Walker Branch Watershed: Temperature Response of Organic-Matter Decomposition in a Headwater Stream

ORNL TERRESTRIAL ECOSYSTEM SCIENCE
SCIENTIFIC FOCUS AREA
Walker Branch Watershed

Summary:

This data set reports the results of a field study investigating the effect of temperature on organic-matter decomposition in the West Fork of Walker Branch (Figure 1), a headwater stream on the Oak Ridge Reservation in east Tennessee. The West Fork is a spring-fed headwater stream and the spring inputs create a natural longitudinal temperature gradient. In winter, the upstream sites near the springs are warmer due to the spring input. In summer, the temperature gradient reverses and the upstream sites are cooler. One experiment examined the decomposition of senesced leaves from 3 tree species (red maple [*Acer rubrum*], tulip poplar [*Liriodendron tulipifera*], and white oak [*Quercus alba*]) along the temperature gradient in winter (December 2011 – March 2012). The second experiment examined the breakdown of cotton strips, a substrate of consistent quality (95% cellulose), along the temperature gradient with approximately month-long incubations over ~2 years (August 2011 to October 2013).

Environmental Data:
- Environmental measurements included stream water temperature, stream water chemistry (nitrate, ammonium, soluble reactive phosphorus concentrations), and stream discharge.

Leaf-litter Decomposition Data:
- Measurements included mass loss, leaf-litter breakdown rate, microbial respiration, and invertebrate abundance and density.

Cotton-strip Decomposition Data:
- Measurements included tensile loss of cotton strips after approximately 35 day-long incubation periods.

Figure 1 – The West Fork of Walker Branch Watershed in autumn.

Data Citation:

Cite this data set as follows:

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Acknowledgement of Sponsor for the ORNL Terrestrial Ecosystem Science - Scientific Focus Area (TES SFA):

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Data and Documentation Access:

For public access to WBW data please visit the ORNL TES-SFA Web Site: http://tes-sfa.ornl.gov/

Description and Links to Supplemental Information: Paper in *Freshwater Science* describes the WBW organic-matter decomposition methods and results (Griffiths and Tiegs, 2016).

Walker Branch Watershed website: http://walkerbranch.ornl.gov

Data Policy - Sharing, Access, and Use Recommendations: ORNL TES-SFA Data Policy - Data Policy and Fair-Use Statement

Related Data Sets: Historical precipitation, stream discharge, and stream chemistry data are available at http://walkerbranch.ornl.gov/data.shtml

Walker Branch Watershed (WBW) Project Description:

Walker Branch Watershed (WBW) is a forested watershed on the Oak Ridge Reservation and has been the site of long-term environmental research since the 1960s. Hydrological, biogeochemical, and ecological studies in WBW have made important contributions to our understanding of the effects of changes in atmospheric deposition and climate variability and change in this region (see http://walkerbranch.ornl.gov/publications.shtml for complete list of publications).
Objectives of the WBW long-term observations have been to:

1. Quantify responses of an eastern upland oak forest ecosystem to inter-annual and long-term variations in climate and atmospheric deposition of sulfur and nitrogen, and
2. Provide integrated, long-term data on climate, forest vegetation, soil chemistry, and hydrologic and chemical fluxes at the catchment scale to support other focused research projects on the Oak Ridge Reservation and elsewhere in the region.

DOE-BER funded WBW research is being phased out, and long-term monitoring of WBW will continue through the National Ecological Observatory Network (NEON; http://www.neoninc.org/). This experiment on organic-matter decomposition is one of several studies focused on understanding biogeochemical dynamics at the terrestrial-aquatic interface.

Table of Contents:

1. Data Set Overview:

This data set reports the results of an experiment examining the effect of temperature on organic-matter decomposition in the West Fork of Walker Branch. Two experiments were carried out.

- The first examined the decomposition of senesced leaves from 3 tree species (red maple [*Acer rubrum*], tulip poplar [*Liriodendron tulipifera*], and white oak [*Quercus alba*]) along a longitudinal (downstream) temperature gradient in winter (December 2011 – March 2012). Mass loss, breakdown rate, microbial respiration, and invertebrate abundance and density were measured on 4 dates over the 90-day study.

- The second experiment examined the breakdown of cotton strips, a substrate of consistent quality (95% cellulose), along the temperature gradient monthly for ~2 years. Tensile strength loss was measured every approximately 35 days for ~2 years (August 2011 to October 2013).

2. Data Characteristics:

Spatial Coverage:

The research was conducted in the West Fork of Walker Branch. There are 4 perennial springs that discharge to the West Fork of Walker Branch: two main springs form the headwaters (S4 and S5), and two main springs discharge approximately 160 m downstream (S3 and S3A). The West Fork is approximately 300 m in length from the headwaters to the location where the East and West Forks meet.

The organic-matter decomposition experiment took place along a 152-m long reach, with the first sampling site located 10 m downstream of the S3 spring.

The site locations, with the distances in meters downstream from the largest spring (S3) were: site 1 = 10 m, site 2 = 29 m, site 3 = 46 m, site 4 = 75 m, site 5 = 103 m, site 6 = 133 m, site 7 = 162 m (Figure 2).

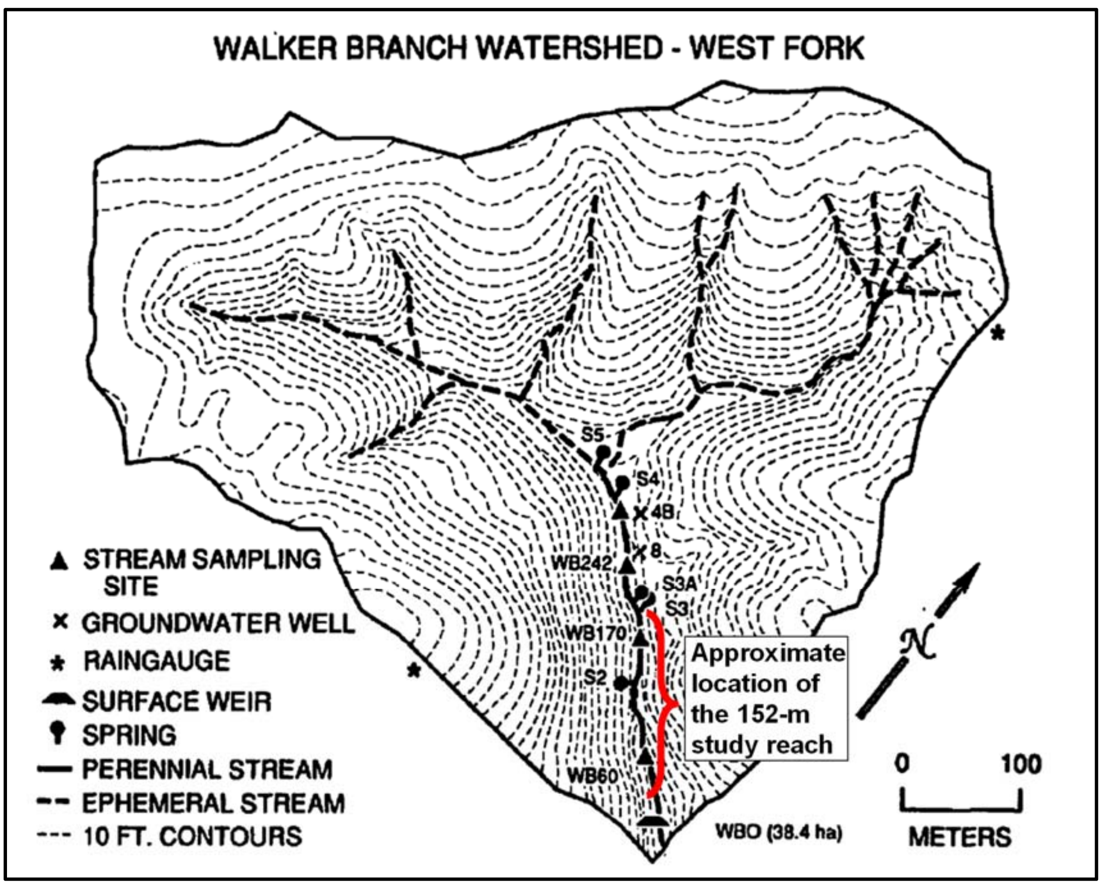

Figure 2 – Map of the West Fork of Walker Branch with the approximate location of the 152-m study reach shown. Map is from Genereux et al. 1993.

Site boundaries: Latitude and longitude given in decimal degrees. Source Google Earth.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Elevation (meters amsl)	Geodetic Datum
West Fork of Walker Branch Watershed	- 84.27981	- 84.27858	35.96071	35.95949	265	WGS84

Temporal Coverage:

Environmental Data

- Water temperature was measured every hour beginning on August 1, 2011 and ending on October 1, 2013. Water temperature was measured at the S3 spring beginning on December 16, 2011.
- Stream discharge was measured at the weir every 15 minutes as part of the long-term monitoring project. Data are reported as mean discharge during each cotton-strip incubation period, beginning on August 10, 2011, and ending on October 1, 2013.
- Water chemistry samples were collected at one downstream sampling location weekly as part of the long-term monitoring project. Data were reported as mean concentrations during each cotton-strip incubation period, beginning on August 10, 2011, and ending on October 1, 2013. Water chemistry samples were also collected at each leaf-litter decomposition site on 2 dates (February 8, 2012, and March 14, 2012).

Leaf-litter Decomposition

- The leaf-litter decomposition experiment lasted for 90 days, with the deployment of litterbags on December 15, 2011 and the final pick up of litterbags on March 14, 2012. There were 4 retrieval dates throughout the 90-day experiment (December 20, 2011 [day 5], January 10, 2012 [day 26], February 8, 2012 [day 55], and March 14, 2012 [day 90]).

Cotton Strip Incubation

- Sets of cotton strips were placed in the stream and incubated for approximately 35 days for just over 2 years. There were 22 deployments of cotton strips from August 10, 2011 to October 1, 2013.

Time period: The data set covers the period from August 2011 to October 2013.

Data File Description:

All of the data are contained in 6 comma separated (*.csv) files. Missing values are represented by -9999.

Environmental Data:
- File #1: WBW_decomp_site_water_temp.csv
- File #2: WBW_decomp_site_water_chem.csv
- File #3: WBW_cotton_strip_dates_water_chem_discharge.csv

Leaf-litter Decomposition Data:
- File #4: WBW_leaf_litter_decomp_rate.csv
- File #5: WBW_leaf_litter_decomp_mass_loss_resp_inverts.csv

Cotton-strip Decomposition Data:
- File #6: WBW_cotton_strip_tensile_loss.csv

Data Dictionary:

Environmental Data

File #1: WBW_decomp_site_water_temp.csv

Column	Column Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	SEASON		Season (winter, spring, summer, autumn) is defined by equinoxes and solstices.	
3	S3_SPRING_TEMP	°C	Mean daily temperature of the S3 spring.	Temperature logger: TidbiT v2, Onset Computer Corporation, accuracy = 0.2ºC. Same for all temperature measurements.
4	S3_SPRING_DIEL_TEMP	°C	Diel temperature range of the S3 spring calculated as the maximum minus minimum hourly temperatures measured that day. Same for all diel temperature ranges.	
5	SITE_1_TEMP	°C	Mean daily temperature at site 1.	
6	SITE_1_DIEL_TEMP	°C	Diel temperature range at site 1.	
7	SITE_2_TEMP	°C	Mean daily temperature at site 2.	
8	SITE_2_DIEL_TEMP	°C	Diel temperature range at site 2.	
9	SITE_3_TEMP	°C	Mean daily temperature at site 3.	
10	SITE_3_DIEL_TEMP	°C	Diel temperature range at site 3.	
11	SITE_4_TEMP	°C	Mean daily temperature at site 4.	
12	SITE_4_DIEL_TEMP	°C	Diel temperature range at site 4.	
13	SITE_5_TEMP	°C	Mean daily temperature at site 5.	
14	SITE_5_DIEL_TEMP	°C	Diel temperature range at site 5.	
15	SITE_6_TEMP	°C	Mean daily temperature at site 6.	

16	SITE_6_DIEL_TEMP	°C	Diel temperature range at site 6.	
17	SITE_7_TEMP	°C	Mean daily temperature at site 7.	
18	SITE_7_DIEL_TEMP	°C	Diel temperature range at site 7.	
Site locations, with the distances in meters downstream from the largest spring (S3): site 1 = 10 m, site 2 = 29 m, site 3 = 46 m, site 4 = 75 m, site 5 = 103 m, site 6 = 133 m, site 7 = 162 m. Missing values are designated as -9999.				

Example Data Records:

```
DATE,SEASON,S3_SPRING_TEMP,S3_SPRING_DIEL_TEMP,SITE_1_TEMP,SITE_1_DIEL_TEMP,SITE_2_TE
MP,
SITE_2_DIEL_TEMP,SITE_3_TEMP,SITE_3_DIEL_TEMP,SITE_4_TEMP,SITE_4_DIEL_TEMP,SITE_5_TEMP,
SITE_5_DIEL_TEMP,SITE_6_TEMP,SITE_6_DIEL_TEMP,SITE_7_TEMP,SITE_7_DIEL_TEMP
20110801,summer,-9999,-9999,16.4,1.1,16.3,1,16.5,1.1,16.7,1.5,17.2,1.8,17.8,2,18.1,2.1
20110802,summer,-9999,-9999,16.3,1.1,16.2,1,16.4,1.1,16.6,1.5,17,1.7,17.5,2,17.8,2.2
20110803,summer,-9999,-9999,16.2,0.7,16.1,0.9,16.3,1,16.5,1.3,17,1.6,17.5,2,17.8,2.1
20110804,summer,-9999,-9999,16.6,2.1,16.4,1.5,16.6,1.3,16.8,1.2,17.2,1.4,17.8,1.5,18.1,1.4
20110805,summer,-9999,-9999,16.3,0.7,16.2,0.9,16.4,1,16.6,1.5,17.1,1.6,17.6,1.9,17.9,2
….
20130927,autumn,14.4,0.1,15.1,0.7,15.2,0.8,15.3,1.1,15,1.1,15.3,1.1,15.5,1.5,15.6,1.5
20130928,autumn,14.4,0,15,0.5,15.1,0.6,15.2,0.8,14.9,0.8,15.2,0.8,15.4,1.1,15.6,1.1
20130929,autumn,14.4,0,15,0.4,15.1,0.5,15.2,0.6,14.9,0.6,15.2,0.6,15.3,0.9,15.5,0.9
20130930,autumn,14.4,0.2,14.9,0.7,14.9,0.7,15,1,14.7,0.9,15,1,15.1,1.3,15.2,1.4
20131001,autumn,14.4,0.1,15,0.8,15,0.9,15.2,1.1,14.8,1.1,15.1,1.1,15.3,1.5,15.4,1.6
```

File #2: WBW_decomp_site_water_chem.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	SITE		Site number (1, 3, 5, 6, or 7).	
3	DISTANCE	m	Distance of each site (in meters downstream) from the largest (S3) spring.	Meter tape. Distance is to the nearest meter.
4	REP		Replicate. Three (3) replicate water samples were collected per site for analysis of ammonium, nitrate, and soluble reactive phosphorus.	
5	NH4_N_CONC	µg NH4-N/L	Ammonium concentration expressed as N in stream water.	Ammonium-N concentrations were measured using the phenol-hypochlorite method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported. Users may choose to remove values below the DL.

6	NO3_N_CONC	µg NO3-N/L	Nitrate concentration expressed as N in stream water.	Nitrate-N concentrations were measured using the cadmium reduction method. Detection limit is 2.0 µg N/L. Concentrations below the detection limit (DL) are reported. Users may choose to remove values below the DL.
7	SRP_CONC	µg P/L	Soluble reactive phosphorus (SRP) concentration in stream water.	Soluble reactive phosphorus (SRP) concentrations were measured using the molybdate-antimony method. Detection limit is 2.0 µg P/L. Concentrations below the detection limit (DL) are reported. Users may choose to remove values below the DL.
Site locations, with the distances in meters downstream from the largest spring (S3): site 1 = 10 m, site 3 = 46 m, site 5 = 103 m, site 6 = 133 m, site 7 = 162 m. Missing values are designated as -9999. Historical water chemistry data are available at: http://walkerbranch.ornl.gov/				

Example Data Records:

```
DATE,SITE,DISTANCE,REP,NH4_N_CONC,NO3_N_CONC,SRP_CONC
20120208,1,10,1,-9999,-9999,-9999
20120208,1,10,2,1.9,12.6,1.3
20120208,1,10,3,1.5,14,3
20120208,3,46,1,1.7,11.6,2.8
20120208,3,46,2,2.4,13,3.2
….
20120314,6,133,2,4.4,6.5,1.8
20120314,6,133,3,5.8,6.2,2.3
20120314,7,162,1,5.4,6.5,4.3
20120314,7,162,2,5.1,6.1,1.7
20120314,7,162,3,7.4,6.4,2
```

File #3: WBW_cotton_strip_dates_water_chem_discharge.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DEPLOY_DATE	YYYYMMDD	Date each set of cotton strips were deployed.	
2	PICKUP_DATE	YYYYMMDD	Date each set of cotton strips were retrieved.	
2	NH4_N_CONC	µg N/L	Mean ammonium concentration for each 35-day cotton-strip deployment period. One water sample was collected approximately weekly just upstream of site 7. This is the location where the samples from the historical water chemistry dataset were collected.	Ammonium-N concentrations were measured using the phenol-hypochlorite method. Detection limit (DL) is 2.0 µg N/L. Concentrations below the detection limit are reported. Users may choose to remove values below the DL.

3	NO3_N_CONC	µg N/L	Mean nitrate concentration for each 35-day cotton-strip deployment period. One water sample was collected approximately weekly just upstream of site 7. This is the location where the samples from the historical water chemistry dataset were collected.	Nitrate-N concentrations were measured using the cadmium reduction method. Detection limit is 2.0 µg N/L. Concentrations below the detection limit (DL) are reported. Users may choose to remove values below the DL.
4	SRP_CONC	µg P/L	Mean soluble reactive phosphorus (SRP) concentration for each 35-day cotton-strip deployment period. One water sample was collected approximately weekly just upstream of site 7. This is the location where the samples from the historical water chemistry dataset were collected.	Soluble reactive phosphorus (SRP) concentrations were measured using the molybdate-antimony method. Detection limit is 2.0 µg P/L. Concentrations below the detection limit (DL) are reported. Users may choose to remove values below the DL.
5	DISCHARGE	L/s	Mean daily stream discharge for each ~35-day cotton-strip deployment period.	Stream water discharge was measured at a v-notch weir every 15 min.
Historical water chemistry data are available at: http://walkerbranch.ornl.gov/				

Example Data Records:

```
DEPLOY_DATE,PICKUP_DATE,NH4_N_CONC,NO3_N_CONC,SRP_CONC,DISCHARGE
20110810,20110914,5.4,37.2,3.6,8.7
20110914,20111019,7,18.4,3.4,6.4
20111019,20111122,9.7,13.4,1.8,10.5
20111122,20120105,6.6,20.7,0.8,33.5
20120105,20120210,6.1,12.2,0.9,31.6
….
20130416,20130524,6,2.9,2.1,28
20130524,20130621,5.2,10.9,3.2,9.8
20130621,20130723,4.7,27.6,3.3,18.2
20130723,20130826,3.6,25.1,4,7.5
20130826,20131001,3,14.3,3.8,6.2
```

Leaf-litter Decomposition Data

File #4: WBW_leaf_litter_decomp_rate.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	LITTER_TYPE		Leaf-litter type used in the decomposition experiment. Litter types are 'maple' (red maple; *Acer rubrum*), 'poplar' (tulip poplar; *Liriodendron tulipifera*), and 'oak' (white oak; *Quercus alba*).	
2	SITE		Site number (1, 3, 5, 6, or 7).	
3	DISTANCE	m	Distance of each site (in meters downstream) from the largest (S3) spring.	Meter tape. Distance is to the nearest meter.

4	BREAKOWN_RATE	/day	Breakdown rate (k) calculated as the slope of the natural log of ash free dry mass (AFDM) remaining over time for each litter type in each site along the downstream temperature gradient.	Litterbag technique (Benfield 2006).
5	BREAKDOWN_RATE_SE	/day	Standard error of breakdown rate.	Standard error from the regression of the natural log of AFDM remaining over time.
6	BREAKDOWN_RATE_DEGREE_DAY	/degree day	Breakdown rate (k) calculated as the slope of the natural log of AFDM remaining vs degree day for each litter type in each site along the downstream temperature gradient.	Litterbag technique (Benfield 2006).
7	BREAKDOWN_RATE_DEGREE_DAY_SE	/degree day	Standard error of breakdown rate.	Standard error from the regression of the natural log of AFDM remaining over time.
8	SAMPLE_SIZE		Number of litterbags used to calculate each breakdown rate.	

Site locations, with the distances in meters downstream from the largest spring (S3): site 1 = 10 m, site 3 = 46 m, site 5 = 103 m, site 6 = 133 m, site 7 = 162 m.

There are no missing values.

Example Data Records:

```
LITTER_TYPE,SITE,DISTANCE,BREAKOWN_RATE,BREAKDOWN_RATE_SE,BREAKDOWN_RATE_DEGREE_DAY,BREAKDOWN_RATE_DEGREE_DAY_SE,SAMPLE_SIZE
maple,1,10,0.0452,0.0029,0.0038,0.0002,14
maple,3,46,0.0431,0.0021,0.0037,0.0002,15
maple,5,103,0.0291,0.0018,0.0025,0.0001,15
maple,6,133,0.0311,0.0023,0.0027,0.0002,15
maple,7,162,0.0312,0.0013,0.0027,0.0001,15
poplar,1,10,0.0376,0.0034,0.0031,0.0003,15
….
oak,5,103,0.0101,0.0004,0.0009,0.00003,15
oak,6,133,0.011,0.0005,0.001,0.00004,7
oak,7,162,0.0107,0.0006,0.0009,0.0001,15
```

File #5: WBW_leaf_litter_decomp_mass_loss_resp_inverts.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DATE	YYYYMMDD	Measurement date.	
2	DAYS	Days	Number of days the litterbag was in the stream before being retrieved and contents analyzed (day 5, 26, 55, or 90).	
3	LITTER_TYPE		Leaf-litter type used in the decomposition experiment. Litter types are 'maple' (red maple; *Acer rubrum*), 'poplar' (tulip poplar; *Liriodendron tulipifera*), and 'oak' (white oak; *Quercus alba*).	
4	SITE		Site number (1, 3, 5, 6, or 7).	

5	DISTANCE	m	Distance of each site (in meters downstream) from the largest (S3) spring.	Meter tape. Distance is to the nearest meter.
6	REP		Replicate. Three (3) replicate litterbags were retrieved from each site on each pick up date.	
7	INITIAL_AFDM	g AFDM	Initial ash free dry mass (AFDM) of the 3 replicate litterbags per litter type that were brought to the field and retrieved on the same day to assess breakage due to handling and provide the time zero (initial) AFDM for litter in the litterbags..	Dry mass of the litter was measured after the material was dried at 60ºC for 48 hours. A subsample was combusted at 500ºC for 4 hours, and the difference in mass was used to calculate ash free dry mass (AFDM).
8	FINAL_AFDM	g AFDM	Final AFDM of the litter in the litterbags after retrieval.	Dry mass of the litter was measured after the material was dried at 60ºC for 48 hours. A subsample was combusted at 500ºC for 4 hours, and the difference in mass was used to calculate AFDM.
9	AFDM_REMAIN	%	Percent AFDM of litter remaining in the litterbags after retrieval.	The percentage of AFDM remaining was calculated as the final mass divided by the initial mass multiplied by 100.
10	RESP	mg O2 consumed/g AFDM/h	Microbial respiration measured on a 0.1 g dry mass subsample of leaf litter.	Litter was placed into a 60 mL amber polypropylene tube filled with stream water and incubated in the stream at each site for 3 h. The change in dissolved oxygen from the beginning to the end of the 3 hr incubation period was used to calculate microbial respiration. Dissolved oxygen was measured using a hand-held dissolved oxygen sensor (YSI ProODO).
11	INVERT_ABUNDANCE	# individuals/litterbag	Number of invertebrates (excluding snails) counted on each litterbag.	Invertebrates were washed from litterbags over 1-mm and 500-µm sieves, and collected and stored in 80% ethanol prior to numeration.
12	INVERT_DENSITY	# individuals/g AFDM leaf litter remaining	Invertebrate density (excluding snails) calculated as invertebrate abundance divided by the mass (as g AFDM) of leaf litter remaining on that collection date.	Invertebrates were washed from litterbags over 1-mm and 500-µm sieves, and collected and stored in 80% ethanol prior to numeration.
13	ELIMIA_ABUNDANCE	# individuals/litterbag	Number of snails (*Elimia clavaeformis*) counted on each litterbag.	Snails were washed from litterbags over 1-mm and 500-µm sieves, and collected and stored in 80% ethanol prior to numeration.
14	ELIMIA_DENSITY	# individuals/g AFDM leaf litter remaining	Snail (*Elimia clavaeformis*) density calculated as snail abundance divided by the mass (as g AFDM) of leaf litter remaining on that collection date.	Snails were washed from litterbags over 1-mm and 500-µm sieves, and collected and stored in 80% ethanol prior to numeration.

Site locations, with the distances in meters downstream from the largest spring (S3): site 1 = 10 m, site 3 = 46 m, site 5 = 103 m, site 6 = 133 m, site 7 = 162 m.

Missing values are designated as -9999.

Example Data Records:

```
DATE,DAYS,LITTER_TYPE,SITE,DISTANCE,REP,INITIAL_AFDM,FINAL_AFDM,AFDM_REMAIN,RESP,INVERT_ABUNDANCE,INVERT_DENSITY,ELIMIA_ABUNDANCE,ELIMIA_DENSITY
20111220,5,maple,1,10,1,10.7,8.32,77.7,0.3,3,0.4,32,3.8
20111220,5,maple,1,10,2,10.7,8.72,81.5,0.24,6,0.7,50,5.7
20111220,5,maple,1,10,3,10.7,8.43,78.7,0.21,6,0.7,35,4.2
20111220,5,maple,3,46,1,10.7,8.45,79,0.28,6,0.7,54,6.4
20111220,5,maple,3,46,2,10.7,8.49,79.3,0.44,17,2,38,4.5
….
20120314,90,poplar,6,133,2,10.28,1.68,16.4,0.24,22,13.1,48,28.5
20120314,90,poplar,6,133,3,10.28,2.37,23.1,0.23,47,19.8,21,8.9
20120314,90,poplar,7,162,1,10.28,1.37,13.3,0.22,62,45.4,11,8.1
20120314,90,poplar,7,162,2,10.28,0.63,6.2,0.3,29,45.7,32,50.4
20120314,90,poplar,7,162,3,10.28,1.43,13.9,0.22,23,16.1,42,29.4
```

Cotton-strip Decomposition Data

File #6: WBW_cotton_strip_tensile_loss.csv

Column	Heading	Units/ Format	Description	Measurement Method
1	DEPLOYMENT_DATE	YYYYMMDD	Date cotton strips were deployed in the stream.	
2	PICKUP_DATE	YYYYMMDD	Date cotton strips were retrieved from the stream.	
3	SEASON		Season (winter, spring, summer, autumn) as defined by equinoxes and solstices.	
4	DAYS	Days	Number of days the cotton strips were in the stream before being retrieved and analyzed for tensile loss.	
5	SITE		Site number (1, 2, 3, 4, 5, 6, or 7).	
6	DISTANCE	m	Distance of each site (in meters downstream) from the largest (S3) spring.	Meter tape. Distance is to the nearest meter.
7	REP		Replicate. Three (3) replicate cotton strips were deployed at each site on each date.	
8	TENSILE_LOSS	% tensile loss/day	Cotton-strip tensile loss per day.	Cotton strip assay (Tiegs et al. 2013).
9	TENSILE_LOSS_DEGREE_DAY	% tensile loss/degree day	Cotton-strip tensile loss per degree day.	Cotton strip assay (Tiegs et al. 2013).

Site locations, with the distances in meters downstream from the largest spring (S3): site 1 = 10 m, site 2 = 29 m, site 3 = 46 m, site 4 = 75 m, site 5 = 103 m, site 6 = 133 m, site 7 = 162 m.

There are no missing values.

Example Data Records:

```
DEPLOYMENT_DATE,PICKUP_DATE,SEASON,DAYS,SITE,DISTANCE,REP,TENSILE_LOSS,TENSILE_LOSS_DEGREE_DAY
20110810,20110914,summer,35,1,10,1,1.95,0.12
20110810,20110914,summer,35,1,10,2,2.18,0.13
20110810,20110914,summer,35,1,10,3,2.11,0.13
20110810,20110914,summer,35,2,29,1,2.5,0.15
20110810,20110914,summer,35,2,29,2,2.67,0.16
….
20130826,20131001,summer,36,6,133,2,2.21,0.13
20130826,20131001,summer,36,6,133,3,2.28,0.14
20130826,20131001,summer,36,7,162,1,1.34,0.08
20130826,20131001,summer,36,7,162,2,1.02,0.06
20130826,20131001,summer,36,7,162,3,1.52,0.09
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3. Data Application and Derivation:

The goal of this project was to evaluate the effect of temperature on organic-matter decomposition in a stream ecosystem to better understand how carbon dynamics across terrestrial-aquatic carbon interfaces may change with warming. A manuscript published in *Freshwater Science* describes the WBW organic-matter decomposition methods and results (Griffiths and Tiegs, 2016).

4. Quality Assessment:

These data are considered at Level 2. Level 2 indicates that, in addition to the Level 1 checks, the product is a complete, externally consistent data product that has undergone interpretative and diagnostic analyses and can be shared with the public. Level 1 indicates an internally consistent data product that has been subjected to quality checks and data management procedures. Instrument calibrations were carried out following the manufacturer's instructions and analyses followed published procedures.

5. Data Acquisition Materials and Methods:

Site Description:
Walker Branch Watershed (WBW) is a 97.5 ha second-growth forest on the U.S. Department of Energy's Oak Ridge Reservation in east Tennessee, USA. There are two headwaters streams that drain the watershed: the West Fork drains 38.4 ha and the East Fork drains 59.1 ha (Curlin and Nelson 1968) (Figure 2). The watershed is underlain by bedrock (Knox Dolomite) with deep soils, primarily Utisols. Vegetation is primarily oaks (*Quercus prinus, Quercus alba*), tulip poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), and American beech (*Fagus grandifolia*) (Johnson 1989, Kardol et al. 2010). The climate is typical of the southern Appalachian region, with a mean annual temperature of 14.5ºC and mean annual precipitation of 135 cm (Curlin and Nelson 1968, Johnson 1989). Long-term records have documented a 1.8ºC increase in mean annual air temperature over the past 40 years (Lutz et al. 2012). More detailed site descriptions are available in: Curlin and Nelson (1968) and Johnson (1989).

The organic-matter decomposition study was carried out in the West Fork of WBW. The West Fork is approximately 300 m in length from the headwaters to the location where the East and West Forks meet. Four perennial springs discharge to the West Fork. The S3 spring that is located approximately 160 m downstream from the headwater springs provides the majority of baseflow compared to the other springs (Curlin and Nelson 1968, Genereux et al. 1993, Figure 2). The stream bed is composed primarily of bedrock outcrops, areas of cobble and gravel, and deposits of organic matter. Stream water nutrient concentrations are low (Mulholland 2004, Lutz et al. 2012) and the snail, *Elimia clavaeformis*, is the dominant invertebrate in the stream (Newbold et al. 1983, Rosemond et al. 1993, Griffiths and Hill 2014).

Leaf-litter decomposition experiment:

<u>Leaf-litter breakdown:</u>
Leaf-litter breakdown rates were calculated for leaves from 3 tree species in 5 locations along the downstream temperature gradient in winter. The leaf-litter decomposition experiment followed a typical litterbag approach (Benfield 2006). Leaves from 3 species were used in the experiment: red maple (*Acer rubrum*), tulip poplar (*Liriodendron tulipifera*), and white oak (*Quercus alba*). In autumn 2011, abscised, senescent leaves of tulip poplar, red maple, and white oak were collected daily from tarps laid on the forest floor in WBW. After collection, the leaves were air dried in the laboratory 2 weeks before constructing the litterbags. A total of 12.0 g (± 0.1 g dry mass) of dried red maple, tulip poplar, or white oak leaves were placed in each litterbag. The nylon litterbags were 37.5 cm long, 20.0 cm wide, and had a mesh size of 3 x 3 mm to allow aquatic invertebrates access to the leaf material contained in each litterbag.

Figure 3 – Litterbags deployed in Walker Branch.

The litterbags were deployed in the West Fork on December 15, 2011 (Figure 3). Twelve litterbags per litter type were attached to strings and then to a cinder block to hold the litterbags in place. The 12 litterbags per type were placed in each of 5 sites (sites numbers 1, 3, 5, 6, and 7). Only 4 litterbags of white oak leaves were deployed at site 6 due to a limited number of white oak litterbags. The sites (and distances downstream from the largest spring [S3]) where the litterbags were deployed were as follows: site 1 = 10 m, site 3 = 46 m, site 5 = 103 m, site 6 = 133 m, site 7 = 162 m (Figure 2). The litterbags were retrieved 5, 26, 55, and 90 days after deployment (final pick up date was March 14, 2012). On the December 15, 2011 deployment date, 3 replicates per litter type were brought into the field and then immediately returned to the laboratory to account for mass loss due to handling and to measure initial mass.

On each collection date, the litterbags were retrieved from each site and placed into pre-labeled plastic bags. A subsample (~0.1 g dry mass) of leaf litter from each litterbag was removed for a microbial respiration analysis. The litterbags were then placed on ice and returned to the laboratory for processing. The leaf litter was removed from each litterbag and washed over nested 1-mm and 500-µm sieves. All leaf litter on the 1-mm sieve was collected for the mass loss measurement, and all invertebrates on both 1-mm and 500-µm sieves were collected for numeration.

The cleaned leaf litter was placed into paper bags and dried at 60ºC for 48 hours. The leaf litter was then weighed to estimate dry mass (grams; to the nearest 0.1 g) and a subsample was removed for ash-free dry mass (AFDM) determination. To measure AFDM, approximately 1 g of dry mass was placed into a pre-weighed aluminum pan, weighed, combusted at 500ºC for 4 h, and then re-weighed. Ash-free dry mass was calculated as the difference between dry and ashed masses. The AFDM of the entire sample was then calculated based on the dry mass of sample used for AFDM determination and the total dry mass of sample. The ~0.1 g of dry mass collected for the microbial respiration assay was also included in this total.

For each litter type in each site, the breakdown coefficient (k, /day) was calculated as the slope of the natural log of AFDM remaining over time, and a temperature-corrected breakdown coefficient (k, /degree day) was also calculated by substituting degrees days for time (Benfield 2006). Degree days were calculated as the sum of the mean daily stream water temperature at each site for each incubation period.

Microbial respiration:

Microbial respiration was measured in the field on all 3 litter types on each collection date (days 5, 26, 55, and 90) and at each site throughout the leaf-litter decomposition experiment. A subsample of ~0.1 g of litter from each retrieved litterbag was rinsed with stream water, placed into a 60 mL amber polypropylene tube filled with stream water (no air bubbles), and then capped. The initial dissolved oxygen concentration of the stream water was measured prior to filling the tubes using a hand-held dissolved oxygen sensor (YSI ProODO). Three 'control' tubes per site filled with stream water only were used to account for changes in background dissolved oxygen concentrations. All tubes were then placed in the stream at each of the 5 sites (the same site where the litterbags were retrieved) for 3 hours. After the 3-hour incubation period, the dissolved oxygen concentration in each tube was measured. The change in dissolved oxygen concentration before and after the incubation period was used to calculate microbial respiration. The dissolved oxygen sensor was calibrated following the manufacturer's instructions prior to each use. After the microbial respiration measurement, the subsample of litter was returned to the laboratory and dry mass and AFDM were measured (and the AFDM of the subsample was also included in the measurement of mass loss). Microbial respiration was expressed as mg O_2 g^{-1} AFDM h^{-1}.

Invertebrate density:
Invertebrate density was measured on all 3 litter types on each date (days 5, 26, 55, and 90) and at each site throughout the leaf-litter decomposition experiment. All invertebrates from each litterbag that were collected on the nested 1-mm and 500-µm mesh sieves were immediately stored in 15 mL glass scintillation vials in 80% ethanol. Because the snail *Elimia clavaeformis* is dominant invertebrate in Walker Branch (Figure 4), all snails and all other invertebrates were counted separately. Invertebrate (or snail) abundance was expressed as the number of individuals per litterbag, and invertebrate (or snail) density was expressed as the number of individuals per g AFDM of litter remaining in each litterbag.

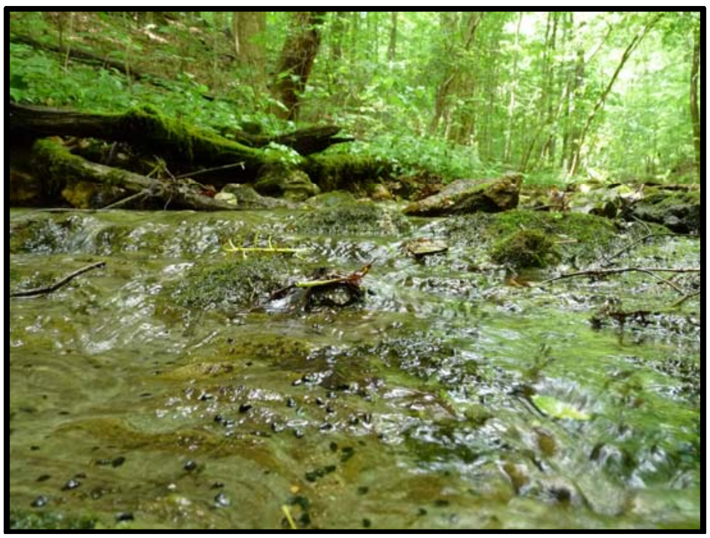

Figure 4 – The dominant snail in Walker Branch (*Elimia clavaeformis*) in the foreground in spring.

Cotton-strip decomposition experiment:

Cotton-strip tensile loss was measured at each of the 7 sites every ~35 days for ~2 years. There were a total of 22 deployments over the 2-year period, with the first deployment beginning on August 10, 2011 and the last deployment beginning on October 1, 2013. The 7 sites used in the experiment were as follows (with distance in meters downstream from the largest [S3] spring): site 1 = 10 m, site 2 = 29 m, site 3 = 46 m, site 4 = 75 m, site 5 = 103 m, site 6 = 133 m, site 7 = 162 m. Five (1, 3, 5, 6, 7) of these 7 sites were used in the leaf-litter decomposition experiment.

Cotton strips were 80 mm in length and 25 mm in width, and were cut from bolts of Fredrix-brand unprimed 12-oz. heavy-weight cotton fabric (Style #548; Slocum et al. 2009). The specific methods to make cotton strips are described in Tiegs et al. (2013). A cable tie was inserted through a hole made with a small pin near the top of each cotton strip. Three cotton strips (3 replicates per site) were then attached to a string and the string was attached to a brick that was placed at each site in the stream. The cotton strips were incubated for approximately 35 days at a time. After the incubation period, the cotton strips were retrieved from the stream, cleaned in 80% ethanol, and air dried.

To measure the tensile strength of the cotton strips, the ends of each strip were placed in the grips of a tensiometer (Mark-10 brand, Model #MG100) located at Oakland University. Each cotton strip was pulled at a rate of 2 cm/min until it tore, and the tensile strength achieved during the pull was recorded. Tensile loss of each cotton strip (%/day) was calculated as:

$$Tensile\ loss = \frac{\left(\frac{Tensile\ strength_{REF} - Tensile\ strength_{TRT}}{Tensile\ strength_{REF}}\right)\times 100}{Incubation\ time}$$

where *Tensile* $strength_{TRT}$ is the tensile strength recorded for each cotton strip incubated in the field, *Tensile* $strength_{REF}$ is the mean tensile strength of 6 cotton strips that were not incubated in the field, but were cleaned with 80% ethanol and air dried, and *Incubation time* was the total number of days the cotton strips were deployed in the stream (Tiegs et al. 2013). Tensile strength was also calculated per degree day by replacing '*Incubation time*' with '*degree days*'. Degree days were calculated as the sum of the mean daily stream water temperatures over the incubation period.

Environmental data:

Stream water temperature:
Temperature was measured every hour using temperature loggers (TidbiT v2, Onset Computer Corporation, accuracy = 0.2ºC) placed in the largest (S3) spring and at each site (1-7) in the West Fork of Walker Branch. Temperature measurements began at sites 1-7 on August 1, 2011, and began at the S3 spring on December 16, 2011. Data are missing for 7 days in August/September 2011 from sites 1 and 2 when the loggers were out of water.

Mean daily stream water temperature was calculated from the hourly data. Diel temperature range was calculated as the maximum hourly temperature measured on a given day minus the minimum hourly temperature measured on that same day.

Stream water chemistry:
Water samples for chemistry analysis were collected at 5 sites along the downstream temperature gradient on days 55 and 90 of the leaf-litter decomposition experiment. The 5 sampling sites were the same 5 sites used in the leaf-litter decomposition experiment. Three filtered water samples (Whatman GF/F; 0.7 µm nominal pore-size) were collected from each site on each sampling date into acid-washed, HDPE bottles, and frozen at -20ºC until analysis. Filtered water samples were also collected weekly at one location upstream of site 7 during the cotton-strip decomposition experiment as part of the long-term monitoring project in Walker Branch (http://walkerbranch.ornl.gov/data.shtml). To accompany the cotton-strip decomposition experiment data, reported chemistry data are the average nutrient concentrations calculated for each deployment period.

All water samples were analyzed for nitrate-N, ammonium-N, and soluble reactive phosphorus-P using standard methods. Nitrate-N concentrations were measured using the cadmium reduction method, ammonium-N concentrations were measured using the phenol-hypochlorite method, and soluble reactive phosphorus-P (SRP) concentrations were measured using the molybdate-antimony method (APHA 2005) on an autoanalyzer (AA3, SEAL Analytical). Stream water chemistry analyses followed the QA/QC protocols for the analyzer, including calibration curves, QC (standard checks), and baseline and drift checks. The standards used for the calibration curve were diluted from stock solutions (nitrate: SM-772-00; ammonium: SM-772-002, phosphate: SM-772-003) from High-Purity Standards (Charleston, SC). For additional information on the nutrient analyses, see Mulholland (2004) and Lutz et al. (2012). Stream water chemistry was measured weekly in the West Fork beginning in 1989, and historical data are available at: http://walkerbranch.ornl.gov/data.shtml.

Stream discharge:

Stream water level was measured in a stilling well beside a v-notch weir located at the downstream end of the West Fork of Walker Branch (just upstream of where the East and West Forks meet). Stream water level was measured every 15 minutes using a compact bubble water level sensor (CS471, Campbell Scientific) attached to a datalogger (CR1000, Campbell Scientific). Logged water level was checked via a manual measurement of water level every week or month. Stream discharge was calculated using established relationships with water level and the v-notch weir (Curlin and Nelson 1968). Measurement of stream discharge in the West Fork began in 1969 and historical data are available at: http://walkerbranch.ornl.gov/data.shtml. To accompany the cotton-strip decomposition experiment data, reported discharge data are the average discharge values calculated for each deployment period.

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7. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Carbon Dioxide Information Analysis Center (CDIAC)

Data Archive Center:

Contact for Data Center Access Information:
E-mail: http://cdiacservices.ornl.gov/feedback.cfm