires in the Mediterranean-type habitat of southern CA and northern Mexico. Although vegetation type is similar in both areas, fire histories have been quite different since the early 20th century. Before this time lightening-set fires were common on both sides of the border. Sheep and cattle farmers also set fire to improve grazing, and both natural and set fires could burn for months. However, in 1892 the Los Angeles coastal plain region became the nation's first federal forest reserve, and fire suppression was initiated north of the U.S/Mexico border.

Minnich tested the hypothesis that fire suppression has resulted in recent severe and large-scale wildfires in southern CA by comparing burns in southern CA with those in northern Mexico. He found that during the study period of 1972-1980 total area burned was similar in the two areas, but size of burns differed. Large burns (< 3000 ha) occurred more often in southern CA while small burns (>100ha) were more frequent in northern Baja California. Median burn size in southern CA was about twice the size measured in Mexico (3500 ha as opposed to about 1500 ha).

Minnich concludes that:

> *"fire suppression in southern California has lead to larger fires. especially in chaparral... The effect of fire suppression in the coastal sage scrub and grassland of southern California appears to be limited. Since biomass in these stands is dominated by herbaceous dead fuels, fire escapes easily out of control. Most occur in early summer and have a size distribution similar to those in Baja California... in southern California chaparral... the great achievement of suppression seems to be extinguishing of small fires. Once fires are large, man has trivial impact on their progress... Since 1910 small fires have been replaced by ever-larger ones with numerous conflagrations since the 1950's despite increased suppression investment."*

This study therefore gives evidence to support the Forest Service's more recent policies on controlled burns.

According to Minnich, Figure 3B shows "a broad gradient of increasing fire area northward in Baja California [that] shifts to a pattern of infrequent small to very large fires north of the border. Divergences in fire size between the two countries are most evident in chaparral." In Figure 3B, the slopes of fire size distributions for chaparral are different for the U.S. and Mexican sites. In Baja California burns less than 800 ha were more frequent than in southern CA.

Literature Cited

Briggs, J. M. and A. K. Knapp. 1995. Interannual variability in primary production in tallgrass prairie: climate, soil moisture, topographic position and fire as determinants of aboveground biomass. American Journal of Botany 82:1024-1030.

Briggs, J. M., A. K. Knapp and B. L. Brock. 2002. Expansion of woody plants in tallgrass prairie: A 15-year study of fire and fire-grazing interactions. The American Midland Naturalist 147: 287-294.

Clements, F. E. 1916. Plant Succession: An Analysis of the Development of Vegetation. Carnegie Institution of Washington Publication 242. Carnegie Institution of Washington, Washington, D. C.

Foster, D. R. et al. 1997. Forest response to disturbance and anthropogenic stress, BioScience 47: 437-445.

Heinselman, M. L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Quaternary Research 3: 329-382.

Raup, H. M. 1937. Recent changes in climate and vegetation in southern New England and adjacent New York. Journal of the Arnold Arboretum 18: 79-117.

Russell, E. W. B. 1983. India-set fires in the forests of the northeastern United States. Ecology 64: 78-88.

STUDENT INSTRUCTIONS

In this exercise you will use the data from one of two studies to support your role as a concerned citizen speaking out at a public meeting. (You can invent your own role or you have been assigned a role). In public sessions about controversial topics affecting communities, citizens are often given an opportunity to speak their opinion and concerns. You (or your group) will have a maximum of 2 minutes to state your case. You can read your statement or speak it freely. In either case you must use the data in one of the figures during the statement.

The focus of this controversy is fire. Obviously fire is a real concern for us all. Anyone who has seen a house burn down or a forest in flames appreciates the power and destructive force of fire.

Fire management has been a point of dispute in the U.S. for a long time. In the days of the early settlers and ranchers in the west, people who grazed cattle and sheep set fire to stimulate growth of forage. This angered others whose homes and businesses were threatened by escaped fires. Early conservationists also wanted the land left undisturbed.

Today headlines about huge forest fires are unfortunately commonplace. What is your citizen's reaction to these headlines http://www.nbc4.tv/news/2582283/detail.html and http://www.spaceimaging.com/newsroom/2003_calif_fires.htm about the fires in California in 2003? There is a good deal of argument about the fire suppression policies of the past. How would your citizen view the Forest Service's past policy of fire suppression?

As you can imagine debates about controlled burns and letting natural fires burn are as hot as the fires themselves.

Bormann and Likens Data

These are fire statistics in northern hardwood forests in the Great Lakes region and the northeast. See the figure legend for more details.

Pollen studies in sediment cores from the Great Lakes have indicated that catastrophic fires have been frequent in some northern hardwood forests. One study from the Boundary Waters Canoe Area in Minnesota show a natural fire rotation of about 100 years in the presettlement period.

Minnich Data

Minnich studied fires in the Mediterranean-type habitat of southern CA and northern Mexico. Although vegetation type is similar in both areas, fire histories have been quite different since the early 20th century. Before this time lightening-set fires were common on both sides of the border. Sheep and cattle farmers also set fire to improve grazing, and both natural and set fires could burn for months. However in 1892 the Los Angeles coastal plain region became the nation's first federal forest reserve, and fire suppression was initiated north of the U.S/Mexico border.

Minnich tested the hypothesis that fire suppression has resulted in recent severe and large-scale wildfires in southern CA by comparing burns in southern CA with those in northern Mexico. He especially focused on size of burned areas. See the figure legends for more information.

FIGURES

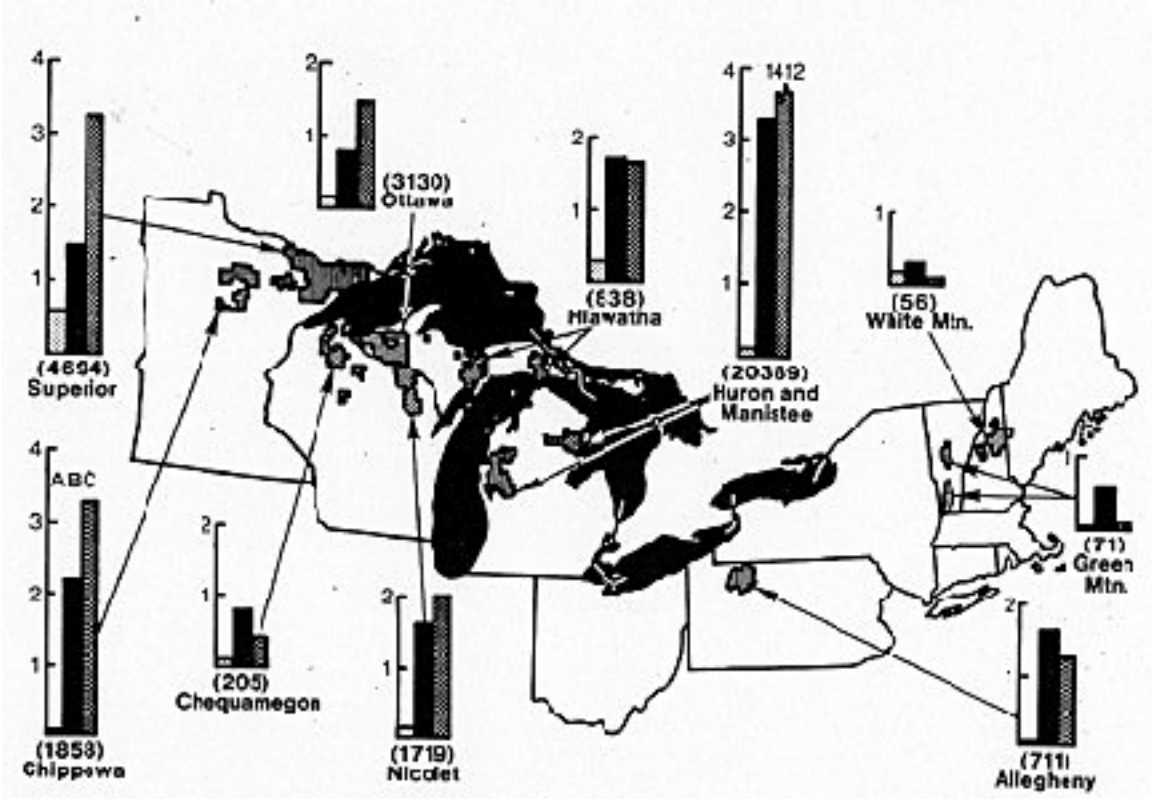

Figure 3A. Fire statistics for northern hardwood forests. Average annual numbers of fires (x10) caused by lightening (Column A: stippled) and humans (Column B: black). Average acres (in 100 acre units) burned annually (Column C: cross hatch). Number in parentheses is largest acreage burned in one year. Data are per million acres of national forest land. Calculated from U.S. Forest Service Annual Fire Reports from national forests from 1945-1976. From F. H. Bormann and G. E. Likens 1979. Pattern and Process in a Forested Ecosystem. Springer-Verlag, New York.

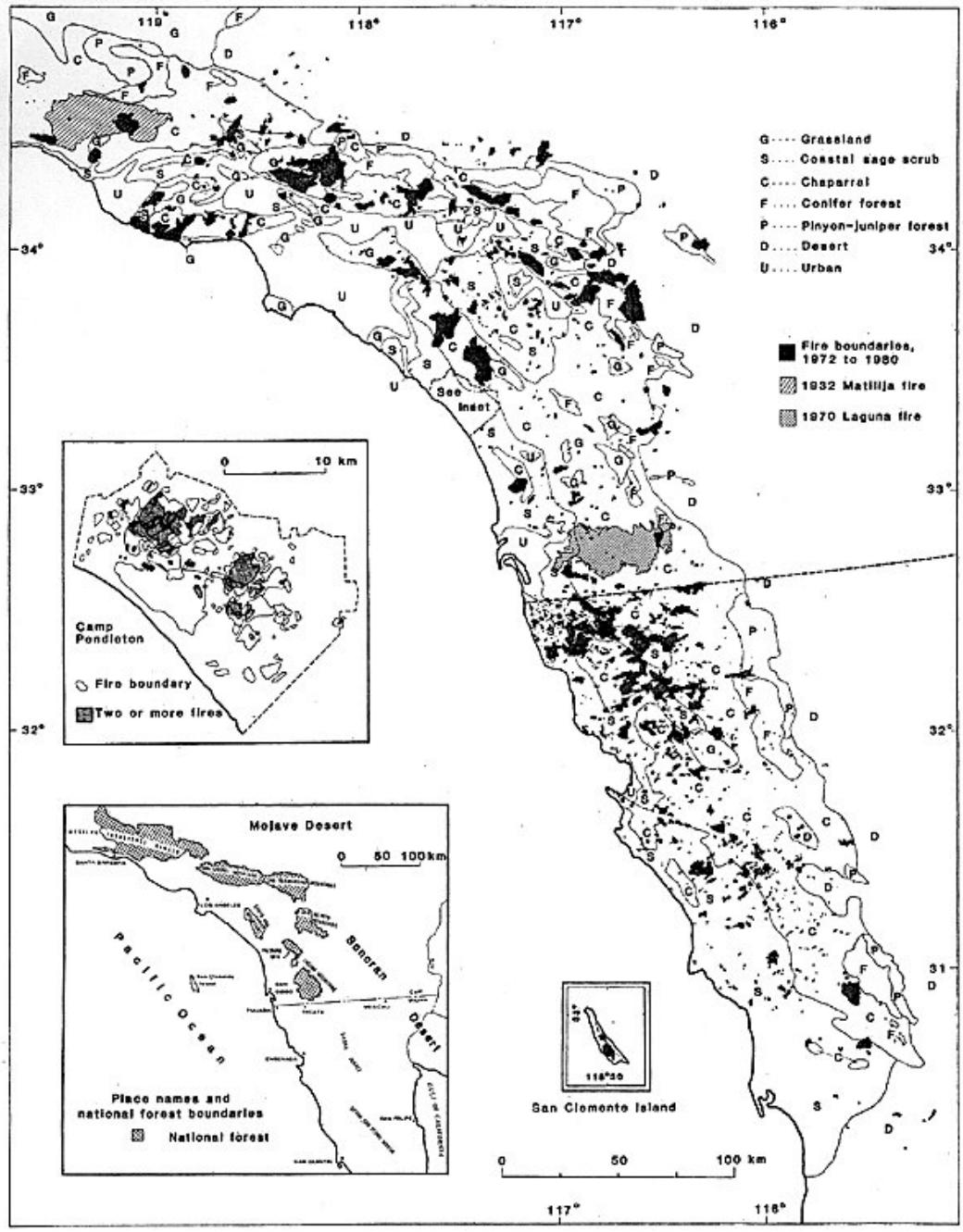

Figure 3B. Wild-land fires in southern CA and northern Baja California, 1972-1980, and vegetation categories. Fire data mapped from Landsat images and vegetation from aerial photographs. From R. A. Minnich. 1983. Fire mosaics in southern California and northern Baja California. Science 219: 1287-1294.

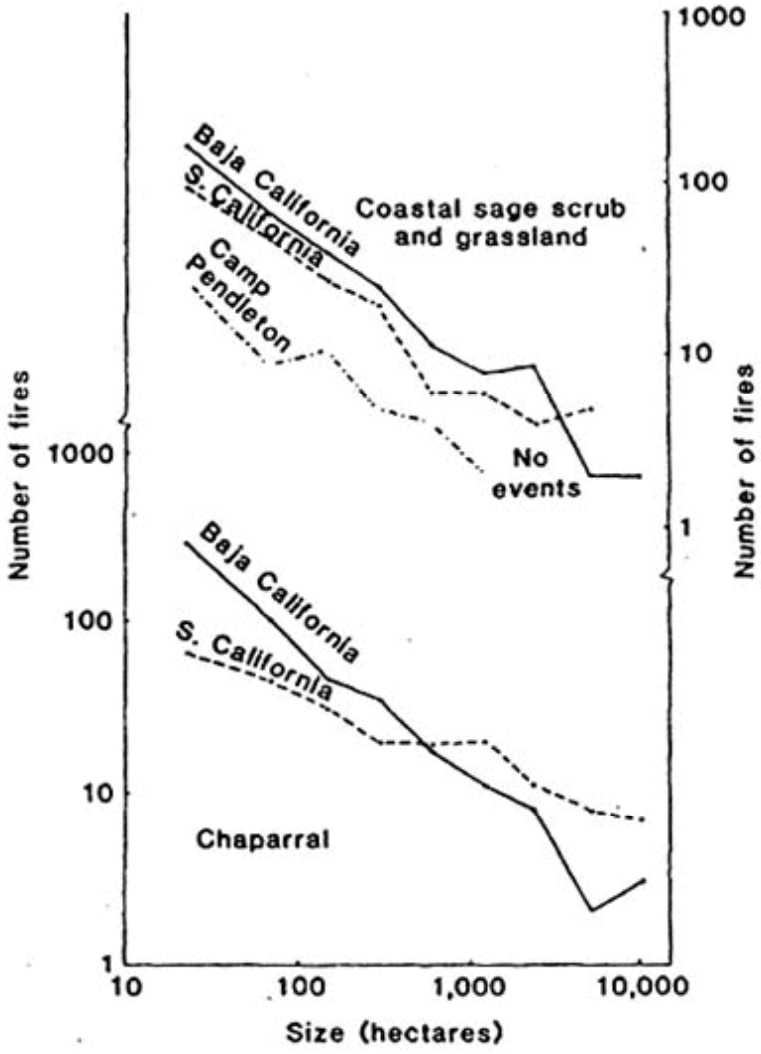

Figure 3C. Number of fires plotted against burn area for coastal sage scrub/ grassland and for chaparral in the two study region, 1972-1980. From R. A. Minnich. 1983. Fire mosaics in southern California and northern Baja California. Science 219: 1287-1294.

FACULTY NOTES

It will take some time for students to make sense of the data in these three figures. To save time, you can project or hand out the figures and lead a discussion instead. Then students can do the "citizen's debate" if you wish. This exercise will help students improve their speaking skills (although only a few students will get a chance to speak - one modification is for students to presents their arguments to each other in smaller groups (e.g. 10 students per group). To engage students in a ecological debate, you can use Keely's response to Minnich's study; it is quite strong (see first URL below).

"Citizen's argument" imitates what citizens do in town meetings or similar venues. Students are given either the Minnich or the Likens/Bormann data and asked to assume a role (such as environmentalist or worried house owner near national park). You can assign the roles or let the students invent their own. In a 2 minute speech — which they read — they present their point of view using the data from their study as support plus information from the web or other sources. They must use the data though. Students can work in pairs or small groups on their speeches (in or outside of class). Depending on the class size you can ask each group to present their speech or randomly choose some from both data set groups.

The dramatic fires of fall 2003 in California were well advertised, and therefore some of your students will likely remember this event, especially if they have ties to CA. Listed here are several links to sites documenting these fires. In addition, for some of Minnich's critics (see San Diego University link) such as Jon Keeley, this fire was an opportunity to promote their opposing points of view.

- http://map.sdsu.edu/fire2003/firehistory.htm (San Diego University)
- http://www.werc.usgs.gov/fire/firerelated.html — USGC fact sheets and publication briefs
- http://fire.textamerica.com — people's photographs of the CA fires, 2003
- http://www.nbc4.tv/news/2582283/detail.html — NBC new brief

Student Assessment: Oral presentation of the Citizen's arguments.

In addition to grading each student's oral presentation, or for individual assessment when groups present together, ask each student to submit their own written version of their argument.

Evaluating an Issue: How do you know whether it is working?

On-going (also called formative) evaluation of the approaches your are using is critical to the success of student-active teaching. Why try out new ideas if you don't know whether or not they are working? This is a brief overview of formative evaluation. For more information, go to the Formative Evaluation essay in the Teaching Section.

Course Goals:

Formative evaluation only works if you have clearly described your course goals - because the purpose of the evaluation is to assess whether a particular technique is helping students reach these goals. For instance, most of us have "learn important ecological concepts and information" as a course goal. If I reviewed the nitrogen cycle in a class, for evaluation I might ask students to sketch out a nitrogen cycle for a particular habitat or system. Each student could work alone in class. Alternatively, I might ask students to work in groups of 3 and give each group a different situation (e.g. a pond receiving nitrate from septic systems, an organic agricultural field, an agricultural field receiving synthetic fertilizer). The students could draw their flows on a large sheet of paper (or an overhead transparency) and present this to the rest of the class.

The Minute Paper:

Minute papers are very useful evaluative tools. If done well they give you good feedback quickly. Minute papers are done at the end of a class. The students are asked to respond anonymously to a short question that you ask. They take a minute or so to write their response in a 3x5 card or a piece of paper. You collect these and learn from common themes. In the next class it is important that you refer to one or two of these points so that students recognize that their input matters to you. The UW - FLAG site (www.wcer.wisc.edu/nise/cl1/flag/) gives a good deal of information about using minute papers including their limitations, how to phrase your question, step-by-step instructions, modifications, and the theory and research behind their use.