



## Litter decomposition rates of two grass species along a semi-arid grassland–forest ecocline

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### ABSTRACT

The climatic controls on decomposition rates have gained considerable interest in recent years because of a perceived risk that elevated global temperatures could lead to positive green house gas feedbacks from soil ecosystems. Previous relationships between decomposition rates and abiotic variables like temperature and moisture have been proved confounding, particularly for dryland ecosystems. Decomposition rates of two grass species, *Pseudoroegneria spicata* (Pursh) Á. Löve and *Calamagrostis rubescens* Buckley, which represent dominant understory cover at either end of a semi-arid grassland to forest ecocline near Kamloops, British Columbia, Canada, were measured. Despite differences in %N and C:N, decomposition rates between the two species were similar. Elevation was strongly correlated with rate of decomposition for both species. We provide evidence of a positive correlation of water availability and a negative correlation of temperature on decomposition rates along the elevational ecocline. Decomposition rates were higher during the wetter spring period than during summer, at higher elevations and in more mesic ecosystems. We found no 'home-field' advantage for *P. spicata* and *C. rubescens* on decomposition rates. Our results provide evidence that available moisture is an important control on decomposition rates in dryland ecosystems.

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### 1. Introduction

Approximately ninety percent of plant growth falls directly to the soil where it becomes available for decomposition and soil building (Beare et al., 1995). Decomposition is critical to terrestrial carbon cycling, soil formation and plant nutrient availability (Berg and McClaugherty, 2008). The strong apparent linkage between decomposition and climate has led to concerns that climatic change could accelerate global decomposition rates and a positive feedback of green house gasses (GHGs) to the atmosphere (Cao and Woodward, 1998; Kirschbaum, 1995; Trumbore and Chadwick, 1996). However, no clear consensus regarding the relationship between climate change and changes in short-term carbon pools exists (Aerts, 2006; Berg and Laskowski, 2005; Giardina and Ryan, 2000; Kirschbaum, 2006).

Decomposition rates in arid and semi-arid ecosystems have been particularly difficult to explain using climatic data, and the rate of decomposition appears to be either unrelated or related to temperature and available moisture (See for example: Elking et al., 1982; Kirschbaum, 1995; Throop and Archer, 2009; Vanderbilt et al., 2008; Whitford et al., 1981). Photodegradation, other abiotic activities (e.g., wind action) and the activity of microarthropods have been used to explain the apparent lack of linkage between climate and decomposition rates in arid ecosystems (Austin and Vivanco, 2006; Couteaux et al., 1995; Gallo et al., 2009). Given the wide variability in both causal and correlative factors outlined by a multitude of decomposition studies, ecosystem-specific approaches may better explain controls on decomposition rates. For example, several researchers have indicated that litter species may decompose faster in their native ecosystems where their specialized saprotrophs exist (Ayres et al., 2009; Gholz et al., 2000). This phenomenon has been referred to as a "home-field advantage".

Increased understanding of the variables that govern decomposition in drylands will help to further elucidate whether global climatic change is likely to increase GHGs releases from these ecosystems and will help to provide a better understanding of the processes that control nutrient cycling and soil building.

Abbreviations: B.C., British Columbia; BG, Bunchgrass prairie; BW, Weight of the oven dry paper bag; C:N, Carbon:Nitrogen; DF, Douglas fir forest; GHG, Green house gasses; IW, Initial weight of sample; %M, Percent moisture; OVDW, Oven dry weight; T1, Time 1; T2, Time 2;  $\bar{x}\%M$ , Mean percent moisture.

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Climatically derived ecoclines present a convenient way to study potential shifts in climate by substituting shifts in time with shifts in space. This is particularly relevant since predicted shifts in ecosystem range due to climate change are expected to directly influence ecoclines (Hamann and Wang, 2006). Our study used a climatically derived ecocline that transitioned from grassland to forest, rose over nearly 700 m in elevation and crossed three distinct plant community types along a gradient in increasing available moisture and decreased temperature. The overall objective of this study was to determine how decomposition rates of two grass species *Pseudoroegneria spicata* (Pursh) Á. Löve and *Calamagrostis rubescens* Buckley, that represent dominant understory cover at either end of the ecocline used, vary according to elevation and plant community, co-variates of climate.

We set out to test three hypotheses: (1) The species with a lower leaf C:N content or higher %N will have a higher rate of decomposition (2) Decomposition rates will be positively correlated with elevation due to the fact that high elevation sites are wetter and cooler; and (3) Decomposition rates of *C. rubescens* and *P. spicata* will be greater in the ecosystems in which they are distributed; in other words, there will be a “home-field advantage”.

## 2. Materials and methods

The study was conducted in the Dewdrop Range near Kamloops, British Columbia (B.C.), Canada. Slopes from the valley bottom in the Dewdrop Range lead to a clear altitudinal gradation in plant community types and a rapid grassland-to-forest ecocline. Across this ecocline, a transect was created from 50° 45.323' N; 120° 37.433' W to 50° 46.967' N; 120° 36.427' W, and decomposition plots were established every 100 m ( $n = 34$ ) using a Trimble GeoXM global positioning system. We utilized the methods described by Lloyd et al. (1990), which categorize the plant communities in the Kamloops region using indicator species and physiographic variables (soil depth, slope angle, slope position, slope shape, elevation) and establishes 1955–1985 climate normals for each major community type. Ecosystem types along the transect ranged from lower elevation semi-arid bunchgrass (BG) prairie characterized by the absence of tree cover, to ponderosa pine (PP) savannah and temperate Douglas fir (DF) forest (Table 1).

Litter materials were collected 20 days prior to field deployment from within 7 km of the transect, from plots dominated by *P. spicata* (plot centered on 50° 45.792 N; 120° 37.462 W) or *C. rubescens* (plot centered on 50° 45.745 N; 120° 31.532). Senesced but still standing litter materials from the previous growing season was cut approximately 15 cm above the soil surface to avoid crown material and tillers that had been matted to the ground. Litter materials were allowed to air-dry indoors at approximately 22 °C. Then 3.0000 g ( $\pm 0.0200$  g) of *P. spicata* or *C. rubescens* was placed in a 10 cm  $\times$  10 cm pre-made litter bag of 1 mm hole size geotextile fabric. On April 22, 2009, immediately after the transect was free of snow cover, two litter bags of *P. spicata* and two of *C. rubescens* were deployed at each plot by pinning bags to the surface, on top of existing litter. An additional 12 bags of each species were reserved for determination of litter moisture content before field

deployment (as described below). As well, six samples of each litter species were reserved for determination of C:N values. After oven drying, approx 5.0 mg ( $\pm 0.5$  mg) from each sample was ground in a standard coffee grinder, placed into a pre-weighed aluminum autosampler vial, reweighed to the nearest mg, and analyzed for %C, %H and %N in a CE-440 elemental analyzer (Exeter Analytical, Inc.) using lysine as a calibration substance.

On June 21, 2009 ( $T = 1$ ), one litter bag of each species was collected from each plot. On August 30, 2009 ( $T = 2$ ), the two remaining bags (one of each species) were collected from each plot. Collected decomposition bags were placed in individual zip lock bags, brought to the lab and processed within 48 h. Processing involved cutting open the litter bags, emptying litter materials into a Petri dish and removing any obvious contaminants (e.g., mineral soil or insects) under a hand lens. Cleaned litter materials were placed into an oven-dry, pre-weighed paper bag and weighed on an analytical balance to the nearest 0.1 mg to determine wet weight. Processed litter materials were then placed in a drying oven at 60 °C for at least three days. Dry litter materials were then reweighed to determine dry weight.

Percent moisture (%M) was determined using the following formula:  $100[(WW - BW) - (OVDW - BW)] / (OVDW - BW)$ . Percent change in mass (% $\Delta$ ) was calculated as:  $100(1 - IW) / (WW - BW) - \bar{x}\%M$ . Where OVDW is the oven dry weight of the sample, WW is the pre-oven dry weight of the sample, BW is the weight of the oven dry paper bag used for sample storage, IW is the initial weight of the sample before litter bag construction, and  $\bar{x}\%M$  is the mean percent moisture of litter bags reserved for determination of pre-field moisture content for that particular litter species. Percent change in mass per day was determined by dividing % $\Delta$  by the number of days the sample was in the field.

Two unpaired two sample *t*-tests were done to test differences in leaf C:N and %N values between *P. spicata* and *C. rubescens*. Three linear regressions were applied to test the effect of (1) elevation on decomposition rates by species and by time; (2) elevation on percent moisture of litter bags by species and by time; and (3) percent moisture of litter bags on decomposition rates by species and by time. Two paired two sample *t*-tests were done to determine differences in decomposition rates between *P. spicata* and *C. rubescens*, and between sampling periods T1 and T2. To test the “home field advantage” hypothesis, a factorial 3-way ANOVA including ecosystem type, plant species, and time was applied to determine main and interacting effects on daily decomposition rates. All statistical analyses were performed in “R” (v2.11.1) (R Development Core Team, 2010). Statistical tests were performed on arcsine transformed data to satisfy the assumption that the data were normally distributed, but all values reported and graphed below are actual daily decomposition rates, not transformed values.

## 3. Results

Before deployment in the field, *C. rubescens* had a mean C:N value of  $72.89 \pm 9.43$  (mean  $\pm$  STD) and a N concentration of  $0.51 \pm 0.05$  g/kg; whereas, *P. spicata* had a C:N value of  $57.79 \pm 9.07$  and a N concentration of  $0.68 \pm 0.13$  g/kg. An unpaired two sample

**Table 1**  
Number of plots, elevation ranges and 1955–1985 temperature and precipitation normals across the three ecosystems used in this study. Temperature and precipitation data from Lloyd et al. (1990). Note that, a single Douglas fir (DF) plot occurred in a gully at the bottom of the transect and that otherwise bunchgrass (BG), ponderosa pine (PP) and DF sites occurred in strict elevational sequence.

Ecosystem	Elevation (m ASL)	Number of plots	Annual precipitation (mm)	Annual temperature (°C)	Dominant understory plant
BG	631–675	7	285 (160–458)	7.9 (4.4–10.0)	<i>P. spicata</i>
PP	681–1013	15	335 (258–391)	7.8 (5.4–9.4)	<i>P. spicata</i>
DF	585–1277	12	476 (295–843)	5.0 (2.5–7.9)	<i>C. rubescens</i>

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