METHODS FOR IN-SITU SURVEYS AND PHYSICAL MEASUREMENTS

Sediment Deposition and Accretion

The following are a few methods that are used in shallow marsh environment. Project managers and principal investigators should work closely in determining the most suitable method for a specific project. Any subsequent changes in the method of measuring sediment deposition for the same project must be carefully evaluated against the other method, so that continuity and comparability in the data set can be maintained. The specific method used must be specified in data reports and in the database for future reference.

Accuracy and precision of individual measurements are specified below. Report sediment deposition in g/m^2 in dry sediment basis.

A. Sediment Trap Method

Short-term sedimentation can be measured as the accumulation of material on Whatman™ glass fiber ashless filters placed on the marsh surface and collected at pre-determined time intervals (Reed, 1989, 1992 and Hutchinson et al., 1995). Traps are made of cylindrical plastic pipe with an inside diameter of 38 mm and a length to width ratio of 4:1, following the recommendations of Kirchner, (1975). The traps consist of pre-ashed, pre-weighed glass fiber filters attached to an aluminum sheet with bobby pins or wire staples. The plates are secured to the marsh surface, between clumps of vegetation, with two large nails and small flags are placed in the mud as markers. Since re-suspension is defined as the amount of sediments lifted 6 cm or more above the sediment surface, traps are installed with approximately 6 cm of PVC pipe extending above the substrate surface to reduce trapping unsuspended, shifting surface material.

The collected filters are returned to the laboratory where they are dried at 60^oC overnight and re-weighed. The increase in weight between the original filter weights and that after collection and drying provide the measurement of marsh surface sediment deposition in g/m^{-2}. When parts of filters were lost, the percentage area lost was estimated and corrected for this. The filters were then combusted at 550°C and re-weighed. The loss on combustion was considered organic matter and the material remaining was inorganic (Day et al., 1999).

B. Sediment Accretion by Sediment Collection Tiles Method

Net rates of marsh sediment deposition were measured using 117 cm^2 ceramic sedimentation tiles positioned flush with the marsh surface (Pasternack and Brush, 1998; Christiansen et al., 2000). Tile deployment and retrieval took place when the marsh surface was exposed to air and occurred every other week. After removing fallen dead stems and roots from each tile, deposited sediments were scraped and washed with deionized water into clean, pre-weighed plastic specimen cups. Samples were dried at 50°C and weighed to calculate mass sedimentation rates (Neubauer et al., 2002).

C. Sediment Accretion By Feldspar Marker Technique

The Feldspar marker horizon is simple and consists of placing a layer of feldspar clay on the surface of the marsh. Feldspar material is recommended for use as marker horizons due to the fact that its brilliant white appearance make it distinguishable from the surrounding sediment and it can be used for both dryland and submerged systems. Feldspar plots must be established before taking the sediment erosion table (SET) baseline.

Feldspar marker horizons are usually laid down in sufficiently-sized plots; recommended are 50 x 50-cm plots. The layer should be about 5 mm thick and should be uniform in thickness. The plot must be well marked, usually with pipes or rods that are visible above the water column or vegetation height, for ease of location in future sampling. Over time, material is deposited on top of the feldspar. The depth of material that has accumulated on the marker is determined by collecting a core in the sample plot and measuring the distance from the top of current marsh surface to the feldspar layer. The sample can be collected by using either a thin-walled core tube or by a cryogenic technique (copper tube filled with liquid nitrogen). The feldspar marker should be distinctly evident as a white line in the recovered core for the method to be successful. After the core is collected, it is refrigerated and taken to the laboratory in a vertical position. In the laboratory, if processing is delayed, the cores are stored in the freezer.

The core is then sectioned to determine the thickness of the material deposited on top of the feldspar marker. Because melting can ruin the cores, particularly when dealing with peat samples, ensure that the cores remain frozen during processing. The thickness of the newly deposited sediment, located above the feldspar marker, is measured with calibrated calipers. Record the measurement to the nearest mm. Note down also areas where feldspar marker is missing.

Feldspar marker measurements should be combined with measures of soil bulk density and organic content (Reed 1992) to allow for the calculation of organic and inorganic accumulation. The method is described in detail by Cahoon (1994), Cahoon et al. (1996), Reed (1992), Steyer et al. (1995), and Cahoon and Turner (1989).

QC Goals:
Accuracy: ± 0.1 cm;
Precision: ≤30%;
Report depth (of feldspar horizon) in mm;
Sediment accretion rate in g/m^2 in dry sediment basis.

D. Sediment Accretion Using Isotopic Tracers: 137Cs and 210Pb Dating

This method description is taken from DeLaune et al. (1989). Sampling sites were established along a representative transect of the marsh. Cores, 15 cm in diameter and not less than 50 cm in length, were taken along each transect with a thin wall cylinder for 137Cs dating. Cores, 100 cm in length, were taken for 210Pb dating. Sediment accumulation and marsh aggradation rates were determined on all cores using 137Cs and 210Pb dating. Bulk density, percent carbon, and percent organic matter were also determined with depth in each core.

Sediment accretion is measured by counting the 137Cs or 210Pb activity as a function of distance down into the core. The measurement of 137Cs is straightforward. Sediment cores are taken with care to minimize any compaction. When a suitable core has been collected, be sure to record compaction measurements and tube number on data sheets (Steyer et al., 1995). The core is then sectioned, dried, and 137Cs activity is counted and reported in dpm/g using known detector efficiency factors.

For 210Pb dating, the method described in DeLaune et al. (1989) determines the activity of 210Pb. 210Pb is in secular equilibrium with 210Pb (Flynn, 1968; Armentano and Woodwell, 1975; Robbins and Edington, 1975). 210Pb is measured because it is an alpha emitter (alpha spectrometry gives better resolution and lower background than beta counting). Sections of sediment profiles were digested in acid. After the digestion, the 210Pb was plated on a silver planchet and counted as it decayed to 206Pb, a stable isotope (Flynn, 1968). A 210Pb spike was used to determine chemical yield.

QC Goals:
Accuracy (distance measurement): ±5 mm;
Precision: ≤30%;
Report distance (of isotopic activity) in mm;
137Cs activity 210Pb activity in dpm/g.

E. Sediment Accretion Using Beryllium-7

Sediment inventories of 7Be (t1/2= 53.3 d) are used to estimate marsh sediment deposition and erosion rates on a time scale of months (after He and Walling, 1996; Goodbred and Kuehl, 1998). The inventory approach assumes that any radioisotope activity above that supplied by atmospheric fallout is due to sediment input (Walling et al., 1992) and that atmospheric inputs are evenly distributed across the study area (i.e. there is no `focusing' of fallout 7Be due to land topography).

This method description is taken from Neubauer et al. (2002). Sediment cores of 2 cm diameter were taken to a depth of approx. 15 cm. Each core was sectioned at 1 to 5 cm intervals, each section was homogenized and a subsample was gamma counted (477 keV) for 24 hours using a high-purity germanium detector. There are calculations for total core 7Be inventories included in the body of the text.

QC Goals:
Accuracy (depth measurement): ±5 mm;
Precision: ≤30%;
Report distance (of isotopic activity) in mm;
7Be activity in dpm/g.

F. Sediment Accretion by Rare Earth Element (REE)

This is a method described in Knaus and Van Gent (1989) of marking and measuring new (<1 year) marsh sediment layers in such a way that markers laid today will be unambiguous as to their placement in future months to years. Individual rare earths were purchased in soluble nitrate form. Measured amounts were diluted with natural marsh water, then applied to marsh vegetation (e.g., Typha sp. and Spartina sp.) and sediment and water surfaces at the experimental sites by a CO_2-driven spray apparatus typically used for herbicide and insecticide applications. Knowing the area covered by the spray and the concentration of the spray, a minimum of 100 µg of the metal of each of the tracers was applied per square centimeter of marsh area. The sensitivity of the Instrumental Neutron Activation Analysis (INAA) technique for Dy and Sm in environmental matrices is 0.10 µg per 0.1 g (wet wt) of sample that is equivalent to 10 ppm (dry wt). Sediment samples were taken using a cryogenic coring device developed by Knaus (1986) that freezes the core in situ. In this study, the frozen cores were extracted from the sediment, placed on dry ice in the field, and taken to the laboratory for sectioning. Sample preparation, neutron irradiation, and data reduction and analysis are described in detail in Knaus and Van Gent (1989).

QC Goals:
Accuracy (depth measurement): ±5 mm;
Precision: ≤30%;
Report distance (of isotopic activity) in mm;
7Be activity in dpm/g.

Elevation Change Determination Using Sediment Erosion Tables (SETs) and Feldspar Markers

A. Sedimentation and Erosion Tables

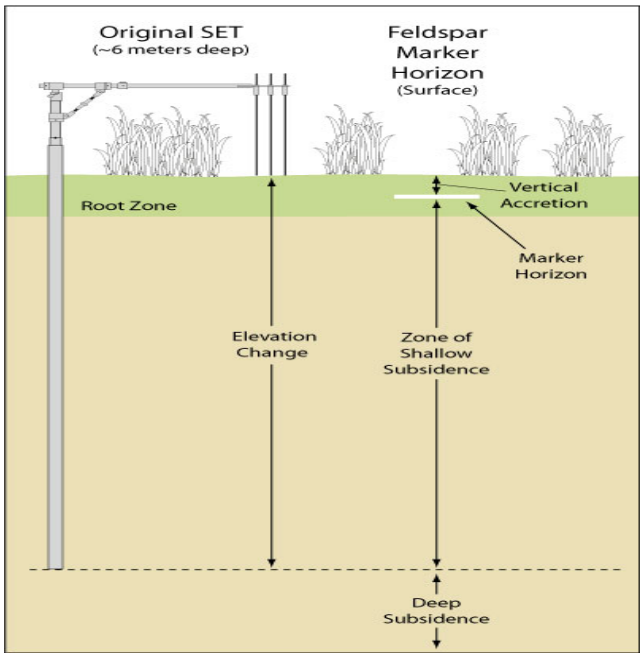
The combined use of SETs and feldspar marker horizons provide an integrated measure of elevation (i.e., deposition minus subsidence). The SET can be used to determine both the influence of a single meteorological event on sediment surface elevation and a long-term trend (i.e., decades) in elevation change. (Boumans and Day,1993; Day, 1993; Cahoon, 1994)

The SET benchmark is a thin-walled aluminum pipe that is driven into the soil to the point of refusal. A thick-walled base pipe is cemented inside the benchmark pipe to attach the SET. It provides fixed locations around the benchmark for repeated measurements. The portable part of the SET has four components: a vertical arm, a horizontal arm, a flat plate or table, and nine pins. The SET is placed in the base pipe and is leveled both vertically and horizontally prior to taking measurements. The pins are placed in the sliding plate, lowered to the sediment surface, and locked in place by tightening the locking screw. The length of each pin above the table is measured with a ruler to the nearest mm. Changes in the distance between the marsh and the table represents changes in the elevation of the marsh surface. For each base, the table can be placed in multiple positions, coinciding with the points of the compass, to give a total of replicate measures of marsh elevation for each plot.

When establishing the SET installation, it is essential that the supporting base pipe be driven past the peat layer, and to a point of true refusal. The primary concern in this regard is that the base pipe may stop at a plant root, rock, or relatively firm, but ultimately non-stable upper soil layer, and not have reached a truly hard layer which would provide a static, stable support layer for the base pipe. An excellent means of determining that the base pipe has reached a layer of true refusal is to drive a thin rod, such as ½" rebar into the soil adjacent to the base pipe. Such thin rods or pipes are much easier and more inclined to be driven past a root, rock, or through a soil layer such as firm clay. Once such a rod or pipe has reached a point of refusal, this depth can be utilized as the depth of true refusal to which the base pipe must be driven, and the base pipe relocated if need to achieve this state.

When setting the base pipe in quick-setting concrete, the concrete should be finished level, and the station head must be level before the concrete sets, and remain level after the concrete has fully set. If the station head ultimately is not level, the installation must be redone.

QC Goal:
Accuracy (depth measurement): ± 5 mm;
Precision: ≤30%;
Report depth in mm.



B. Rod Surface Elevation Tables (RSET)

A new portable mechanical leveling device was developed for high-precision measurements of sediment elevation in emergent and shallow-water wetland systems. It works on the same principle as the SET. However, the new device is an improvement in the determination of elevation change occurring over different parts of the sediment profile because it can be attached

to benchmarks that are driven to both deeper and shallower depths than the SET. Cahoon et al. (2002b) provides descriptions and several detailed diagrams of the Rod SET (RSET) and the deep (driven to refusal) and shallow (< 1 m depth) stable benchmarks to which it can be attached. In a given wetland, the rod benchmarks can typically be driven deeper than the SET pipe benchmarks because the 15 mm diameter rods encounter less resistance.

QC Goal:
Accuracy (depth measurement): ± 5 mm;
Precision: ≤30%;
Report depth in mm.

C. QA/QC Elements for SETs

Various sources of error may occur in the installation and use of SETs for the measurement of sediment elevation in wetlands. More detailed information on SET and RSET instruments can be obtained in http://www.pwrc.usgs.gov/resshow/cahoon/

1. Every crew member should be trained and tested on how to properly set up, operate, and take SET measurements correctly and consistently.
2. When taking measurements, be sure the instrument is level, and check the level state as the instrument is moved radically throughout the measurement taking process. Check for level before and after readings, and if the instrument has not remained level, re-level and repeat the measurement process until the instrument has remained level.
3. Flag data with a note where there was an odd surface situation at the pin or pins, such as when there was a branch or shell imbedded in the surface, or a depression such as a crab hole was present.
4. Utilize different personnel to check measurements throughout the day in order to effectively reduce errors introduced by any given individual.
5. Confirm that the tops of the pins reflect the profile of the ground. If any do not, reset such pins before taking any reading.
6. Where the surface is submerged or muddy, be sure to install the specialized feet on the bottom of the pins for such situations.
7. Be aware of and minimize parallax error when taking measurements. This is the error that occurs when viewing a measuring device such as a ruler not on a straight line to the device.
8. Check for position of instrument with respect to magnetic north. This is especially important with long-term studies, as the Earth's magnetic north does move over time.
9. Periodically conduct a performance assessment of team personnel by having them take measurements of a known test scenario, and assess the results of their work for quality.
10. Compare the standard deviation of the measurements within a given quadrat, and between each of the four quadrats to establish that the data is of acceptable quality. Consider the nature of any data flags and determine if the data should be used or rejected as suspect.

Bank Erosion Monitoring Using Photo-electronic Erosion Pin (PEEP)

The PEEP sensor consists of a row of photovoltaic cells connected in series, enclosed within a waterproofed, transparent, acrylic tube of 10 mm I.D. and 16 mm outer diameter (O.D.). The sensor generates an analogue voltage directly proportional to the total length of tube exposed to visible light (designed such that 1 mV of cell series output 1 mm of tube length). Networks of PEEP sensors are inserted into the eroding/accreting feature, and connected by screened cable to a datalogger housed in a weatherproofed enclosure nearby. Subsequent erosion (retreat of the bank face) exposes more photosensitive material to light, which increases PEEP voltage outputs. Conversely, deposition reduces sensor voltage outputs. Data periodically interrogated or downloaded from the logger thus reveal the magnitude, frequency and timing of individual erosion and deposition events much more precisely than has hitherto been possible, as demonstrated for fluvial sites by Lawler (1992, 1994). Logging intervals are user-defined and depend solely on datalogger capabilities, as PEEP sensors output continuously. For most field monitoring purposes our scan frequencies have ranged from 1-30 minutes, but they can be less than 1 second. if desired.

Organic Matter Decomposition Rates

Introduction

Organic matter decomposition is an important process controlling internal nutrient cycling and soil accumulation/loss. An important component of long-term removal and storage of nutrients is their incorporation into aquatic macrophytes and burial of this biomass in the sediments (Chimney and Pietro, unpubl.; Kadlec, 1997; Reddy et al., 1999). However, decomposition of plant material before burial returns nutrients to the water column. Therefore, it is important to understand the critical role that plant decomposition plays in nutrient cycling. However, the quantification of environmental effects on decomposition is complicated.

A frequently used method of separating out environmental effects is to quantify mass loss rates of a common substrate such as leaves from a single plant in various microsites by way of litter bag studies. Based on Mike Chimney's (personal comm.) review of the literature, the litterbag method is by far the most common approach used in decomposition studies in standing waters. Another approach is the measurement of fiber tensile strength loss in strips of cotton fabric inserted vertically in the soil by way of cotton strip assays.

MAP Component or CERP Projects

Macrophyte litter decomposition has been studied as part of the assessment of STA efficiency (i.e. Michael Chimney and Kathy Pietro). It was also studied as part of the phosphorus threshold program (i.e. Shili Miao and Sue Newman).

Reporting Units:

Weight loss: %
Tissue nutrient concentration: mg/kg
Cellulose decomposition rates: CTSL (cotton tensile strength loss) %/day

A. Cotton Strip Assays

The cotton strip assay (CSA) has been used in the Everglades to measure comparative differences in cellulose decomposition induced by nutrient loadings. These types of assays can provide information regarding the impact of nutrients in both the water column and submerged peat, which can be used to understand ecological processes and system stability (Maltby, 1988). The cotton strip assay has also been used successfully as a measure of biological activity in soils.

Composed entirely of cellulose, the cotton strips are commonly inserted vertically into the top 10–20 cm of soil, removed after a specified period (usually one to several weeks) and then tested for the loss of tensile strength using a tensiometer. Loss in tensile strength is used to calculate an index of potential soil biological or decomposer activity on the basis that cellulose is a major constituent of soil organic matter. The technique has been especially useful in describing differences between soils and the impact of various management treatments upon soils (Correll et al., 1997).

The cotton strip assay has been used at a variety of sites in an attempt to determine the effects of environmental variables and treatments on the organic matter decomposition cycle, and to produce a range of baseline data on cellulose decomposition in contrasting wetlands (Maltby, 1988).

Pros and Cons

This technique offers scientists an inexpensive, versatile and relatively quick technique for detecting ecological impacts, which can be used in the planning of buffer zones for water quality control and the maintenance of ecological stability (Maltby, 1988). The cotton-strip assay is also a useful tool for comparing microbial communities because the assay enables researchers to detect differences in degradation potential of the soil microbial communities (Correll et al., 1997).

The assay's advantages include the method's simplicity and the fact that it can be used in remote and waterlogged environments. The ease of insertion, retrieval, and preparation for analysis mean operators with limited training can use this method. As the strips are light, they can be air-mailed from remote locations for standardized laboratory analysis (Boulton and Quinn, 2000).

The technique is inexpensive (each individual strip costs less than US$ 0.20). Compared with other techniques for measuring microbial activity (e.g., FDA hydrolysis, Battin, 1997), no chemicals are handled (safety issues), and required field equipment is minimal. If the aim is to obtain a general indication of cellulolytic activity for comparative purposes or to supplement other environmental data on functional responses, this approach is useful and has been validated by many terrestrial studies (Boulton and Quinn, 2000).

The cotton fabric is qualitatively more uniform than leaves or wood, and vertical insertion provides an excellent evaluation of microsite influences over the soil profile in relation to environmental interfaces (Day, 1995). Maltby (1988) has suggested that the greatest value of the technique is microsite comparative analysis within individual studies.

The cotton strip method has some limitations. There is potential for abrasion and damage during placement or removal of the strip at sites with coarse sediments. It requires access

to an accurate tensiometer and an autoclave. Decomposition rates of cotton strips are exceptionally high compared to those of plant material and clearly do not represent realistic rates; pure cellulose is not the equivalent of roots or plant litter.

This method is an assay and should only be used to compare sites or experimental conditions. The results of cotton strip assays should be used cautiously when comparing extremely different habitats, and interpretations should be tempered in regard to extrapolating responses to the decay of real plants. The technique is probably most useful in comparing rates within similar habitat types.

The cotton strip assay offers a surrogate and averaging measure of detailed and complex biological processes in soil, sediment and aquatic environments. It is potentially powerful in differentiating a wide range of ecological environments and in measuring the comparative effects of treatments or natural changes and trends (Maltby, 1988).

QA/QC

The use of humidity conditioning prior to measuring the tensile strength of cotton strips is recommended. It not only reduces the within and between measurement day variance, but also enables the distribution of the tensile strength measurements to approximate normality.

The model with a constant variance and the model where the variance was allowed to vary both gave similar results. From each model it was recommended that an insertion interval be chosen such that the tensile strength of the strips had been reduced by about 30% of the original strength. The estimates of R were almost unbiased and relatively robust against the cotton strips being left in the ground for less or more than the optimal time. However, the estimates become unstable if the strip is left too long in the soil.

Data Analysis

ANOVA's were conducted with the GLM procedure in SAS to test for significant effects of landscape position, time, and soil depth. Tukey's test was used to compare means.

B. Litter Bags

Decomposition in terrestrial ecosystems is commonly studied using the litter bag method, which consists of enclosing plant material of known mass and chemical composition in a screened container. Initially, a large number of bags are placed in the field and at each subsequent sampling date a randomly chosen set of bags is retrieved and analyzed for loss of mass and/or changes in the chemical composition of litter (Weider and Lang, 1982).

The litter bag method remains the most commonly used technique for examining litter decomposition in terrestrial ecosystems. Although the method may underestimate actual decomposition, it is assumed that the results of litter bag studies will reflect trends characteristic of unconfined decomposing litter, and as such allows for comparisons among species, sites, and experimental manipulations.

One point of debate among scientists is pretreatment of leaf litter. It is common practice to kill the plant material before it is placed in the bags, usually through drying (Brock et al., 1982). Dead litter often loses organic matter more quickly than fresh material within the first several days to weeks of exposure (Brock et al., 1982; Larsen, 1982; Gaur et al., 1989; Barlocher and Biddiscombe, 1996; Barlocher, 1998). Differences in organic matter loss between fresh and dried tissue preparations become much less important as the incubation period lengthens to months (Brock et al, 1982).

Pros and Cons

Litter bags have been criticized for a number of reasons. Litter bags have been shown to inhibit loss of material compared to unconfined litter (Riley and DeRoia, 1989). The litterbag technique provides information on the material that remains in the bag and not on the particles that fall through the mesh or low-molecular weight organic compounds lost through leaching and thus, may overestimate the true decomposition rate (Reddy et al. 1999). Small mesh sizes reduce the loss of fine particles, but at the same time exclude colonization by larger macroinvertebrates responsible for much of the initial breakdown of plant material. Differences in mesh size results in the so-called "bag effect" in which decomposition is comparatively faster in course-mesh bags which allow passage of macroinvertebrates than in fine-mesh bags (Mason and Bryant, 1975; Winterboum, 1978; Pidgeon and Cairns, 1981; Brock et al. 1985b; Stewart and Davies, 1989; Janssen and Walker, 1999). Litter bags also can alter microhabitat conditions important to decomposition, such as flow regimes, chemical conditions, light intensity, and litter position in the environment (Schnitzer and Neely, 2000).

Despite the shortcomings of litterbags, no other technique has been as widely adopted for conducting decomposition studies. Many of the authors who have commented on the limitations of litterbags have used them in their own research. Litterbags, to varying degrees, integrate the effects of temporal changes in environmental variables and can provide a general picture of decomposition rates and processes (Gallagher, 1978; Brock et al., 1982; Barlocher, 1998).

Data Analysis

A number of different mathematical approaches have been used to model decomposition of plant material. These include simple exponential decay models (Wieder and Lang, 1982) and more complex models that account for temperature variation (Morris and Lajtha, 1986; Carpenter, 1980; Hietz, 1992), refractory and labile biomass fractions (Jewell, 1971; Brock et al., 1985b; Morris and Lajtha, 1986), various plant organs (Howard-Williams and Davies, 1983) and nonlinear decay coefficients (Godshalk and Wetzel, 1978a, 1978c; Brock et al., 1985b). Literature surveys revealed that first-order exponential models have been employed most often. Although more complex models may better mimic the multiple decay processes occurring during decomposition (Godshalk and Wetzel, 1978c; Brock et al., 1985b), first-order models can adequately describe litter breakdown and are useful for comparative studies (Howard-Williams and Davies, 1979; Carpenter et al., 1983; Chergui and Pattee, 1990). The first-order models derived in Chimney and Pietro (unpubl.) using nonlinear regression had explanatory power that was comparable to the more complex decreasing-coefficient models and support the statement above on the utility of simple models.

Any comparison of decomposition rates reported in the literature is complicated by the inability to separate out variance in the data associated with between-study differences in experimental methodology (i.e., method effect) from the variance related to differences associated with environmental and physiological factors (Howard-Williams and Davies, 1979; Brock et al., 1982). A variety of different techniques have been used to measure decomposition. However, with a sufficiently large dataset, random biases due to method effect should largely cancel out. Chimney and Pietro (unpubl.) feel that the trends identified in the literature data reflect real differences in decomposition rates among individual species and groups of plants over a wide range of wetland habitats.

QA/QC

Standard QA/QC procedures for weighing materials in the laboratory and incorporation of replicates into field design would certainly be appropriate for these types of studies (Chimney, pers comm.).

C. Leaf Packs

This method involves fastening leaves together with plastic buttoners or monofilament fishing line (e.g. Petersen and Cummins, 1974; Benfield et al., 1977; Reice and Herbst, 1982; Mutch et al., 1983) and tethering it at a suitable position in the stream.

Pros and Cons

This method seems to be used mostly in streams, therefore it is uncertain whether it would work well in a wetland environment. Litter bags appear to be the preferred method according to what is available from the literature.

The method of pack construction determines the apparent rates of leaf breakdown and invertebrate colonization (reviewed by Webster and Benfield, 1986). In-stream mass loss from natural leaf accumulations is better approximated by leaf packs than by similarly sized mesh (litter) bags (Cummins et al., 1980), although the risk of losing large fragments of material is certainly greater with the former technique. Because leaf packs are very difficult to construct if the leaves are small or needle-like, mesh (litter) bags are the only method available for materials that cannot be readily tethered.

QA/QC for Both Litter Bags and Leaf Packs

When designing an experiment, methodological considerations such as leaf selection; leaf pre-treatment; leaf-pack or litter bag construction, mesh size, timing and placement, and measurement of environmental conditions should be considered.