Ecosystem Restoration Modeling - SPD

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SPD Districts and Offices

- SPL – Los Angeles District
  - Phoenix Office
- SPK – Sacramento District
- SPN – San Francisco District
- SPA – Albuquerque District

Typical tools used

- HEP – Habitat Evaluation Procedure; also mHep
  - HSI
- HGM – Hydrogeomorphic
  - FCI
- Other tools:
  - Standard Assessment Methodology
  - HEAT

What is HEP?

- Biological Accounting System

- **Currency = Habitat Units (HU's)**

- **Habitat Units = Quality X Quantity**

What is an HSI?

HSI = Habitat Suitability Index

$$= \frac{\textbf{Study Area Habitat Conditions}}{\textbf{Optimum Habitat Conditions}}$$

Score = 0.0 to 1.0

Measure of Quality:
HSI vs. FCI (used in HGM)

Index = $\frac{\text{value of interest}}{\text{standard of comparison}}$

HSI = $\frac{\text{Habitat condition in Study Area}}{\text{Optimum habitat condition}}$

FCI = $\frac{\text{Functional capacity index}}{\text{Reference wetland standard}}$

Use of HGM by Phoenix

- Used to measure riverine wetland and riparian functions
  - Santa Cruz River
  - Salt River
  - Rillito River
- Performed reference site sampling; study site sampling
- Used EXHGM software

Standard Assessment Methodology (SAM) - SPK

- Sacramento River Bank Protection Project
- Developed by SPK, ERDC, and numerous universites
- Assesses impacts on listed salmonids and delta smelt
- Used to assess effects of 29 critical erosion sites

Standard Assessment Methodology

Considers Habitat Requirements for Six Focus Fish Species:

- Central Valley spring-run Chinook salmon (Threatened)
- Central Valley fall-run Chinook salmon (Candidate)
- Central Valley late fall-run Chinook salmon (Candidate)
- Sacramento River winter-run Chinook salmon (Endangered)
- Central Valley steelhead (Threatened)
- Delta smelt (Threatened)

SAM Modeled Variables

Reviewed Factors Affecting Focus Fish Species

- Hydraulics (*e.g.,* depth, velocity, timing and duration)
- Water Quality (*e.g.,* temperature, turbidity, salinity)
- Structural Features (*e.g.,* grain size, bank slope, instream wood, proximity to cover).
- Riparian and Aquatic Community (*e.g.,* riparian and aquatic vegetation, predator habitat suitability, prey food availability).

Selected Variables by their relevance to:

- Life history requirements
- Habitat use
- Whether they are affected by SRBPP actions
- Ease of field measurement or computer-based modeling

SAM Modeled Variables

Bank Slope – indicator of shallow water refuge for juveniles as well as food and resting areas.

Floodplain Inundation Ratio – inundation area ratio of infrequently flooded habitat to average in-channel area in winter and spring is used as an indicator of juvenile refuge in high flow periods as well as food supply.

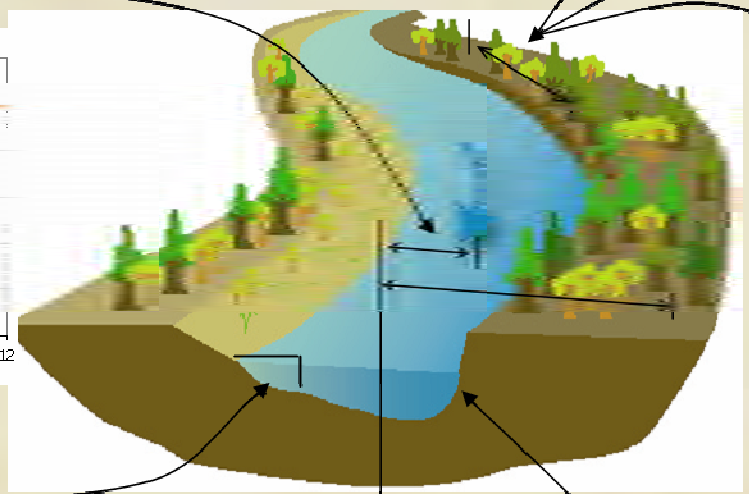
Bank Substrate Size – indicator of juvenile predator refuge, suitable predator habitat, and food availability for juvenile and adult life stages.

Instream Structure – indicator of juvenile predator refuge, suitable predator habitat, as well as adult resting and feeding station availability.

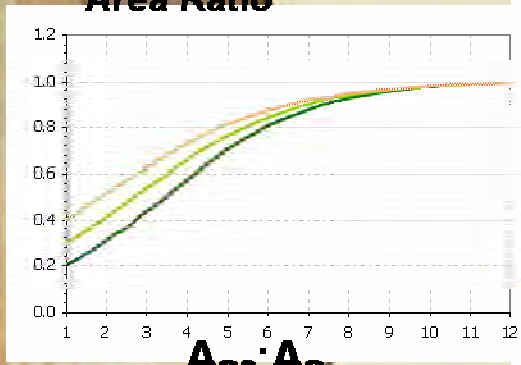
Aquatic Vegetation – indicator of juvenile predator refuge and suitable predator habitat.

Overhanging Shade – indicator of juvenile and adult predator refuge.

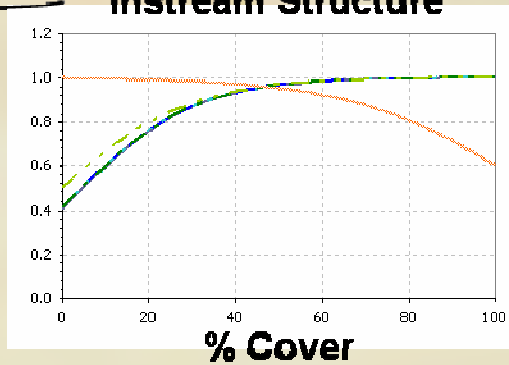
SAM Conceptual Response Models



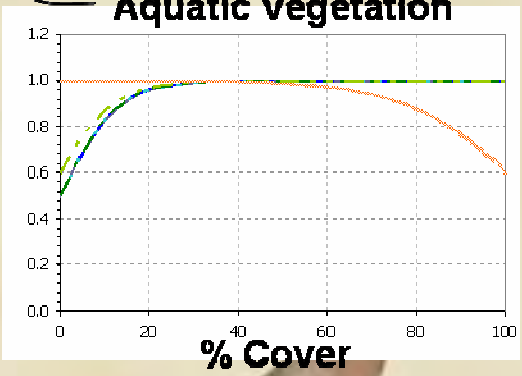
Floodplain Inundation Area Ratio



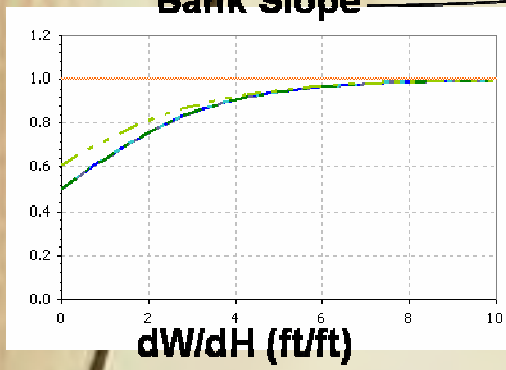
Instream Structure



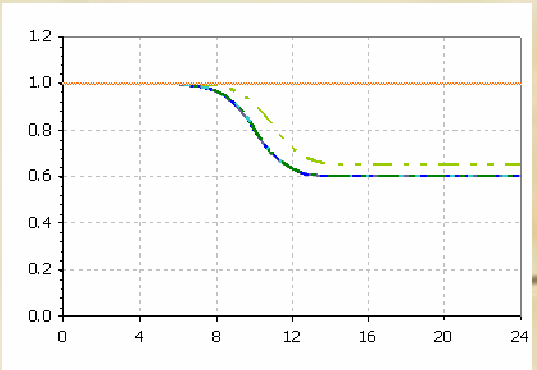
Aquatic Vegetation



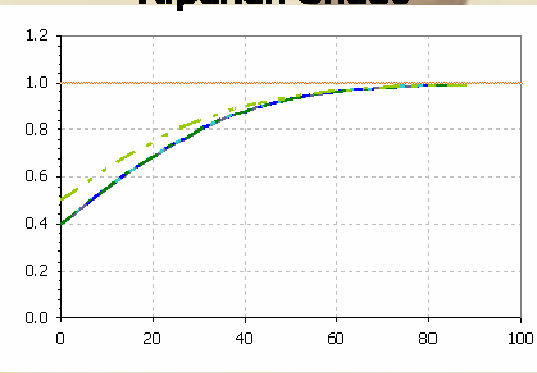
Bank Slope



Bank Substrate Size



Riparian Shade



Stillwater Sciences

SAM Response Index

$$I = I_{dW/dH} \times I_{A_{Q2}:A_{Qavg}} \times I_{D50} \times I_{LWD\%} \times I_{Veg\%} \times I_{Shade\%}$$

Where:

$I_{dW/dH}$ – Bank slope at mean WSEL

$I_{A_{Q2}:A_{Qavg}}$ – Ratio of wetted area at Q2 & Qavg in winter or spring

I_{D50} – Bank substrate size at mean WSEL

$I_{LWD\%}$ – Instream structure (%) bank-line at mean WSEL

$I_{Veg\%}$ – Aquatic vegetation (%) bank-line at mean WSEL

$I_{Shade\%}$ – Overhanging shade (%) bank-line at mean WSEL

SAM Habitat Assessment

- Uses CEQA/NEPA framework for ESA listed species.
- Compares relative responses between With-Project and Pre-Project baseline conditions:

$$R_{i,j,k} = (I_{ijk} \, x \, w_{ijk})_{With\ Project} - (I_{ijk} \, x \, w_{ijk})_{Without\ Project}$$

(ft of ft²)

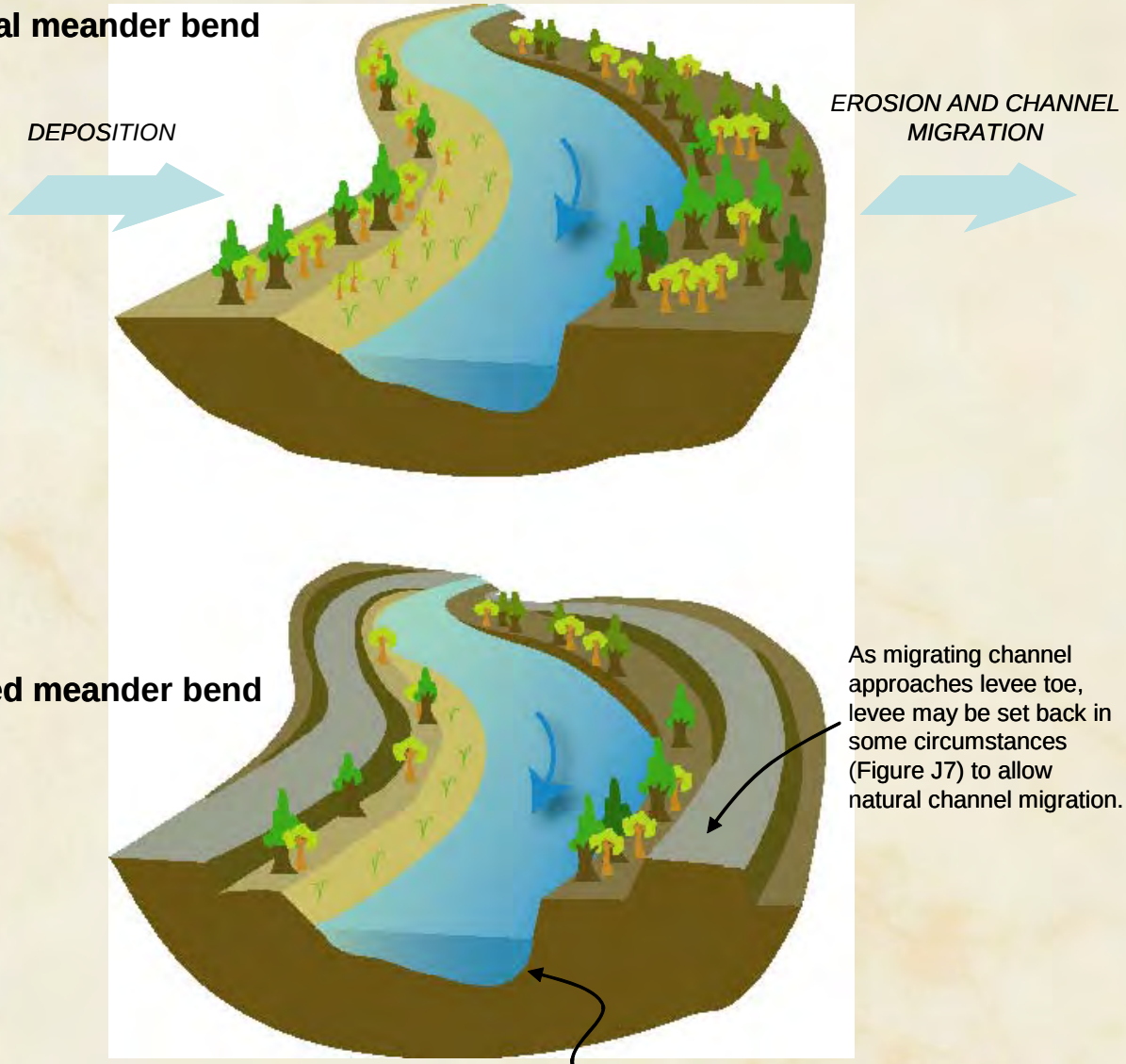
- Examines relative responses through time to find when deficits or excesses occur.
- Determine Off-Site Compensation by cumulative deficit of un-met mitigation over the analysis timeframe (e.g., 50 years):

$$CR_{jk} = \frac{1}{t_k} \sum_{k=1}^{n} \frac{\Delta t}{2} \left[R_{t_{k-1}} + R_{t_k} \right]$$ **(ft of ft²)**

- Negotiate whether deficits can be compensated at other times (*e.g.*, self-mitigating at t=0, 1, 10 yrs?)

SAM Comparisons of Responses to Eleven Typical Bank Types

a) Natural meander bend

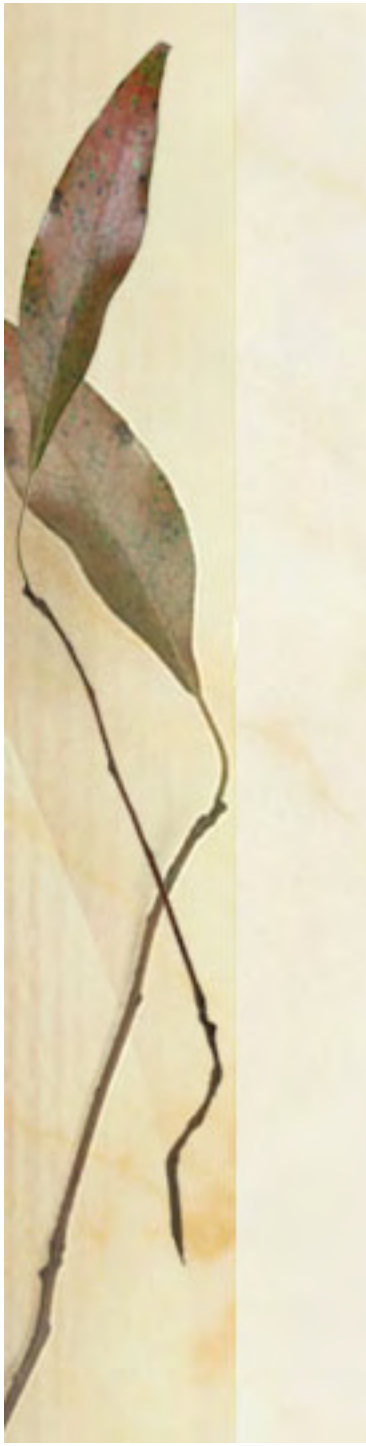


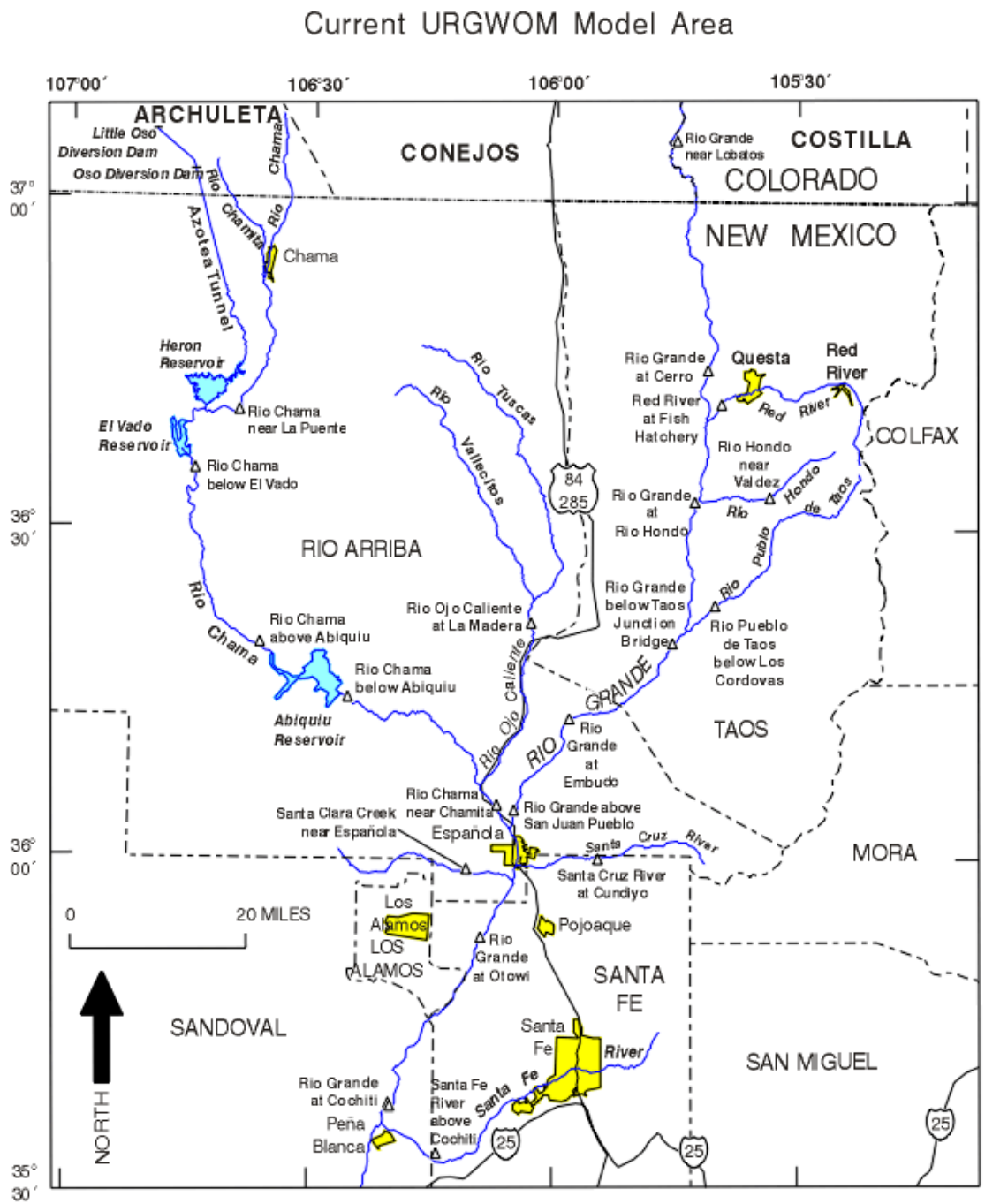
b) Leveed meander bend

Stillwater Sciences

Tools being used by SPA

- Upper Rio Grande Water Operations Model (URGWOM) – HSI for riparian & wetland hydrologic parameters
- Middle Rio Grande Bosque Feasibility Study (GI) – combining HEP and HGM into a HEAT (Habitat Evaluation Assessment Tool) model with ERDC





URG = Headwaters in CO south to Bosque del Apache

URGWOM

- Water Operations Model (considering existing flows, habitat needs, wildlife needs, Compact delivery needs)
  - Completed H&H Modeling – FLO2D (also used HEC-RAS and RMA2)
  - Aquatic Habitat Model – riverine habitat only
  - Biological conditions – Riparian habitat, wetlands, fauna, T&E species (measured in field)

URGWOM

- Used ETtool, many other pieces
- Using RiverWare – developed by Center for Advanced Decision Support for Water and Environmental Systems
- http://www.spa.usace.army.mil/urgwom/default.asp

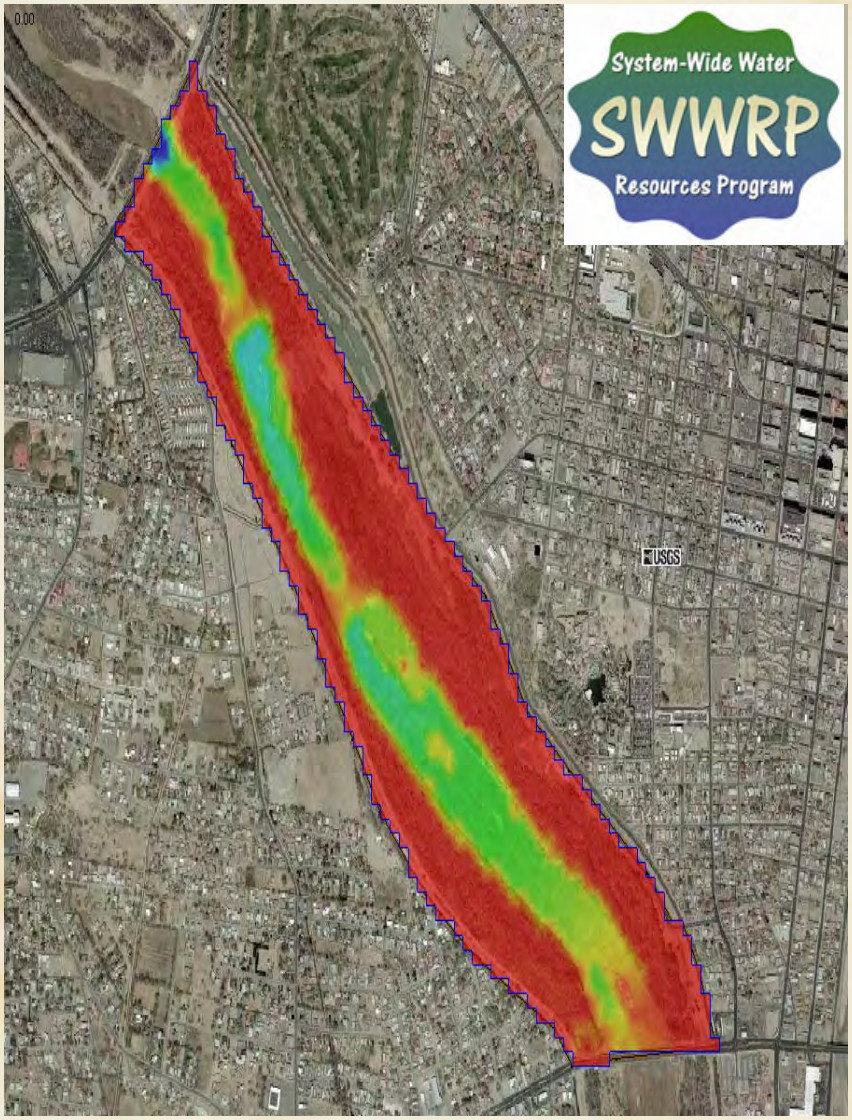
Middle Rio Grande Bosque Feasibility Study (GI)

USACE Albuquerque District contracted with ERDC for: "Project Planning, Ecosystem Evaluation, and Incremental Cost Analysis"

- √ **Model Development including workshops, meetings, data management and data entry**
- √ **Baseline / Without-Project Analysis**
- √ **Training on Habitat Evaluation Assessment Tool (HEAT) software See System-wide Water Resources Research Program Booth**
- √ **Develop products to be used in EA**
- √ **Complete 1 / 3 of HEAT runs**
- √ **Perform Incremental Cost Analysis (ICA)**

Assessment effort to date

- **Functional Model Building Workshop held February 28 – March 4, 2005**
- **Field work completed by SPA mid-May through mid-July 2005**
- **Baseline Results and Without-Project Trends Meeting held August 18-19, 2005**
- **Initial Gridded Surface-Subsurface Hydrologic Analysis (GSSHA) - See System-wide Water Resources Research Program Booth**



Functional Model Building Workshop

- E-Team developed Model components
- Used vegetation types defined for the Middle Rio Grande (Hink & Ohmart) and chose 10 (there are 6 types, we added treated/untreated/wet):
  - **Type 1, Type II Untreated (U), Type II Treated (T), Type III, Type IVU, Type IVT, Type V, Type VITDry (D), Type VIUD, Type VIWet (W)**

Functional Model Building Workshop

- Forest
  - What's important?
    - **Water**
    - **Biota**
    - **Soils**
    - **Landscape**

$$\frac{V_{BBIOTA} + V_{BWATER} + V_{BLANDSCPAPE}}{3}$$

- Meadow

Mathematical Formulas

- Component = BIOTA

$$\frac{\left\{2 \times \left[\left(\left\{\frac{\left[\left(V_{CANTREE} \times V_{NATIVETREE}\right)^{1/2} \times V_{SIZETREE}\right] + \left(V_{CANSHRUB} \times V_{NATIVESHRB}\right) + \left(V_{CANHERB} \times V_{INDICATHB}\right)}{3}\right\}\right) \times V_{SPPCOUNT}\right]\right\} + V_{DEPTHOM} + V_{COVGRND}}{3}$$

$$\left[\frac{\left(V_{CANSHRUB} \times V_{NATIVESHRB}\right) + \left(V_{CANGRASS} \times V_{INDICATGR}\right) + \left(V_{CANFORB} \times V_{INDICATFB}\right) + \left(V_{CANSEDGE} \times V_{NATIVESDG}\right)}{4}\right] \times V_{SPPCOUNT}$$

Mathematical Formulas

- Component = WATER

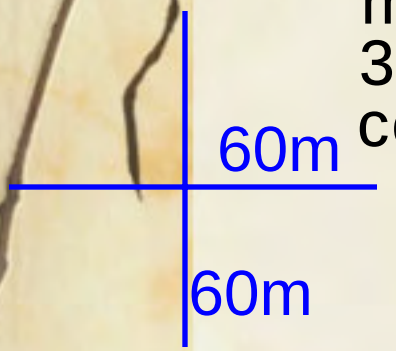
$$\frac{\left(V_{FLOODFREQ} \times V_{DURATION}\right)^{1/2} + \left(V_{DEPTHGW} \times V_{MACROTOPO}\right)^{1/2}}{2}$$

- Component = LANDSCAPE

$$\left[V_{PATCHSIZE} \times \left(V_{DISTPATCH} \times V_{TYPEPATCH}\right)^{1/2}\right]^{1/2} \times V_{TYPDISTURB}$$

Field Method Development

- Developed by Parametrix
- Ten different cover types; need at least 3 site samples for each type so 30 sites total
- Transect placed at each site: 60m x 60m (middle 10 m was not sampled to allow access) so 100 m total at each site = 300m total for each cover type



Field Methods

- **Canopy** (aerial) cover of shrubs (species level), trees (species level) and herbaceous plants (life-form level, indicator species).
- **Ground cover** (soil, rock, litter, mulch, live basal vegetation, downed woody material <3 in., Downed woody material >3in.).
- **Density and basal** stem diameter of native and non-native trees (species level).
- **Density of native and non-native root-spouts** (species level).
- **Depth of organic material** (o-horizon).
- **Presence/absence of macro-topographic features** (mounds, depressions).

Field Methods, mid-May to mid-July, 2005

Point Center Quarter (PCQ) - to measure trees at the end of each line, then measured the distance to the nearest tree and its basal stem diameter

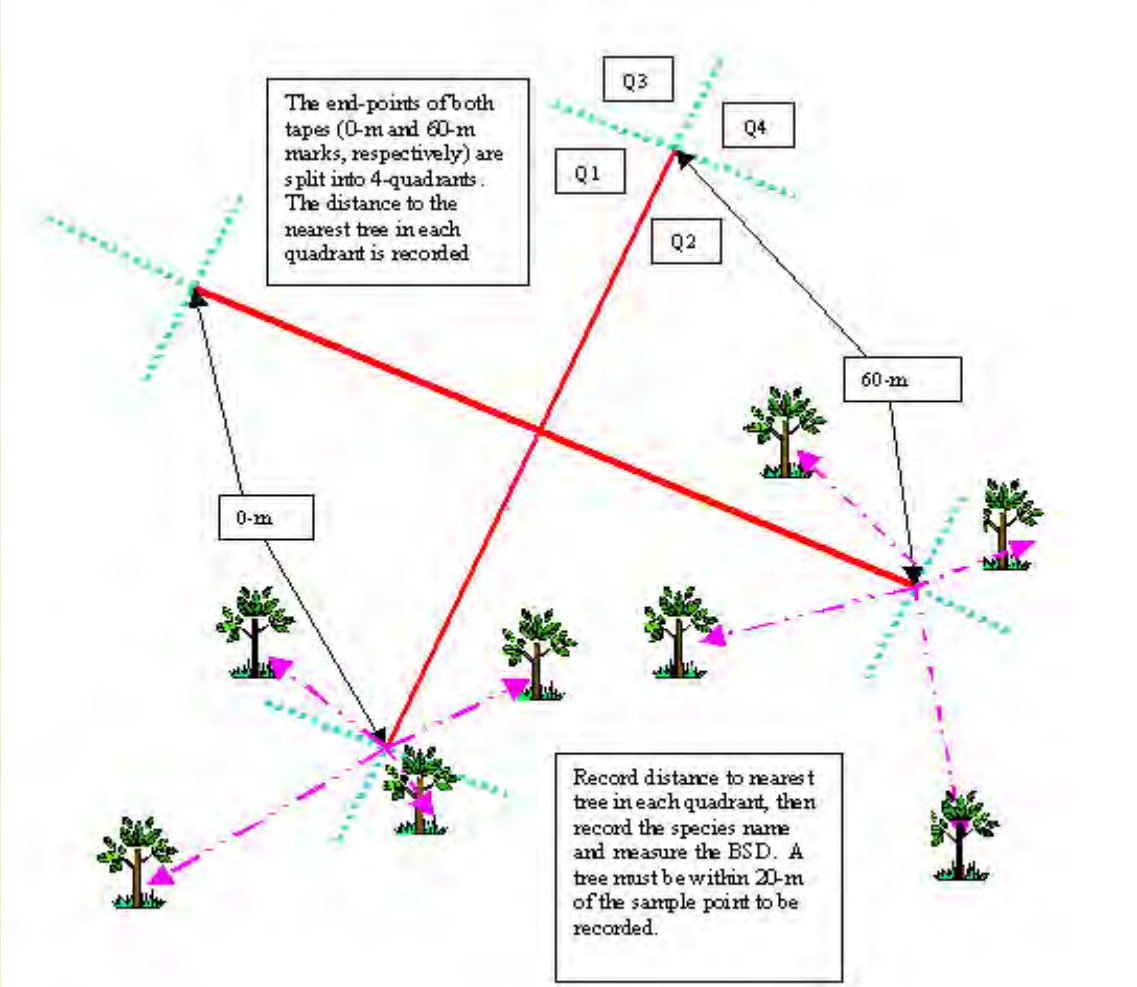
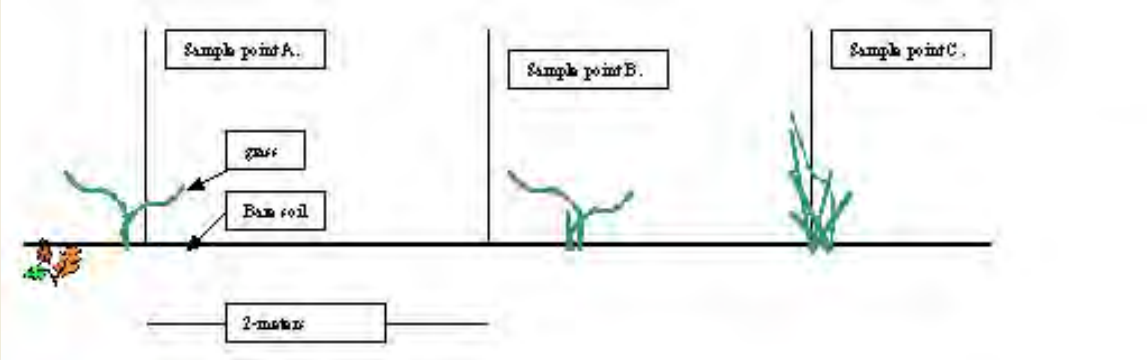


Figure 3. Conceptual illustration of PCQ method.

Field Methods

- Every 2m, measured point-intercept for plants and used vertical densiometer for trees
  - Categories: bare soil, litter, mulch, live basal vegetation, small woody debris (< 3 in. diameter), large woody debris (> 3 in. diameter)

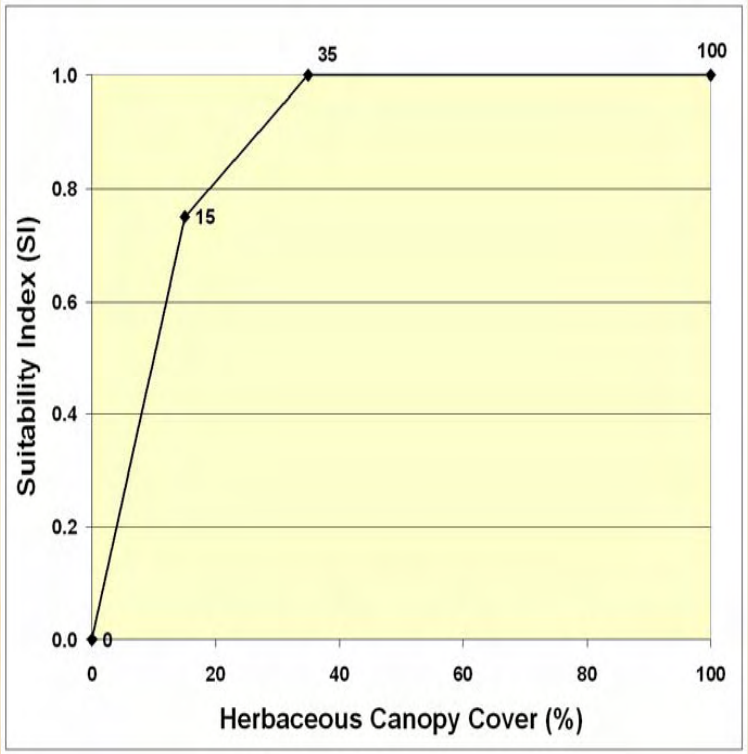


Field Methods

- Every 10m measured depth of organic matter (DOM) in centimeters with ruler
- Shrubs measured by line-intercept; start/stop
- Recorded Negative and Positive species indicators
- Noted macrotopography – channel, hill, etc.
- Measured depth to groundwater

Field Analysis and Trends

- Entered information into formulas
- Also included hydrology information – flood frequency and duration
- Reviewed results August 18-19 with ERDC
- Made changes to Suitability Index's (SI)



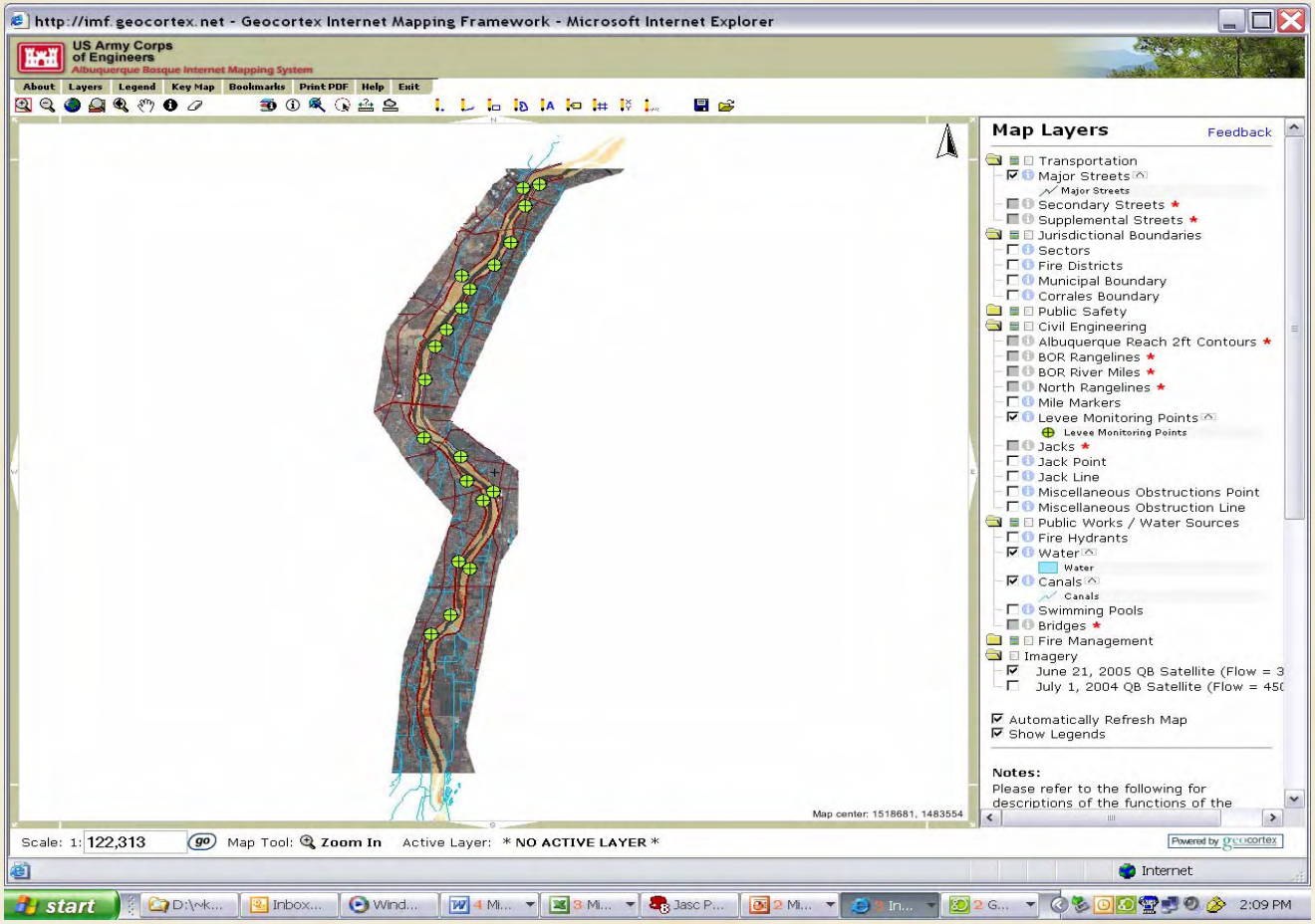
Current Status

- **Just completed additional information to complete Baseline Conditions and Without Project analysis:**
  - **2005 Vegetation Survey**
  - **Final H&H information**
  - **Protocols – H&H and GIS information (distance to next patch, distance to disturbance, etc.)**
- **With-project Trends Meeting set for May '06**

Next Steps

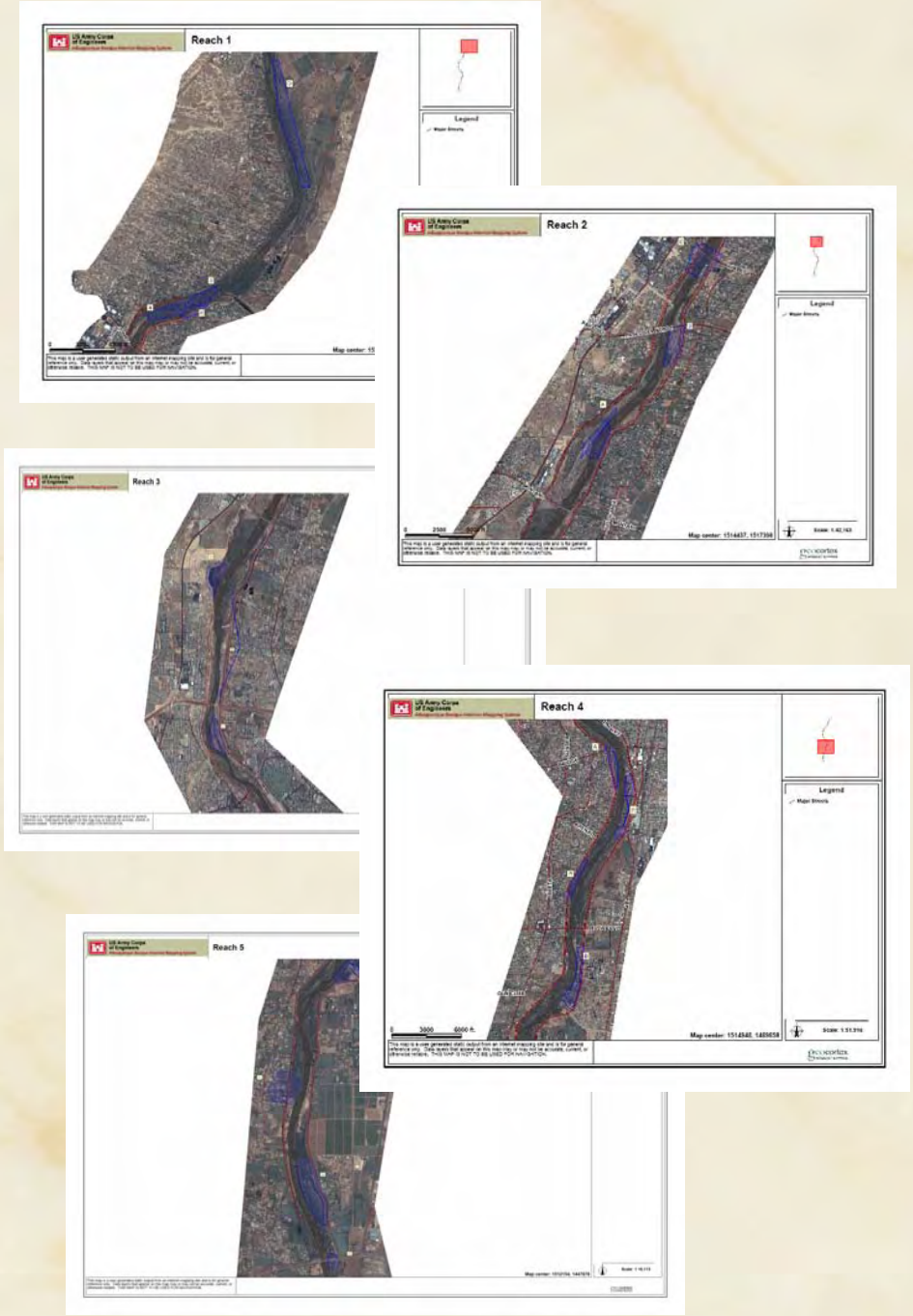
- Alternative development initiated using new tool: Albuquerque Bosque Internet Mapping System . . .

  www.bosquerevive.com



Next Steps

- Multiple Alternatives formulated per reach based on cover types, O&M and phasing
- Assess Alternatives with HEP model and GSSHA
- Compare Alternatives with CEA/ICA



Take Home Points

- **HEP Works! HGM Works!**
- **Don't be afraid to build your own models**
- **New technology can provide critical information for your study (HEAT, GSSHA, SAM)**
- **Be prepared to do a lot of field work!**
- **Needs:**
  - **Wildlife component inferred in HEAT model**
  - **SAM – would like to improve model or apply concept to other areas (ie: newly listed species)**