7-2016

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Publication Info
Published in *Legacy*, Volume 20, Issue 1, 2016, pages 22-25.
http://artsandsciences.sc.edu/sciaa/

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By J. Christopher Gillam

Archaeological predictive modeling at the Department of Energy's Savannah River Site (DOE-SRS) has paralleled efforts elsewhere in the Southeast. First published in 1989, the previous archaeological predictive model was developed by the Savannah River Archaeological Research Program (SRARP) to aid cultural resource management of prehistoric sites on the SRS (SRARP 1989). Generated prior to the availability of a Geographic Information System (GIS), the model was understandably based upon only three environmental variables and univariate statistics. Similar to other predictive models, it provided three zones of relative archaeological sensitivity, including low, moderate, and high probability areas, plus an indeterminate zone representing wetland areas typically avoided by land-use planners on the SRS (and therefore not archaeologically tested on a regular basis. (Figure 1).

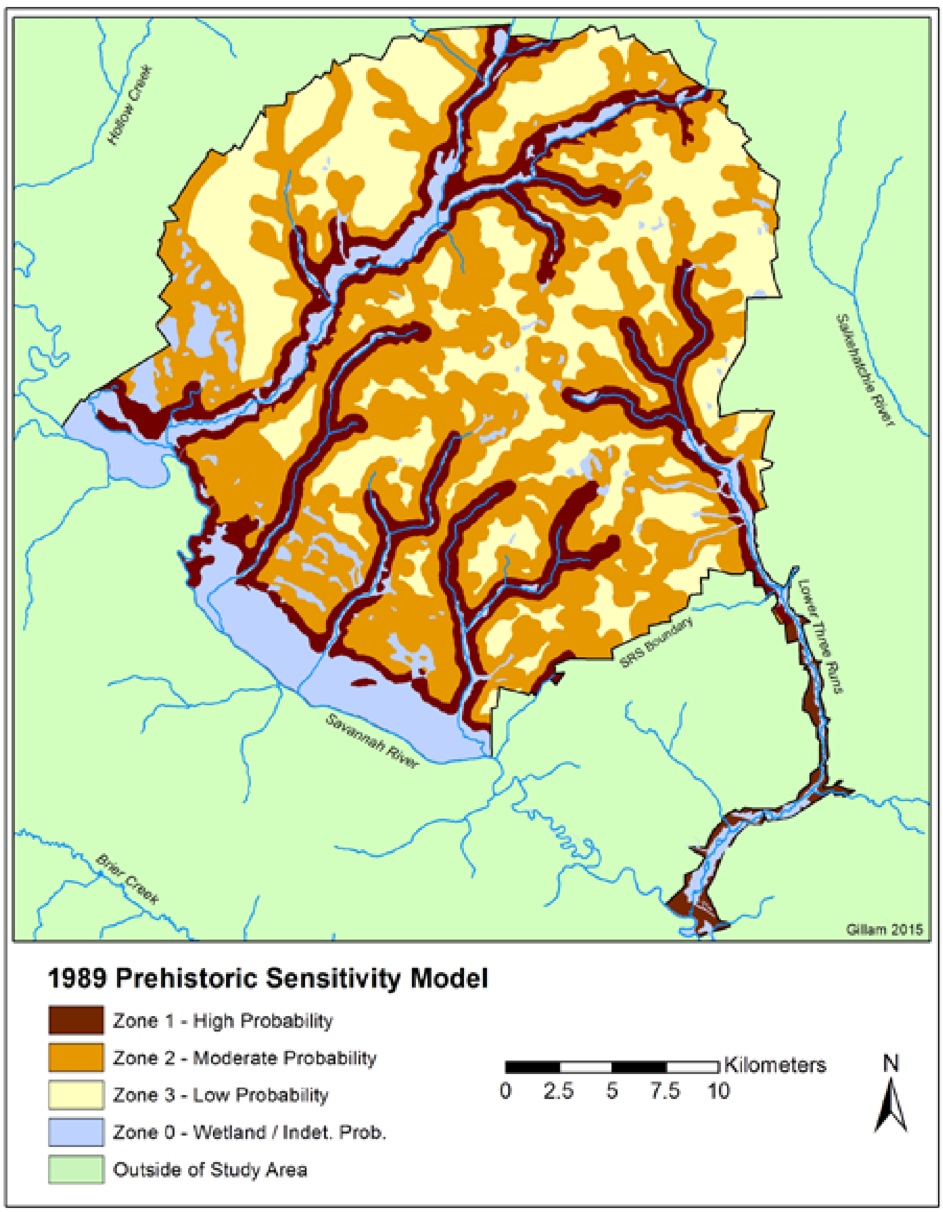

Figure 1: The 1989 Sensitivity Zone Model for the SRS. (Map by J. Christopher Gillam)

Since its development, the extant 1989 model has served as a guide for fieldwork enabling archaeologists to focus testing and minimize the cost of archaeological surveys. Ongoing research suggested that the 1989 model was significant, but in need of further evaluation (Gillam 2005:21-23). Analysis of a subsequent, independent model validation sample (n=89 prehistoric sites) demonstrated that a revised model is warranted, resulting in the development of a new multivariate logistic regression model of prehistoric site location on the SRS (Gillam 2015: In Press).

Following a knowledge-based approach for the current study, seven environmental variables were selected for model production based on existing knowledge of significant elements of the prehistoric cultural landscape. This method is preferred to other approaches, such as stepwise or best subset variable selection, due to archaeology's focus on selective, agent-based human systems, processes and decisions that are not necessarily dependent on environment. That is, an expedient "shotgun" approach might yield a statistically valid model that does not correlate meaningfully to cultural decisions and activities that the resulting model attempts to represent. The anthropologically-relevant variables chosen for analysis include: elevation, relative elevation to streams, local elevation range, caloric cost-distance to wetlands/streams/bays, percent slope, and landform plan- and profile-curvature (land curvature parallel and perpendicular to slope direction, respectively). The

#	Estimate	Parameter
0	0.499	Intercept
1	-0.013	Elevation (dem_ned30)
2	0.014	Elev. Range (elev_rng900)
3	-0.005	Water Cost-Distance (fbs_c4)
4	6.853	Plan Curvature (plan_ned30)
5	-2.238	Profile Curvature (prof_ned30)
6	-0.009	Rel. Elev. Stream (rel_strm3k)
7	0.064	Percent Slope (slp_ned30p)

Table 1: Coefficient estimates for the binary logit model (n=199 prehistoric sites; n=200 random, non-sites). (Table constructed by J. Christopher Gillam)

values were extracted in ArcGIS (ESRI 2016), exported to tabular format, and analyzed statistically in SAS (SAS 2016) to derive binary, multivariate logistic regression (binary logit) coefficient estimates for model generation (Table 1). The preliminary binary logit model was subsequently generated in the GIS using the equation, grid layers, and associated coefficient estimates below:

preh_mod15 = 1 div(1 + (exp(-(0.499 + (-0.013 * dem_ned30) + (0.014 * elev_rng900) + (-0.005 * fbs_c4) + (6.853 * plan_ned30) + (-2.238 * prof_ned30) + (-0.009 * rel_strm3k) + (0.064 * slp_ned30p)))))

The resulting raster grid layer, containing values from 0.0 to 1.0 probability, was then reclassified to create zones for high probability areas at 0.5 to 1.0 probability, moderate probability at 0.5 to 0.37 (0.5 minus 0.13; 1-standard deviation), and low probability at 0.37 to 0.0 probability. There were also subtractive and additive landscape elements used to produce the final prehistoric predictive model. Wetland areas that are typically inaccessible set-asides at the SRS were reclassified as indeterminate probability areas (though there is likely a high probability of wet and deeply buried sites in floodplains). Carolina Bays were under-represented in the archaeological sample and are known to be significant prehistoric resources, so previously recorded Carolina Bay sites were used to determine an appropriate buffer for bay rims. A histogram of distance to Carolina Bays indicated typical land-use peaked within 70-m of wetland edges; these areas were then added to the high probability zones resulting in the final predictive model (Figure 2).

To test the model, two samples were used to statistically evaluate the probability zones. The first is the same validation sample used to evaluate the prior model. This sample includes 89 prehistoric sites recorded during independent, intensive archaeological surveys that were specifically excluded

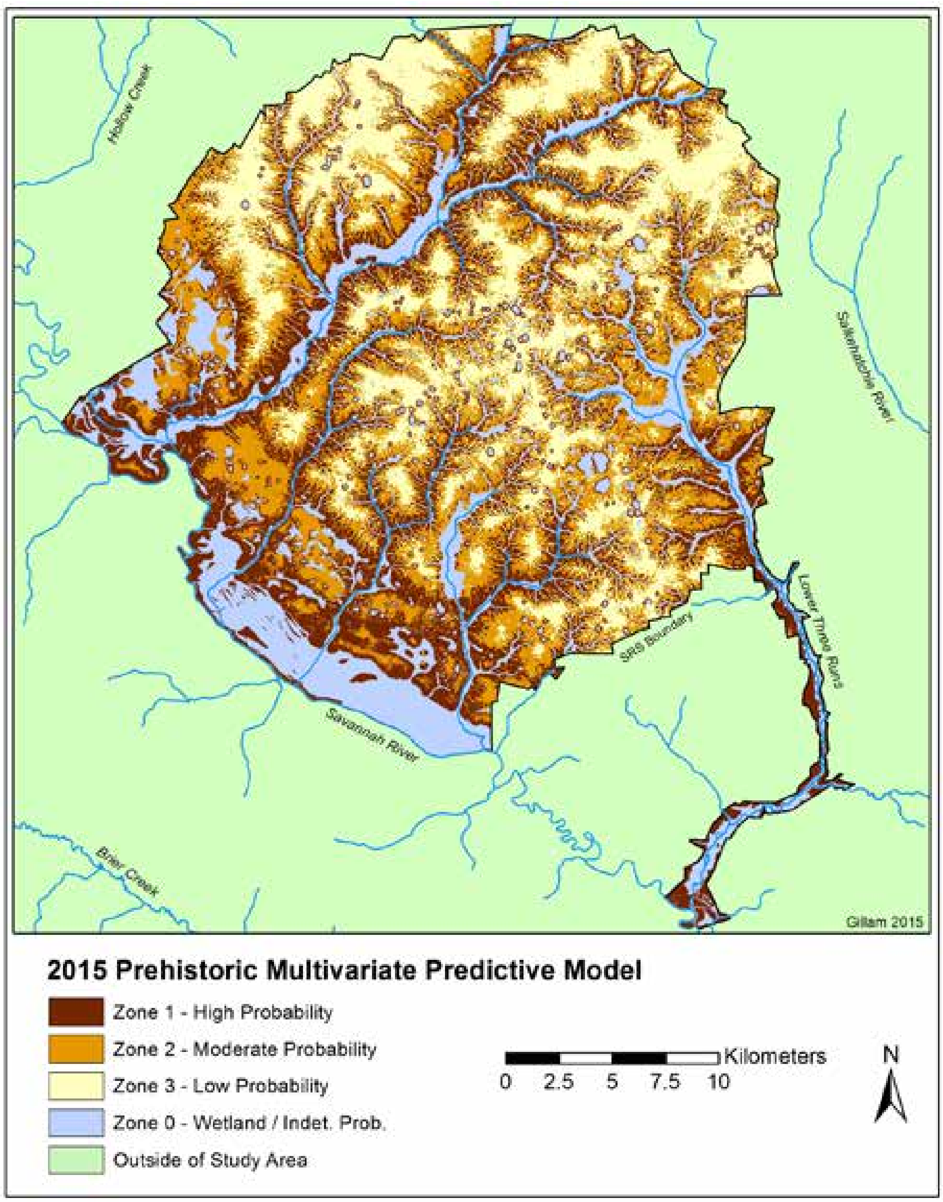

Figure 2: Revised Prehistoric Multivariate Predictive Model for the SRS. (Map by J. Christopher Gillam)

Zone	% Area	Expected Sites	Observed Sites	$(O-E)^2 / E$	df	Significant	%Sites
0	9	8	6	0.500	1	no	7
1	**34**	30	**46**	**8.533**	1	**more**	**51**
2	33	30	23	1.633	1	no	26
3	24	21	14	2.333	1	no	16
Total	100	89	89	**13.0**	3	**Yes**	100

where $X^2 \geq 3.84$ at 0.05 probability and 1 degree of freedom and

where $X^2 \geq 7.82$ at 0.05 probability and 3 degrees of freedom.

Table 2: 2015 Model tested with Independent Intensive Prehistoric Site Sample (n=89). (Table constructed by J. Christopher Gillam)

from the new model's development for validation purposes. The overall model was significant at much greater than the 0.05 probability level, as was the observed frequency of sites in the highest probability areas of Zone 1 (Table 2). High probability areas, Zone 1, contain some 51-percent of sites (n=46) in only 34-percent of the surveyed area. Although fewer sites were observed than expected by chance alone for the lower probability areas (Zones 0, 2, and 3), these were not significantly low frequencies. This likely reflects limitations of the relatively small validation sample size, as the expected- and observed sub-sample sizes for each zone ranged from only 8 to 30 expected sites. To illustrate this point, a second validation sample (n=1078) from the likewise excluded, non-intensive surveys was analyzed.

The much larger prehistoric sample of independent, non-intensive survey sites (n=1078) demonstrates that the model is much more significant, and therefore effective, than indicated by the small, intensive validation sample alone. Indeed, it indicates a pattern of significance that is nearly ideal. That is, there are significantly more sites observed than expected by chance alone for the highest probability areas (Zone 1), and significantly fewer sites than expected for all other, lower probability, areas (Zones 0, 2, and 3; Table 3). Indeed, Zone 1 high probability areas contain some 56-percent of sites (n=606) in only 28-percent of the SRS area.

Distribution maps of prehistoric sites along Upper Three Runs Creek illustrate the increased effectiveness of the multivariate predictive model. The 1989 model displays a weak correlation between sites and its corresponding probability zones (Figure 3). In contrast, the probability zones of the new multivariate predictive model demonstrate a high correlation with prehistoric site distributions (Figure 4). That is, most of the documented sites fall within the highest probability zone of the model, Zone 1.

Despite its apparent strengths, the SRARP will continue to regularly collect intensive, independent data during the normal compliance activities at SRS. This will enable future refinements to the model, further model testing and validation, and allow for new methodologies to improve our understanding of the Central Savannah River Area's prehistoric cultural landscape. Likewise, the methodologies developed

Zone	% Area	Expected Sites	Observed Sites	$(O-E)^2/E$	df	Significant	% Sites
0	19	205	85	**70.095**	1	**fewer**	8
1	**28**	302	**606**	**306.498**	1	**more**	**56**
2	27	291	245	**7.289**	1	**fewer**	23
3	25	270	142	**60.320**	1	**fewer**	13
Total	100	1078	1078	**444.202**	3	**Yes**	100

where $X^2 \geq 3.84$ at 0.05 probability and 1 degree of freedom and

where $X^2 \geq 7.82$ at 0.05 probability and 3 degrees of freedom.

Table 3: 2015 Model tested with Independent Non-Intensive Prehistoric Site Sample (n=1078). (Table constructed by J. Christopher Gillam)

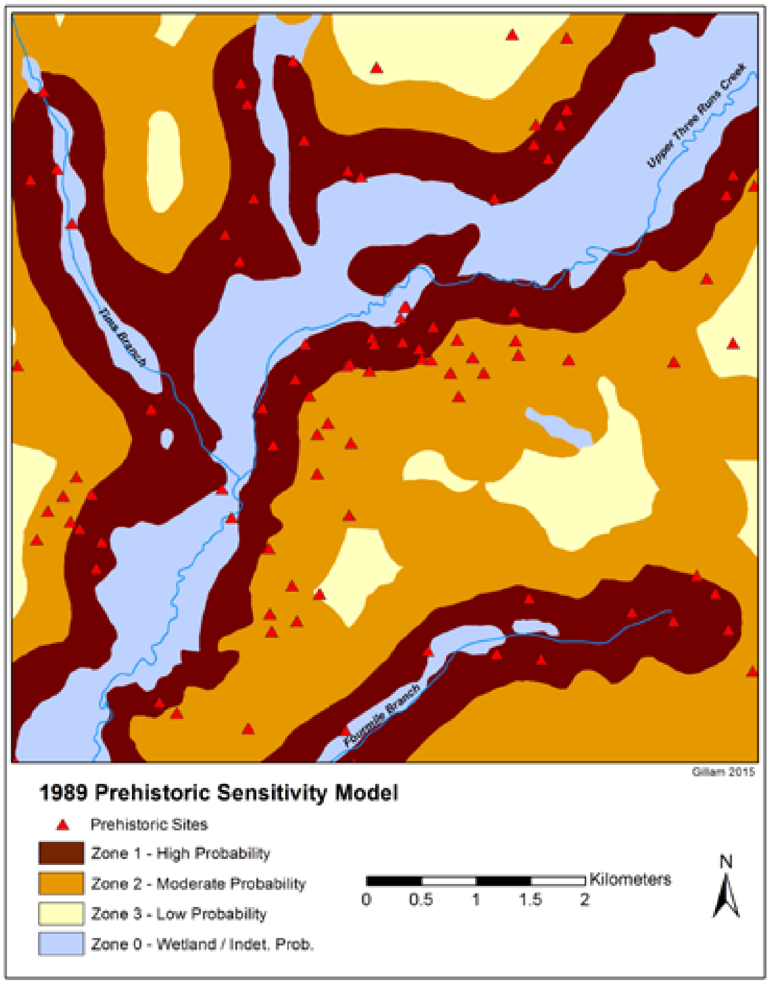

Figure 3. Recorded prehistoric sites demonstrate the limitations of the 1989 Prehistoric Sensitivity. (Model by the SRS)

on the SRS may be employed in other locations of the Southeast, and elsewhere, to enable more cost-effective cultural resource management and archaeological research.

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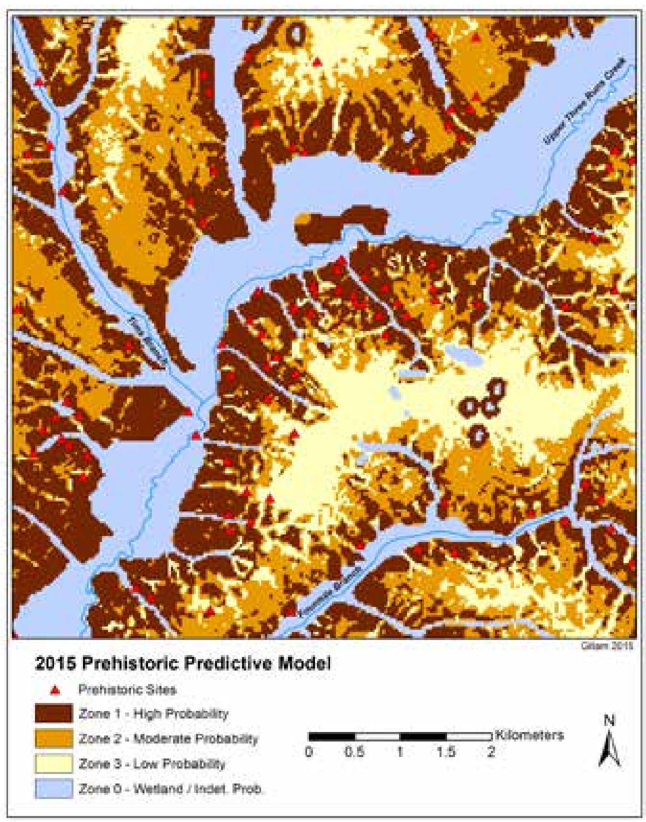

Figure 4. Recorded prehistoric sites demonstrate the effectiveness of the 2015 Prehistoric Multivariate Predictive Model of the SRS. (Map by J. Christopher Gillam)