**Supplementary Information**

Title:  
Potential for soil legacy phosphorus release from restored floodplain wetlands within an agricultural landscape

Authors:

Adrian R. H. Wiegman\*1,2,a

G. Harrison Myers3

Isabelle C. Augustin3

Marcos L. Kubow2

Maya Fein-Cole2

Vanesa L. Perillo4,5,6

Donald S. Ross4

Rebecca M. Diehl1,7

Kristen L. Underwood1,3

William B. Bowden2

Eric D. Roy1,2,3

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1 Gund Institute for Environment, University of Vermont, Burlington, Vermont 05405, USA

2 Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, Vermont 05405, USA

3 Department of Civil and Environmental Engineering, University of Vermont, Burlington, Vermont 05405, USA

4 Department of Plant and Soil Science, University of Vermont, Burlington, Vermont 05405, USA

5 Instituto Argentino de Oceanografía (IADOCONICET-UNS), Camino La Carrindanga km 7 E1, B8000CPB Bahía Blanca, Argentina

6Departamento de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur, San Juan 670 Piso 1, Bahía Blanca, Argentina, B8000ICN

7 Department of Geography, University of Vermont, Burlington, Vermont 05405, USA

a (Current Affiliation) USDA-ARS Pasture Systems and Watershed Management Research Unit, One State Bog Rd., East Wareham, Massachusetts 02538, USA

\*Corresponding Author:Adrian Wiegman (adrian.wiegman@gmail.com)

# Farming History of Wetland Restoration Candidates in Vermont

We calculated the percent overlap of potential wetland restoration sites (VTDEC 2018) with the 2016 0.5m resolution agricultural land cover data from the Vermont Center for Geographic Information (VTADS 2021) using the “Clip” tool available in ArcGIS Pro 2.7.

# Time horizon of SRP release

Based on the upper and lower end estimates of the effect of YSF on intact core final SRP (b1 = -0.0884 ± 0.017 which translates to 0.0714 to 0.01054, Table S3), we estimated that the mean annual rate of decay in SRP release for time after farming is between approximately 7.1% and 10.5%. Consequently, the average (time after farming stops) for the magnitude of SRP release to half is roughly ~7 – 10 years and the time for final SRP to decrease 10-fold is roughly ~22 - 32 years. The estimates above were calculated from the formula for the multiple regression models equation given below (and in Table S3).

(Eqn. S1)

Where y = final SRP, and X1 = years since farming, and b1 is the effect off years since farming on final SRP. We set the b0 (intercept) and b2 (gas treatment) parameters to zero, which reduced the model to the following (Eqn. S2).

(Eqn. S2)

We let b1 = k (decay rate of final SRP with respect to YSF) and X1 = t (time) and y = 1/z or the factor of decrease (z) in final SRP between time 0 and time t:

y

(Eqn. S3)

where is the time at which y = 1/z, we took the natural log of both sides of Eqn. S3, reduced, rearranged, and solved for with values of z of 2 and 10 and values of k of 0.071 and 0.105 (Eqn S6).

(Eqn. S6)

# Supplemental Figures and Tables

**Table S1** Geographic characteristics of sampling plots. 1IC = Intact Core and RA = Rapid Assessment, 2HSG = NRCS hydrologic soils group, 3Land Cover Class in 2016 0.5m resolution (VTADS 2021), 4 WBD = Watershed Boundary Dataset (USGS 2018)

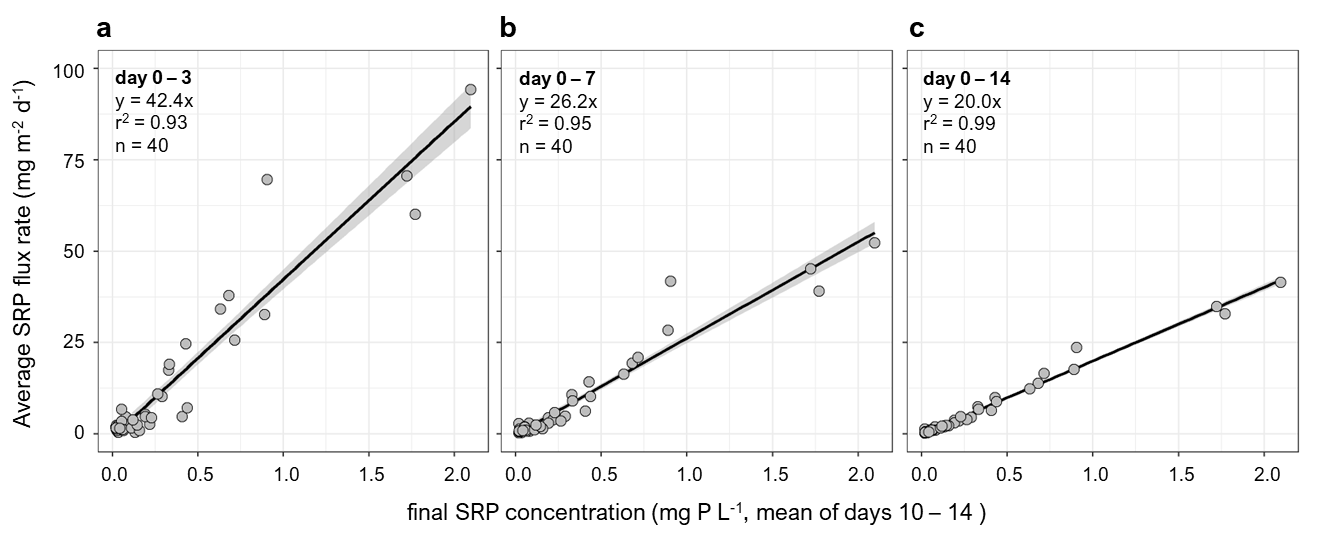
| **PID** | **1Plot Type** | **2HSG** | **Lat.** | **Lon.** | **Elevation (m, NAD83)** | **3Land Cover Class in 2016** | **4WBD HUC10 Name (ID)** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | IC | B | 44.26 | -73.1 | 116.87 | Hay | Lewis Creek (0430010805) |
| 2 | RA | B | 44.26 | -73.1 | 116.94 | Hay | Lewis Creek (0430010805) |
| 3 | RA | B/D | 43.78 | -73.1 | 107.84 | Tree Canopy | Middlebury River-Otter Creek (0430010203) |
| 4 | RA | B/D | 43.78 | -73.1 | 106.57 | Hay | Middlebury River-Otter Creek (0430010203) |
| 5 | RA | B/D | 43.78 | -73.1 | 107.52 | Hay | Middlebury River-Otter Creek (0430010203) |
| 6 | RA | A | 43.79 | -73.1 | 117.21 | Hay | Middlebury River-Otter Creek (0430010203) |
| 7 | RA | B/D | 43.78 | -73.1 | 106.73 | Hay | Middlebury River-Otter Creek (0430010203) |
| 8 | RA | C | 44.5 | -73.2 | 32.34 | Hay | Winooski River (0430010307) |
| 9 | RA | C | 44.5 | -73.2 | 32.10 | Hay | Winooski River (0430010307) |
| 10 | IC | C | 44.5 | -73.2 | 32.37 | Hay | Winooski River (0430010307) |
| 11 | RA | C | 44.5 | -73.2 | 32.25 | Hay | Winooski River (0430010307) |
| 12 | IC | C | 44.5 | -73.2 | 32.04 | Hay | Winooski River (0430010307) |
| 13 | RA | B/D | 43.95 | -73.2 | 105.24 | Hay | Middlebury River-Otter Creek (0430010203) |
| 14 | IC | B/D | 43.96 | -73.2 | 104.32 | Crops | Middlebury River-Otter Creek (0430010203) |
| 15 | IC | C/D | 43.95 | -73.2 | 104.55 | Hay | Middlebury River-Otter Creek (0430010203) |
| 16 | IC | A/D | 43.96 | -73.2 | 103.93 | Hay | Middlebury River-Otter Creek (0430010203) |
| 17 | IC | B/D | 43.81 | -73.2 | 105.91 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 18 | IC | B/D | 43.81 | -73.1 | 105.88 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 19 | RA | B/D | 43.87 | -73.2 | 104.85 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 20 | IC | D | 44.29 | -73.2 | 112.90 | Grass/Shrubs | Lewis Creek (0430010805) |
| 21 | IC | C/D | 44.29 | -73.2 | 112.88 | Grass/Shrubs | Lewis Creek (0430010805) |
| 22 | IC | C/D | 44.29 | -73.2 | 113.22 | Grass/Shrubs | Lewis Creek (0430010805) |
| 23 | IC | D | 44.3 | -73.2 | 112.96 | Grass/Shrubs | Lewis Creek (0430010805) |
| 24 | IC | C/D | 44.29 | -73.2 | 113.24 | Grass/Shrubs | Lewis Creek (0430010805) |
| 25 | RA | B/D | 44.57 | -73.2 | 30.68 | Emergent Wetland | Malletts Bay (0430010809) |
| 26 | RA | B/D | 44.57 | -73.2 | 31.06 | Emergent Wetland | Malletts Bay (0430010809) |
| 27 | IC | B/D | 44.57 | -73.2 | 30.97 | Emergent Wetland | Malletts Bay (0430010809) |
| 28 | RA | B/D | 44.57 | -73.2 | 31.40 | Emergent Wetland | Malletts Bay (0430010809) |
| 29 | RA | B/D | 44.57 | -73.2 | 31.40 | Emergent Wetland | Malletts Bay (0430010809) |
| 30 | RA | B/D | 44.96 | -73.2 | 30.40 | Forested Wetland | Missisquoi Bay (0430010811) |
| 31 | RA | C/D | 44.99 | -72.9 | 133.58 | Emergent Wetland | Riviere aux Brochets (0430010810) |
| 32 | RA | C/D | 44.99 | -72.9 | 133.38 | Hay | Riviere aux Brochets (0430010810) |
| 33 | RA | C/D | 44.99 | -72.9 | 133.54 | Forested Wetland | Riviere aux Brochets (0430010810) |
| 34 | RA | D | 44.95 | -72.8 | 204.81 | Crops | Riviere aux Brochets (0430010810) |
| 35 | RA | D | 44.95 | -72.8 | 204.45 | Crops | Riviere aux Brochets (0430010810) |
| 36 | RA | B/D | 44.95 | -72.8 | 205.66 | Grass/Shrubs | Riviere aux Brochets (0430010810) |
| 37 | RA | B/D | 44.95 | -72.8 | 205.38 | Emergent Wetland | Riviere aux Brochets (0430010810) |
| 38 | RA | B/D | 44.57 | -73.2 | 30.79 | Emergent Wetland | Malletts Bay (0430010809) |
| 39 | IC | B/D | 43.78 | -73.1 | 106.21 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 40 | IC | B/D | 43.78 | -73.1 | 106.45 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 41 | IC | B/D | 43.78 | -73.1 | 106.48 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 42 | IC | B/D | 43.78 | -73.1 | 106.72 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 43 | IC | B/D | 43.78 | -73.1 | 106.59 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 44 | IC | B/D | 43.78 | -73.1 | 107.10 | Hay | Middlebury River-Otter Creek (0430010203) |
| 45 | IC | B/D | 43.78 | -73.1 | 106.56 | Hay | Middlebury River-Otter Creek (0430010203) |
| 46 | IC | B/D | 43.92 | -73.2 | 104.15 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 47 | IC | C | 43.92 | -73.2 | 104.56 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 48 | IC | C | 43.92 | -73.2 | 104.52 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 49 | IC | C | 43.92 | -73.2 | 105.03 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 50 | IC | B | 43.92 | -73.2 | 104.91 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 51 | RA | B | 43.74 | -73.1 | 108.25 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 52 | RA | B/D | 43.75 | -73.1 | 106.91 | Hay | Middlebury River-Otter Creek (0430010203) |
| 53 | RA | D | 43.8 | -73.1 | 108.20 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 54 | IC | B/D | 43.79 | -73.1 | 106.08 | Hay | Middlebury River-Otter Creek (0430010203) |
| 55 | IC | C | 43.79 | -73.1 | 114.01 | Tree Canopy | Middlebury River-Otter Creek (0430010203) |
| 56 | RA | A | 43.65 | -73.1 | 155.52 | Scrub\Shrub Wetland | Poultney River (0430010103) |
| 57 | RA | C/D | 44.95 | -72.9 | 133.01 | Hay | Tyler Branch-Missisquoi River (0430010704) |
| 58 | RA | C/D | 44.95 | -72.9 | 133.06 | Forested Wetland | Tyler Branch-Missisquoi River (0430010704) |
| 59 | RA | A/D | 43.86 | -73.2 | 105.35 | Forested Wetland | Middlebury River-Otter Creek (0430010203) |
| 60 | RA | D | 43.87 | -73.2 | 104.61 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 61 | IC | A/D | 43.87 | -73.2 | 104.44 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 62 | IC | A/D | 43.87 | -73.2 | 104.15 | Emergent Wetland | Middlebury River-Otter Creek (0430010203) |
| 63 | RA | C | 43.97 | -73.2 | 104.76 | Hay | Middlebury River-Otter Creek (0430010203) |
| 64 | RA | B/D | 43.74 | -73.1 | 107.52 | Forested Wetland | Middlebury River-Otter Creek (0430010203) |

**Table S2** Matrix of Spearman rank correlation rho (ρ) comparing bulk density weighted mean soil properties (0-10cm) for each sampling plot (n=42, except for sand, silt, clay where n = 15). Variable names are listed on the top, left and diagonal of the matrix, see Table 1 for variable definitions. The upper right triangle shows the correlations significance code (\*0.05 > p ≥ 0.01, \*\*0.01 > p ≥ 0.001, \*\*\*0.001 > p), the lower left triangle shows Spearman rho values. Non-significant (p>0.05) correlations are left blank.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **FF** | | **YSF** | **sand** | | **silt** | | **clay** | | **MC** | | **BD** | | **LOI** | | **WEP** | | **HCl-Pi** | | **HCl-TP** | | **HCl-Po** | | **HCl-[Pi:TP]** | **MM-P** | | **Alox** | | **Feox** | | **Pox** | | **[P:Fe]ox** | | **PSRox** | | **SPSox** |
| **FF** | |  | | \*\*\* | \* | | \* | |  | | \*\*\* | | \*\*\* | | \*\*\* | | \*\* | | \*\*\* | |  | | \*\* | | \*\*\* |  | | \*\* | | \*\* | |  | | \*\* | | \*\* | | \*\* |
| **YSF** | | -0.94 | |  |  | | \* | |  | | \*\*\* | | \*\*\* | | \*\*\* | | \* | | \*\* | |  | | \*\* | | \*\*\* |  | | \*\* | | \*\* | |  | | \* | | \*\* | | \*\*\* |
| **sand** | | 0.62 | |  |  | | \* | | \*\*\* | | \*\* | | \*\* | | \*\* | |  | |  | |  | | \*\*\* | | \* |  | | \*\* | | \* | |  | |  | |  | | \* |
| **silt** | | -0.53 | | 0.54 | -0.64 | |  | |  | | \* | | \* | |  | |  | |  | |  | | \*\* | | \* |  | |  | |  | |  | |  | |  | |  |
| **clay** | |  | |  | -0.80 | |  | |  | | \* | | \* | | \*\* | |  | |  | |  | | \* | | \* |  | | \*\* | | \* | |  | |  | | \* | | \*\* |
| **MC** | | -0.75 | | 0.68 | -0.69 | | 0.53 | | 0.53 | |  | | \*\*\* | | \*\*\* | | \* | | \*\*\* | |  | | \*\*\* | | \*\*\* |  | | \*\*\* | | \*\* | |  | |  | | \*\* | | \*\*\* |
| **BD** | | 0.76 | | -0.69 | 0.74 | | -0.52 | | -0.62 | | -0.96 | |  | | \*\*\* | | \* | | \*\*\* | |  | | \*\*\* | | \*\*\* |  | | \*\*\* | | \*\* | |  | | \* | | \*\*\* | | \*\*\* |
| **LOI** | | -0.61 | | 0.56 | -0.72 | |  | | 0.73 | | 0.89 | | -0.91 | |  | | \* | | \*\*\* | |  | | \*\*\* | | \*\*\* |  | | \*\*\* | | \*\* | |  | |  | | \*\*\* | | \*\*\* |
| **WEP** | | 0.42 | | -0.38 |  | |  | |  | | -0.34 | | 0.39 | | -0.35 | |  | | \*\*\* | | \* | |  | | \*\* | \*\*\* | |  | |  | | \*\*\* | | \*\*\* | | \*\*\* | | \*\*\* |
| **HCl-Pi** | | 0.51 | | -0.44 |  | |  | |  | | -0.63 | | 0.67 | | -0.66 | | 0.60 | |  | |  | | \*\* | | \*\*\* | \* | | \* | |  | | \* | | \* | | \*\*\* | |  |
| **HCl-TP** | |  | |  |  | |  | |  | |  | |  | |  | | 0.38 | |  | |  | | \*\*\* | |  |  | | \*\*\* | | \*\*\* | | \*\*\* | |  | |  | | \*\* |
| **HCl-Po** | | -0.48 | | 0.43 | -0.81 | | 0.69 | | 0.58 | | 0.76 | | -0.76 | | 0.77 | |  | | -0.49 | | 0.55 | |  | | \*\*\* |  | | \*\*\* | | \*\*\* | | \* | |  | |  | | \*\*\* |
| **HCl-[Pi:TP]** | | 0.57 | | -0.51 | 0.60 | | -0.61 | | -0.54 | | -0.80 | | 0.82 | | -0.81 | | 0.40 | | 0.83 | |  | | -0.85 | |  |  | | \*\*\* | |  | |  | |  | | \*\*\* | | \*\*\* |
| **MM-P** | |  | |  |  | |  | |  | |  | |  | |  | | 0.54 | | 0.32 | |  | |  | |  |  | | \* | | \*\*\* | |  | | \*\*\* | | \*\*\* | | \*\*\* |
| **Alox** | | -0.44 | | 0.41 | -0.73 | |  | | 0.75 | | 0.66 | | -0.62 | | 0.71 | |  | | -0.36 | | 0.53 | | 0.76 | | -0.60 | -0.33 | |  | | \*\*\* | | \*\* | |  | | \* | | \*\*\* |
| **Feox** | | -0.42 | | 0.40 | -0.62 | |  | | 0.53 | | 0.40 | | -0.41 | | 0.40 | |  | |  | | 0.55 | | 0.50 | |  | -0.52 | | 0.66 | |  | | \*\* | | \*\*\* | | \*\* | | \*\*\* |
| **Pox** | |  | |  |  | |  | |  | |  | |  | |  | | 0.52 | | 0.39 | | 0.84 | | 0.36 | |  |  | | 0.49 | | 0.45 | |  | | \*\* | | \* | |  |
| **[P:Fe]ox** | | 0.43 | | -0.35 |  | |  | |  | |  | | 0.32 | |  | | 0.59 | | 0.38 | |  | |  | |  | 0.62 | |  | | -0.50 | | 0.42 | |  | | \*\*\* | | \*\*\* |
| **PSRox** | | 0.48 | | -0.41 |  | |  | | -0.57 | | -0.48 | | 0.54 | | -0.52 | | 0.73 | | 0.64 | |  | |  | | 0.51 | 0.68 | | -0.40 | | -0.45 | | 0.38 | | 0.85 | |  | | \*\*\* |
| **SPSCox** | | -0.51 | | 0.45 | -0.56 | |  | | 0.68 | | 0.57 | | -0.61 | | 0.60 | | -0.53 | | -0.49 | |  | | 0.57 | | -0.54 | -0.72 | | 0.74 | | 0.78 | |  | | -0.66 | | -0.83 | |  |

**Table S3** Multiple linear regression summary from the best fitting predictor variables of the ln(final SRP) with gas treatment as a factor (I) and as final DO concentration (II) (n = 40). To translate the values in this table to final SRP (mg P L-1) use . All parameters for soil variables are for the 0-5cm layer. All models meet the assumptions of normality and homoskedasticity. See Table 1 for variation definitions. Significance code (type II sum of squares): \*0.05 > p ≥ 0.01, \*\*0.01 > p ≥ 0.001, \*\*\*0.001 > p).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **X1** | **adj-R2** | **b0** | **b1 (site conditions)** | **b2 (oxygen conditions)** |
| 1. **X2 = gas treatment aerobic (O2 = 0), anaerobic (N2 = 1)** | | | | |
| ln([P:Fe]ox) | 0.65 | 0.576 ± 0.41 | 2.47 ± 0.31\*\*\* | 0.864 ± 0.25\*\* |
| SPSCox | 0.64 | -1.54 ± 0.21 | -0.00307 ± 4e-04\*\*\* | 0.864 ± 0.26\*\* |
| FF | 0.56 | -3.31 ± 0.25 | 2.83 ± 0.43\*\*\* | 0.864 ± 0.28\*\* |
| ln(PSRox) | 0.54 | 1.85 ± 0.7 | 2.25 ± 0.36\*\*\* | 0.864 ± 0.29\*\* |
| ln(MM-P) | 0.49 | -3.96 ± 0.37 | 0.797 ± 0.14\*\*\* | 0.864 ± 0.3\*\* |
|  |  |  |  |  |
| 1. **X2 = final DO (mg/L, day 10 – 14 average)** | | | | |
| ln([P:Fe]ox) | 0.67 | 1.46 ± 0.39 | 2.38 ± 0.3\*\*\* | -0.182 ± 0.046\*\*\* |
| SPSCox | 0.66 | -0.588 ± 0.21 | -0.00295 ± 0.00039\*\*\* | -0.182 ± 0.046\*\*\* |
| FF | 0.6 | -2.27 ± 0.26 | 2.74 ± 0.41\*\*\* | -0.182 ± 0.046\*\*\* |
| ln(PSRox) | 0.59 | 2.79 ± 0.66 | 2.2 ± 0.34\*\*\* | -0.182 ± 0.046\*\*\* |
| ln(MM-P) | 0.55 | -2.88 ± 0.36 | 0.788 ± 0.13\*\*\* | -0.182 ± 0.046\*\*\* |
| YSF | 0.51 | 0.00305 ± 0.32 | -0.0858 ± 0.016\*\*\* | -0.182 ± 0.046\*\* |



**Fig. S1** Scatterplot of linear regression results for final SRP (x) verses average SRP flux rates (y) estimated for days 0 – 3 (a), 0 – 7 (d), and 0 – 14 (c).

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**Fig. S2** Intact core incubation soluble reactive phosphorus (SRP) concentration over time for each site and plot, showing mean ± 1 standard deviation gas treatment, aerobic (O2) in red and anaerobic (N2) gas treatments in grey (n = 3 per plot per treatment).

# References

USGS. 2018. Watershed Boundary Dataset. The National Map.

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