RESACA REFERENCE CONDITION MODEL DOCUMENTATION

LOWER RIO GRANDE VALLEY, CAMERON AND HIDALGO COUNTIES, TEXAS

GALVESTON DISTRICT

DANNY ALLEN, CWB (RPEC)

Resaca Reference Condition Model Documentation

Brownsville Resaca Ecosystem Restoration Study

Background

Purpose of Model

The Resaca Reference Condition Model (RRCM) is designed to quantify the habitat quality of potential resaca restoration sites by comparing the existing habitat against reference conditions of high quality resacas and their associated riparian habitats.

Model Description and Depiction

The RRCM utilizes high quality reference condition sites as a habitat quality target. Three modules are included in the RRCM, one for each vegetation community that may be encountered in the study area: Texas Ebony Resaca Forest, Texas Ebony-Snake Eyes Shrubland, and Subtropical Texas Palmetto Woodland.

The RRCM is composed of five suitability index (SI) categories: invasive species, aquatic habitat, bank habitat, riparian habitat, and water regime/depth. The metrics and indices incorporated into each category is described in the following section. The invasive species, aquatic habitat, bank habitat indices and water regime/depth are the same across the three modules; however, the riparian habitat component is dependent on the vegetation community target for restoration. The reference conditions were based on data from 10 sampling locations: four at Resaca de la Palma State Park, three at the Nature Conservancy's Southmost Preserve, and two at Camp Lula Sams.

Contribution to Planning Effort

The RRCM will be used to establish existing conditions and to project future with and without project conditions of potential restoration areas. The data outputs will be incorporated Cost Effective/Incremental Cost Analysis within the IWR Planning Suite.

Description of Input Data

As stated above, the RRCM is composed of four suitability index (SI) categories: invasive species, bank habitat, vegetative habitat, and water regime/depth. The invasive species index is comprised of a single metric, the percent of the vegetative community of a site that is comprised of invasive species. The bank habitat suitability index is comprised of two metrics, the percent vegetative canopy cover of the shoreline and the slope of the terrestrial/aquatic interface of the resaca.

The vegetative habitat index is comprised four metrics: riparian species composition, riparian species richness, percent riparian canopy cover, and percent aquatic canopy cover. The riparian species composition metric is a community specific metric based on one of the three vegetation communities identified above. A species function curve was constructed for each of the three vegetation communities and the species composition metric is a measure of the closeness of fit to these curves (see model documentation). The species richness metric is the total number of plant species identified on

the site. The remaining two metrics are a measure of the percent canopy cover of the riparian and aquatic vegetation.

The final index is comprised of two metrics: the water regime of the resaca and the mean depth of the resaca. The water regime is a categorical metric describing the resaca as permanently connected, semi permanently flooded yet disconnected, or a dry resaca.

Description of Output Data

The data output of the RRCM is an index between 0.0 and 1.0 that reflects the degree that a site reflects high quality resaca sites as represented by the reference resacas identified above.

Capabilities and limitations of the model

The RRCM is to be used only in Cameron County, Texas for resacas that would have historically supported the three vegetation associations identified in the model documentation (Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland). As of this date, resacas associated with more saline soils closer to the coast or differently vegetated resacas were not evaluated due to their rarity within the Brownsville city limits. Because accurate plant species identification is critical in the quantification of habitat quality using the RRCM, botanical expertise of the flora of the resacas is essential in the field collection of data inputs.

Due to the uniqueness of the resaca habitats and the incredible density of the lower, mid, and upper canopy vegetation layers, this model may be applied to riparian corridors as narrow as 25-30 feet. Finally, the field data collection team must include at least one person with the expertise to identify plant species associated with resaca ecosystems.

Model development process

Key ecosystem metrics were identified utilizing a resaca conceptual model developed in cooperation with biologists from the U.S. Fish and Wildlife Service (USFWS) Santa Ana Wildlife Refuge, USFWS Alamo Ecological Field Office, Palo Alto Battlefield National Historical Park, Texas Parks and Wildlife (TPWD) Wildlife Division, TPWD Parks Division, TPWD Inland Fisheries Division, the Nature Conservancy's Southmost Preserve, University of Texas Rio Grande Valley, Brownsville Public Utilities Board, and USACE Regional Planning and Environmental Center. In addition, the riparian species composition functional curves were developed in consultation with botanists with the USFWS, TPWD, and the Nature Conservancy. The functionality of the resulting model was tested in the Resaca Boulevard Resaca Section 206 Continuing Authority Program study.

Technical Quality

Theory

The RRCM is based on the assumption that the more closely a potential site reflects the structural and species diversity of relatively high quality resacas, the more closely it will function as a high quality resaca.

Description of system being represented by the model

Resacas are defined as paleochannels of the Rio Grande delta that have long been cut off from the Rio Grande. These aquatic and riparian habitats are becoming increasingly rare as approximately 99 percent of resaca habitats have been lost to agriculture and urban development. Historically, the resacas were maintained by the periodic flooding of the Rio Grande. The floodwaters would reconnect the resacas within the floodplain and the resacas would retain the isolated floodwater well into the dry season serving as a refuge for fish and wildlife species dependent on the diverse aquatic and riparian habitats. Over time, the floodplain connectivity of the resacas and the river has been lost due to the construction of dams along the Rio Grande, irrigation canals diverting water from the river, and flood control projects within the basin. The ecosystem restoration study attempts to restore the ecological function of the system by artificially reconnecting the resacas with the river and the floodplain.

Analytical requirements

The RRCM is a spreadsheet model developed in Excel.

Assumptions

The primary assumption of the RRCM is that the model development team has identified the highest quality remnant resaca sites in the study area and that these sites are reflective of the natural resaca ecosystem. In addition, the model assumes that the metrics identified are reflective and representative of high quality resacas in the Lower Rio Grande Valley. The model also assumes that the inherent variability of the vegetation and structural components of the resacas are effectively captured and reflected in the RRCM.

Conformance with Corps policies and procedures

The RRCM is compliant with Engineering Circular 1105-2-412: Assuring Quality of Planning Models, dated 31 March 2011.

Formula identification and computational accuracy

The formulas incorporated in the RRCM were developed by the multiagency model development team.

Invasive Species

The invasive species component of the RRCM is simply an index between 0.0 and 1.0 and is measured as the percent of the vegetative community comprised of non-native and non-native invasive species. The index is calculated as follows:

$$I_{SI} = 1 - \left(\frac{I_i}{100}\right)$$

Where I_{SI} = Invasive Species Suitability Index and

I_i = The percent of the vegetative community of site *i* comprised of invasive species

The resulting invasive species index approaches zero as the percent of cover of invasive species approaches 100 percent, thereby penalizing a site with a higher proportion of non-native, invasive species.

Bank Habitat

The Bank Habitat Suitability Index is comprised of two components, the percent canopy cover of vegetation along the shoreline and the slope of the bank measured across the terrestrial/shoreline/aquatic continuum. The percent canopy cover of shoreline vegetation across the 10 reference sites averaged approximately 75 percent. Therefore, the canopy cover index for the shoreline is assumed to be 1.0 for canopies greater than or equal to 75 percent. For canopy covers between 0 and 75 percent, a linear relationship between 0 and 75 was assumed:

$$BC_i < 75, BC_{SI} = \frac{BC_i}{75};\ BC_i \geq 75, BC_{SI} = 1.0$$

Where BC_{SI} = Bank Canopy Cover Index and
BC_i = Percent bank canopy cover for site *i.*

The bank slopes of the reference resacas were very relaxed with slopes ranging from 1:15 to 1:30. Therefore, for slopes less than 1:15, the bank slope index is 1.0. For slopes greater than 1:15, a linear relationship was assumed with vertical or bulkheaded banks resulting in a 0.0 bank slope index and a 1:15 slope resulting in a 1.0 index:

$$BS_i > 1{:}15, BS_{SI} = 0.0667 \times BS_i;\ BS_i \leq 1{:}15, BS_{SI} = 1.0$$

Where BS_{SI} = Bank Slope Suitability Index and
BS_i = Bank slope at site *i.*

The Bank Habitat Suitability Index (B_{SI}) is the mean of the bank canopy cover index and the bank slope index and calculated as follows:

$$B_{SI} = \frac{BC_{SI} + BS_{SI}}{2}$$

Vegetation Metric

Riparian Habitat

The Riparian Habitat Suitability Index is comprised of three components: species composition, species richness, and percent canopy cover. The species composition index is dependent on the target vegetation association that is being proposed for a specific restoration site. This metric is calculated separately for the Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and the Texas

Ebony/Snake-eyes Shrubland vegetation associations. For each vegetation association, the respective reference site was evaluated to develop a plant list of native species inhabiting each association. Sampling sites were located within a patch of relatively homogenous habitat to minimize the effect of edge habitats. The RRCM development team (Jason Singhurst – Texas Parks & Wildlife Department, Chris Hathcock – U.S. Fish and Wildlife Service, Rolando Garza – U.S. National Park Service, Max Pons – The Nature Conservancy, and Danny Allen - USACE) determined the range of a species' abundance within a 0.1-acre sampling plot for each site. These abundance ranges (**Tables 1-3**) were used as the reference standard for species composition for each vegetation association. For potential restoration sites, species abundance falling within the range identified on the reference condition sites would result in a species abundance index of 1.0. The abundance of a specific species outside of the reference condition range was calculated as a linear function around the bounds of the range. Specific ranges and Abundance Suitability Index curves for each species is located in the "TERF Species SI", "STPW Species SI", and "TESES Species SI" tabs of the model spreadsheet for the Texas Ebony Resaca Forest, Subtropical Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland respectively. The Species Composition Suitability Index is then calculated as the mean of all the species abundance metrics for the site:

$$SC_{SI} = {\textstyle\sum_{i=1}^{n} f(SC_i)}/{n}$$

Where SC_{SI} = Species Composition Suitability Index of a site,

$F(SC_i)$ = The species composition index as calculated by the species abundance curve function for species *i,* and

n = the number of species identified at the sampling location.

The species richness component of the riparian habitat suitability index is simply the number of plant species identified at the potential restoration site. For the reference sites, the mean species richness for the three vegetation associations was 24 (Texas Ebony Resaca Forest), 18 (Subtropical Texas Palmetto Woodland), and 20, (Texas Ebony/Snake-eyes Shrubland). The species richness suitability index is calculated as follows:

$$RR_i < RR_{RC}, RR_{SI} = \frac{RR_i}{RR_{RC}};\ RR_i \geq RR_{RC}, RR_{SI} = 1.0$$

Where RR_{SI} = Riparian Species Richness Suitability Index of the sampling location,

RR_i = Species richness of the sampling location, and
RR_{RC} = Species richness for the corresponding reference vegetative association.

The final component of the Riparian Suitability Index is the percent canopy cover of riparian vegetation. The mean percent canopy cover of riparian species for the 10 reference condition resacas was 80-percent; therefore, the riparian canopy index attains a value of 1.0 from 80-percent to 100-percent canopy cover. For canopy covers between 0 and 80 percent, a linear relationship between 0 and 80 was assumed and calculated as follows:

$$RC_i < 80, R_{SI} = \frac{RC_i}{80};\ RC_i \geq 80, RC_{SI} = 1.0$$

Where, RC_{SI} = Riparian Canopy Cover Suitability Index and
R_i = The percent canopy cover of riparian vegetation at site *i.*

Aquatic Habitat

The aquatic habitat component of the RRCM is based on the percent canopy cover of emergent and aquatic vegetation within the resaca. The mean percent canopy cover of emergent and aquatic species for the 10 reference condition resacas was 60-percent; therefore, the aquatic habitat index attains a value of 1.0 from 60-percent to 100-percent canopy cover. For canopy covers between 0 and 60 percent, a linear relationship between 0 and 60 was assumed and calculated as follows:

$$A_i < 60, A_{SI} = \frac{A_i}{60};\ A_i \geq 60, A_{SI} = 1.0$$

Where, A_{SI} = Aquatic Habitat Suitability Index and
A_i = The percent canopy cover of emergent and aquatic vegetation at site *i.*

The vegetation metric (V_{SI}) is then calculated as the average of the aquatic and three riparian indices:

$$V_{SI} = \frac{SC_{SI} + RR_{SI} + RC_{SI} + A_{SI}}{4}$$

Water Regime and Mean Maximum Resaca Depth

The final components of the RRCM is comprised of a water regime metric and a water depth metric. The water regime metric (W_{SI}) is a discrete index where a resaca with a permanent water supply and

active connectivity to the resaca system results in an index of 1.0. Resacas with a semi-permanent, yet disconnected water regime results in an SI of 0.5, while resacas that have been sedimented in or remain dry through much of the year are assigned a value of 0.0.

The mean maximum resaca depth SI is a linear index function where the index maximizes at mean maximum depths greater than five feet. This metric is based on historic resacas and measures the water quality and habitat benefits due to deeper waters such as water temperature, dissolved oxygen, and habitat variability.

RRCM Index Calculation

The final Resaca Reference Condition Index was calculated as the product of the invasive species, aquatic, bank, and riparian habitat suitability indices:

$$RRCI = \frac{B_{SI} + I_{SI} + V_{SI} + W_{SI} + D_{SI}}{4}$$

System Quality

Description and rationale for selection of supporting software tool/programming language and hardware platform

The RRCM is an Excel spreadsheet based model. The software was utilized due to the ubiquitous application of Excel within the USACE and natural resource agency arena. The spreadsheet and RRCM can be run on any PC based system.

Programming accuracy

Model software and hardware availability

The Excel spreadsheet software and PC hardware are widely used by USACE and natural resource agencies.

Model testing and validation

The RRCM was tested by Mr. Brandon Wadlington, an RPEC biologist who is independent from the resaca study. Data inputs were entered into the model within and outside of valid parameters in an effort to identify errors in the RRCM. The ECO-PCX managed an independent external review (Intermediate Level) of the RRCM. Due to the uniqueness of Resaca ecosystems and the limited number of biologists with this specific expertise, two Resaca experts were withheld from the development team to serve as the external reviewers. Ms. Amie Treuer-Kuhne is a landscape ecologist for TPWD with over 10 years experience in resaca ecosystems and Mr. Chris Best is a botanist with the USFWS in Austin, TX. He has spent over 15 years evaluating remnant resaca habitats and actively restoring thorn-scrub

habitat, including those associated with resacas, in the Lower Rio Grande Valley. Additionally, Mr. Mike Scuderi, a Biologist Regional Technical Specialist in Seattle District, provided an agency technical review of the RRCM and application in the study. The reviewers received electronic versions of the model review documents and RRCM application spreadsheet along with a charge that solicited comments on specific model assessment criteria (Encl 1). The review resulted in 22 comments (11 medium significance and 11 low significance; Encl 3). None of the comments were critical to the effective and appropriate technical application of the RRCM. All comments were evaluated, incorporated in the model, and closed to the satisfaction of the ECO-PCX, model proponent, and reviewers. Low significance comments were generally related to formatting, readability, and recommendations for future model development.

Usability

Input data availability
The data required by the RRCM is readily available through surveys conducted by qualified botantists and field biologists. Data collection can be accomplished in approximately 30 minutes per site.

Output format
The data output is provided on the data entry tab of the Excel spreadsheet model. The data output is the quantified estimate of habitat quality rated from 0.0 (no resaca habitat) to 1.0 (habitat is equivalent with high quality resacas).

Results application
The model results will be incorporated in the ecological benefits assessment and annualized over the course of the project prior to application of the CE/ICA.

Training availability
Training for the RRCM can be provided by Danny Allen (RPEC) as needed.

User documentation
User documentation is provide in the information tab of the spreadsheet model. TPWD biological diversity staff is currently working with the model developer in the documentation of the model for use by TPWD biologists in assessing resaca habitats.

Technical support
Technical support can be provided as needed by Danny Allen (RPEC).

User access to software/hardware
The model development team can provide future users with the RRCM upon request.

Model accessibility
The model is accessible for any party requesting access to the model.

Model transparency

All formulas and species curves are provided in the RRCM Excel spreadsheet and associated documentation.