The Importance of Leaf Demographic Data for Calculations of Annual Production by Sawgrass (*Cladium jamaicense*)

Verdon, Emilie and Childers, Daniel L.

Department of Biological Sciences

Florida International University Miami, FL 33199

Abstract

Net annual primary productivity (NAPP) is an important measure of ecosystem energetics, and its near-universality allows cross-comparison among a tremendous variety of ecosystems. As part of the FCE LTER Program, we are currently quantifying NAPP of sawgrass (*Cladium jamaicense*)—the dominant macrophyte in freshwater Everglades wetlands. A reliable estimation of mortality is critical to these measures of NAPP. We have been quantifying leaf turnover data to best estimate this mortality term by following the demographics of individual sawgrass leaves on select plants in Taylor Slough, the C-111 Panhandle region (Southern Everglades), and in Shark River Slough. All leaves were individually tagged as they emerged from the culm with small colored bands and counted bimonthly, allowing for each leaf to be tracked throughout its lifetime. From these data, we calculated new leaf production, leaf mortality (the key term for our NAPP models), and sloughing rates. New leaf production rates were significantly different across theses Southern Everglades sites, although mortality and loss rates were not. An average of one leaf was produced bimonthly, lived approximately 4.5 months, and remained on the plant for an additional 7.5 months until sloughing off. Leaf mortality rates were used in a multiple regression analysis in order to obtain an equation in which a mortality term can be calculated from turnover data at sites throughout the Southern Everglades.

Introduction:

Sawgrass (*Cladium jamaicense* Crantz) is the common and characteristic plant of the Everglades freshwater marsh ecosystem (Davis and Ogden 1994), covering 65-70% of the marsh in dense monospecific stands (Loveless 1959). This perennial sedge grows centripetally with a phyllotaxy of I/3 and as new leaves emerge, older leaves move to the outside. Leaf production, growth, and mortality continue throughout most of the plant's life span as its biomass increases and/or decreases (Davis 1989). However, little or no research has focused on the rates of leaf turnover on a small scale. This study intends to quantify leaf productivity, longevity, and sloughing rates (Figure 1: A, B, and C), which will provide an estimate of mortality, which is needed, along with biomass and turnover (Figure 1: I and II) data, in order to calculate net annual primary productivity (NAPP). An estimate of NAPP is important because the sawgrass community is among the most productive systems in the United States with an NAPP of 2991± 891 gdw $m^{-2}y^{-1}$ (Daoust and Childers 1998) that is attributed to *C. jamaicense* alone (Daoust and Childers 1999).

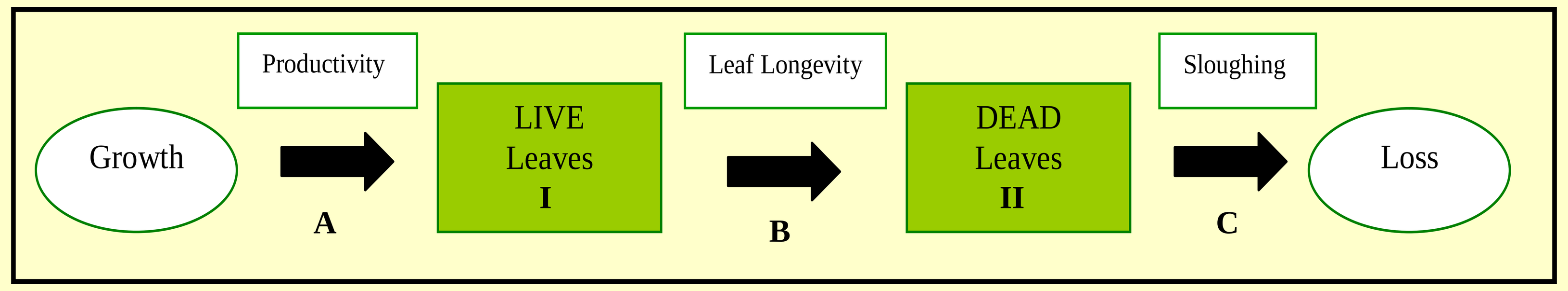

Figure 1. Box Model of Leaf Demographics (*Cladium jamaicense*).

Methods:

We calculated the mortality term of our NAPP model by following the demographics of individual leaves on select sawgrass plants in Taylor Slough (TS), the C-111 Canal area (from Aug 1999 to Jul 2002) and in Shark River Slough (SRS) (from Jan 2000 to Jul 2002). Three tagged turnover plants in each $1m^2$ plot at select sites were haphazardly selected (1 each small, medium, and large) and leaves were individually tagged with colored bird bands in a color series (Figure 2). Leaf age was determined by relative location on the culm. Each leaf was tagged according to its relative age, using this color series, allowing us to track each leaf throughout its lifetime. A leaf was determined to be "live" if there was any green color, and we measured the length of all live leaves plus the culm diameter at the base of the tagged plants. Leaf longevity was the time a leaf remained "live" after separating from the main stem, and sloughing rate was calculated from time a "dead" leaf remained on the plant (determined if a tagged leaf could not be located). We identified and tagged new leaves when they separated from the stem.

Figure 2. Colored bird bands were used to track individual sawgrass leaves throughout their lifetime.

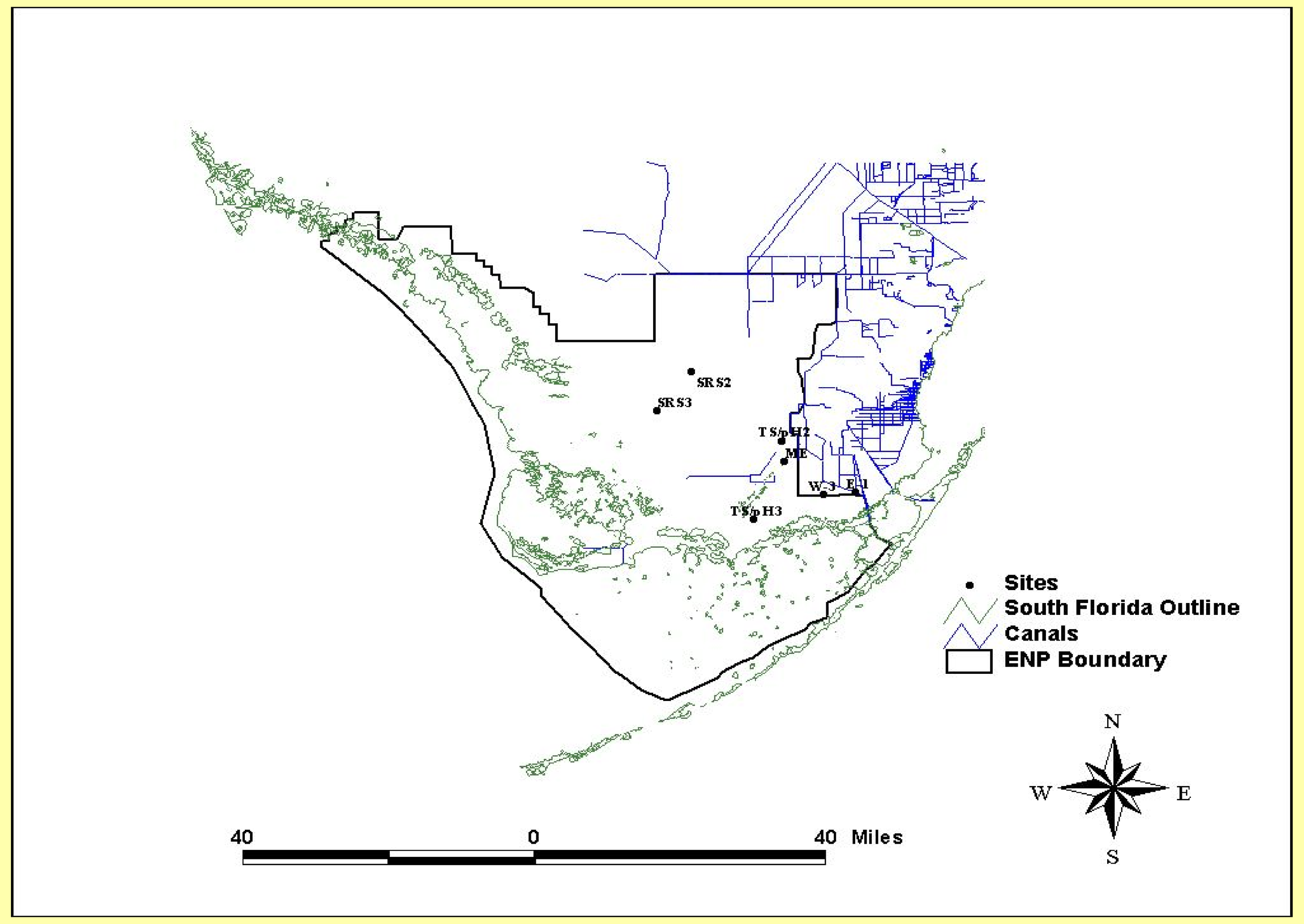

Figure 3. Study Area in the Florida Southern Everglades Region.

Study Area:

This study was conducted along the two major drainage basins of Everglades National Park (Taylor Slough (TS) and Shark River Slough (SRS)) in southern Florida (Figure 3), an area covered predominantly by sawgrass marshes, tree islands, wet prairies, and slough communities (Loveless 1959). It is an oligotrophic wetland system and water levels are typically provided by direct rainfall, rising and falling with the accompanying June-November rainy seasons and December-May dry seasons (Davis 1989). Two sample sites (E-1 and W-3), in an East-West direction, were located parallel to the C1-111 canal in the southeast Panhandle region. Three sample sites (TS/pH2, TS/pH3, and ME), in Taylor Slough Basin, were placed in a North-South direction. The remaining two sites were located along the Shark River Slough LTER transect (SRS2 and SRS3). Each sampling site contained established triplicate square meter plots of sawgrass; each containing ten individually tagged plants being used in turnover a study.

Results and Discussion:

New leaf production (Figure 1: A), mortality (Figure 1: B), and sloughing rates (Figure 1: C) were calculated for all seven sites, across all years, and an ANOVA was conducted to determine whether any of the sites differed. New leaf production rates were calculated by averaging the number of new leaves produced per month. The C-111 Basin had significantly lower leaf productivity rates than either Taylor Slough (p =0.0007) or Shark River Slough (p <0.0001) using Fisher's PSLD Post hoc Test. New sawgrass leaves are produced every 0.39 months in the C-111 Basin and every 0.52 months in Taylor and Shark River Sloughs (Figure 4). Leaf mortality or death rates (Figure 5) and sloughing or loss rates (Figure 6) were calculated for each month in the same way. Mortality and loss rates were not significantly different across the three basins. New leaf production, mortality, and sloughing rates were similar across the four years of the study.

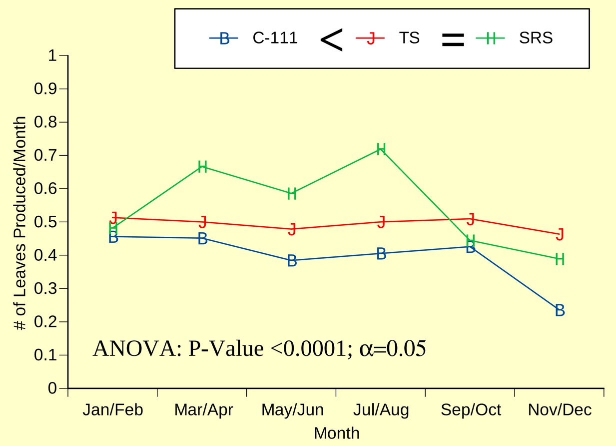

Figure 4. New Leaf Productivity. Average number of new leaves produced per month

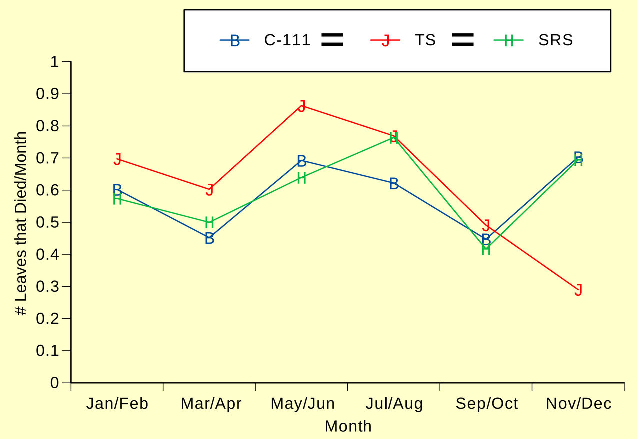

Figure 5. Leaf Mortality. Average number of leaves that died per month.

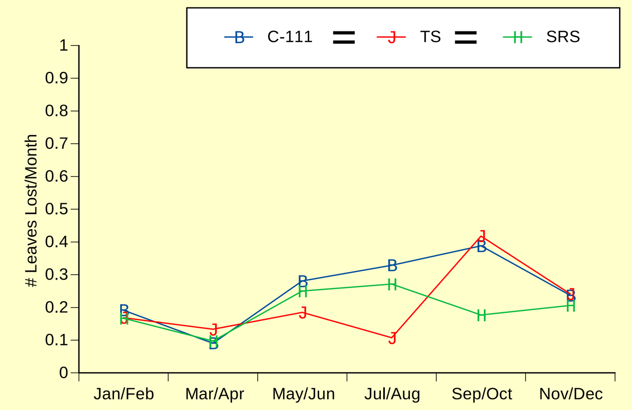

Figure 6. Leaf Loss. Average number of leaves lost per month.

The percentage of leaves that died from the previous sampling was used in a multiple regression analysis in addition with change of live and dead leaves (turnover data) in order obtain an equation in which a mortality term can be calculated from turnover data (Figure 1: I and II) at sites throughout the southern Everglades :

$$\% \text{ Mortality} = (\Delta \text{ in Dead})(0.059) - (\Delta \text{ in Live})(0.039) \quad n = 472; \text{P-value} < 0.0001; R^2 = 0.233$$

This % mortality term is then multiplied by total live biomass to calculate mortality (in gdw $m^{-2}mo^{-2}$), which in turn is used to calculate NAPP.

In addition, green leaf and dead leaf longevity rates were calculated from average leaf longevity of leaves (live or dead), or how long a leaf was alive or remained on the culm respectively. Leaf longevity rates in the C-111 Basin were significantly lower than TS (p = 0.0165) and SRS (p = 0.0013). On average, leaves died 4.36 months after separating from the culm in C-111 and every 4.83 months in Taylor and Shark River Sloughs (Figure 7). Dead Leaf longevity was determined from the length of time a leaf stayed attached to the culm after it had died. SRS data were not included because few (n = 15) leaves have sloughed off since January 2000. On average sawgrass leaves remained on the culm 7.66 months before sloughing off (Figure 8), there were no significant differences between Taylor Slough and C-111. Although, there are leaves at present on plants that have still not sloughed off and have been on the plant for over 32 months.

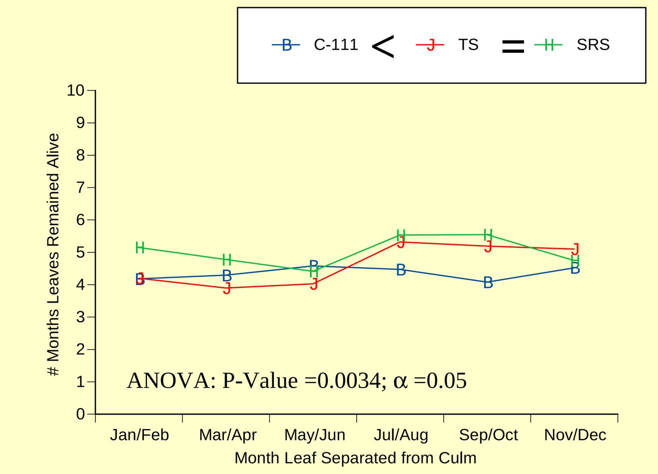

Figure 7. Green Leaf Longevity. The month a leaf separated from the culm determined its longevity.

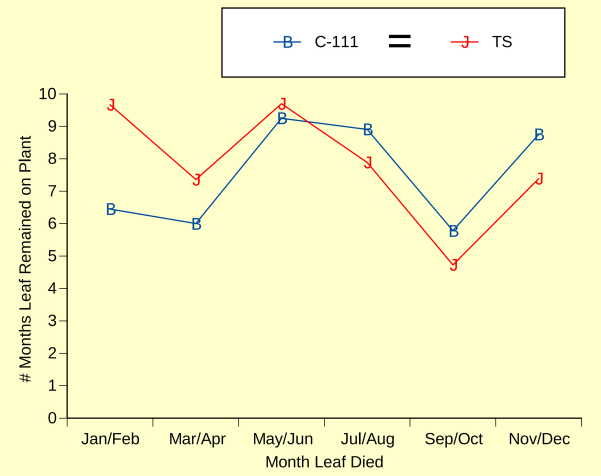

Figure 8. Dead Leaf Longevity. The month a leaf died determined how long the dead leaf remained attached to the culm.

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