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## Using artificial neural networks to improve phosphorus indices.

Supplementary Table 1
A brief description of current treatments at the Water Quality Field Station (abbreviations and year of establishment), any previous treatment (cropping system and nitrogen rates applied to maize) dating back to 1997, and phosphorus, nitrogen, and tillage management. An estimate of the cumulative $P_2O_5$ applied from 1997 – 2013 is shown parenthetically. Current nitrogen management identifies the nitrogen rates applied to perennial crops, sorghum, and continuous and rotated maize.

| Current Treatment (**abbrev.**/yr. est.)* | Previous Treatment (maize N rate, kg $ha^{-1}$ $yr^{-1}$)† | Plots‡ | P management (cumulative $P_2O_5$ applied 1997-2013; kg $ha^{-1}$)§ | Current N management (annual rate, kg $ha^{-1}$ $yr^{-1}$) | Tillage |
|---|---|---|---|---|---|
| Native prairie mixture (**Prairie**/1993) | NA | 1, 17, 36,**42** | No fert. (0) | No fert. (0) | No till since 1993 |
| Miscanthus x giganteus (**Mxg**/2008) | Annual soybean-maize rotation (180-P) | 11,**22**,32,43 | Commercial fertilizer based on STP (180) + starter (80) | Spring broadcast urea (56) | No till since 2008 |
| Continuous maize w/ residue removal (**CM-RR**/2008) | Continuous maize w/ residue return (202-P) | 12,**23**,30,46 | Commercial fertilizer based on STP (265) + starter (272) | Preplant UAN (180) + starter | No till since 2008 |
| Switchgrass var. Shawnee (**Switch**/2007) | Annual maize-soybean rotation (180-P) | 10,18,26,44 | Commercial fertilizer based on STP (180) + starter (80) | Spring broadcast urea (56) | No till since 2007 |
| Continuous sorghum w/ residue removal (**Sorgh**/2008) | Continuous maize w/ residue return (157-S) | 6,16, 29,39 | Commercial fertilizer based on STP + starter (176) | Preplant UAN (180) | Till |
| Maize-soybean rotation trt#1 w/ residue return (**MS-R1**/1997) | NA | 5,**13**, 35,40 | Commercial fertilizer based on STP (265) + starter (144) | Preplant UAN (157) + starter | Till |
| Soybean-maize rotation trt#1 w/ residue return (**SM-R1**) | NA | 8,20, 27,47 | Commercial fertilizer based on STP (265) + starter (128) | Preplant UAN (157) + starter | Till |
| Maize-soybean rotation trt#2 w/ residue return (**MS-R2**/1997) | NA | **2**,14, 33,45 | Commercial fertilizer based on STP (265) + starter (144) | Sidedress UAN (135) + starter | Till |
| Soybean-maize rotation trt#2 w/ residue return (**SM-R2**/1997) | NA | **9**,19, 34,48 | Commercial fertilizer based on STP (265) + starter (128) | Sidedress UAN (135) + starter | Till |
| Continuous maize w/ residue return & spring manure (**CM-SpM**/1998) | NA | 4,15, 25,37 | 16 yr annual spring swine effluent (approx. 1461) + starter (272) | Preplant swine effluent (avg. 255) + starter | Till |
| Continuous maize w/ residue return & fall manure (**CM-FM**/1998) | NA | 7,24, 28,**38** | 14 yr annual fall swine effluent (approx. 1278) + starter (272) | Post-harvest swine effluent (avg. 255) + starter | Till |
| Continuous maize w/ residue return (**CM**/1997) | NA | 3,21, 31,**41** | Commercial fertilizer based on STP (265) + starter (272) | Preplant UAN (180) + starter | Till |

Source: Welikhe et al. (2020)
* Treatments other than the Prairie were variable and not consistently maintained prior to 1997.
† N rates are only for the maize year in a rotation with P or S following the rate indicating a preplant or side dress application. Not application (NA) indicates a treatment was maintained from 1997 – 2013.
‡ An italicized plot number indicates a tile line that ceased to function, and the plot was therefore eliminated from analysis of relationships between soluble P in drainage water and measures of soil P saturation.
§Cumulative $P_2O_5$ added as commercial fertilizer differs among cropping systems as perennial crops did not receive applications. Cumulative starter $P_2O_5$ varies reflecting the number of times maize was grown on a specific treatment and includes current and previous systems. Cumulative $P_2O_5$ applied as manure differs as there were 16 spring applications but only 14 fall applications reflecting weather and termination of both manure treatments in fall 2013; quantities are based on an estimated amount of 91.3 kg $P_2O_5$ $ha^{-1}$ per application.

Supplementary Table 2

Summary for organic matter, phosphorus, aluminum, phosphorus saturation ratio, soil phosphorus storage capacity, and annual flow-weighted mean dissolved reactive phosphorus concentrations obtained from the monitored plots at the Water Quality Field Station for 2011 -2013 water years (e.g. October 1, 2010 – September 30, 2011 for 2011 water year).

| | | 2011 water year | | | | | | 2012 water year | | | | | | 2013 water year | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cropping system | Plot# | OM | P | Al | PSR | SPSC | fDRP | OM | P | Al | PSR | SPSC | fDRP | OM | P | Al | PSR | SPSC | fDRP |
| Prairie | 1 | 4.8 | 27 | 846 | 0.23 | -12.02 | 0.0084 | 5.1 | 26 | 860 | 0.22 | -9.46 | 0.0055 | 5.3 | 29 | 845 | 0.23 | -14.54 | 0.0093 |
| | 17 | 4.7 | 23 | 758 | 0.22 | -5.55 | 0.0090 | 4.7 | 26 | 821 | 0.23 | -10.68 | 0.0299 | 5.3 | 24 | 855 | 0.22 | -5.26 | 0.0163 |
| | 36 | 4.9 | 14 | 788 | 0.18 | 19.06 | 0.0027 | 4.2 | 11 | 785 | 0.17 | 28.87 | 0.0075 | 5 | 16 | 820 | 0.19 | 13.31 | 0.0147 |
| Mxg | 11 | 4.6 | 26 | 900 | 0.22 | -10.04 | 0.0599 | 5 | 24 | 922 | 0.22 | -5.10 | 0.0217 | 5.4 | 25 | 895 | 0.22 | -6.61 | 0.0701 |
| | 32 | 3.3 | 9 | 734 | 0.16 | 35.01 | 0.0017 | 3.1 | 8 | 798 | 0.15 | 41.03 | 0.0058 | 3.6 | 8 | 753 | 0.15 | 41.81 | 0.0052 |
| | 43 | 4.2 | 13 | 767 | 0.18 | 20.63 | 0.0018 | 3.7 | 12 | 811 | 0.17 | 23.76 | 0.0013 | 4.1 | 11 | 770 | 0.17 | 28.37 | 0.0062 |
| CM - RR | 12 | 5.3 | 27 | 862 | 0.23 | -10.89 | 0.0045 | 5.2 | 32 | 969 | 0.24 | -18.34 | 0.0162 | 5.6 | 26 | 932 | 0.22 | -7.79 | 0.0214 |
| | 30 | 4.1 | 11 | 927 | 0.17 | 30.73 | 0.0020 | 4.2 | 12 | 934 | 0.17 | 26.88 | 0.0068 | 4.5 | 21 | 932 | 0.21 | 0.44 | 0.0064 |
| | 46 | 4.9 | 22 | 846 | 0.21 | -1.93 | 0.0021 | 4.3 | 17 | 916 | 0.20 | 10.03 | 0.0016 | 5.4 | 25 | 906 | 0.22 | -6.50 | 0.0129 |
| Switch | 10 | 4.8 | 22 | 810 | 0.21 | -2.57 | 0.0036 | 5 | 22 | 883 | 0.21 | -1.30 | 0.0220 | 5.4 | 23 | 889 | 0.21 | -2.61 | 0.0031 |
| | 18 | 5 | 23 | 810 | 0.22 | -4.30 | 0.0047 | 4.9 | 17 | 838 | 0.20 | 10.41 | 0.0111 | 4.9 | 14 | 805 | 0.18 | 19.31 | 0.0066 |
| | 26 | 3.6 | 15 | 816 | 0.19 | 12.91 | 0.0055 | 3.8 | 11 | 801 | 0.17 | 28.04 | 0.0061 | 4 | 10 | 779 | 0.16 | 32.78 | 0.0086 |
| | 44 | 4.4 | 16 | 816 | 0.19 | 11.90 | 0.0043 | 4.2 | 11 | 824 | 0.17 | 29.47 | 0.0017 | 4.8 | 13 | 787 | 0.18 | 22.37 | 0.0000 |
| Sorgh | 6 | 3.7 | 15 | 843 | 0.19 | 13.55 | 0.0014 | 3.9 | 17 | 859 | 0.20 | 8.31 | - | 4.6 | 32 | 888 | 0.24 | -20.21 | 0.0018 |
| | 16 | 4.2 | 25 | 821 | 0.22 | -9.89 | 0.0019 | 4.8 | 37 | 806 | 0.25 | -27.60 | 0.0109 | 4.7 | 36 | 751 | 0.25 | -27.03 | 0.0029 |
| | 39 | 4.6 | 34 | 860 | 0.24 | -23.40 | 0.0021 | 4.5 | 31 | 916 | 0.24 | -18.62 | 0.1116 | 4.8 | 28 | 869 | 0.23 | -13.53 | 0.0029 |
| MS – R1 | 5 | 3.8 | 16 | 839 | 0.19 | 10.69 | 0.007 | 3.7 | 16 | 875 | 0.19 | 10.88 | 0.0161 | 4.4 | 28 | 944 | 0.23 | -13.64 | 0.0033 |
| | 35 | 3.7 | 12 | 809 | 0.17 | 23.73 | 0.0017 | 3 | 12 | 793 | 0.18 | 21.35 | 0.0079 | 3.7 | 16 | 825 | 0.19 | 10.23 | 0.0050 |
| | 40 | 5.1 | 33 | 888 | 0.24 | -20.74 | 0.0083 | 5.2 | 33 | 840 | 0.24 | -21.03 | 0.2683 | 5.1 | 28 | 915 | 0.23 | -12.49 | 0.0106 |
| SM – R1 | 8 | 4.9 | 20 | 882 | 0.21 | 3.10 | 0.0074 | 4.8 | 23 | 896 | 0.22 | -3.72 | 0.0131 | 5.5 | 27 | 934 | 0.22 | -9.79 | 0.0204 |
| | 20 | 5.3 | 31 | 886 | 0.23 | -17.37 | 0.0072 | 5.7 | 31 | 854 | 0.23 | -17.01 | 0.0274 | 6 | 33 | 839 | 0.24 | -19.75 | 0.0136 |
| | 27 | 3.7 | 16 | 831 | 0.19 | 10.31 | 0.0046 | 3.4 | 11 | 788 | 0.17 | 26.68 | 0.0090 | 4 | 11 | 760 | 0.17 | 27.95 | 0.0028 |
| | 47 | 4.1 | 20 | 814 | 0.21 | 0.47 | 0.0023 | 4.7 | 15 | 815 | 0.19 | 15.68 | 0.0054 | 4.9 | 19 | 883 | 0.20 | 5.60 | 0.0030 |
| MS – R2 | 14 | 4.8 | 27 | 849 | 0.23 | -11.99 | 0.0029 | 4.9 | 24 | 856 | 0.22 | -6.02 | 0.0180 | 4.8 | 32 | 846 | 0.24 | -20.22 | 0.0041 |
| | 33 | 3 | 10 | 802 | 0.16 | 30.16 | 0.0023 | 3.1 | 11 | 761 | 0.17 | 25.32 | 0.0054 | 3.3 | 12 | 827 | 0.18 | 22.82 | 0.0082 |
| | 45 | 4.3 | 25 | 849 | 0.22 | -9.35 | 0.0020 | 3.9 | 21 | 809 | 0.21 | -2.43 | 0.0021 | 4.6 | 20 | 794 | 0.21 | 1.38 | 0.0123 |
| SM – R2 | 19 | 4.9 | 41 | 904 | 0.25 | -31.51 | 0.0100 | 4.6 | 51 | 922 | 0.27 | -42.53 | 0.0185 | 5.3 | 52 | 888 | 0.27 | -42.53 | 0.0170 |
| | 34 | 3.3 | 11 | 811 | 0.17 | 26.73 | 0.0027 | 3 | 10 | 756 | 0.17 | 29.42 | 0.0054 | 3.5 | 17 | 781 | 0.20 | 6.19 | 0.0080 |
| | 48 | 4.6 | 26 | 782 | 0.23 | -11.33 | 0.0061 | 3.6 | 25 | 727 | 0.23 | -12.50 | 0.1001 | 5 | 26 | 778 | 0.23 | -10.58 | 0.0115 |
| CM -SpM | 4 | 4.3 | 59 | 815 | 0.28 | -50.85 | 0.1373 | 4.8 | 83 | 811 | 0.31 | -66.38 | 0.0761 | 4.6 | 92 | 833 | 0.31 | -71.53 | 0.1368 |
| | 15 | 4.6 | 89 | 836 | 0.31 | -69.92 | 0.1266 | 4.5 | 79 | 769 | 0.30 | -64.76 | 0.1264 | 4.7 | 104 | 818 | 0.32 | -77.34 | 0.1617 |
| | 25 | 4.1 | 74 | 824 | 0.30 | -62.04 | 0.1371 | 4.2 | 91 | 763 | 0.32 | -72.07 | 0.1500 | 3.9 | 73 | 776 | 0.30 | -62.11 | 0.1251 |
| | 37 | 4.3 | 56 | 786 | 0.28 | -48.57 | 0.0586 | 3.9 | 68 | 774 | 0.30 | -58.74 | 0.2785 | 4.9 | 64 | 803 | 0.29 | -53.79 | 0.1718 |
| CM - FM | 7 | 5.4 | 62 | 849 | 0.28 | -51.20 | 0.1928 | 5.1 | 88 | 932 | 0.31 | -68.23 | 0.1087 | 5.5 | 76 | 995 | 0.29 | -60.27 | 0.3732 |
| | 24 | 4.9 | 59 | 836 | 0.28 | -49.64 | 0.1194 | 5.1 | 73 | 785 | 0.30 | -59.94 | 0.1055 | 5.5 | 81 | 827 | 0.30 | -64.18 | 0.2010 |
| | 28 | 3.4 | 38 | 819 | 0.26 | -31.95 | 0.1609 | 3.5 | 41 | 782 | 0.26 | -35.62 | 0.1080 | 4.1 | 41 | 813 | 0.26 | -33.87 | 0.2160 |
| CM | 3 | 3.8 | 20 | 846 | 0.21 | 0.09 | 0.0043 | 4.8 | 26 | 967 | 0.22 | -8.96 | 0.0085 | 4.4 | 28 | 918 | 0.23 | -13.89 | 0.0055 |
| | 21 | 5.1 | 43 | 888 | 0.26 | -33.60 | 0.0059 | 5 | 48 | 906 | 0.26 | -38.99 | 0.0123 | 5.6 | 50 | 915 | 0.27 | -39.99 | 0.0117 |
| | 31 | 3.7 | 13 | 819 | 0.18 | 20.06 | 0.0042 | 3.8 | 13 | 774 | 0.18 | 19.68 | 0.0062 | 4.2 | 16 | 822 | 0.19 | 11.50 | 0.0097 |

Source: Welikhe et al. (2020).

Note 1: Cropping system abbreviation and management histories are provided in Table S1.

Note 2: OM, organic matter; P, phosphorus; Al, aluminum; PSR, phosphorus saturation ratio; SPSC, soil phosphorus storage capacity; fDRP, annual flow-weighted mean dissolved reactive phosphorus concentrations.

Supplementary Table 3
Field data (empirical dataset) used to generate the theoretical dataset and for the calculation of phosphorus index values. Treatment (cropping system) abbreviation and management histories are provided in supplemental Table 1.

| Plot # | Treatment | Water year | STP (mg $kg^{-1}$) | FPR (lbs $P_2O_5$ $A^{-1}$) | FPA (unitless) | OPR (lbs $P_2O_5$ $A^{-1}$) | OPA (unitless) | SE (unitless) | SR (unitless) | SDP (unitless) | DTW (unitless) §§ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Prairie | 2011 | 27 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 1 | Prairie | 2012 | 26 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 1 | Prairie | 2013 | 29 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 2 | MS-R2 | 2011 | 15 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 2 | MS-R2 | 2012 | 17 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 2 | MS-R2 | 2013 | 26 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 3 | CM | 2011 | 20 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 3 | CM | 2012 | 26 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 3 | CM | 2013 | 28 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 4 | CM-SpM | 2011 | 59 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 4 | CM-SpM | 2012 | 83 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 4 | CM-SpM | 2013 | 92 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 5 | MS-R1 | 2011 | 16 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 5 | MS-R1 | 2012 | 16 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 5 | MS-R1 | 2013 | 28 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 6 | Sorgh | 2011 | 15 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 6 | Sorgh | 2012 | 17 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 6 | Sorgh | 2013 | 32 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 7 | CM-FM | 2011 | 62 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 7 | CM-FM | 2012 | 88 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 7 | CM-FM | 2013 | 76 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 8 | SM-R1 | 2011 | 20 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 8 | SM-R1 | 2012 | 23 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 8 | SM-R1 | 2013 | 27 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 10 | Switch | 2011 | 22 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 10 | Switch | 2012 | 22 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 10 | Switch | 2013 | 23 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 11 | Mxg | 2011 | 26 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |

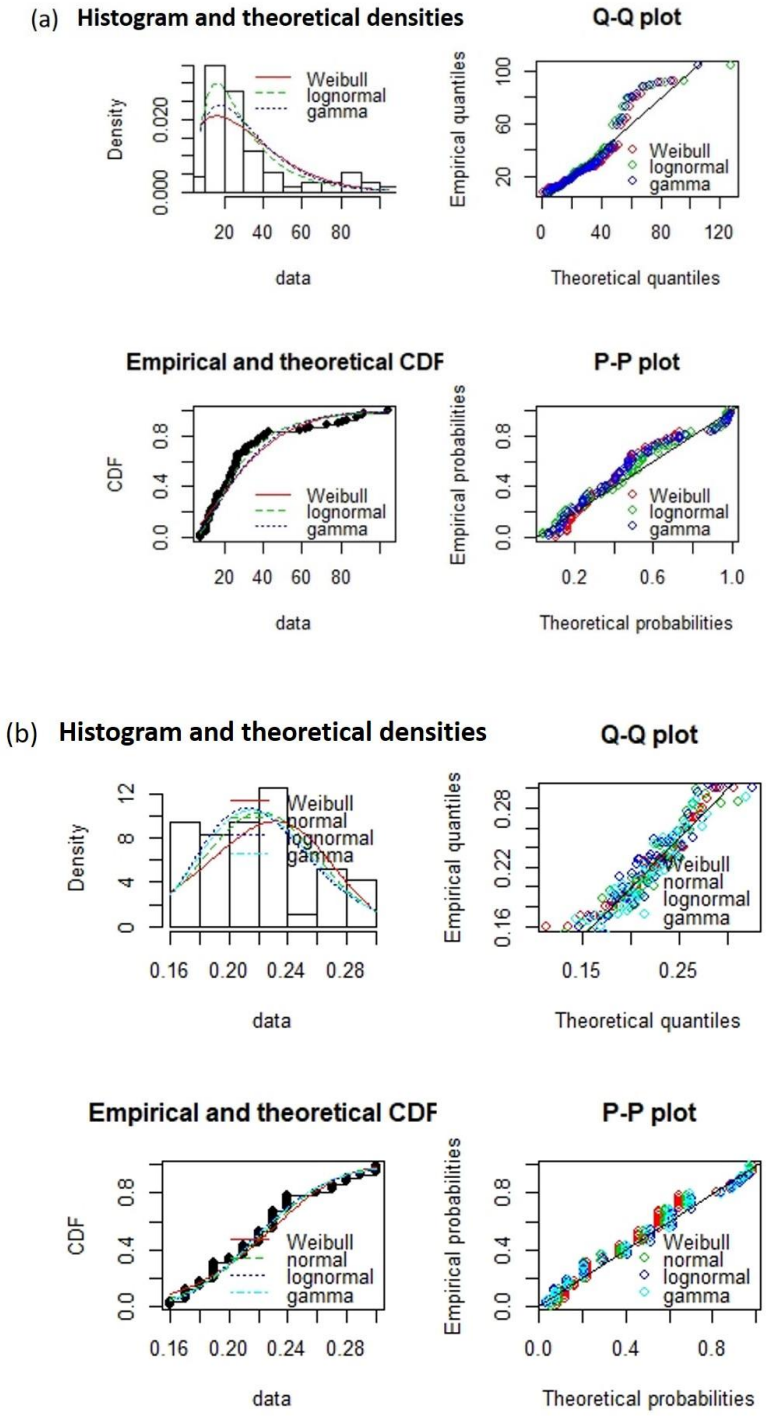
| Plot # | Treatment | Water year | STP (mg $kg^{-1}$) | FPR (lbs $P_2O_5$ $A^{-1}$) | FPA (unitless) | OPR (lbs $P_2O_5$ $A^{-1}$) | OPA (unitless) | SE (unitless) | SR (unitless) | SDP (unitless) | DTW (unitless) §§ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Mxg | 2012 | 24 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 11 | Mxg | 2013 | 25 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 12 | CM-RR | 2011 | 27 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 12 | CM-RR | 2012 | 32 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 12 | CM-RR | 2013 | 26 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 14 | MS-R2 | 2011 | 27 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 14 | MS-R2 | 2012 | 24 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 14 | MS-R2 | 2013 | 32 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 15 | CM-SpM | 2011 | 89 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 15 | CM-SpM | 2012 | 79 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 15 | CM-SpM | 2013 | 104 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 16 | Sorgh | 2011 | 25 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 16 | Sorgh | 2012 | 37 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 16 | Sorgh | 2013 | 36 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 17 | Prairie | 2011 | 23 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 17 | Prairie | 2012 | 26 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 17 | Prairie | 2013 | 24 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 18 | Switch | 2011 | 23 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 18 | Switch | 2012 | 17 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 18 | Switch | 2013 | 14 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 19 | SM-R2 | 2011 | 41 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 19 | SM-R2 | 2012 | 51 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 19 | SM-R2 | 2013 | 52 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 20 | SM-R1 | 2011 | 31 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 20 | SM-R1 | 2012 | 31 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 20 | SM-R1 | 2013 | 33 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 21 | CM | 2011 | 43 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 21 | CM | 2012 | 48 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 21 | CM | 2013 | 50 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 24 | CM-FM | 2011 | 59 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 24 | CM-FM | 2012 | 73 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |

| Plot # | Treatment | Water year | STP (mg $kg^{-1}$) | FPR (lbs $P_2O_5$ $A^{-1}$) | FPA (unitless) | OPR (lbs $P_2O_5$ $A^{-1}$) | OPA (unitless) | SE (unitless) | SR (unitless) | SDP (unitless) | DTW (unitless) §§ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | CM-FM | 2013 | 81 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 25 | CM-SpM | 2011 | 74 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 25 | CM-SpM | 2012 | 91 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 25 | CM-SpM | 2013 | 73 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 26 | Switch | 2011 | 15 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 26 | Switch | 2012 | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 26 | Switch | 2013 | 10 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 27 | SM-R1 | 2011 | 16 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 27 | SM-R1 | 2012 | 11 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 27 | SM-R1 | 2013 | 11 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 28 | CM-FM | 2011 | 38 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 28 | CM-FM | 2012 | 41 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 28 | CM-FM | 2013 | 41 | 18.96 | 1 | 81 | 1 | 1 | 0 | 4 | 1 |
| 30 | CM-RR | 2011 | 11 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 30 | CM-RR | 2012 | 12 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 30 | CM-RR | 2013 | 21 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 31 | CM | 2011 | 13 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 31 | CM | 2012 | 13 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 31 | CM | 2013 | 16 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 32 | Mxg | 2011 | 9 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 32 | Mxg | 2012 | 8 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 32 | Mxg | 2013 | 8 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 33 | MS-R2 | 2011 | 10 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 33 | MS-R2 | 2012 | 11 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 33 | MS-R2 | 2013 | 12 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 34 | SM-R2 | 2011 | 11 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 34 | SM-R2 | 2012 | 10 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 34 | SM-R2 | 2013 | 17 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 35 | MS-R1 | 2011 | 12 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 35 | MS-R1 | 2012 | 12 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 35 | MS-R1 | 2013 | 16 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |

| Plot # | Treatment | Water year | STP (mg $kg^{-1}$) | FPR (lbs $P_2O_5$ $A^{-1}$) | FPA (unitless) | OPR (lbs $P_2O_5$ $A^{-1}$) | OPA (unitless) | SE (unitless) | SR (unitless) | SDP (unitless) | DTW (unitless) §§ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 36 | Prairie | 2011 | 14 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 36 | Prairie | 2012 | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 36 | Prairie | 2013 | 16 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 37 | CM-SpM | 2011 | 56 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 37 | CM-SpM | 2012 | 68 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 37 | CM-SpM | 2013 | 64 | 0 | 0 | 81 | 1 | 1 | 0 | 4 | 1 |
| 39 | Sorgh | 2011 | 34 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 39 | Sorgh | 2012 | 31 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 39 | Sorgh | 2013 | 28 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 40 | MS-R1 | 2011 | 33 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 40 | MS-R1 | 2012 | 33 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 40 | MS-R1 | 2013 | 28 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 43 | Mxg | 2011 | 13 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 43 | Mxg | 2012 | 12 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 43 | Mxg | 2013 | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 44 | Switch | 2011 | 16 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 44 | Switch | 2012 | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 44 | Switch | 2013 | 13 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 1 |
| 45 | MS-R2 | 2011 | 25 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 45 | MS-R2 | 2012 | 21 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 45 | MS-R2 | 2013 | 20 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 46 | CM-RR | 2011 | 22 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 46 | CM-RR | 2012 | 17 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 46 | CM-RR | 2013 | 25 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 47 | SM-R1 | 2011 | 20 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 47 | SM-R1 | 2012 | 15 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 47 | SM-R1 | 2013 | 19 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 48 | SM-R2 | 2011 | 26 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |
| 48 | SM-R2 | 2012 | 25 | 57.00 | 4 | 0 | 0 | 1 | 0 | 4 | 1 |
| 48 | SM-R2 | 2013 | 26 | 18.96 | 1 | 0 | 0 | 1 | 0 | 4 | 1 |

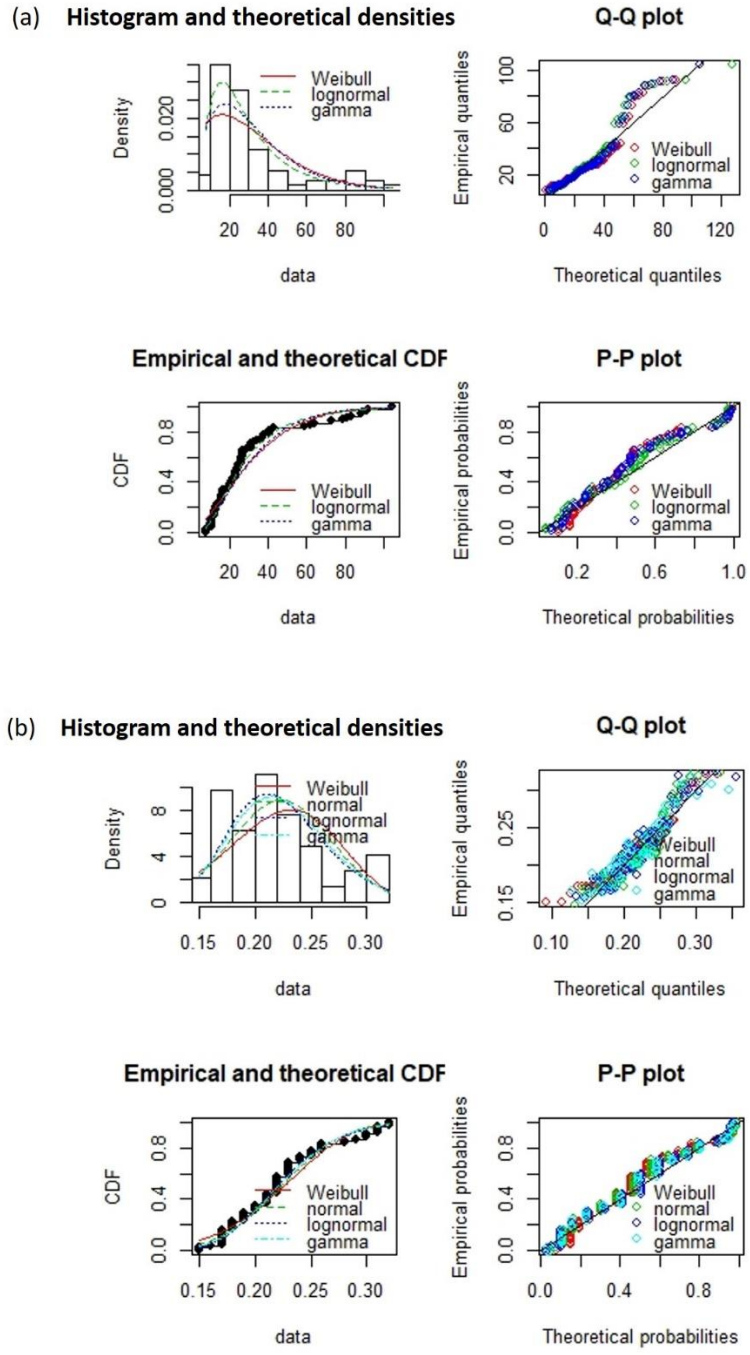
Note 1: STP, soil test phosphorus; FPR, inorganic phosphorus fertilizer rate; FPA, inorganic phosphorus fertilizer application method and timing; OPR, organic phosphorus fertilizer rate; OPA, organic phosphorus fertilizer application method and timing; SE, soil erosion; SR, surface runoff; SDP, subsurface drainage potential; DTW, the distance to water body.
Note 2: Swine manure was applied at rates meant to supply ~ 228 lbs N $ha^{-1}$ $yr$.

Supplementary Figure 1
Histogram and theoretical densities, Q-Q plot, empirical and theoretical cumulative distribution functions, and P-P plots for continuous variables in the testing dataset (a) Mehlich 3 soil test phosphorus, and (b) Phosphorus saturation ratio.

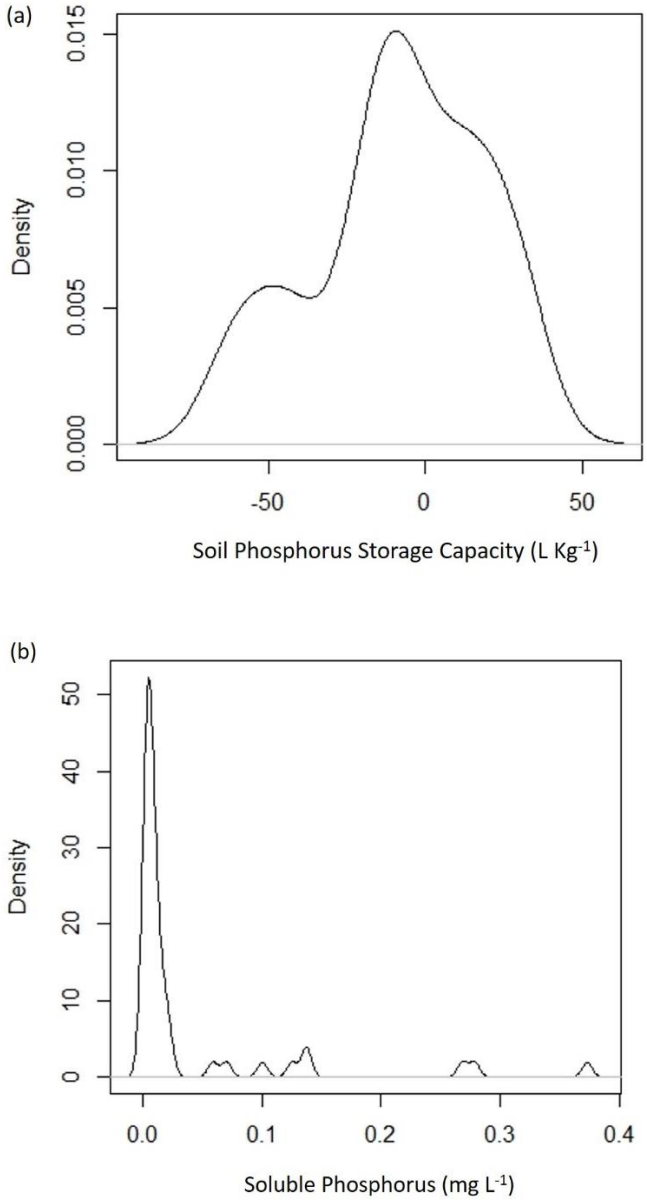


Supplementary Figure 2

Histogram and theoretical densities, Q-Q plot, empirical and theoretical cumulative distribution functions, and P-P plots for continuous variables in the training dataset (a) Mehlich 3 soil test phosphorus, and (b) Phosphorus saturation ratio.



Supplementary Figure 3
Density plots for continuous variables in the testing dataset (a) Soil phosphorus storage capacity, and (b) Soluble phosphorus.



Supplementary Figure 4
Density plots for continuous variables in the training dataset (a) Soil phosphorus storage capacity, and (b) Soluble phosphorus.