Terrestrial Biotic Monitoring: Status and Long-term Approach Part I: Background

Barbara E. Ralston, GCMRC, USGS

Background

2000 PEP Recommendations (Urquhart and others 2000) associated with Goal 6.

•Expand vegetation sampling.

•Integrate across terrestrial resources.

•Develop GIS vegetation map.

Completed Projects

•Developed probabilistic sampling approach (vegetation transects, Kearsley, 2006).

•Collected multi-taxa data at single sites (Kearsley and others, 2006).

•Completed GIS vegetation map (2002 imagery, Ralston and others, 2008).

Methods

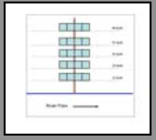
Vegetation Transects

Purpose: track local annual change of annual/perennial herbs and forbs (CMIN 6.1.1, 6.5.1.)

•Annually rotated plots.

•60 sites/year; 140 sites sampled by end of year 3.

•Surface elevation of 15, 25, 35, 45, and 60k cfs associated with each site w/four 1m² plots/surface elevation/site.



Transect design

Single Taxon and Integrated Biotic Data Collection

Purpose: Determine benefit of single site sampling across taxa and evaluate sampling methods.

•One site/geomorphic reach rotated each year. 12 sites/year with three zones/site (Fluctuating zone [FLZ], new high water zone [NHWZ] and old high water zone [OHWZ]).

•Vegetation, bird abundance, small mammals, reptiles/amphibians and arthropods sampled.

•Multiple sampling approaches used depending on taxon (e.g., walking survey (birds, herps), live traps (mice), pitfall traps (beetles, ants).

Pitfall trap

Vegetation Mapping

Purpose: A system wide vegetation map for randomized sampling and large-scale woody vegetation area change monitoring (CMIN 6.1.2, 6.1.2)

•Automated supervised classification using image processing software.

•Ground-truthing in field to identify vegetation classes initially and map accuracies afterward.

Results

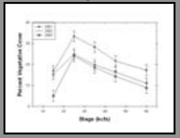
Vegetation Transects

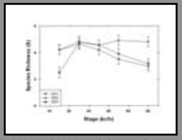
•Yearly operations and local weather affect vegetation up to the 35k cfs surface elevations.

•Local weather has a greater effect on vegetation above the 35k cfs surface elevation than annual operations from Glen Canyon Dam.

•Over the three years of collecting data (2001-2003), cover declined across all years but the degree of decline varied between years and zones.

•Richness (number of species encountered) was generally greatest at the 25k cfs surface elevation and showed declines over time at elevations above 35k cfs, likely due to drought conditions.





Percent cover and species richness in five stage zones in 2001 and 2002, and changes between years. Vertical bars represent +/- 1 s.e.

Single Taxon and Integrated Biotic Data Collection

Arthropods

•Composition between fluctuating, new high water and old high water zones differed among ground-dwelling, plant-dwelling and flying taxa.

•Indicator species existed within each zone among taxa encountered.

•Ground-dwelling species affected by soil texture and moisture which is linked to sediment supply and Glen Canyon Dam operations in FLZ and NHWZ.

Small mammals

•Available area was most important predictor of abundance within zones.

•OHWZ was had greatest abundance vs. FLZ were abundance was lowest.

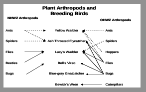
Reptiles/amphibians

•Available open area was most important predictor of abundance/encounters.

•Richness varied seasonally, but all species encountered in each zone.

Bird/arthropod interactions

•Significant non-parametric correlations between plant-dwelling arthropods and individual bird species. (Solid lines indicate positive correlations, dashed lines show negative)



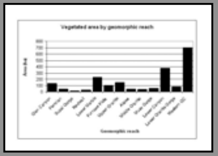
Vegetation Mapping.

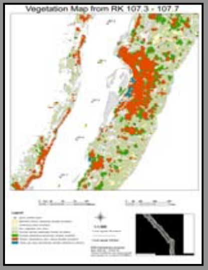
•7 classes identified (see map on right)

•Final mapping accuracy > 80%.

•Sparse shrub, arrowweed and saltcedar had greatest cover values.

•Vegetated area generally increased downstream.





Study Recommendations

Vegetation Transects

•Probabilistic sampling provides ability to detect significant change in cover after 7-15 years.

•Changes of 5% per year would show significance in 7 years. Smaller change takes longer.

•Rotating panel design reduces investigator impact.

Single Taxon and Integrated Biotic Data Collection

Arthropods

•Focus monitoring on spring/early summer when abundance and richness is high.

•Identify taxa to order (e.g., flies, beetles) rank rather than genus and species.

•Monitoring ground-dwelling arthropods with pitfall traps.

•Monitor midges and identify to family with malaise traps

•Consider monitoring plant-dwelling arthropods, but identify only to functional groups (e.g., caterpillars, grasshoppers, spiders).

Small mammals/Reptiles/Amphibians

•Spend multiple days at a single site to get better abundance information.

•Use timed sampling in addition to area standardization for reptiles.

•Specific information needs would need to be developed to warrant monitoring small mammals and herpetofauna.

Overall recommendations

•Use randomly selected sites associated with vegetation map.

•Focus monitoring on vegetation, breeding birds and a subset of arthropods.

•Sampling arthropods would need to be done separately from birds or vegetation.

Darkling beetle

Malaise trap

Blue-gray gnatcatcher

Vegetation Mapping

•Consider using multispectral imagery instead of 4-band imagery.

•Decrease resolution from 44 cm to 1m, if acquiring multispectral data.

•Use additional environmental data to improve accuracy (e.g., surface elevation).

•Use alternative multivariate statistics for vegetation class identification.

•Explore object-oriented software to improve classification accuracy.

Products:

•Kearsley, M.J., Cobb, N.S., Yard, H.K., Lightfoot, D.C., Brantley, S.L., Carpenter, G.C. and Frey, J.K. 2006. Inventory and monitoring of terrestrial riparian resources in the Colorado River corridor of Grand Canyon: an integrative approach. Final report to Grand Canyon Monitoring and Research Center, USGS, Flagstaff, AZ.

Ralston, B.E., Davis, P.A., Weber, R.M., and Rundall, J.M. 2008. A vegetation database for the Colorado River ecosystem from Glen Canyon Dam to the western boundary of Grand Canyon National Park, Arizona. U.S. Geological Survey Open-File Report 2008-1216, 37 p. [http://pubs.usgs.gov/of/2008/1216/]

GIS Vegetation Coverage on IMS (http://www.gcmrc.gov/website/vegmap2002/run.htm

USGS

A Vegetation Database for the Colorado River Ecosystem

B.E. Ralston[1], P.A. Davis[1], R.M. Weber[2] and J.M. Rundall[3]

U.S. Geological Survey, [1]GCMRC, [2]Pinnacle Mapping Technologies, Inc., [3]Northern Arizona University

Background

AMWG GOAL 6: Protect or improve the biotic riparian and spring communities, including threatened and endangered species and their critical habitat.

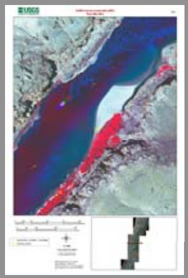
PROJECT GOAL: Develop a GIS vegetation basemap for Core Monitoring (large-scale vegetation area change monitoring [CMIN 6.1.1, 6.2.1]) and for random sampling points for other terrestrial resources (e.g., birds) linked to vegetation.

2000 - Urquhart and others recommend vegetation base map for random sampling and large-scale change detection and monitoring

2002 - 4-band color infrared orthorectified digital imagery acquired over 10 days in May/June or CRE. Imagery used for vegetation database

January 2003 - vegetation database project initiated

Map of Study Area.



2002 Color infrared imagery with GCMRC river mile and sample locations for vegetation classification relevé plots.

Methods

Combination of field and lab work

Field work –

- **Identify training* areas for preliminary vegetation classes.**
- **$30m^2$ relevé plots plots used to estimate species cover and presence to identify vegetation classes and community associations.**
- **Randomly sampled points to verify preliminary classifier accuracies.**
- **Ground-truth revised vegetation classification accuracy.**

Lab work –

- **Evaluated imagery for utility of automated classification**
- **Built masks to exclude non-vegetative areas to reduce processing time and improve classification accuracy.**
- **Used training areas* to determine reflectance values for each vegetation class**
- **Used TWINSPAN (two-way indicator species analysis) to separate/identify vegetation classes used in classification**
- **Considered imagery capabilities and vegetation classification results to refine vegetation classes.**
- **Ran automated classification routine to process imagery and provide classification**

***(sites on imagery that are homogenous areas of a single vegetation type and that provide a uniform reflectance value for the vegetation type.)**

Results

Seven Vegetation Classes

Wetland - *Phragmites/Scirpus*, combined with *Typha domingensis/Carex aquatilis* (common reed/cattails/sedges)

***Baccharis emoryi/Salix exigua* - (**seepwillow/coyote willow)

Tamarix ramosissima/Aster spinosa (saltcedar)

Pluchea sericea (arrowweed)

Prosopis glandulosa/Acacia greggii/Baccharis sarothroides (mesquite/catclaw acacia/desert broom)

Sparse Shrubs (desert shrubs, bunch grasses)

Non-vegetated (rocks, sand)

Classification Accuracy

Initial accuracies varied with each class from 49-100%.

Accuracies affected by similar reflectance values of classes, sparse density of vegetation

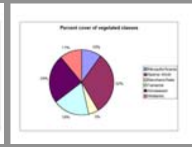
Accuracies improved to >80% among all classes with application of fuzzy logic*

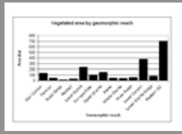
***(alternative assessment approach that allows for degrees of membership to particular classes. Accuracies are assessed in categories of agreement such that a class might be mostly correct instead of simply correct or incorrect.)**

Land Cover

Sparse shrub, arrowweed and saltcedar had greatest cover values.

Vegetated area generally increased downstream.



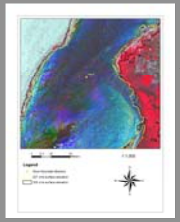


Applications

Large-Scale Change Detection for Core Monitoring (CMIN 6.1.1, 6.2.1)

Comparison of total vegetation change between 1992 and 2002. Vegetation increased by 6 hectares in 10 years between RK 126 and 140.

Terrestrial-Aquatic Linkages Assisting Aquatic Food Base Project



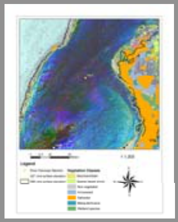
Estimate annual terrestrial inputs up to 566 m^3/s (20k cfs) using vegetation map and virtual shorelines (Magirl and others 2008).

Annual system-wide estimate is:

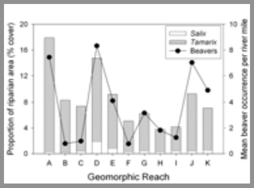
3.46×10^8 gAFDM·yr-1

- **1,207 gAFDM·m-1·yr-1 of shoreline**
- **13.80 gAFDM·m-2·yr-1**

(Kennedy and Ralston, in review)



Terrestrial Community Interactions



Using location and area of saltcedar, coyote willow from vegetation map and beaver data from NPS (1999-2003) to correlate changes in vegetation cover and species occurrence with beaver densities (Mortenson and others, in press).

Products: GIS Vegetation Coverage on Internet Map Server (IMS) (**http://www.gcmrc.gov/website/vegmap2002/run.htm**)

Ralston, B.E., Davis, P.A., Weber, R.M., and Rundall, J.M. 2008. A vegetation database for the Colorado River ecosystem from the Glen Canyon Dam to the western boundary of Grand Canyon National Park, Arizona. Open-file report 2008-1216 (http://pubs.usgs.gov/of/2008/1216)

Literature Cited

Mortenson, S.G., Weisberg, P.J., and Ralston, B.E. *in press.* Do beavers promote the invasion of non-native *Tamarix* in the Grand Canyon riparian zone? Wetlands.

Urquhart, N.S., Auble, G.T., Blake, J.G., Bolger, D.T., Gerrodette, T., Leibowitz, S.G., Lightfoot, D.C. and Taylor A.H. 2000. Report of a peer review panel on terrestrial aspects of the biological resources program of the Grand Canyon Monitoring and Research Center. Report to GCMRC, U.S. Geological Survey, Flagstaff, Ariz. 54p.

Acknowledgments: Funding for this work was provided through the Glen Canyon Dam Adaptive Management Program. Cooperative agreements between USGS/GCMRC and Northern Arizona University (99HQAG0175 cooperative project award 99175HS021) and between USGS/GCMRC and Pinnacle Mapping Technologies, Inc (Agreement Number 03WRAG0004) ensured the completion of data collection and image processing.

Terrestrial Biotic Monitoring: Status and Long-term Approach Part II: 2008 PEP Recommendations and Next Steps

Barbara E. Ralston, GCMRC, USGS

Background

August, 2007 Protocol Evaluation Panel Convened to Review:

•Goal 6 Management Objectives and Core Monitoring Information Needs

•Vegetation transects

•Vegetation mapping

•Inventory and monitoring of terrestrial organisms

2008 PEP Recommendations

Management Objectives and Core Monitoring Information Needs

•CMINs need re-evaluation some are not pertinent, others might be reformulated relative to restoration.

•Spring communities not directly influenced by dam operations.

•Clarification of "community" that is maintained (e.g., Tamarisk is undesirable but existed in 1984 community.)

•Focus on vegetation restoration - tamarisk and other vegetation removal.

Terrestrial Biological Resources

•Continue and develop research approach to monitoring.

•Develop an ecosystem model comparable to aquatic system model – identified in 2000 PEP.

•Utilize arthropod/vegetation/bird sampling for integrative monitoring.

Vegetation Monitoring (Transects & Mapping)

•Use both local scale (transects) and large scale (mapping) monitoring approaches to meet Core Monitoring Information Needs

•Incorporate geomorphic features (debris fans, pools, riffles) into transect sampling variables

•Expand area measured for transect (>4m² per sample point)

•Evaluate other scale factors besides narrow and wide reaches wrt composition (e.g., gradient, light availability, elevation).

•Use alternative analysis approaches to identify community types in mapping

Implementation Strategy For PEP Recommendations FY09

Core Monitoring Information Needs and Management Objectives Re-evaluation

Re-evaluation is role of the Technical Working Group and Adaptive Management Working Group.

Technical Work Group recommendations/response to the PEP report may ideas about reformulating Management Objectives and associated Information needs.

Terrestrial Vegetation Monitoring – Local Scale

CMIN 6.5.1 Determine and track the abundance and distribution of non-native species in the Colorado River as measured at 5-year or other appropriate intervals…

FY09 - Research toward monitoring – Vegetation Transects – *Transects provide good local information about cover and abundance changes of herbaceous and small shrub/grass species (e.g., brome grasses, exotic mustards, knapweed) not available from aerial photography.*

FY09 Activities

•Release an RFP in Fall 2008 for cooperative agreement to continue transect sampling in September 2009

•Approach will use established points (Kearsley and others, 2006) expand sampling area per sampling point and ask cooperator to determine how to incorporate smaller sampling areas (2001-2005 data) into trends analysis. Report in FY10.

•Identify appropriate sampling interval to meet information needs associated with non-native species distribution and abundance.

Terrestrial Vegetation Monitoring – Large Scale Monitoring

CMIN 6.2.1: Determine and track patch number, distribution, composition and area of NHWZ community as measured at 5-year or other appropriate intervals… (6.1.1 and 6.3.1 similar CMIN language)

FY09 – Research toward monitoring – Vegetation Mapping - While CMINs may be reformulated, mapping approaches can still provide information about vegetation area change thought time.

FY09 Activities

•Complete Second Vegetation Map using 2005 imagery and provide vegetation change analysis comparing 2002/2005 imagery

•Ground-truth 2005 map during May 2009 over flight for subsequent 2009 mapping effort.

Overall Terrestrial Monitoring Program Strategy

•Develop a long-term strategy and schedule for monitoring and research for terrestrial resources that compliments strategic plan and monitoring and research plans.

USGS