Land use and water quality in Missouri's Lakes

According to the EPA, nutrients (i.e. phosphorus and nitrogen) are the top pollutants that impair the country's lakes and reservoirs. Some of these nutrients come from point sources such as sewage treatment plants, but the majority enter our lakes through nonpoint source runoff from urban areas and agriculture. In Missouri, the number of lakes that have point source pollution are few and generally limited to the large reservoirs. Nutrient levels in most Missouri lakes are determined by nonpoint source impacts within the watershed.

We once thought that differences in soil fertility (i.e. nutrient levels) explained regional differences in lake water quality in Missouri. Thin, nutrient-poor soils in the Ozark led to clear lakes with low nutrient levels. Deeper, nutrient-rich soils in northern Missouri equated to productive, nutrient-rich lakes. With continued analysis we identified the differences in land use across the regions of the state (the Ozarks have forest, while agriculture dominates in northern Missouri). The quality and amount of soil definitely helps determine land use, as nobody has much luck farming ridge tops in the Ozarks! But analysis indicated that if you had a watershed in northern Missouri that looked like a southern Missouri watershed; that is, mostly forested, the lake would also look like an Ozark lake even though it was surrounded by nutrient-rich soils. Some examples of northern Missouri lakes that have relatively low-nutrient levels and high water clarity include Bowling Green Lake, Lake Nehai Tonkeia, and Lincoln Lake.

Bowling Green Lake #1 is in northern Missouri, where the soils are nutrient-rich and yet has a mean Secchi transparency of 60 inches. Nearly half of the watershed of Bowling Green Lake #1 is forested.

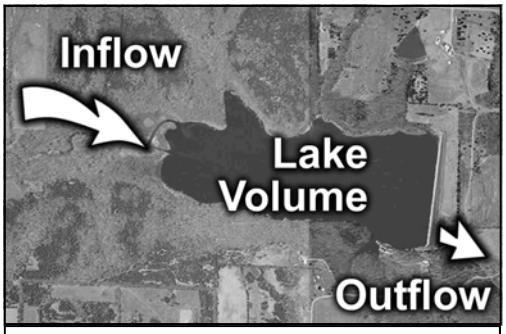
We now realize that land cover within a lake's watershed plays a large role in water quality. In Missouri (and elsewhere) more agriculture in a watershed leads to more nutrient inputs into the lake. In contrast, a forested watershed generally equates to less human impact and therefore lower nutrient inputs into the lake. Grass and pasture land do not show a strong relation to in-lake nutrients, probably because these land types range from low impact (e.g. Conservation Reserve Program land) to highly managed (litter/manure application).

But land use is not the only factor that plays a role in determining lake water quality in Missouri. The amount of water that flows into a lake during a given year (i.e. hydrology) plays a much larger role than we previously thought. If a lake has a large watershed relative to its lake volume, it will be more impacted by inflows from the watershed. On the other hand, if a lake has a small watershed relative to lake volume, inputs from the watershed will have less impact on water quality.

One way of looking at hydrology is by calculating what is known as residence time. Simply put, this is a measure of how long water remains in the lake before new inflows replace it. If a lake has a volume of 100 acre/feet and the annual inflow is 200 acre/feet, then residence time equals 6 months. That means, on average, the volume of the lake is replaced every 6 months. Residence time is a theoretical measurement, but a valuable one all the same.

How much of a factor is residence time on lake water quality in Missouri? If a Missouri lake has 50% of its watershed in agriculture, the overall phosphorus concentrations within the lake may range from as low as 40 µg/L to as high as 150 µg/L. This large range occurs because the residence time of our lakes vary greatly. The lake with 40 µg/L of phosphorus probably has a residence time of over 18 months. A lake with a residence time of 6 months might have 100 µg/L phosphorus, while a lake with a 3 month residence time would have close to 150 µg/L phosphorus.

The three factors that determine residence time are: lake volume, watershed area, and the amount of precipitation. Of these, precipitation is not a constant. During dry years there is less inflow into the lake, so the residence time is, in effect, longer than normal. During wet years the opposite is true; more inflow leads to a shorter residence time. We find that dry years usually have lower than normal nutrient levels, while wet years have higher than normal nutrient concentrations. Annual differences in hydrology (i.e. residence time) can help explain why a lake's water quality varies over time.



Inflowing water replaces the lake water, which leaves via the outflow. Residence time is a measure of how long a volume of water "resides" in the lake.

Some lakes have watersheds dominated by cropland. These lakes tend to have higher concentrations of nutrients and suspended sediments.

This information is excerpted from the Lakes of Missouri Volunteer Program 2004 Data Report, available at www.lmvp.org