# The Fertility of North American Soils: A Preliminary Look at 2015 Results

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**The 2015 soil test summary** is the fourth in a series of summaries dating back to 2001, 2005, and 2010. For the first time, trends in relative frequencies in soil test levels are being examined.

**Preliminary results for Corn Belt states** are showing a reduction in percentages of samples testing high in P, but an increase in samples testing low, reflecting a greater need for P fertilization. For K, ranges with the highest percentages of samples, as well as their changes over time, are in general agreement with university recommendations.

Periodically, the International Plant Nutrition Institute (IPNI) summarizes data from public and private soil testing laboratories in North America. Laboratories provide data voluntarily, contributing their own staff time and computing resources. Summaries would not be possible without their generous contributions. This year marks the fourth summary using the same data collection protocol. Previous summaries were conducted in 2001, 2005, and 2010 (Fixen, 2002; Fixen, 2006; Fixen et al. 2010). The 2015 summary is not yet complete, and data continue to be submitted; however, the total number of samples collected for Corn Belt states is already substantially higher than previous summaries (**Table 1**). Until all data have been submitted, results are considered preliminary and the names of participating laboratories are being withheld.

**Table 1.** Total number of samples submitted for Corn Belt states as of 31 Oct. 2015.

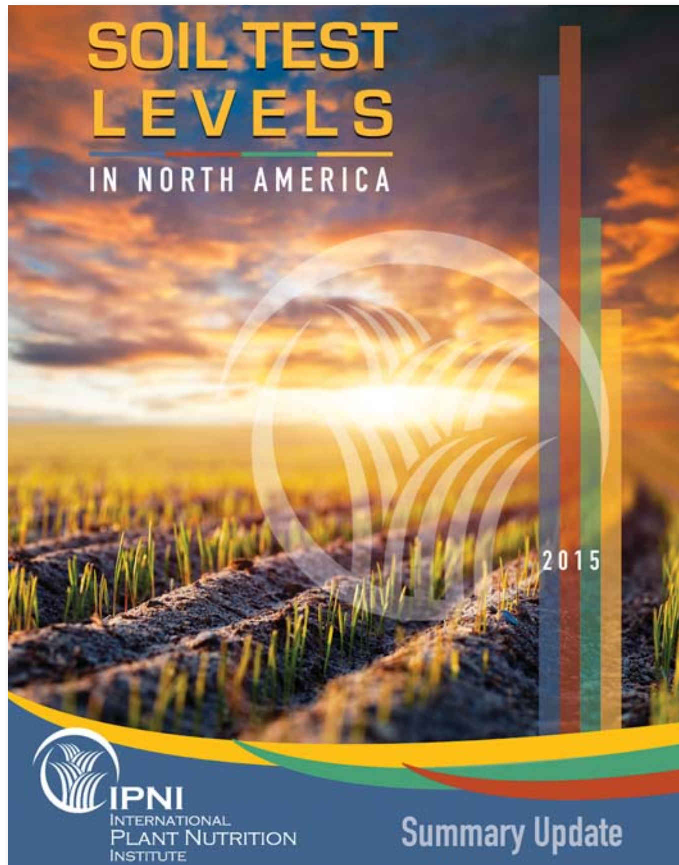
| | Total number of samples | |
|---|---|---|
| Year | P | K |
| 2001 | 1,207,716 | 1,137,302 |
| 2005 | 1,846,736 | 1,821,570 |
| 2010 | 2,775,050 | 2,633,145 |
| 2015 | 4,285,253 | 3,951,195 |

Note: Corn Belt states are defined in this publication as Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin.

The protocol distributed to laboratories requested the numbers of samples in various soil test ranges. As in the 2010 summary, data were collected for P, K, S, Mg, Zn, $Cl^-$, and pH. Only preliminary data for P and K are presented. A total of 15 categories were used for P and 9 were used for K. Categories were unequal in width and were right-censored, with the highest category representing samples "greater than" the upper limit of the highest defined interval. Without censoring, a much larger number of categories would have been needed to characterize the few, very high levels characteristic of highly positively skewed soil test distributions.

Different soil test ranges were used for various combinations of extractants and detection methods in an attempt to create equivalency in soil test calibration interpretation. Land Grant University Extension information was used where possible and scientific judgment was used to fill in knowledge gaps. Although equivalencies lacked scientific rigor, the same equivalencies were used in all summaries, giving credence to examining temporal trends. Because separate summaries were conducted each survey year, laboratory participation and total sample volume varied over time.

**Abbreviations and notes: P = phosphorus; K = potassium; S = sulfur; Mg = magnesium; Zn = zinc; $Cl^-$ = chloride; ppm = parts per million.**




Data presented in this publication use a subset of the protocol categories for P. The seven higher categories are grouped into the ">50" category. Data from the "31-40" category in the protocol were divided equally into "31-35" and "36-40" categories. Similarly, data in the "41-50" protocol category were divided equally into the "41-45" and "46-50" categories. These subdivisions were created to make it easier for the reader to visualize the distributions.

In each survey year, laboratories were asked to contribute samples for that year's cropping season rather than within standardized dates to allow for variation in sampling seasons across North America. However, many laboratories chose July

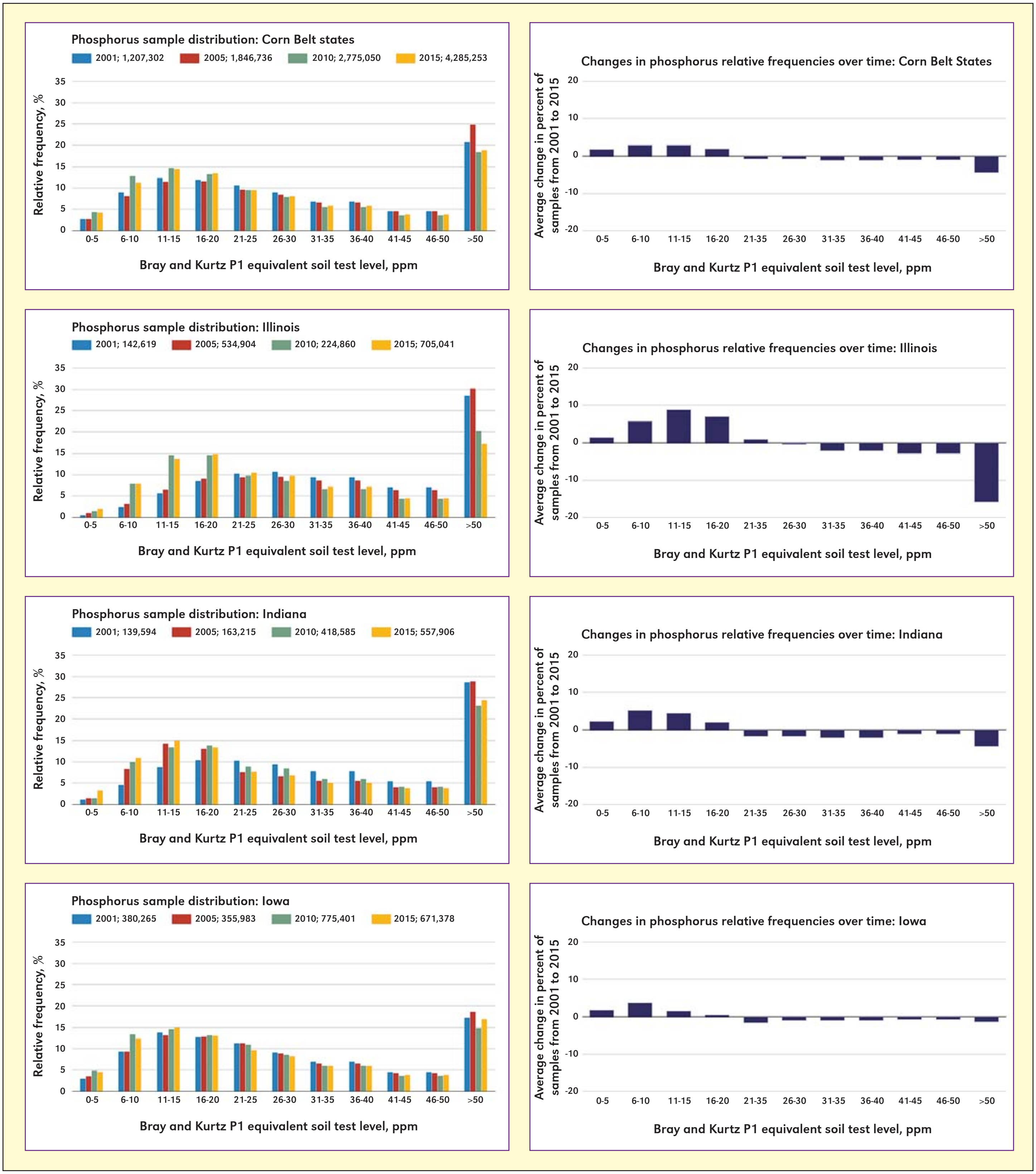



**Figure 1.** Relative frequencies (left) and average changes in relative frequencies (right) of soil test phosphorus levels from 2001 to 2015, expressed on a Bray and Kurtz P1 equivalent basis, for Corn Belt states and a subset of those states: Illinois, Indiana, and Iowa.

1 of the previous year to June 30 of the survey year as the sampling interval.

Some laboratories were not able to follow the protocol in its entirety. In some cases, a laboratory was not able to definitively associate a sample with a state or province. When this occurred, the state or province assigned to those samples was the one where the majority of the samples was thought to originate.

Additionally, soil test categories provided by the laboratory did not always match those in the protocol. In such cases, data were interpolated into protocol categories.

With the 2015 summary, four sampling periods were available which enabled a more intensive evaluation of trends over

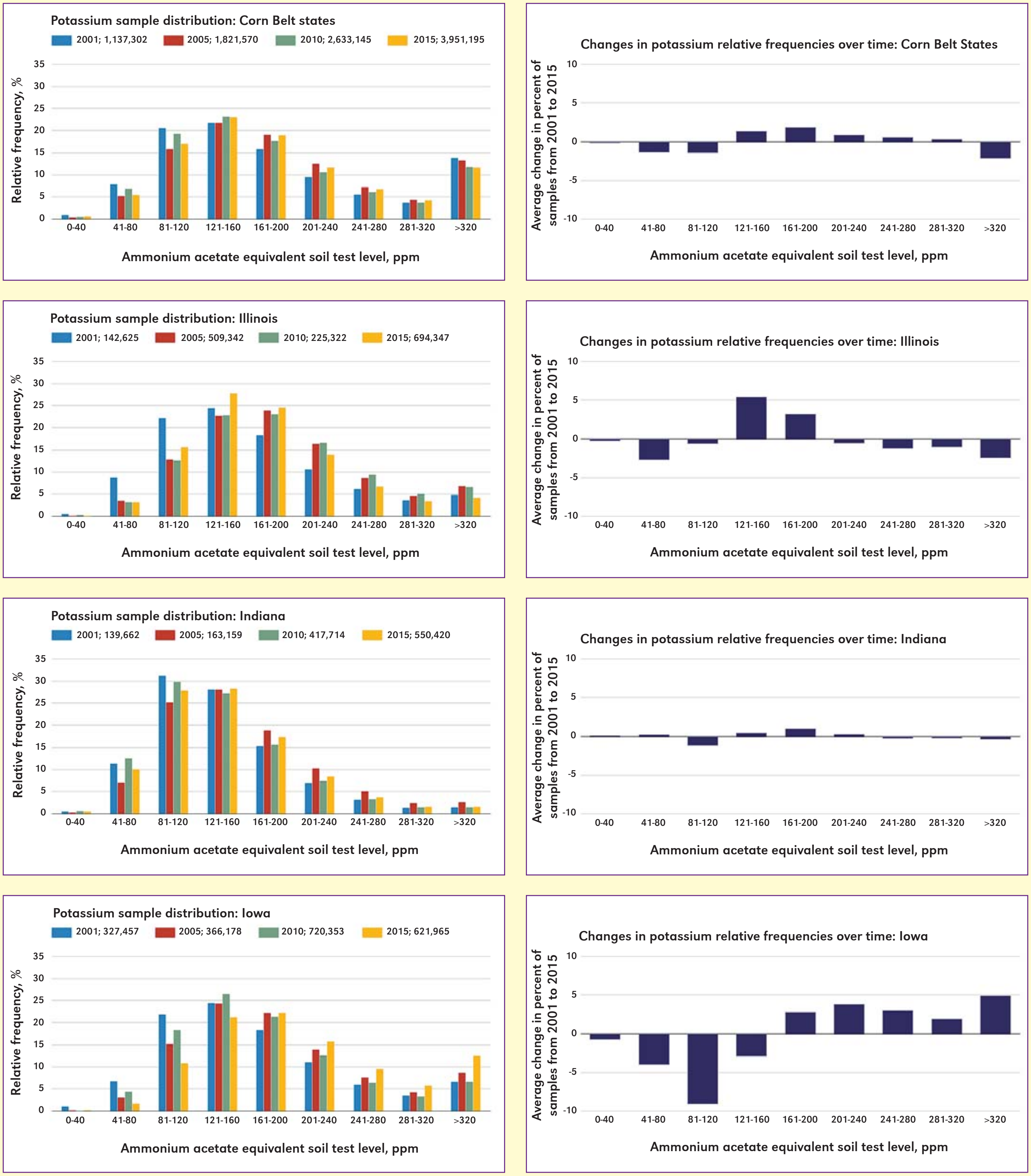



**Figure 2.** Relative frequencies (left) and average changes in relative frequencies (right) of soil test potassium levels from 2001 to 2015, expressed on an ammonium acetate equivalent basis, for Corn Belt states and a subset of those states: Illinois, Indiana, and Iowa.

time than has been possible in the past. To examine trends over time, logistic regression was performed for each soil test category, using a linear model. In this analysis, relative frequencies were converted to an odds ratio and that ratio transformed to a logarithmic scale. Because of the large number of samples, used as weights in the regression, the slopes of all regression models were statistically significant (p-value was 0.05 or less). The difference between 2001 and 2015 log odds ratios, predicted by the regression, was back-transformed to the relative frequency scale and presented as the "average change in percent of samples from 2001 to 2015." Positive values denoted an increase over time.

## Results: Phosphorus

**Figure 1** shows relative frequencies and average changes in relative frequencies of soil test P levels from 2001 to 2015, expressed on a Bray and Kurtz P1 equivalent basis. Across the Corn Belt as well as for the individual states shown, the largest numbers of samples occurred in the 11-15, 16-20, and >50 ppm ranges. The large percentage of samples in the >50 ppm range encompasses data that span a wide range of higher levels representative of a highly positively skewed distribution. The relative frequencies of samples in higher soil test categories, those above 20-25 ppm, have been decreasing. Conversely, relative frequencies of samples testing below 20 ppm have been increasing.

Interpretation of the observed changes is subjective. Reductions in the percentages of samples testing at higher P levels may reflect improved integration of fertilizer and manure management practices over time, reducing over-applications. Increased percentages of P samples testing in lower ranges are not expected, given university recommendations. As an illustration, Indiana, Illinois, and Iowa are states that follow the build and maintenance philosophy. Recommendations are to build soils to levels where only moderate to low probabilities of yield response to P additions exist and, once there, maintain them. Maintenance ranges for corn and soybean production for each of these states are: Illinois, 20-35 ppm (Fernández and Hoeft. 2015); Indiana, 15-30 ppm (Vitosh et al., 1995); and Iowa, 16-20 ppm. If fertility were being managed according to these recommendations, relative frequency decreases, rather than increases, would be observed for these lower soil test ranges. A possible explanation is that over time, greater use of grid and zone sampling has revealed low testing areas previously unidentified when more traditional practices of sampling larger areas were followed. Regardless of the causes, the increases in percentages of samples in low soil test P ranges mean the identified need for P fertilization is increasing.

## Results: Potassium

**Figure 2** shows results for K expressed on an ammonium acetate equivalent basis. In 2015, the Corn Belt states considered as a group had the largest percentages of K samples in the 81-120, 121-160, and 161-200 ppm ranges, and the percentages of samples among these ranges have been increasing the most. Percentages in lower categories have been decreasing, as have percentages in the >320 ppm category. These are in general agreement with university recommendations in this region.

Illinois had the largest number of 2015 samples in the 121-160 and 161-200 ppm ranges. Over time, percentages of samples decreased above and below these ranges. These observations are consistent with Illinois' recommendation to build soils to the 130-200 ppm range and maintain them there.

In Indiana, the largest percentage of 2015 samples were in the 81-120, 121-160, and 161-200 ppm ranges, also in agreement with university recommendations to build and maintain soils in the 88-180 ppm range (Vitosh et al., 1995). These recommendations have been in place during all soil test summary years, and this consistency is likely reflected in the small changes over time in each soil test category.

Iowa has seen more marked changes over time. Iowa State University has revised its K recommendations two times during the span of the soil test summaries. In 2002, the recommended maintenance range for soils with low subsoil K (the majority of Iowa soils) was increased from 91-130 to 131-170 ppm (Sawyer et al., 2002; Voss et al., 1999). In 2013, the maintenance range was further increased to 161-200 ppm (Mallarino et al., 2013). In 2015, the highest percentages of samples were in the 121-160, 161-200, and 201-240 ppm ranges. Increases in percentages of samples over time have occurred in soil test categories above 160 ppm, with concomitant decreases occurring at or below that level. Directionally, these changes are in agreement with the changes made in university recommendations over time; however, the increases in sample percentages in higher categories, above 240 ppm, may reflect nutrient management approaches that differ from those recommended by the university.

## Summary

The 2015 soil test summary is the fourth in a series of summaries conducted by IPNI. For the first time, changes over time were analyzed. More samples continue to be submitted to the summary, but preliminary results indicate that for Corn Belt states, lower percentages of samples are testing high in P while larger percentages are testing low, indicating a growing need for P fertilization. For K, soil test levels and their changes are generally in agreement with university recommendations. BC

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