

# Analysis of loadings

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## 1 Data

**Description** The data in this report comes from four Wisconsin streams that were monitored (with some gaps in data collection) between 1989 and 2007. The streams and the period during which each was monitored are:

Stream	Events	Years
Eagle	429	1991-1994, 2003-2007
Joos Valley	473	1990-1994, 2002-2007
Otter	424	1990-1997, 2000-2002
Brewery	670	1989, 1994-2002, 2004-2005
Garfoot	527	1985, 1990-1993, 1995-1998
Kuenster	218	1992-1995
Rattlesnake	170	1991-1994
Bower	373	1990-1994, 2006-2009

Each entry in our data set represents one loading event, which is defined based on the hydrograph - the event begins when the loading rises from a base level toward a peak, and ends when the loading falls back to its new base level. Two kinds of load are measured for each event - the sediment load and the phosphorus load. There are two typical ways that sediment and phosphorus get into streams - they can be carried either by runoff during a rainstorm or by melting snow.

Not all of the data can be collected for each event. For instance, rainfall is measured only when the ground is free of snow because snow interferes with the rain gauges. And the amount of snowmelt is estimated by multiplying the water content of the snow by the change in snow depth a warm snap, which is inaccurate when

additional snow falls during that event. Broadly, there is one set of measurements that are made during rainfall-driven events and a different set of measurements that are made during snowmelt-driven events. Because of this, the two types of event are modeled separately.

**Exploratory Analysis** Our analysis targets the phosphorus and sediment loads carried by each stream. Using Rainmaker software, each load can be broken into two parts: base load and storm load. We will consider models of the storm load and of the total load.

The first task was to decide whether most of the annual load is produced by snowmelt-driven or rainfall-driven events. The total loads from each kind of event are tabulated in Tables ?? (sediment) and ?? (phosphorus). Figure ?? presents the same information as the tables, while Figure ?? also compares the load from individual snowmelt- and rainfall-driven events. About two thirds of the sediment loading comes from rainfall-driven events, along with about half of the phosphorus loading.

We investigated dividing the snow-free seasons into early and late subseasons, separating the two on May 15th of each year. If vegetation serves to hold the soil together, and to increase both evapotranspiration and infiltration, then erosion may be more common early in the spring before most of the summer's vegetation appears. If so, the relationship between rainfall and the stream's loading might change during the summer.

The investigation was done by making linear models to describe the sediment and phosphorus loading during the two subseasons and comparing them to a single model fit to the entire snow-free period. Because the split makes the model more flexible, it will certainly improve the model's fit - the question is whether that improvement is enough to justify making the model more complex. At all four streams, the model improvement was statistically significant but too small to matter (the split models explained about 1%-2% more of the loads). We will not use the split in the rest of the analysis.

Over the course of the monitoring period, the majority of the total load (both of sediment and of phosphorus) was carried during just a few major events. Just 10% of the events carried between 73.1% (at Otter) and 96.9% (at Bower) of the total sediment load; the same events produced between 64.6% (at Otter) and 88%

	snowmelt-driven	rainfall-driven
Eagle	27.0%	73.0%
Joos	26.9%	73.1%
Otter	35.4%	64.6%
Brewery	32.8%	67.2%
Garfoot	55.6%	44.4%
Kuenster	68.5%	31.5%
Rattlesnake	48.9%	51.1%
Bower	28.8%	71.2%

Table 1: Proportion of total suspended solids loading contributed by each type of event

	snowmelt-driven	rainfall-driven
Eagle	32.8%	67.2%
Joos	36.4%	63.6%
Otter	46.5%	53.5%
Brewery	49.6%	50.4%
Garfoot	55.2%	44.8%
Kuenster	61.1%	38.9%
Rattlesnake	52.6%	47.4%
Bower	62.9%	37.1%

Table 2: Proportion of total phosphorus loading contributed by each type of event

(at Joos) of the total phosphorus load.

## 2 Analysis

### 2.1 Variable selection

In order to make a model of the load carried by the stream, we need to select the predictor variables that have explanatory power. We used stepwise regression with the Bayesian Information Criterion (BIC) to screen the potential predictor variables.