COOPERATIVE ECOSYSTEM STUDIES UNITS
NATIONAL NETWORK

PR Number: **20046334**
Award Number: **P14AC00711**
Project Number: **PC-13**
CFDA #: 15.945
Park/NPS Unit: Mesa Verde National Park
Title of Project: Characteristics of resiliency in *Pinus edulis-Juniperus osteosperma/Purshia tridentata* woodlands of Mesa Verde, Part II

Administered through the: Colorado Plateau Cooperative Ecosystem Studies Unit Cooperative Agreement Number H1200-09-0005

CESU Partner: Prescott College, Arizona

PROJECT CONTACTS:
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NPS Certified ATR: George L. San Miguel, Natural Resource Manager, Mesa Verde National Park, PO Box 8, Mesa Verde CO 81330, Tel.: 970-529-5069, Email: george_san_miguel@nps.gov

NPS Technical Expert (if appropriate):

FUNDING INFORMATION:
Amount Funded: $15,541

NPS Account Numbers (amounts in parentheses): PPIMMEVE6G PPMRSNR1Z.NI0000 ($15,541)

Fund Source (e.g., ONPS, FLREA, CRPP, CESU, etc.): ONPS
☒ NPS Funding
☐ Is this funded using a reimbursable account number? If yes, IMR contracting needs a copy of the Interagency Agreement.

PROJECT DATES:
Start Date: (Tentative date) May 1, 2014

NOTE*: *This Task Agreement will become effective on the date of final signature or the effective date of the Award document, whichever is later.

End Date: *(please make end date the last day of the month if possible)* December 31, 2015

NPS Administrative Contacts
CESU Coordinator: Judy Bischoff, National Park Service/CPCESU, NAU P.O. Box 5765, Flagstaff, AZ 86011, 928-523-6638, Fax: 928-523-2014; judy_bischoff@nps.gov

Intermountain Region Administrative Contact: Kelly Adams, Grants and Agreements Specialist, National Park Service, 12795 West Alameda Pkwy, Lakewood, CO 80228. Phone: 303-969-2303 Fax: 303-969-2992 Email: kelly_adams@nps.gov

FEDERAL FINANCIAL REPORTS AND DRAWDOWN SCHEDULE:

Federal Financial Reports (Check as required for project based on spending plan, period of performance, risk, cooperator history, etc.)
{ } Quarterly { } Semi-annually {X} Annually {X} Final

PROJECT SCHEDULE AND TECHNICAL REPORT DEADLINES:

List all technical reports and products in sequential order as required in the scope (more lines and milestones can be added as needed):

Project Start Date – May 1, 2014

Technical progress reports – { } Quarterly {X} Semi-annually { } Annually
(Check as needed from PI to monitor progress of specific project. Content should be addressed in the scope.)

Investigator's Annual Reports (IAR) – April 1, 2015 and April 1, 2016

Database, Collections/Specimens, Archives, and Maps provided to the NPS ATR or Technical Expert – December 1, 2015

Draft Final Report – November 1, 2015

Final Report – December 1, 2015

Project End Date – December 31, 2015

Final SF425 FFR must be submitted within 90 days of project end date

PAYMENTS

2 CFR PART 215.22*:* Cash advance (drawdown) to recipient organization shall be limited to the minimum amounts needed and be timed to be in accordance with the actual immediate cash requirements of the recipient organization in carrying out the purpose of the approved program or project. The timing and amount of cash advances shall be as close as is administratively feasible to the actual disbursements by the recipient organization for direct program or project costs and the proportionate share of any allowable indirect costs.

2 CFR PART 215.25 (8)(e)(1): Incur pre-award costs 90 calendar days prior to award or more than 90 calendar days with the prior approval of the Federal awarding agency. All pre-award costs are incurred at the recipient's risk. (i.e. the Federal awarding agency is under no obligation to reimburse such costs if for any reason the recipient does not receive an award or if the award is less than anticipated and inadequate to cover such costs.)

CESU REQUIRED PRODUCTS (may be different from those products required by the ATR – See Statement of Work for Products required by the NPS unit):

The Principal Investigator will prepare a brief report abstract suitable for public distribution and two hard copies and an electronic version (in PDF file format) of the final report and mail all to Judy Bischoff, National Park

Service, CPCESU, NAU P.O. Box 5765, Flagstaff, AZ 86011. Please be sure to include the project number (e.g.; NAU-###, UMT-###, UAZDS-###) and the P number on the cover page of the final report.

PROJECT ABSTRACT:

Piñon-juniper woodlands are a widespread vegetation type occupying 15 percent of the landscape in New Mexico, Arizona, Colorado, Utah, and Nevada. The understory of "persistent" woodlands is often composed of significant bare-ground within a matrix of grasses, forbs, shrubs, and biotic crusts. The woodlands appear highly resistant to invasion by aggressive exotic plant species. This appears to be true despite the availability of ample weed propagules merely a few meters away. However, when the soil is highly disturbed, for example by severe stand replacing fires or grazing, resistance is destroyed. This project will investigate, in an expanded pilot study, some of the physical and biological factors that confer resiliency in "persistent" piñon-juniper woodlands at Mesa Verde National Park. The study will address: a) Are native species diversity and intact soil crusts components of resistance to invasion? b) Do actinorhizal shrubs contribute to ecosystem stability and to resilience? and c) Is it possible to detect growth patterns in piñon pine that can be attributed to cover and abundance of *Purshia tridentata*? In a related study (Reed et al. 2013); we have gathered data from Mesa Verde that can be used to address, in part, the last questions d) What characteristics of soil nutrients and properties confer resilience? This information will provide information that will aid in the conservation of "persistent" piñon-juniper ecosystems and the biodiversity they support.

SCOPE OF WORK:

Objectives

Faced with continuing drought and rising temperatures across the southwestern United States (i.e. Breshears et al. 2005, Hansen and Sato 2011) and severe soil erosion (i.e. Jones 2000), the importance of resilient landscapes dominated by persistent vegetation becomes increasingly critical. Piñon-juniper woodlands cover 15 percent of the southwestern landscape and they are the dominant perennial vegetation covering 40 million hectares. Our pilot research and years of observations suggest these are ecosystems of remarkable stability and resiliency. At least three broad types of piñon-juniper woodlands are recognized by Romme et al. (2009); here we focus on the long-lived "persistent" woodlands which are the prominent type on the Colorado Plateau and much of the southern Rockies. Prehistoric fires were very infrequent; for example intervals in southwestern Colorado's piñon-juniper woodlands and elsewhere were centuries long (Baker and Shinneman 2004; Floyd et al. 2000, Floyd et al. 2004), hence ecosystem development is slow and biodiversity is significant (Floyd 2003). Across much of this ecosystem is a legacy of chaining/seeding, intense grazing (Fleischner 2010), vehicle use, and recent changes in temporal and spatial patterns of wildfires (Morgan et al. 2001). Yet, in many of the region's national parks, including Mesa Verde National Park (MEVE) and Dinosaur National Monument (DINO), undisturbed piñon-juniper woodlands are preserved, at least at the present time. Conservation of these remaining persistent ecosystems is critical and underlies this study to investigate mechanisms of resiliency in piñon-juniper woodlands. We will investigate resiliency by the woodland's resistance to exotic plant species. In this expanded pilot study, we will focus on MEVE where a variety of disturbances and intact woodlands occur in close proximity and on similar soils, and where the investigators have related, on-going studies (Floyd et al 2013, Reed et al. 2013 reports to NPS).

Previous data and observations made at MEVE and elsewhere demonstrate that persistent woodlands are highly resistant to invasion by aggressive exotic plant species (e.g. *Bromus tectorum, Carduus nutans, Salsola species, Cirsium arvense* and *Circium vulgare)* when not subjected to severe environmental stressors (Floyd et al. 2006, Sherril and Romme, 2013). However, when stress occurs, a threshold appears to be breached and the resistance to invasion is lost. This threshold is highly variable depending on the type of woodland and the type of disturbance. Our study areas have been subjected to both large and small disturbances that mirror those which have occurred throughout the southwest in the past few decades. Large wildfires have occurred throughout the southwest in recent decades, specifically in MEVE 1989, 1996, 2000, 2002 and 2003. Widespread *Ips confusus* bark beetle infestations occurred throughout the southwest in 2001-4, e.g. killing over one third of the piñon pines (Breshears et al. 2005, Floyd et al.2009, Negron and Wilson 2003). Over 11 percent of junipers have died of various causes in MEVE and we recently completed a study of the changes in canopy cover, surface and coarse woody fuels, and potential for changes in fire cycle on the Mesa Verde cuesta (Floyd et al 2012). In the past two years at MEVE, rotted snags are beginning to fall, leaving virtually no disturbance in soils as they "snap" off at ground level (personal observations); therefore soil disturbance is much less severe than that resulting from widespread fires. Gaps in the canopy also have been created by piñon death from *Ophiostoma (=Verticicladiella) wagenerii*, black stain root disease, during the past century (Kearns and Jacobi 2005). Our preliminary data from MEVE suggest that smaller canopy disturbances (beetles and black stain) are protected by as-yet undefined factors of resiliency and exotics do not enter these lightly disturbed systems despite their nearby presence. In contrast, large portions of the post-fire landscape in MEVE have been colonized by *Bromus tectorum* (cheatgrass) and *Carduus nutans* (musk thistle), the presence of which may create unprecedented fuel conditions and may further shorten future fire intervals, especially as drought and rising temperatures continue (Belnap et al. 2003, Floyd et al. 2006, Miller et al. 2001, Hansen and Sato 2011). Burnt landscapes maintain these exotic components for at least three decades (i.e. since the 1972 fires in MEVE). Invasibility may be, in part, due to soil nutrient status and deterioration of soil crusts, but much is unknown about weed resistance and invasibility in these systems (Floyd et al. 2006). Other types of disturbance, such as nitrogen deposition, horse grazing, mechanical thinning of woodlands for fire protection, and visitor impacts occur throughout the piñon-juniper woodlands as well. MEVE is considering expansion of trails for visitor access; therefore additional woodlands may become open to visitor impacts.

Peterson et al. (1998) proposed a much-discussed model of the relationship of species diversity to ecosystem function and resiliency. They stated that "ecological resilience is generated by diverse, but overlapping function by apparently redundant species that operate at different scales, thereby reinforcing function across scales. The distribution of functional diversity within and across scales enables regeneration and renewal..." Numerous studies link biodiversity to ecosystem stability and while it is not usually clear which species contribute necessary functions; it is generally thought that the chances of stability increases with the level of species diversity. The authors proposed that "redundant species" that serve a similar ecological function may increase ecosystem resilience; when one fails, another may take its place. We hypothesize that a critical part of the stability of Mesa Verde's piñon-juniper woodlands comes from a balanced soil nutrient status especially involving nitrogen; we test here whether actinorhizal shrubs (*Purshia tridentata*, bitterbrush and *Cercocarpus montanus*, mountain mahogany) and biotic soil crusts alternatively provide resilience by providing a similar ecosystem function, that of nitrogen balance within the biogeochemical pathway.

We are learning much about invaded ecosystems (i.e. Alpert et al. 2000, Choy-ing et al. 2010, D'Antonio and Vitousik 1992, Corbin and D'Antonio 2004, Keeley 2006, Ortega and Pearson 2005, and others listed in the references). But, if we could understand more about the resiliency components and when the threshold is breached beyond which resiliency erodes, it may be possible to conserve such ecosystem stability and emulate specific resiliency characteristics in future restoration of piñon-juniper ecosystems. *The overarching goal of this project is to define resiliency in persistent piñon-juniper woodlands*.

We will investigate the nature of this resistance through quantitative sampling of species diversity, piñon ring width growth patterns, size and abundance of nitrogen fixing actinorhizal shrubs and biotic soil crusts**,** and numerous physical attributes of linked plots (each set will have 3 treatments: + Purshia, + biotic crust, and - both) at Mesa Verde National Park. The study design will also take advantage of recently completed soil nutrient profiles conducted by the author and Dr. Sasha Reed, USGS Moab. We compared the levels of NH_3, NO_2, P, C and C:N in a series of plots on Arabrab Longhorn soils on Wetherill Mesa from old-growth resilient piñon-juniper woodland and nearby fires in 1934, 1989, 1972 and 2000. In order to utilize these biogeochemical tests in the current study, we will return to these precise locations and establish a series of plots in which to measure the variables listed below.

In this 2014-15 project part II expansion, we will add to the existing project in two ways:

1) We will investigate characteristics of growth using tree ring widths in piñons to explore the relationship of growth indices to historical climate data and measures of *Purshia* cover and abundance, biotic crust cover, and biogeochemical data collected at each site.

2) We will add additional visits to study plots in 2015 to record plant diversity in the established plots (this will allow us to capture another year's data and increase the chances of Mesa Verde experiencing normal precipitation patterns).

Methods

We will address the following questions:

What biological and physical attributes confer resiliency in "persistent" piñon-juniper woodlands? Specifically:

- Is native species diversity a component of resistance to invasion? *This will be repeated in 2015.*
- Does resiliency vary with light spectra, local ground-level wind condition, and soil moisture*? Soil moisture levels will be repeated in 2015*
- Are intact soil crusts, specific soil structures, specific ranges in soil temperatures, and nutrient patterns components of resistance to invasion?
- Do actinorhizal shrubs contribute to ecosystem stability and contribute to resilience in piñon-juniper woodlands?
- Does resiliency vary with level of soil nutrients (using data from Reed et al. 2013)?
- Can we detect a difference in tree ring growth that can be attributed to the presence of actinorhizal shrubs or biotic crust cover?

Three field experiments will be conducted. In all three cases we will rely on an existing network of sites in which previous data can be utilized. In parts 2 and 3, fertilization plots and soil nutrient testing has been completed and the new study will take advantage of these previously collected data.

1) <u>Fertilization plots</u>: In a related study we applied nitrogen fertilizer three times in 2011 and 2012 to 60 plots in the 2002 fire and adjacent unburned piñon-juniper woodlands on Chapin Mesa (Reed et al. 2012). These plots will allow us to determine if excessive nitrogen inputs is a factor in reducing resiliency. The diversity and abundance of exotic and native plant species will be recorded in the current study.

2) Four sets of three plots were chosen in piñon-juniper woodland from among the sites recently used in a completed study of fuels in Mesa Verde (Floyd et al. 2012). Triplicates in each set include + Purshia, + biotic crust and controls lacking both and are similar to one another in soil type, slope and aspect. Plots are on Wetherill Mesa and Chapin Mesa. Much of the data needed to characterize the woodlands is available, i.e. existing sites have been characterized by plant species, canopy opening using fisheye with GLA software (Keane et al. 2005), age structure, vertical and horizontal fuel structures.

<u>Field Sampling</u>: At each site in 2014 we will collect data on the diversity, density, and cover of each plant species. The cover of *Purshia tridentata*, other actinorhizal shrubs, and black biotic crusts will be recorded to estimate potential nitrogen fixation and tissue samples will be taken and analyzed for amino sugar N, which has been shown to correspond with N inputs from actinorhizal N fixation (Wang et al. 2010, Neff et al. 2006). The cover of biotic crusts and actinorhizal shrubs will be used as indicators of nitrogen fixation. Physical structure of the sites will be measured including soil temperatures, soil depth to bedrock, and light spectra, and a few samples will be analyzed for soil N and C at the USGS lab in Moab. If moisture levels permit exotic species germination, the *dependent variable* "resistance" will be measured by the density of exotic forbs and the cover of exotic grasses.

<u>Biogeochemistry sampling:</u> we will determine the biogeochemical pools of nitrogen (NH4 and NO3), carbon, and phosphorus that might contribute to ecosystem stability and resiliency of the old-growth woodlands. Samples will be collected by Prescott College personnel and transported to Dr. Sasha Reed, USGS, Moab Utah, for analysis under separate funding.

<u>Dendrochronology Sampling:</u> We will use increment bores to extract one core from 10 to 15 trees (>15 cm diameters) in each sample plot. Cores will be returned to the Prescott College dendrochronology lab for processing. The cores will be mounted and sanded with increasingly fine grits of sandpaper until the ring structure is clearly visible and then cross-dated using standard dendrochronology techniques (Stokes and Smiley 1968). Next, the total ring width for each individual year will be measured to the nearest 0.001 mm creating a time series of annual growth for each tree. Ring widths will be measured on a Velmex "TA" linear encoder, model # TA4030H1-S6 (Velmex Inc. 2008), in conjunction with "Measure J2X" software which records all series measurements in decadal format (VoorTech Consulting 2007). The quality control program COFECHA will be used to ensure accuracy in cross dating (Holmes 1983). The raw ring widths in decadal format will be converted into columns using the program YUX (Holmes 2001). The columns will be copied to an Excel spreadsheet where the individual ring width could be ordered from 1 to N; 1 being the innermost (closest to the pith) full ring of each series and N being the outermost full ring. This organization disassociates each ring from its calendar year. In this way we will be able to analyze growth sensitivity throughout each tree's life span regardless of the climatic

environment in which the tree germinated and data will be reformatted into compact format, readable by programs such as ARSTAN, using the program CASE (Holmes 2001).

The program ARSTAN will be run to standardize each individual series removing any low frequency trend associated with the geometry of tree growth. The high frequency, year to year variation, in each series is preserved; 50% of the variation will be preserved in order to remove the low frequency variation while emphasizing the high frequency variation (Cook and Peters 1997). Within ARSTAN each series will be detrended by fitting either a negative exponential or a linear fit line. An index value around a mean of 1 was created by dividing the raw ring width by the fit line value. ARSTAN generates a table of descriptive statistics for the detrended series, including mean, median, standard deviation, mean sensitivity (MS) and first, second and third order partial autocorrelation. Mean sensitivity (MS) is a statistical measure of the year to year variations of ring growth (Fritts 1976). It is an indicator of the climate sensitivity of tree growth. The MS of a given series is related to the mean, variation, and first order auto correlation; the growth of one year relative to the growth of the previous year (Hoff 1983).

In addition, raw ring widths for all series will be put in column format using the program YUX (Holmes 2001) and copied to an Excel spreadsheet. The data will be filtered to only include data for a common period (about 1500 to 2010). These filtered series were converted to compact format using the program CASE (Holmes 2001). ARSTAN will be run on all trees for this common period. The same detrending methods will be applied and the detrended descriptive stats tables will be used to characterize the climate/growth relationship of each tree ring series. To address the question concerning growth responses during the past we will run multiple regressions on dependent variables MS, CV, ring index, against the possible components of resiliency (*Purshia tridentata* cover, physical factors of soil, biotic crust cover and diversity, and so on) for the entire common period data set.

Statistical Analysis

Statistical analysis will be carried out using SPSS software (IBM, 2010) after testing all variables for normality and homogeneity of variances. We will run stepwise regression analyses of the dependent variable “density of exotics” with all measured independent variables to determine which variables predict influxes of exotics. Logistic regression may be applicable as an alternative. Correlation analyses will be run on exotic density and all continuous variables listed above. Analysis of Variance may be used to determine if the mean density of exotics varies across experimental factors (added N or P, soil crust disturbance).

Spatial treatment

A geodatabase will be created to record the locations of all study plots as well as the extent of significant disturbances within the study areas. This information will be used to refine a spatial model of invasibility, initiated by Floyd et al. (2006), tying weed presence or absence to the measured physical and biological parameters listed above. This will be accessible to resource managers in GIS format.

Additional References (for new treatments)

Cook, E. R., and R. L. Holmes. "Program ARSTAN." *Version* 1 (1986): 72.
Cook, Edward R., and Kenneth Peters. "Calculating unbiased tree-ring indices for the study of climatic and environmental change." *The Holocene* 7.3 (1997): 361-370.
Fritts, H. C. "Tree rings and climate, 567 pp." *Academic, San Diego, Calif* (1976).
Hoff, John C. *A practical guide to Box-Jenkins forecasting*. Belmont: Lifetime Learning Publications, 1983.
Holmes, R. 2001. Dendrochronology Program Library (DPL). The University of Arizona. Tucson.
Holmes, Richard L. "Computer-assisted quality control in tree-ring dating and measurement." *Tree-ring bulletin* 43.1 (1983): 69-78.
Stokes, Marvin A., and Terah L. Smiley. "Tree-ring dating." *Tree-ring dating* (1968).
Strackee, J., and E. Jansma. "The statistical properties of ‘mean sensitivity’ a reappraisal." *Dendrochronologia* 10 (1992): 121-135.
Velmex Inc. 2008. The Velmex “TA” system for research and non-contact measurement analysis. Velmex, Inc., Bloomfield, N.Y.
VoorTech Consulting. 2007. Measure J2X. VoorTech Consulting, Holderness, N.H.

COOPERATIVE AGREEMENTS OR TASK AGREEMENTS INVOLVING COOPERATORS WORKING ON-SITE

Background

In cooperative agreements or task agreements with universities where the university utilizes interns, student employees, research associates (RAs) or cooperators on-site (hereafter called "cooperator personnel"), these cooperator personnel sometimes work on government sites in close proximity to federal employees. It is illegal (without specific statutory authority) for federal employees to directly supervise the cooperator personnel or any university employees or for the students or other university employees to supervise federal employees. When cooperator personnel are working on an NPS site, it is important that there is a clear distinction between students and federal employees.

Office Environment and Vehicles

- The office space of the cooperator personnel and NPS personnel should be clearly labeled (Name and NPS or University affiliation on office or cubicle space).
- Cooperator personnel should be listed separately from NPS personnel in telephone lists, other identification or organizational rosters, and publication credits.
- Cooperator personnel should not receive "all-employee" e-mail or other communications intended for NPS personnel (unless it relates directly to the work the cooperator is doing for the NPS). When the e-mail does relate to the work being done, a copy of the same e-mail message should be sent to the University or cooperator's supervisor.
- Cooperator personnel may use NPS e-mail systems when the communication relates directly to the work the cooperator is doing for the NPS. The e-mail addresses of the cooperator personnel must include a label associated with their NPS e-mail address that identifies the cooperator's status (i.e., "Linda Webb, Cooperator" would be the label associated with the e-mail address, linda_webb@contractor.nps.gov). Doing so clearly identifies this individual each time they send an e-mail message using the NPS system, and it identifies their status as a research associate, student intern or student employee in the e-mail directory.
- Unless stipulated in the agreement, cooperator personnel should not drive government vehicles.
- Unless stipulated in the agreement, cooperator personnel should not ride as a passenger in a government vehicle. When this is planned as part of the agreement, an appropriate amount of liability insurance should be negotiated.
- Prior written approval by the Park Superintendent or Center Manager must be obtained in order for a task to allow cooperator personnel to drive or ride in government vehicles.

Supervision and Scheduling

- Each task must specify the university's/cooperator's supervisor for the cooperator personnel.
- Unless stipulated in the agreement, NPS staff should not set hours for cooperator personnel, specify where the work should be done, or conduct performance appraisals. National Park Service staff may give performance feedback to the cooperator personnel supervisor.
- Cooperator personnel should report leave, scheduling, and other related issues to the university or cooperator's supervisor, not to NPS employees. The supervisor of the cooperator personnel should then communicate with the NPS. National Park Service employees cannot directly supervise cooperator

personnel on a day-to-day basis. Work should be given to the cooperator personnel (via the cooperator's supervisor) on a "task basis." Cooperators should work without NPS supervision to accomplish each task, although technical consultations and cooperation is permissible.

- The Cooperator will be responsible for any disciplinary action needed to correct student employee conduct or performance problems. The NPS agreements technical representative will inform the university/cooperator's supervisor of any conduct or performance problems.
- The Cooperator will remove student employees from their positions if they fail to improve performance or address conduct issues.
- The NPS will review and provide feedback to students or interns regarding work assignments.
- The NPS will inform the cooperator of conduct or performance problems with cooperator personnel so that the university can counsel employees and correct the performance problems.
- The NPS will recommend to the cooperator dismissal of cooperator personnel based on conduct or performance issues.
- The Cooperator will hire students, interns or RAs to work on NPS tasks identified in the agreement. Hiring will be conducted in consultation with the NPS Agreements Technical Representative (ATR).
- The Cooperator will: pay students, interns or RAs for hours they have worked in support of the agreement.

Representation and Communication

- Cooperator personnel cannot in any way represent themselves to the public as NPS employees.
- Cooperator personnel are required to wear visible identification at all times.

Other Issues

- Cooperator personnel should not list an NPS affiliation on publications, but rather should list the cooperative agreement under which the work was performed.
- Cooperator personnel should not be invited to official NPS "social" events.
- Cooperator personnel will follow the local policy of the facility when federal facilities are closed due to early release for holidays, snow days, etc.

PRODUCTS:

Final Report

A final report summarizing work completed under this scope of work, will be provided in digital format, including digital photographs, to the NPS key official/ATR (CD-ROM/DVD) George L. San Miguel, Mesa Verde National Park, PO Box 8, Mesa Verde, CO 81330. Three hard copies (in color) of the final report will also be provided to the park. Two hard copies and an electronic version of the report on DVD will be sent to the Colorado Plateau Ecosystem Studies Unit.

Data Development

All digital and tabular data, calculations, graphs, and photographs will be included with the final products. All digital geospatial data will be documented using the Content Standard for Digital Geospatial Metadata (CSDGM), also referred to the Federal Geographic Data Committee (FGDC) Metadata Standard.

Voucher Specimens and Curatorial Data

Plant specimens collected during surveys that have not been previously vouchered for the park, if any, will be delivered to MEVE staff. If so, the investigators will provide a spreadsheet of required specimen information for entry into the

Automated National Catalog System software (ANCS+). Photographs and original data forms will be provided to the NPS in a format to be discussed and agreed upon after project initiation.

BUDGET: *(You may create your budget in a spreadsheet and attach it as a separate document when you submit your project coversheet and Justification for Use of Financial Assistance.)*

See separately attached budget table.