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A Wetland-Based Habitat Suitability Model for Spotted Turtles (*Clemmys guttata*) in West Virginia, USA, Using Field Surveys and Regional Data

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Abstract.—**The Spotted Turtle (*Clemmys guttata*) is a small freshwater turtle that is currently under review for federal listing under the U.S. Endangered Species Act. Recent distributional models suggest that Spotted Turtles potentially occur in the eastern panhandle, northcentral, and northern panhandle regions of West Virginia, with previous survey efforts documenting the species at three wetlands in the eastern panhandle. We sampled 62 sites across 41 unique wetlands in West Virginia to assess the contemporary region-scale distribution and identify occupied wetlands. We used the results of these surveys to help inform the development of a Habitat Suitability Model (HSM) to guide future survey efforts. We encountered Spotted Turtles at seven wetlands in the eastern panhandle region but did not encounter the species in the northcentral or northern panhandle regions. The HSM projected habitat suitability across 17,724 wetlands and classified 387 (2%) of those wetlands as high suitability within the potential distribution of Spotted Turtles in West Virginia. The results of our study indicate that Spotted Turtle populations are likely restricted to the eastern panhandle region and that a low proportion of wetlands within their potential distribution in West Virginia represent suitable habitat.**

Key Words.—conservation; distribution; field survey; habitat suitability model; wetland.

Introduction

The Spotted Turtle (*Clemmys guttata*; Fig. 1) is a small freshwater turtle endemic to portions of eastern North America, occurring from central Florida north to coastal Maine and southern Ontario, and west to northern Indiana (Willey et al. 2022). Optimal habitat has been characterized as shallow, lentic or slow moving, periodically inundated wetlands with a loamy, soft substrate dominated by emergent vegetation, such as bogs and marshes (Joyal et al. 2001; Ernst and Lovich 2009). This species, however, has also been documented using ponds, ditches, flooded fields, creeks, riparian floodplains, vernal pools, wet pastureland, and forested wetlands (Joyal et al. 2001; Milam and Melvin 2001; Litzgus and Mousseau 2004; Ernst and Lovich 2009; Oxenrider et al. 2018). Urbanization, farming, and other anthropogenic land use changes have contributed to a reduction in suitable habitat for Spotted Turtles (Joyal et al. 2001; Buchanan et al. 2019), and population declines have been documented throughout their geographic distribution (e.g., Brodman et al. 2002; Browne and Hecnar 2007; Howell et al. 2019). The species was petitioned to be listed under the U.S. Endangered Species Act in July 2012, and the U.S. Fish and Wildlife Service (USFWS) subsequently placed the species under review for potential listing (https://ecos.fws.gov/ecp/species/9264).

In West Virginia, the Spotted Turtle is considered a priority 1 Species of Greatest Conservation Need (SGCN; West Virginia Division of Natural Resources [WVDNR] 2015), but information on the distribution of the species is lacking. Prior to this study, there were two main distribution models for Spotted Turtle that included West Virginia. A Spotted Turtle distribution model created for the Gap Analysis Project of the U.S. Geological Survey (hereafter GAP model) in 2013 identified potential landscape suitability for occurrence at a maximum resolution of 1 × 1 km (Scott et al. 1993; https://www.usgs.gov/programs/gap-analysis-project/science/species-data-download). During the initial phases of our study, a regional landscape capability index model

Figure 1. Adult female Spotted Turtle (*Clemmys guttata*) found at site WV1 located within the eastern panhandle of West Virginia on 17 March 2017. (Photographed by Donald J. Brown).

(0.03 × 0.03 km) was developed by the University of Massachusetts (Brad Compton et al., unpubl. report) and a habitat suitability model (HSM; 0.1 × 0.1 km) was developed by the Eastern Spotted Turtle Working Group using modeled relationships between species occurrence points and landcover variables across the eastern U.S. distribution of the Spotted Turtle (Willey et al. 2022). Notably, a widely used coarse species distribution map developed by The Center for North American Herpetology (CNAH; published in Powell et al. 2016) does not include Spotted Turtles in West Virginia. Previous studies that focused on locating Spotted Turtle populations in the state only surveyed the eastern panhandle region and only documented three extant populations (Breisch 2006; Albaugh 2008; Oxenrider et al. 2019; William Humphries, unpubl. report). Thus, there is a strong need to better understand the current distribution of Spotted Turtle populations in West Virginia to inform species conservation efforts (https://ecos.fws.gov/ecp/species/9264).

Habitat suitability models refer to a broad class of models that quantify the suitability of environments to support a species (Grinnell 1917; Elton 1927; Hutchinson 1987). This class of models is typically used to understand spatial relationships between a species and its environment and to test hypotheses for habitat associations. In recent decades, spatially explicit HSMs have become an important tool for conservation planning and natural resource management because they can be used to map locations of potentially suitable habitat, and thus locations of potential occurrence (Hirzel et al. 2006; Peterman et al. 2013; Stratmann et al. 2016). These models can help to direct occurrence surveys to maximize return on survey efforts, particularly for rare and elusive species (Fernández et al. 2006; Aubry et al. 2017).

There are many statistical methodologies available for HSM construction, with decision tree-based models being among the most widely used (Moore et al. 1991; Prasad et al. 2006; Valavi et al. 2022). These models partition the response data (typically presence-absence) into hierarchically ordered clusters based on environmental conditions, with the goal of minimizing classification errors. Traditional classification and regression tree models are known to suffer from overfitting (Sutton 2005; Hastie et al. 2009), but statistical approaches have been developed to reduce this issue. In particular, the random forest (RF) algorithm uses bootstrapping to create multiple decision trees that are weakly correlated, resulting in minimal overfitting (Prasad et al. 2006). This approach, in conjunction with the non-parametric nature of decision tree models, allows flexibility to accommodate complex species-environment relationships and predictors that are correlated (Li and Wang 2013). Random forest HSMs often have high power for explaining relative probability of occurrence (e.g., Mi et al. 2017; Siders et al. 2020), but with the tradeoff that quantifying occurrence or abundance relationships with individual variables is exploratory in nature (Merow et al. 2014).

Landscapes are typically represented in HSMs as a grid of cells (e.g., Guisan and Hofer 2003; Arntzen 2006; Aubry et al. 2017). While this approach works well for terrestrial species, a grid approach is not optimal for some aquatic species, such as species that inhabit small, isolated wetlands or small headwater streams, where critical landscape features can be smaller than the area of the cell. Spotted Turtles typically occur in small, highly vegetated wetlands and have small home ranges (Ernst 1970; Wilson 1994; Litzgus and Mousseau 2004; Seburn 2012), and thus their potential distribution is highly dependent on the suitability of individual wetlands. Therefore, an HSM that predicts suitability at the wetland (polygon) level could be optimal for Spotted Turtles because it best matches the operational scale in which the species uses the landscape. To our knowledge, however, there are no currently available HSMs for the species that use this approach.

The goal of our study was to improve our understanding of the distribution of Spotted Turtles in West Virginia. We conducted standardized population surveys throughout the potential distribution of the

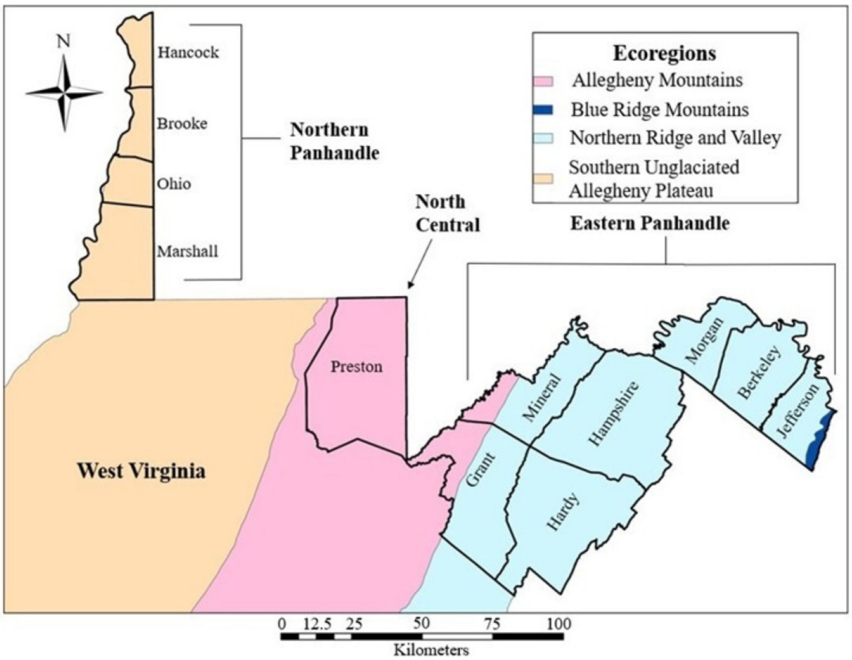

Figure 2. The counties and four physiographic ecoregions that encompass the potential distribution of Spotted Turtles (*Clemmys guttata*) in West Virginia, USA (Cleland et al. 2007; McNab et al. 2007). Potential occurrence is based on the species distribution map of the Gap Analysis Project of the U.S. Geological Survey (https://www.usgs.gov/programs/gap-analysis-project/science/species-data-download). Prior to this study, Spotted Turtles were known to occur in three wetlands within the Blue Ridge Mountains and Northern Ridge and Valley ecoregions.

species in the state to identify previously unknown populations and determine if Spotted Turtles occurred outside of the eastern panhandle region. We then used the survey results and additional species occurrence data to develop a wetland-level HSM to guide future occurrence survey efforts for the species in West Virginia.

Materials and Methods

Study site and site selection.—The study area includes the potential distribution of Spotted Turtles in West Virginia based on the GAP model, which includes counties within the eastern panhandle, north-central, and northern panhandle regions of the state (Fig. 2). While Spotted Turtles have not previously been documented in the north-central and northern panhandle regions, one historical population is known in east-central Ohio (Davis et al. 2021), and a Spotted Turtle was recently observed in southwestern Pennsylvania (https://paherpsurvey.org/viewrecord.php?r_id=179584; approximately 58 miles from the border of Preston County in West Virginia), indicating potential for occurrence in these regions. We surveyed potential Spotted Turtle habitat in spring and early summer from 2019–2021. In 2019, we conducted surveys at wetlands in the eastern panhandle region with historical Spotted Turtle occurrence records and previous survey activity to determine contemporary occurrence at historical survey sites. The survey sites were identified using occurrence records held by the WVDNR and in citizen science databases, gray literature (Knight 1985; Albaugh 2008; William Humphries, unpubl. report), and peer-reviewed literature. We also surveyed additional wetlands encountered during the field season that represented potential habitat. Specifically, we first assessed these wetlands at a distance for evidence of shallow standing water and aquatic vegetation (i.e., rushes and sedges). If granted access to the property, we identified the type of wetland (e.g., wetland complex, vernal pool, wet meadow, bog) presence of saturated soils and the depth of standing water (e.g., ankle height, calf height, knee height). We surveyed the wetlands for Spotted Turtles if aquatic vegetation was present, soils were likely to be saturated year-round, and if standing water was between ankle and knee height (see Mota, 2022 for habitat assessment form). When wetlands were located on private property, we secured landowner permission prior to accessing any wetland. We attempted to contact landowners in person at their residence. If a landowner was not home, we left a flyer at the property containing a description of the project and contact information.

In 2020, we conducted surveys in the northcentral and northern panhandle regions (Supplemental Information Table S1). We used a three-step process to delineate survey sites. First, we used the GAP model and the model of the Eastern Spotted Turtle Working Group to identify general areas within each county that contained potential habitat for the species. Second, we used satellite imagery (Google Earth Pro v7.3.3: Google LLC, Menlo Park, California, USA; and ArcGIS Pro 2.8: Esri, Redlands, California, USA) and a West Virginia wetland map created by the West Virginia Department of Environmental Protection (WVDEP) to identify candidate wetlands within those areas. Third, we visited candidate wetlands to field-validate the wetlands as potential habitat for Spotted Turtles (see Mota, 2022 for habitat assessment form). In 2021, we conducted surveys at additional wetlands in the eastern panhandle region using the same site selection process as the 2020 field season.

Survey methods.—We conducted surveys from April to June coinciding with survey dates conducted during previous Spotted Turtle studies (Albaugh 2008; William Humphries, unpubl. report), which correspond to suitable air temperatures (3°–30° C) and water temperatures (3°–25° C) for Spotted Turtle activity (Ernst 1982). We used a standardized Spotted Turtle sampling protocol developed by the Eastern Spotted Turtle Working Group (https://www.northeastturtles.org/spotted-turtle.html). We sampled aquatic turtle populations using Promar TR-502 0.914 × 0.305 m hoop net traps (Promar & Ahi USA, Gardena, California, USA). Traps were wrapped with poultry netting (91 cm wide with 2.5 cm hexagonal mesh), which we tied to vegetation or staked into the ground to protect captured turtles from mammalian predators and to deter large Snapping Turtles (*Chelydra serpentina*) from entering traps (Oxenrider et al. 2019; Fig. 3). Traps contained a flotation device (pool noodle) to ensure access to air for captured turtles. For a majority of the sampling effort, we baited traps daily with fish-flavored cat food, but traps at WV1 and WV3 were also baited with canned sardines as part of another study (see Oxenrider et al. 2019). We placed bait in a plastic container with holes in the lid to allow for scent dispersal.

A survey site (referred to as a reference plot in the Eastern Spotted Turtle Working Group protocol) consisted of a 200 m radius area centered on potential Spotted Turtle habitat, with site centroids up to 800 m apart. Depending on the size of the wetland, one to three sites were sampled. No wetlands identified as a part of this study were large enough to accommodate four sites. Each site contained five traps spaced at least 30 m apart. We attempted, to the best of our ability, to place one trap near the center of the site and one trap in each cardinal direction. Spacing of traps was dependent on the configuration and habitat characteristics of the site, with the goal of maximizing spatial coverage while also placing traps in locations where Spotted Turtles were likely to be present. Trapping areas included edges of thick vegetation (sedges, grasses, scrub-shrub), edges of structures (e.g., logs), small flow channels (≤ 0.2 m), and near other potential basking sites (Janzen et al. 1992; Haxton and Berrill 1999, 2001). Following the standardized protocol, surveys consisted of sampling each site for four consecutive days, with traps checked every 24 h. If a Spotted Turtle was captured at the site, we performed two additional trap-based surveys to obtain additional demographic data and a greater number of survey replications for future abundance estimation. We performed each additional survey > 7 d after previous surveys.

Figure 3. Potential Spotted Turtle *(Clemmys guttata)* habitat sampled for this study assessing the distribution of the species in West Virginia, USA. We sampled 63 sites across 42 unique wetlands between 2019 and 2021. Shown is a deployed hoop net trap encircled with poultry netting and staked down with rebar. (Photographed by Joel L. Mota).

We measured, marked, determined the sex, and photographed all captured turtles. We used dial calipers (0.1 mm accuracy; Wiha Tools, Monticello, Minnesota, USA) to collect morphometric measurements (Iverson and Lewis 2018), and spring scales to measure body mass (5 g accuracy; Pesola Precision Scales, Chur, Switzerland). For females, we determined if the turtle was gravid by palpation (Tinkle et al. 1981; Congdon et al. 1987;

Litzgus and Mousseau 2001). We uniquely marked each individual captured by notching their marginal carapace scutes with a triangular file using the numbering system in Buhlmann et al. (2008), and we also injected a Passive Integrated Transponder (PIT) tag (BioMark APT12: BioMark, Boise, Idaho, USA) in the inguinal area (Buhlmann and Tuberville 1998).

Habitat suitability modeling.—We bounded our HSM area of inference to the 12 counties in West Virginia that are potentially within the geographic distribution of Spotted Turtles, including Berkeley, Brooke, Grant, Hampshire, Hancock, Hardy, Jefferson, Marshall, Mineral, Morgan, Ohio, and Preston. These counties occur across the Allegheny Mountains, Blue Ridge Mountains, Northern Ridge and Valley, and Southern Unglaciated Allegheny Plateau ecological subregion sections (Cleland et al. 2007; McNab et al. 2007; Fig. 2). The ecological subregion sections (hereafter ecoregions) represent large land areas of similar geological and biological conditions (Cleland et al. 2007; McNab et al. 2007).

We used the 2021 National Wetlands Inventory (NWI) to delineate individual wetland polygons across the area of inference (https://www.fws.gov/program/national-wetlands-inventory/data-download). For this layer, wetland complexes are subdivided into multiple wetland polygons based on dominant vegetation type (Cowardin et al. 1979). We used our field survey data to designate sampled wetland polygons as presence (n = 34) or non-detection (n = 103). To increase the presence data set for model training, we also obtained wetland-level occurrence data from the Virginia Department of Wildlife Resources for the Northern Ridge and Valley and Blue Ridge Mountains ecoregions in Virginia (n = 16 wetlands), under the assumption that environmental characteristics were similar to West Virginia. We included the Virginia data in the model training data set but were not part of the habitat suitability projection area. Unfortunately, we were unable to obtain wetland-level occurrence data from other surrounding states due to sensitive data restrictions. We buffered each wetland polygon by 100 m and 300 m to represent wetland-level and connectivity-level extents, respectively (Joyal et al. 2001).

Using the distribution-wide Spotted Turtle literature, we identified 15 candidate environmental variables that could be important predictors for Spotted Turtle habitat quality (Table 1). We obtained a 1/3 arc second (about 10 × 10 m) resolution Digital Elevation Model (DEM) through the National Elevation Dataset of the U.S. Geological Survey (https://elevation.nationalmap.gov/arcgis/rest/services/3DEPElevation/ImageServer). From this layer, we derived topographical position index (TPI) and topographical ruggedness index (TRI). The TPI compares the elevation of a given cell to that of the mean elevation of a specified neighborhood of cells, with positive TPI values representing locations that are relatively higher than their surroundings (hilltops and ridgelines), and negative TPI values representing locations that are lower than their surroundings (valleys). Index values near zero represent relative flat areas or areas of constant slope (Irvin et al. 1997; Guisan 1999). The TRI quantifies the amount of elevational difference between adjacent cells in a DEM (Nellemann and Fry 1995; Riley et al. 1999).

We used the 2019 National Landcover Database (NLCD; 30 × 30 m resolution) layer to identify landcover types that occurred at our wetland sites (https://doi.org/10.5066/P9KZCM54). We combined the landcover types of Deciduous Forest, Evergreen Forest, and Mixed Forest into the class Forest (Table 1). We classified the landcover types Developed, Open Space, Developed Low Intensity, Developed Medium Intensity, Developed High Intensity, Barren, and Cultivated Crops as Not Suitable (Table 1). We calculated wetland richness using the NWI dataset and distance to stream using stream data from the National Hydrography Dataset Plus High Resolution (NHDPlus HR) across all sites (Moore et al. 2019). We calculated wetland richness, TPI, and TRI at the connectivity-level extent (300 m) and landcover data at the wetland-level extent (100 m). We calculated distance from stream as the minimum distance from the edge of the unbuffered wetland polygon to a ≥ 3rd-order stream. We included wetland type and created hydrological regime classes based on NWI information. Wetland type is described at a subsystem level and class level for lacustrine and palustrine systems, respectively (Cowardin et al. 1979). Hydrological regime is found within the special wetland modifiers (Cowardin et al. 1979), and we binned these modifiers into three classes representing a gradient in perceived habitat quality for Spotted Turtles based on the literature (Joyal et al. 2001; Ernst and Lovich 2009).

Prior to model construction, we calculated variance-inflation factors (VIF) for candidate predictors, which is a common diagnostic to determine collinearity among predictor variables (Naimi and Araújo 2016; Mori et al. 2019). The VIF is a numerical output that

Table 1. Predictors used for development of a habitat suitability model for the Spotted Turtle (*Clemmys guttata*) in West Virginia, USA. Landcover classes are expressed as a percentage of the total area of the buffered wetland (100 m or 300 m) area.

Predictor	Buffer length (100 or 300 m)	Description	Resolution
Hydrological Regime Code	NA	A grouped code based on the NWI special modifiers	1:20,000
Wetland Type	NA	Freshwater Wetland subsystem based on NWI	1:20,000
Wetland Area (m^2)	NA	Area of unbuffered wetland polygon	1:20,000
Wetland Richness	300	Number of wetlands within buffered extent	1:20,000
Open Water	100	Percentage open water data class from NLCD data layer	30 × 30 m
Forest	100	Percentage merged forest classes from NLCD data layer.	30 × 30 m
Scrubland	100	Percentage scrub data class from NLCD data layer	30 × 30 m
Grassland	100	Percentage grassland data class from NLCD data layer	30 × 30 m
Pasture and Hay	100	Percentage pasture/Hay data class from NLCD data layer	30 × 30 m
Woody Wetland	100	Percentage woody wetland class from NLCD data layer	30 × 30 m
Herbaceous Wetland	100	Percentage emergent Herbaceous Wetlands class: NLCD Data layer	30 × 30 m
Not Suitable	100	Percentage merged landcover classes associated with human	30 × 30 m
Topographic Position Index	300	Index of slope position of wetland	10 × 10 m
Terrain Ruggedness Index	300	Expresses difference in elevation between cells	10 × 10 m
Distance to Nearest Stream	NA	Minimum straight-line distance from stream to wetland edge	30 × 30 m

quantifies the percentage of variance in a regression coefficient that is inflated due to collinearity (Fox and Monette 1992). For example, VIF values begin at one, and a VIF value of 2.5 indicates that the variance in that regression coefficient is 150% larger than expected if there was no collinearity. We iteratively removed all predictor variables with VIFs ≥ 10 until all remaining predictors had VIFs < 10 (Neter et al. 1989; Menard 2002). This resulted in us including wetland type, wetland size (m^2), wetland richness, percentage open water, percentage scrub, percentage grassland, percentage pasture/hay, percentage woody wetland, percentage herbaceous wetland, percentage not suitable, topographic position index, topographic roughness index, distance to stream, and hydrological regime class in the final set of candidate environmental predictors for the HSM. We used ArcGIS Pro 2.8 (Esri) and program R (version 3.6.3; The R Foundation, Vienna, Austria) to process predictor variables.

Statistical analyses.—We used RF to construct the HSM (Garzón et al. 2006; Evans et al. 2011; Rather et al. 2020). We set the number of trees produced to 10,000 and used the tuneRF() function to determine the optimal number of predictor variables (three) to randomly sample each iteration (Breiman 2001; Probst and Boulesteix 2018). During preliminary analyses, we found the large imbalance in presence (n = 50) and absence (n = 103) sites resulted in severely imbalanced omission and commission error rates. We used down-sampling at a 1:1 ratio to address this issue, which improved the balance between class-specific error rates. Because RF uses bootstrapping with replacement, down-sampling does not cause data loss (Kuhn 2008). Beginning with the global model, we conducted backwards model selection to select the model that minimized the out-of-bag error (OOB) and considered this to be the most supported model.

To explore the complex model relationships between our final predictors and habitat suitability, we created partial dependence plots. Partial dependence shows the marginal effect a feature has on the estimated outcome of the RF model. Specifically, the plot shows the relative logit contribution of the variable on the estimated class probability (Breiman 2001). Thus, positive values on the y-axis indicate that the positive class (presence) is more likely for that value of the predictor and negative values on the y-axis indicate that presence is less likely at that value. We conducted all RF modeling using program

R (version 3.6.3). We conducted model training and validation using the randomForest package (Breiman 2001) and we calculated the AUC value using the pROC package (version 1.17.0.1; Robin et al. 2011).

We calculated seven metrics to evaluate the performance of our RF model, including kappa, true skill statistic (TSS), area under the operator curve, sensitivity, specificity, out-of-bag error (OOB), and balanced accuracy. Although widely used, there is evidence that kappa is inherently dependent on the prevalence of the modeled species (i.e., proportion of sites where the species was observed) and thus can be biased (Byrt et al. 1993; McPherson et al. 2004). TSS compares the number of true positives, minus the true positives attributed to random chance, to that of a set of hypothetical set of predictions where accuracy is set to 1.0 (Allouche et al. 2006). Both TSS and kappa are similar in that they account for omission and commission, but unlike kappa, TSS is not strongly affected by prevalence (Allouche et al. 2006; Somodi et al. 2016). The OOB error represents the average measure of prediction error for machine learning methodologies that use bootstrap aggregation. Balanced accuracy calculates the overall proportion of correct classifications in each class (i.e., true positives and true negatives). Its calculation is the arithmetic mean of the sensitivity and specificity, which is recommended when there is an unequal number of presences and absences (Kuhn 2008). We calculated all evaluation statistics using the PresenceAbsence (version 1.1.9; Maindonald and Braun 2010) and DAAG (version 1.24; Freeman and Moison 2008) packages in program R (version 3.6.3). We used leave-one-out cross validation to assess the accuracy of the model estimates (Pearson et al. 2007; Peterson et al. 2011).

We used the HSM to project habitat suitability across wetlands within the potential range of Spotted Turtles in West Virginia. We classified estimated suitability values into not suitable, low suitability, and high suitability categories. We used the minimum training presence threshold for the threshold between not suitable and low suitability (Jarnevich et al. 2016). This threshold uses the lowest predicted suitability value for an occurrence point and assumes that this value is the minimum suitability in which the species could occur. For the threshold value between low and high suitability, we used the 10^{th} percentile training threshold (hereafter P10), which excludes all wetlands with suitability values lower than the lowest 10% of occurrence records (Rödder et al. 2010; Brambilla and Ficetola 2012).

Results

Wetland surveys.—We surveyed 63 sites across 42 unique wetlands within 10 counties. We surveyed 29, three, and 10 unique wetlands in the eastern panhandle, northcentral, and northern panhandle regions, respectively. The total sampling effort included 1,824 trap days, with trapping effort per wetland ranging from 20–204 trap days (mean = 44 ± [standard deviation] 14 trap days). We encountered Spotted Turtles in three of the 10 surveyed counties, all of which occur in the eastern panhandle region. We captured Spotted Turtles at five wetlands, observed the species while sampling at one wetland where no trap captures occurred, and received photographic confirmation of presence of the species at one additional wetland where no trapping occurred. In total, we documented 81 unique Spotted Turtles across the seven wetlands (Table 2).

Habitat suitability model.—The most supported model contained distance to stream, wetland richness, pasture/hay (%), herbaceous wetland (%), woody wetland (%), not suitable (%), TPI, and TRI as predictor variables. All assessment metrics indicated good overall performance (AUC = 0.93, kappa = 0.79, TSS = 0.78). The model had an OOB error of 9%, with 16% error rate for presences and a 6% error rate for absences, respectively. Model sensitivity (0.84) and specificity (0.94) mirrored the OOB error pattern. See Mota (2022) for performance metrics of additional candidate models. Our HSM modeling assessment metrics are similar to the assessment metrics (AUC = 0.962, sensitivity = 98.9, specificity = 83) for the ensemble modeling approach used in Willey et al. (2022). Comparable modeling metrics are not provided for the GAP model, but the GAP model is considered a coarse resolution model using environmental data at a 1:100,000 scale (https://www.usgs.gov/programs/gap-analysis-project/science/species-data-download) compared to the environmental data at a 1:24,000 scale used in Willey et al. 2022 and in our model.

Estimated environmental relationships.—Based on mean decrease in accuracy, TPI was the most important variable for delineating Spotted Turtle habitat on mean decrease in accuracy, TPI was the most important variable for delineating Spotted Turtle habitat suitability, with percentage pasture/hay and TRI also having a strong influence. For TRI, TPI, and wetland richness, the partial dependence plots

Table 2. Wetland-level survey information for Spotted Turtle (*Clemmys guttata*) surveys at 63 sites across 42 unique wetlands in West Virginia, USA, including wetland identification (Wetland Code) organized by geographic region, number of sites within wetland (# of Sites), number of trap days (Trap Days), number of unique Spotted Turtles captured (Unique CLGU Captures), and catch per unit effort in traps (CPUE). A trap day is defined as a 24-h period of trap deployment. We sampled wetlands in spring and early summer between 2019 and 2021. At WV9, turtles were observed but not captured, and at WV29, turtles were photographed in October 2021, validating Spotted Turtle occupancy.

Wetland Code	# of Sites	Trap Days	Unique CLGU Captures	CPUE
WV1	3	180	11	0.0722
WV2	2	120	15	0.1583
WV3	3	180	28	0.1611
WV4	1	20	0	0
WV5	2	120	24	0.2916
WV6	1	20	0	0
WV7	1	20	0	0
WV8	2	40	0	0
WV9	1	204	1	0.0049
WV10	1	20	0	0
WV11	2	40	0	0
WV12	1	20	0	0
WV13	2	40	0	0
WV14	2	40	0	0
WV15	1	20	1	0.0500
WV29	1	20	1	0
WV30	1	20	0	0
WV31	1	20	0	0
WV32	1	20	0	0
WV33	2	40	0	0
WV34	2	40	0	0
WV35	2	40	0	0
WV36	1	20	0	0
WV37	2	40	0	0
WV38	1	20	0	0
WV39	1	20	0	0
WV40	1	20	0	0
WV41	1	20	0	0
WV42	2	40	0	0
North Central				
WV23	1	20	0	0
WV24	1	20	0	0
WV28	1	20	0	0
Northern Panhandle				
WV16	1	20	0	0
WV17	1	20	0	0
WV18	2	40	0	0
WV19	1	20	0	0
WV20	2	40	0	0
WV21	3	60	0	0
WV22	1	20	0	0
WV25	1	20	0	0
WV26	1	20	0	0
WV27	3	60	0	0

indicated unimodal responses (Fig. 4). Distance from stream indicates that wetlands adjacent to mapped streams (0 m) and those at a moderate distance (100–200 m) away from mapped streams were most suitable (Fig. 4). Overall, there was a positive linear relationship with percent pasture/hay landcover (Fig. 4). The partial dependence plot for percentage not suitable landcover suggests that small amounts of not suitable landcover types (e.g., roads and impervious surfaces) increased the probability that the wetland was suitable for Spotted Turtle presence (Fig. 4). The partial dependence plot for percentage woody wetland landcover suggests that a moderate amount of woody wetland cover increased the probability of the wetland being suitable for Spotted Turtles with an increase in marginal influence from 20–75% (Fig. 4). The partial dependence plot for percentage herbaceous wetland cover indicated that herbaceous wetland cover of up to about 20% increased the suitability of the wetland for Spotted Turtle presence (Fig. 4).

Habitat suitability projections.—Projected habitat suitability values ranged from 0.12–0.97 (mean = 0.39) across the 17,724 wetlands. Habitat suitability values ranged from 0.69–0.97 (mean = 0.87) at known occurrence points (Supplemental Information Table S2). The minimum training presence threshold was set at 0.6963 and the P10 threshold was set at 0.7649, resulting in 16,703 wetlands categorized as not suitable, 634 wetlands categorized as low suitability, and 387 wetlands categorized as high suitability (Fig. 5). The model correctly categorized all 34 known Spotted Turtle wetland polygons as suitable (three low suitability, 31 high suitability) and all 103 of the wetland polygons with non-detections as not suitable.

Discussion

Our field survey results, coupled with verified occurrence records held by the WVDNR, suggest the current distribution of Spotted Turtles in West Virginia is likely limited to the eastern panhandle region despite the presence of apparently suitable habitat in the northcentral and northern panhandle regions. We sampled the northern panhandle region more intensively than the northcentral region due to a history of turtle sampling efforts in the northcentral region with no Spotted Turtle detections (e.g., Gulette 2018; Lozon 2021), and a relative scarcity of suitable wetlands for the species associated with the Allegheny Mountains ecoregion. We acknowledge the northern

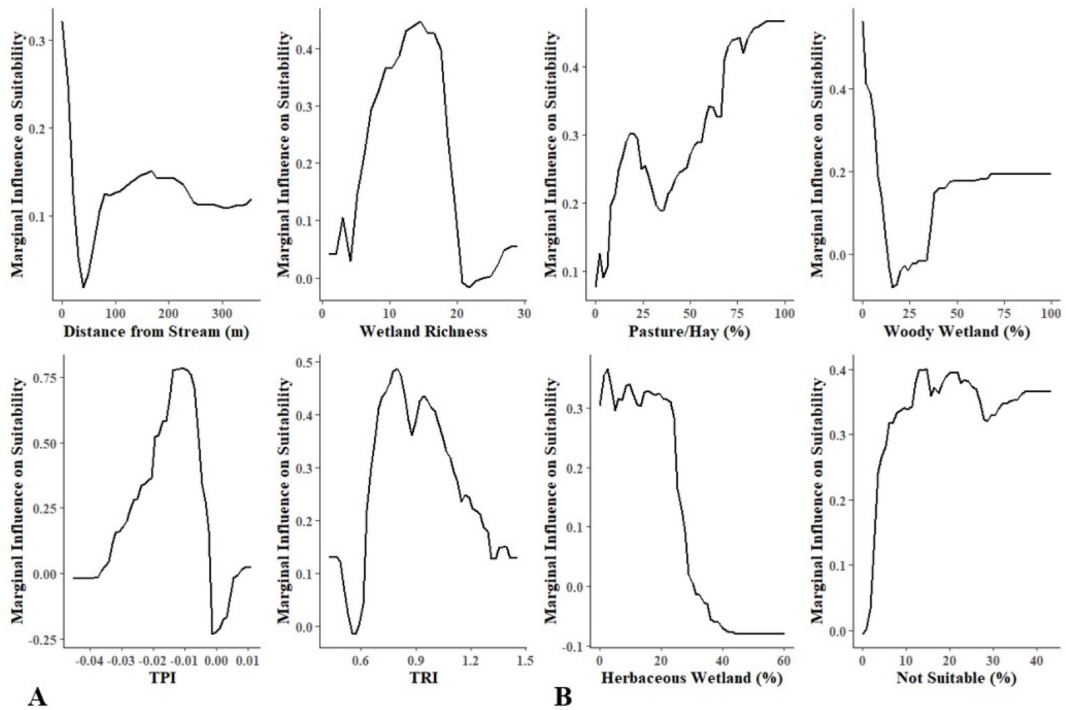

Figure 4. Partial dependence plots estimating occurrence-environment relationships for Spotted Turtles (*Clemmys guttata*) based on presence and non-detection data in West Virginia, USA, and presence data in the Northern Ridge and Valley and Blue Ridge Mountains ecoregions in Virginia, USA. Partial dependence plots show the marginal effect of a predictor on suitability across possible values of the predictor. (A) Partial dependence plots for distance from stream, wetland richness, topographic position index (TPI), and terrain ruggedness index (TRI). (B) Partial dependence plots for pasture/hay landcover (Pasture/Hay [%]), woody wetland landcover (Woody Wetland [%]), herbaceous wetland landcover (Herbaceous Wetland [%]), and not suitable landcover (Not Suitable [%]). Topographic position index, pasture/hay landcover, and topographic ruggedness index were the highest ranked variables for mean decrease in accuracy.

panhandle and northcentral regions under-sampled compared to the eastern panhandle. Prior to initiating our study, we anticipated documenting many new populations in the eastern panhandle region, under the assumption that our limited knowledge was largely reflective of a lack of intensive sampling effort. Our sampling efforts were unsuccessful at identifying occupied wetlands outside of the two counties with known contemporary occurrences, and we only documented occurrence at four additional wetlands within those counties. Opportunistic visual detections did result in documentation of the species in Hardy County, however, which expanded the known distribution of Spotted Turtles in the state (Mota et al. 2022). The property in which this individual was located was previously sampled as part of this study (WV29).

The predominantly mountainous landscape of West Virginia is likely a strong driver of the rarity of Spotted Turtles. Much of the topography of West Virginia is characterized by high levels of relief, sharp ridgelines, and dissected plateaus (Cleland et al. 2007; McNab et al. 2007). These mountainous characteristics result in headwater streams with steep banks that are not suitable for Spotted Turtles (Ernst and Lovich 2009; Stevenson et al. 2015; Buchanan et al. 2019). The topography of the Ridge and Valley ecoregion, which contains the eastern panhandle region, is comparatively less rugged, with broad, shallow parallel valleys separated by relatively low linear ridgelines (Strausburgh and Core 1977; Cleland et al. 2007; McNab et al. 2007). These broad valleys share similar topographic characteristics to coastal plain and piedmont landscapes, where shallow vegetated wetlands can form in local topographic depressions (Horton 1945; Tiner 2003). Thus, it is likely that Spotted Turtles within West Virginia occupy pockets of suitable habitat within a broader landscape that is atypical for their occurrence. Unlike coastal plain and piedmont regions, the ridgelines present in the eastern panhandle act as natural overland barriers. The mean straight-line distance between known occupied sites in West Virginia was approximately 7 km. This is much larger than documented home range sizes for the species (Ernst 1970; Wilson 1994; Litzgus and Mousseau 2004; Seburn 2012),

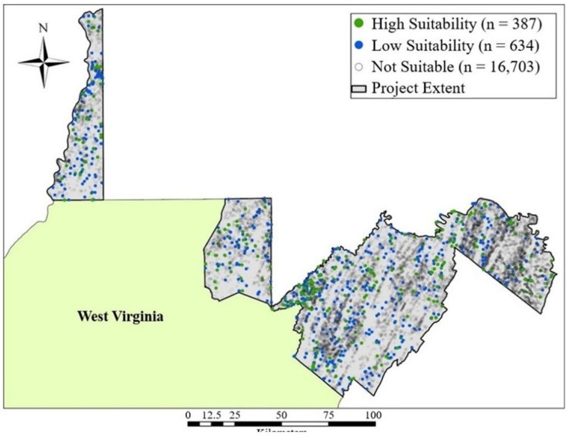

FIGURE 5. Habitat suitability classifications for wetlands within the potential distribution of Spotted Turtles (*Clemmys guttata*) in West Virginia, USA (n = 17,724) based on a random forest classification model. White circles with a gray outline represent non-suitable wetlands (< 0.6963 suitability, n = 16,703), blue circles represent low suitability wetlands (0.6963, < 0.7649 suitability, n = 634), and green circles represent high suitability wetlands (≥ 0.7649 suitability, n = 387).

suggesting that Spotted Turtles in West Virginia may be persisting in isolated habitat patches.

Anthropogenic land-use activities have resulted in broadscale loss of small, shallow, and isolated wetlands, typically for urban and agricultural development (Semlitsch and Bodie 1998; Tiner 2003; U.S. Fish and Wildlife Service 2011; Fluet-Chouinard et al. 2023; Zou et al. 2024). All wetlands that we found with Spotted Turtle occurrence were embedded in an agricultural or exurban landscape. Consequently, the HSM estimated a positive relationship with the predictor percentage not suitable habitat, suggesting that there is spatial correlation between wetlands suitable for Spotted Turtle occurrence and landcover types associated with human development. It is unlikely that probability of Spotted Turtle occurrence is positively influenced by the amount of non-habitat, and we assume this modeled relationship is an artifact of the training data. For presence wetlands, the average percentage of unsuitable habitat was 8.53% (standard deviation = 9.76%) with a minimum value of 0% and a maximum value of 30.52%. Although, the HSM also supported inclusion of the herbaceous wetland and pasture/hay predictors, both of which represent early successional habitat, which agrees with previously described habitat associations for the species (Joyal et al. 2001; Ernst and Lovich 2009). One newly discovered wetland site (WV2) was in pastureland where cattle moved freely throughout the wetland. Livestock grazing can maintain early successional habitats, such as herbaceous wetland vegetation, which could help maintain potential habitat for Spotted Turtles at this location. Livestock grazing, movement, trampling, and excrement, however, can also negatively impact wetland habitat quality as well as the nesting behavior and reproductive output of freshwater turtle species (Lindsay and Dorcas 2001; Schieltz and Rubenstein 2016; Travis et al. 2018). Thus, the long-term viability for the population at this site is of concern.

Another notable occupied wetland (WV3) is a naturally occurring marl marsh, which had the highest number of unique individuals caught throughout this study. Marl is a silty, unconsolidated material primarily composed of calcium carbonate mixed with clay and organic matter (Bartgis and Lang 1984). Marl marshes in West Virginia are characterized as highly vegetated wetlands, with dynamic water regimes, circumneutral surface water, and a thick organic layer (Bartgis and Lang 1984), making them particularly suitable for Spotted Turtle occupancy. Historically, these wetlands were exploited to provide relatively cheap fertilizer for agriculture (Dave Morse and Michael Smith, unpubl. data), making undisturbed marl marshes rare habitats. The WV3 site is currently surrounded by exurban housing and has a railroad running through it. There are what appear to be previously used railroad ties treated with creosote lying in the wetland, potentially affecting the water quality. Furthermore, housing has the potential to introduce feral dogs and cats, which might eat some turtles, and urban runoff pollution, which would further degrade the water quality and overall ecological integrity of the wetland (Dolah et al. 2005; Miller and Wardrop 2006).

We chose to estimate and predict habitat suitability at the wetland level, which represents the operational scale at which Spotted Turtles use the landscape and at which management occurs. The disadvantage of using this method is that we were restricted to the mapped polygons within the NWI layer. Although there have been great improvements in identifying and classifying wetlands, it is known that NWI has not mapped all wetlands on the landscape (Pitt et al. 2011; Gage et al. 2020), and two of the wetlands we sampled were not mapped in the NWI. Thus, our model could exclude some high suitability wetlands in the state.

In conclusion, our field survey and HSM results suggest that Spotted Turtle populations are generally restricted to relatively wide river valleys within the eastern panhandle of West Virginia, where many wetlands have been converted into pastures or hay fields. When some of the wetland conversion efforts fail, portions of the original wetland remain, and the herbaceous wetland vegetation is maintained through grazing, providing potential habitat for Spotted Turtles in these working landscapes. Our HSM can be used to prioritize new survey locations and reduce time spent ground-truthing areas for potential habitat; however, due to the imbalance in presence (n = 50) and absence (n = 103) information available to train the HSM, there is a notably higher error rate for presences (16%) than absences (6%). Given this error imbalance and the results of our field surveys, we emphasize that because Spotted Turtles are likely not currently present in a large proportion of apparently suitable wetlands, the model should be used as a tool for identifying high quality habitat rather than as a prediction of Spotted Turtle population occurrence.

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SUPPLEMENTAL INFORMATION

A WETLAND-BASED HABITAT SUITABILITY MODEL FOR SPOTTED TURTLES (*CLEMMYS GUTTATA*) IN WEST VIRGINIA, USA, USING FIELD SURVEYS AND REGIONAL DATA

JOEL L. MOTA, DONALD J. BROWN, KEVIN J. OXENRIDER, AND MICHAEL P. STRAGER

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TABLE S1. Wetland-level environmental information collected during Spotted Turtle (*Clemmys guttata*) surveys at 63 sites across 42 unique wetlands in West Virginia, USA, including wetland identification (Wetland Code) organized by geographic region. We sampled wetlands in spring and early summer between 2019 and 2021. Wetland size (Wetland Size [acres]) was calculated by manually digitizing wetland areas using satellite imagery in ArcGIS Pro 2.8. Canopy cover (Canopy Cover [%]), emergent herbaceous cover (Emergent Herbaceous [%]), subaquatic herbaceous cover (Subaquatic Herbaceous [%]), shrub cover (Shrub Cover [%]), were rapidly visually estimated at each trap and then averaged per wetland. Water depth (Water Depth [m]) was measured using a ruler or tape measure, at each trap location and averaged.

Wetland Code	CLGU Presence	Wetland Size (acres)	Canopy Cover (%)	Emergent Herbaceous (%)	Subaquatic Herbaceous (%)	Shrub Cover (%)	Water Depth (m)
Eastern Panhandle							
WV1	Present	9.36	31.5	44.9	10.7	13.8	0.18
WV2	Present	1.39	16.6	55.3	6.3	8.2	0.17
WV3	Present	65.13	20.8	63.7	5.9	7.7	0.18
WV4	Not detected	5.68	7.1	90	17	0	0.2
WV5	Not detected	6.55	27	73.2	6.1	10.1	0.15
WV6	Present	1.92	40.5	86	21	19	0.14
WV7	Not detected	2.41	34.7	86	0	9	0.09
WV8	Not detected	8.45	74.7	67.7	0	19.5	0.13
WV9	Present	5.64	56.5	51.5	16.5	37.6	0.24

WV10	Not detected	1.47	37.8	58	0	10	0.18
WV11	Not detected	17.18	8.4	50	10	8	0.12
WV12	Not detected	4.17	21.1	67	11	13	0.13
WV13	Not detected	8.85	36.6	46.3	2	39	0.16
WV14	Not detected	24.39	35.8	81	9.5	7.5	0.12
WV15	Present	9.03	50.2	80	3	35	0.16
WV29	Present	0.72	59.4	49	24	23	0.13
WV30	Not detected	4.42	22	65	10	1	0.11
WV31	Not detected	7.73	42.4	19	56	0	0.28
WV32	Not detected	2.44	60.2	55	10	3	0.17
WV33	Not detected	8.17	2.4	65.5	24.5	0	0.11
WV34	Not detected	3.41	40.2	34	23	10	0.25

WV35	Not detected	8.54	23.8	22.5	24	7	0.28
WV36	Not detected	3.67	12	12	49	9	0.25
WV37	Not detected	4.66	11.4	82	8	1.5	0.15
WV38	Not detected	5.63	12	89	4	0	0.12
WV39	Not detected	1.52	41.8	4	19	0	0.21
WV40	Not detected	1.98	88.6	2	1	2	0.29
WV41	Not detected	1.16	18.8	81	4	1	0.1
WV42	Not detected	3.93	8.8	64.5	1.5	15.5	0.13
North Central							
WV23	Not detected	2.46	14.8	62	2	29	0.16
WV24	Not detected	3.11	11.4	70	7	24	0.24
WV28	Not detected	4.91	4.8	67	0	12	0.21

Northern Panhandle							
WV16	Not detected	5.54	8.4	12	7	29	0.12
WV17	Not detected	7.17	33.6	0	0	11	0.21
WV18	Not detected	7.64	18.4	63.5	17.5	21	0.22
WV19	Not detected	4.03	15.6	19.8	4	29	0.14
WV20	Not detected	11.27	20.5	69.5	11	4.5	0.25
WV21	Not detected	6.90	10.2	49.3	7.7	29.7	0.27
WV22	Not detected	3.82	10.4	80	17	0	0.27
WV25	Not detected	1.90	9.6	64	4	0	0.3
WV26	Not detected	1.46	38.8	34	1	6	0.22
WV27	Not detected	7.82	28.8	42.7	5	15.1	0.26

Table S2. Wetland-level habitat suitability information and environmental predictor values for wetland polygons with observed presence/non-detection of Spotted Turtles (*Clemmys guttata*) in West Virginia, USA (n = 137). Habitat suitability information includes wetland identifier (Wetland ID), observed occurrence (presence = 1, non-detection = 0), raw suitability scores from the random forest model (Estimated Suitability), and binned suitability class based on raw suitability score (Suitability Class). Environmental variables represented values from a 100 m or 300 m buffer, and include number of wetlands (Wetland Richness; 300 m), distance from closest stream (Distance from Stream [m]), mean topographic position index (TPI; 300 m), mean terrain ruggedness index (TRI; 300 m), and several landcover classes derived from the 2019 National Land Cover Database (NLCD), including pasture/hay (%; 100 m), woody wetland (%; 100 m), herbaceous wetland (%; 100 m), and unsuitable environments (not suitable [%]; 100 m). The not suitable class represents a combination of the NLCD classes developed, open space, developed, low intensity, developed, medium intensity, developed, high intensity, barren, and cultivated crops.

Wetland ID	Observed Occurrence	Estimated Suitability	Suitability Class	Wetland Richness	Distance from Stream (m)	TPI	TRI	Pasture/Hay (%)	Woody Wetland (%)	Herbaceous Wetland (%)	Not Suitable (%)
31175	0	0.18	0	4	156.2	-0.01	0.78	98.57	0	0	0
31295	0	0.14	0	3	101.98	-0.01	0.78	43.57	0	0	0
40392	1	0.89	2	10	22.36	0	1.35	0.93	10.03	3.56	1.25
41144	0	0.12	0	9	0	-0.01	0.94	11.63	38.36	24.42	15.29
41230	0	0.1	0	7	0	-0.01	0.83	16.35	43.25	0	1.97
43528	1	0.7	1	2	36.06	-0.02	1.16	15.58	0	0	29.09
44145	0	0.18	0	3	0	0	1.04	22.9	0	0	21.24
44870	0	0.14	0	4	0	-0.01	0.97	21.63	24.96	13.65	23.74
46674	0	0.1	0	5	0	-0.01	1.09	0.46	3.77	0	21.47
48980	0	0.23	0	5	208.81	0	0.51	17.35	0	0.72	24.31
49525	0	0.22	0	4	197.99	-0.01	0.86	3.82	0	0	24.01
50491	0	0.11	0	7	0	-0.01	1.12	7.47	2	0	25.85
51759	0	0.28	0	3	0	-0.01	0.58	0	99.92	0	0
52787	1	0.95	2	7	14.14	-0.04	1.21	0	0	0	0
55012	0	0.24	0	3	58.31	0	0.44	61.31	1.31	3.93	23.38
55522	0	0.23	0	6	323.88	0.01	0.78	89.24	0	0	0
56805	0	0.06	0	8	0	-0.01	1.17	9.15	0	4.58	14.58
56899	0	0.11	0	6	0	-0.01	0.73	7.4	61.36	2.16	0

58991	0	0.23	0	6	0	-0.03	1.37	0	2.82	12.4	14.62
59318	1	0.84	2	11	30	0	1.34	3.93	12.75	0.85	0
60297	0	0.1	0	4	0	-0.01	0.99	13.95	10.06	4.33	21.98
61590	0	0.14	0	5	291.2	0	0.57	96	0	0	1.95
62054	1	0.91	2	6	41.23	-0.03	1.1	0	0	0	0
62752	0	0.11	0	3	0	-0.02	0.94	16.23	4.23	9.41	37.25
62938	1	0.74	1	8	0	0	1.34	3.44	0.27	5.16	9.78
62953	1	0.76	1	8	10	-0.02	1.28	4.03	16.62	2	2.36
63422	0	0.25	0	1	20	-0.02	1.07	0.12	4.49	6.55	14.9
64015	0	0.12	0	3	354.4	-0.01	0.59	100	0	0	0
64166	0	0.28	0	5	291.55	0	0.44	48.05	0	3.11	6.25
64522	0	0.2	0	5	0	0	0.42	56.71	0	0	43.29
64661	0	0.25	0	9	0	-0.01	1.38	0	0	0	0
65656	0	0.17	0	1	0	-0.01	1.21	10.84	0	0	19.1
66159	0	0.12	0	5	0	-0.01	1.27	0.12	0	0	17.77
67274	0	0.2	0	2	171.17	-0.01	0.77	29.94	1.28	0	29.33
73368	1	0.76	2	10	0	-0.04	1.15	5.19	1.27	0	8.57
73989	0	0.13	0	3	0	-0.01	1.13	15.71	0	0	16.21
73991	0	0.23	0	8	0	0	1.19	2.05	0	3.37	15.18
73993	0	0.1	0	7	0	-0.02	1.17	13.18	0	12.04	15.17
73994	0	0.17	0	8	0	0.01	1.16	1.93	0	1.4	14.24
73999	0	0.2	0	5	0	-0.03	1.35	0.08	1.05	2.81	17.73
74000	0	0.3	0	6	0	-0.03	1.35	0	2.07	5.83	9.34
74222	0	0.11	0	10	0	-0.01	1.16	17.4	0.97	0.48	3.71
74223	0	0.2	0	9	0	-0.01	1.29	0.16	3.56	0	0
74226	0	0.15	0	13	0	-0.01	1.27	0.3	0.94	0	4.28
75635	0	0.38	0	16	10	0	0.65	41.44	29.88	3.04	19.83
75730	0	0.05	0	9	0	-0.01	0.83	49.35	3.43	0	0
75760	0	0.23	0	14	0	-0.01	0.64	46.81	27.3	0	12.35
75790	0	0.16	0	10	0	0	0.74	39.8	0	1.13	11.95
76006	0	0.2	0	14	0	0	0.64	37.86	5.04	23.82	5.92

76052	1	0.86	2	24	0	0	0.74	65.47	24.38	2.52	2.79
76092	0	0.09	0	8	0	0	0.54	96.78	0	0	3.22
76094	0	0.3	0	16	0	0	0.58	70.21	13.79	0	2.97
76095	0	0.15	0	14	0	0	0.54	82.44	7.02	0	5.5
76228	0	0.13	0	7	0	0	0.74	96.73	0	0	0.82
76229	0	0.03	0	10	0	-0.01	0.73	92.67	0	0	5.21
76238	0	0.35	0	7	0	0	0.94	21.67	11.65	0	9.15
76246	0	0.07	0	17	0	-0.02	0.94	12.57	0	0	20.61
76411	0	0.06	0	7	0	-0.01	0.73	85.95	0	9.37	0
76412	0	0.18	0	10	0	0	0.76	79.37	3.54	10.11	5.46
76413	0	0.08	0	9	10	-0.01	0.71	61.98	6.28	5.73	26.01
76416	0	0.24	0	14	80.62	0.01	0.98	0	2.69	0	12.08
76417	0	0.21	0	16	94.87	0.01	0.98	11.92	10.42	0	15.96
76418	0	0.07	0	14	10	0	0.56	65.13	0	14.73	11.89
76419	0	0.06	0	14	0	0	0.6	67.26	0	8.23	17.88
76420	0	0.03	0	13	0	0	0.61	80.24	0	6.24	7.44
76424	1	0.95	2	15	0	0	0.6	33.4	13.73	35.76	15.49
76428	1	0.96	2	25	0	0	0.6	35.6	11.45	50.03	1.08
76431	1	0.83	2	19	0	-0.01	0.55	5.06	33.9	35.63	25.41
76432	1	0.91	2	21	10	0	0.57	10.28	29.47	28.94	22.53
76434	1	0.88	2	21	98.49	0	0.61	63.47	7.36	28.43	0.67
76436	1	0.94	2	22	0	0	0.58	29.63	17.43	39.67	2.51
76437	1	0.8	2	16	0	0	0.66	55.94	12.17	12.45	6.26
76466	0	0.05	0	14	20	0	0.58	75.45	0	9.73	7.37
76522	0	0.37	0	12	92.2	0	0.69	22.49	22.35	2.05	8.86
76634	0	0.04	0	18	0	-0.01	0.81	0	37.33	1.99	0.1
76635	0	0.09	0	18	10	-0.01	0.8	0	28.82	0.9	0.07
76636	0	0.08	0	15	20	-0.01	0.8	0	39.77	4.26	0
76637	0	0.06	0	18	0	-0.01	0.82	0	29.15	1.11	5.8
76821	1	0.84	2	14	20	0	0.57	42.54	2.6	37.44	15.38
76827	1	0.95	2	21	0	0	0.57	35.05	3.1	60.25	1.6

77253	0	0.23	0	16	0	0	0.74	9.87	13.6	10.84	41.07
77352	0	0.14	0	12	0	-0.02	0.97	13.04	32.47	0	8.7
77375	0	0.25	0	27	0	0.01	0.99	9.66	4.71	0	10.34
77913	0	0.08	0	14	20	-0.01	0.56	57.16	0	20.01	8.75
77927	0	0.12	0	14	0	0	0.63	59.78	3.52	20.32	9.97
77954	1	0.91	2	21	0	0	0.74	34.71	30.67	6.49	18.17
77956	1	0.83	2	23	0	-0.01	0.74	46.35	33.25	4.59	10.12
77958	1	0.87	2	24	22.36	-0.01	0.74	57.19	26.33	4.27	11.16
77971	0	0.29	0	12	0	0	0.65	25.05	41.22	6.01	16.06
77974	0	0.22	0	17	0	0	0.68	22.46	26.03	2.4	12.58
78076	0	0.33	0	7	0	0	0.95	42.77	21.31	0	12.06
78171	1	0.87	2	14	0	0	0.62	33.64	22.42	11.43	30.52
78173	1	0.92	2	14	0	0	0.58	32.2	23.78	43.2	0
78201	1	0.88	2	21	0	0	0.75	39.93	28.06	6.7	22.2
78202	1	0.88	2	21	14.14	0	0.75	48.93	23.49	7	20.57
78205	0	0.08	0	10	0	0	0.9	51.92	0	0	10.66
78248	1	0.89	2	16	0	0	0.7	32.2	21.1	12.99	1
78408	0	0.11	0	10	10	0	0.74	76.15	5.61	14.29	2.99
78409	0	0.18	0	11	0	0	0.75	70.03	3.42	9.38	17.1
78420	1	0.85	2	6	247.59	0	0.64	10.64	14.39	5.54	14.06
78555	1	0.89	2	14	40	0	0.6	49.09	12.78	11	17.57
78561	0	0.42	0	14	36.06	0	0.72	19.59	19.18	15.77	14.51
78562	0	0.17	0	16	0	-0.01	0.76	15.73	20.27	19.99	14.33
78563	0	0.3	0	16	10	0	0.75	17.17	21.79	21.37	9.96
78572	0	0.06	0	14	0	-0.01	0.8	0	27.71	4.16	0
78574	0	0.08	0	12	0	-0.01	0.8	0	7.66	6.34	0
78577	0	0.07	0	14	0	-0.01	0.82	0	14.66	2.53	6.63
78579	0	0.13	0	14	30	-0.01	0.78	0	10.6	3.11	0
78645	0	0.05	0	14	0	0	0.78	31.62	0	0.97	14.14
78781	0	0.04	0	14	0	0	0.67	58.22	0	0.05	20.1
78857	0	0.24	0	15	0	0	0.63	54.26	9.33	8.66	21.86

78860	1	0.9	2	13	0	0	0.57	37.66	34.52	26.04	0
79085	0	0.3	0	12	92.2	0	0.63	61.26	22.3	0	11.07
79104	1	0.82	2	12	0	0	0.64	24.43	29.68	29.43	0
79726	0	0.01	0	13	0	-0.01	0.74	25.94	0	1.59	12.34
80250	0	0.04	0	14	0	-0.01	0.57	68.02	0	11.56	11.58
80252	0	0.15	0	11	22.36	0	0.7	75.67	0	0	16.91
81432	0	0.12	0	9	10	0	0.91	29.41	1.91	0	13.21
81635	0	0.04	0	14	10	-0.01	0.69	23.18	0	1.52	9.37
81644	1	0.91	2	13	0	0	0.67	52.95	17.9	17.74	0
81664	0	0.14	0	18	0	0	0.62	51.68	2.87	16.81	8.93
81949	0	0.25	0	24	22.36	-0.01	0.84	37.07	19.01	23.84	0
81981	0	0.2	0	20	80.62	-0.01	0.78	29.51	11.55	38.05	0
82016	0	0.12	0	13	28.28	-0.01	0.9	39.32	5.13	0	0
82017	0	0.12	0	13	50	-0.01	0.89	44.91	2.43	0	0
82306	0	0.16	0	29	0	-0.01	0.7	1.35	54.23	29.86	0
82307	0	0.14	0	28	0	-0.01	0.7	0.77	56.24	27.84	0
83870	0	0.13	0	19	100.5	-0.01	0.75	25.54	12.2	24.41	0
83874	0	0.43	0	23	10	0	0.74	9.76	23.84	35.01	0
101890	0	0.27	0	8	80.62	0	0.65	59.17	2.18	9.5	5.44
101891	0	0.3	0	8	243.31	0	0.66	46.03	2.65	9.39	2.64
101892	0	0.05	0	9	10	0	0.64	68	3.09	3.59	11.98
101893	0	0.13	0	9	0	0	0.62	50.61	6.21	2.11	30.6
101894	0	0.08	0	9	10	0	0.63	52.4	4.51	0.01	32.78
102134	1	0.9	2	7	10	-0.04	1.07	0	0	0	0
102137	1	0.9	2	9	31.62	-0.05	1.22	10.96	23.22	0	0
102139	1	0.97	2	4	336.15	0	0.59	11.21	14.15	20.49	0.03