Project Status Report

Upper Mississippi River
Long Term Resource Monitoring Program
U.S. Geological Survey

Estimating Inundation-Induced Tree Mortality Using River Water Level Data

Flooding profoundly affects many forms of vegetation that live in the Upper Mississippi River ecosystem. One of the hardest hit classes is trees. By cutting off oxygen to the roots, floodwater creates an anaerobic environment that is toxic to trees. Woody species in the Upper Mississippi River system, with the exception of bald cypress, can not survive lengthy inundation. The flood of 1993 provided a vivid demonstration of this fact. Inundation lasting much of the 1993 growing season led to the death of almost 40% of the adult trees and up to 80% of the juvenile trees located in Pool 26 near St. Louis, Missouri (Yin et al. 1994).

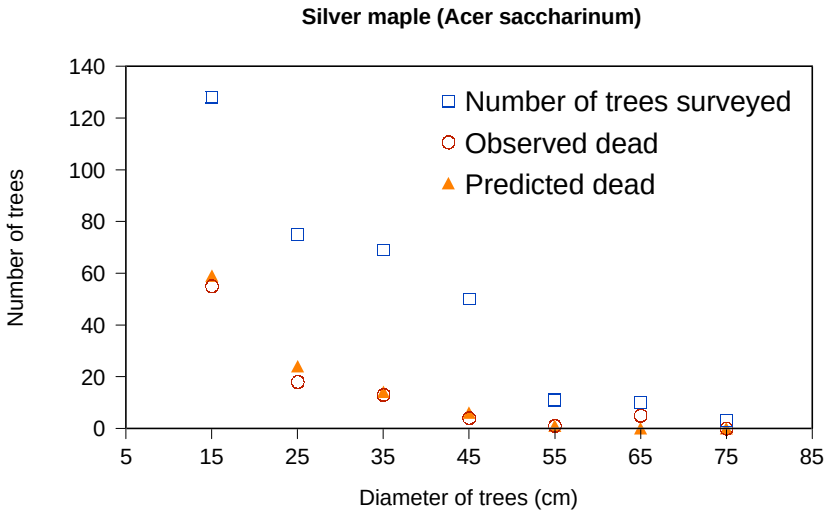

Figure 1. Test of the method against data collected in 1994 in La Grange Pool on the Illinois River

Management of the floodplain forests must be adapted to flood regimes of the river. An important part of such management is the ability to accurately and rapidly assess flood damage. Unfortunately, assessment of flood damage to forests has often been hampered by (1) the high cost of field surveys and (2) the wait for visible signs of damage to appear. Based on these considerations, the Environmental Management Technical Center initiated a project in 1996 to search for an alternative assessment method.

The alternative method under development can potentially be used to calculate the probability of tree mortality based on water level data of the river. In this method, the probability of tree mortality is defined as a function of inundation duration and size of the tree. The method includes a formula to determine the threshold water level of inundation using historical river water level data and formulas to calculate the probability of tree mortality based on inundation duration and tree size. Inundation duration is defined as the total number of days when river water level is at or above the threshold water level between January 1 and December 31. Parameters in the tree mortality probability formulas were estimated by applying linear logistic regression on data collected in 1994 and 1995 at seven reaches along the Upper Mississippi River. The formulas were tested against data collected in 1994 and 1995 at one reach on the Illinois River (Figure 1).

Using this method, we have calculated the threshold water levels for selected reaches of the Upper Mississippi and Illinois Rivers and their corresponding inundation duration in 1993 (Table 1). We have also provided the formulas for the calculation of mortality probabilities of nine woody species (Table 2). Using these formulas and inundation duration data, the percentage mortality of trees killed during

(over)

1993 can be retrospectively estimated by size class of the trees. For example, in Pool 19 the mortality rate of silver maple trees between 10 and 20 cm in diameter during 1993 may be estimated as follows:

a=-4.4345, *b*=.0232, *c*=-.0581 (Table 2)
X=154 (Table1)
Y is the midpoint of the tree size range (10 + 20)/2 = 15 cm

$$P = \frac{e^{-4.3545+(.0232)(154)+(-.0581)(15)}}{1+e^{-4.3545+(.0232)(154)+(-.0581)(15)}} \approx 15.1\%$$

Table 1. Threshold water level and inundation days during 1993

Reach	Gage station river mile	Threshold water level (ft)	Inundation days-1993
Mississippi River			
Pool 2	847.5	697.79	63
Pool 3	815.1	682.81	68
Pool 4	796.69	676.55	58
Pool 5	752.58	666.39	43
Pool 5A	737.9	657.39	42
Pool 6	728.28	652.53	45
Pool 7	714.07	645.23	47
Pool 8	702.24	638.74	46
Pool 9	678.9	629.38	54
Pool 10	647.72	621.47	83
Pool 11	614.9	612.93	83
Pool 12	582.9	601.47	87
Pool 13	556.6	593.57	95
Pool 14	522.4	582.33	92
Pool 15	493.1	567.17	76
Pool 16	482.8	555.68	109
Pool 17	457	546.36	128
Pool 18	436.9	540.02	148
Pool 19	410.4	528.17	154
Pool 20	364.1	490.64	171
Pool 21	343.1	481.54	183
Pool 22	324.8	472.33	189
Pool 24	301.1	460.50	193
Pool 25	273.2	446.61	198
Pool 26	241.2	431.96	201
Cape Girardeau	51.9	333.02	234
Illinois River			
Peoria Pool	230.1	449.83	164
La Grange Pool	157.5	443.66	218
Alton Pool	80.0	433.64	259

Table 2. Formula for the calculation of tree mortality probability

$$P = \frac{e^{a+bX+cY}}{1+e^{a+bX+cY}}$$

P is probability of death
X is flood duration (days)
Y is the diameter (cm) of trees at 1.4m above ground level

Species	*a*	*b*	*c*
Silver maple	-4.3545	.0232	-.0581
Green ash	-3.1213	.0132	-.0398
American elm	-3.1403	.0087	-.0003
Eastern cottonwood	-2.8861	.0123	-.0167
Boxelder	-3.4654	.0185	-.0396
Hackberry	-3.3684	.0341	-.016
Red mulberry	-1.7049	.009	-.0153
Black willow	-1.5593	.0064	-.0674
River birch	-9.3006	.0828	-.0123

Reference

Yin, Y., J. C. Nelson, G. V. Swenson, H. A. Langrehr, and T. A. Blackburn. 1994. Tree mortality in the Upper Mississippi River and floodplain following an extreme flood in 1993. pp 41-60, In: Long Term Resource Monitoring Program 1993 flood observations. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin. LTRMP **94-S011. 190pp.**

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