CRATERS OF THE MOON NATIONAL MONUMENT AND PRESERVE (CRMO)

Start Date: FY06 - Anticipated End Date: FY08

Introduction

Craters of the Moon NM is located on the Snake River Plain spanning southern Idaho and encompasses the Great Rift volcanic rift zone. Although much of CRMO is covered by barren lava flows, it supports a surprising diversity of plant communities. Vegetation occurs here in different successional stages on lava flows, in cinder areas, on kipukas (islands of vegetation surrounded by lava), and in mountain and riparian areas. Cinder cones support three different plant communities: spring wildflower, shrub, and limber pine. Dominant kipuka vegetation includes three-tip sagebrush, big sagebrush, bluebunch wheatgrass, and needlegrass. The northern end of CRMO is characterized by mountain and riparian areas that containing douglas-fir/mountain snowberry, upland quaking aspen, and riparian. CRMO is enormous covering approximately 750,000 acres and with a 2-km environs the total project is about 930,000 acres.

TASK 1.0 Planning Sessions and Scoping Meetings

Preliminary planning and scoping for this project was completed at the 2006 CRMO scoping meeting. Summary notes from this meeting can be found in **Attachment E**. In general it was discussed that the environs should extend 2-km around the current park boundary (**Figure 5**).

Table 20. Level of Effort for Planning and Scoping at CRMO (in days).

Task Topic	CTI, NWM, Others	Costs	Discussion
Project planning meeting	-	$8,400	A planning meeting was held to discuss project needs, timelines, and assign responsibility for completion.
Totals	**-**	**$8,400**	--

* Several entities would be required to attend for a successful planning meeting.

Task Deliverables: A summary of the scoping meeting minutes and copies of the presentations were created and posted on the UCBN vegetation mapping website.

TASK 2.0 Preliminary Plant Alliance/Association and Species Lists

A preliminary list of plant associations and alliances including the known ecological systems for CRMO was solicited and complied by the ICDC (**Attachment F**). This includes an estimate on the likeliness that the type occurs at CRMO. A review of this list was conducted by CRMO and UCBN with additions added to the list and types not occurring in the park removed.

Table 21. Estimated Costs for Preliminary Plant Associations and Alliance for CRMO

Task Topic	ICDC	Costs	Discussion
Preliminary List	-	$5,000	Completed by ICDC
Totals	**-**	**$5,000**	--

Task Deliverables: A preliminary list of plant associations and alliance for CMRO is located in **Attachment F**.

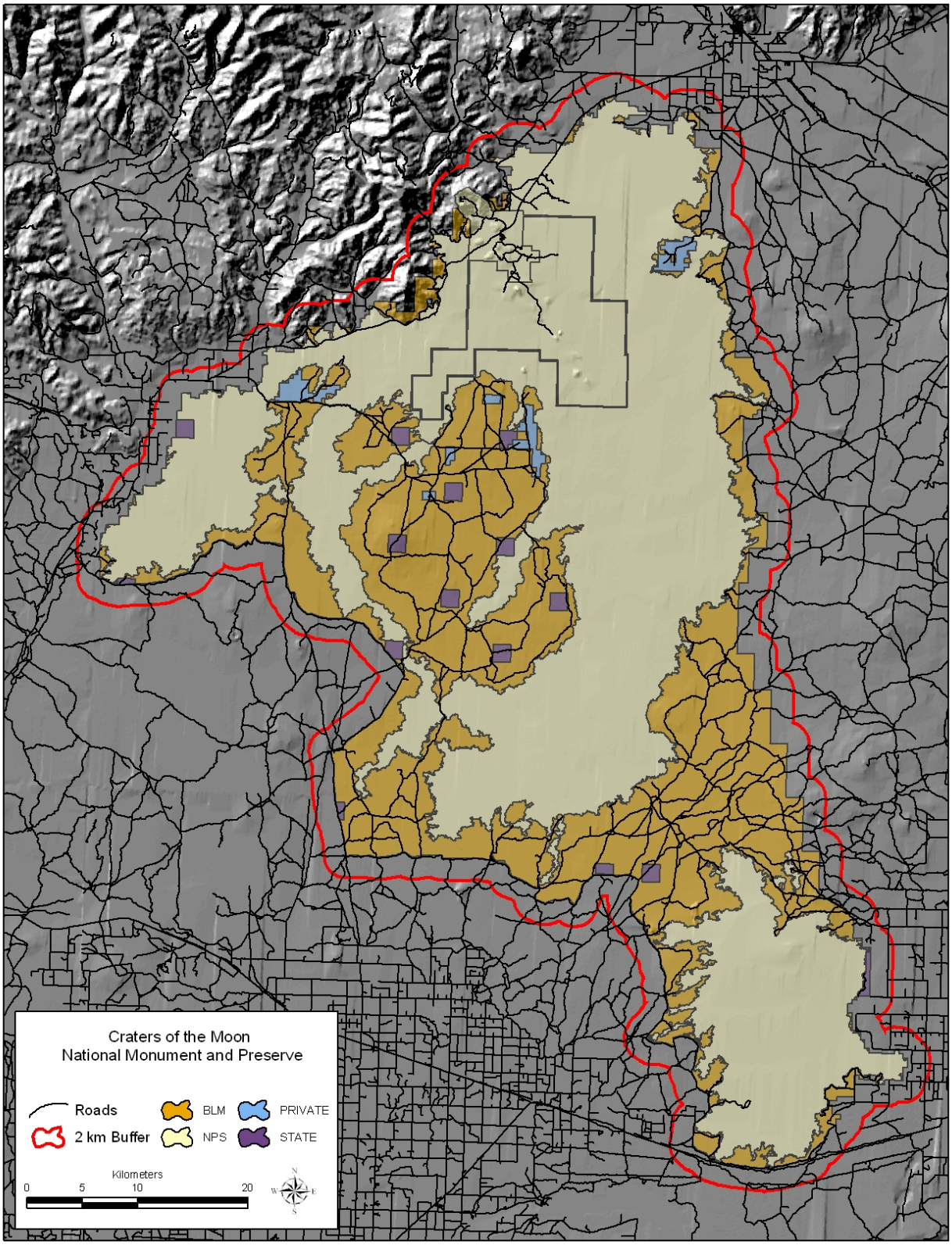

Figure 5. Approximate Project Boundary for CRMO Vegetation Mapping Project.
(Note: Figure does not show the ¼ mile buffer scenario)

TASK 3.0 Aerial Photography and Digital Ortho-photography Acquisition and Preparation

Available imagery includes the various products produced by the National Agricultural Imagery Program (NAIP). These typically include 1-m and 2-m products in both color infrared and true color formats. All available imagery sets will be evaluated prior to the start of work at CRMO and the latest high-quality set will be used as the basemap. Based on the resource management needs in other parks it is anticipated that the NAIP imagery will have to be supplemented with new color-infrared aerial photography. The new photography will insure that the vegetation is captured at peak growth and that any species of interest such as cheatgrass will be documented and delineated. If funded, the new aerial photography would be acquired by a competent contractor using UCBN specifications and acquired in the summer of 2007. The products from this effort would likely include 1:12,000-scale prints with sufficient overlap and sidelap to allow for stereoscopic photointerpretation.

Color infrared aerial photography will likely be used to help highlight subtle changes in the vegetation. Also flying near the summer solstice and around the noon hour will also help to eliminate shadows. Additionally, digital orthophotos may be prepared from the photography through scanning and rectification if needed for more accurate transfer of photointerpreted data or if the NAIP imagery is unusable. Currently the BOR has a contract with Horizon's Inc. to provide aerial photography and imagery. This funding mechanism will likely be used due to their success at other parks and the ability to have BOR photogrammatrists create the specifications and review the products.

Assumptions:

- Newly acquired aerial photography will be of sufficient quality to conduct all PI, attribution, and digital (GIS) database development.

Table 22. Estimated Costs for New Aerial Photography for CRMO

Task Topic	BOR	Costs	Discussion
Flight Specifications	1 day*	$800	Time needed to create the specifications for the aerial photography contract.
Aerial Photography		$142,154	This estimate is based on solicited bids from Horizons, Inc. Rapid City, SD in 2005.
Review of Aerial Photography	5 days	$4000	This includes time spent by a trained photogrammatrist to review and accept the delivered photography
Totals	**6 days**	**$146,954**	--

Task Deliverables: A complete set of 1:12,000-scale color infrared aerial photos for CRMO, reviewed and accepted by a certified photogrammatrist.

TASK 4.0 Field Data Collection

Due to its size, CRMO falls into the very large size park category (TNC 1994b) for vegetation mapping. In lieu of a formal gradsect CTI will worked with the UCBN, NWM and CRMO staff to provide existing land cover and vegetation maps already created to create sampling units. These units were visited by the field crews in 2006. A total of plots were sampled throughout the park. The distribution and completeness of this sampling effort is currently being reviewed by CTI and UCBN. If apparent short-coming are found supplemental plot collection efforts will be undertaken in 2007. To date, very minimal legacy data exists for CRMO that would be useful for this project. Standard ancillary data such as soils, geology and hydrology for the area will be used to assist in sample site selection and the photointerpretation.

Vegetation within CRMO was sampled using two approaches. These were observation point data and plot data. Observation points were used to guide aerial photointerpretation and vegetation plot data collection by identifying representative or unique signatures from the aerial photos or field maps concerning the distribution of plant associations within the park. A total of observation points were taken. Vegetation plot data were more rigorous in design than observation points and included precise location, provisional association name, physical environment information, topographic data, physiognomic data, species lists, height classes, foliar cover values, diameter at breast height measurements for trees over 10 centimeters in diameter, and environmental notes and observations by researchers. Vegetation plots are necessary to prepare the classification and as such they are subjectively placed in vegetation types that are representative of an area, relatively homogenous, and larger than the 0.5 hectare (ha) minimum mapping unit (MMU). Ecotones were avoided to the extent possible. A total of plots were taken at CRMO in 2006.

A minimum of two ground photographs for each vegetation plot were taken at each plot. Photos are digital, logged in a summary table, and labeled. Minimal fire fuel and related data were also recorded. Vegetation plot data was collected in accordance with the methods established during the planning meeting. **Table 4** identifies the plot sizes based on the vegetation types sampled.

NWM collected the data and is currently entering it into the UCBN database. This species entered into the database will follow ITIS as a standard. The UCBN database is based on the TNC Plots database used in the USGS-NPS Vegetation Mapping Program. Upon receipt from NWM the database will be checked for completeness and accuracy by UCBN staff.

Assumptions:

- Legacy data useful for this project are minimal at CRMO
- NWM collected vegetation plots (at a rate of 5/day) in 2006.
- NWM also collected observation points at a rate of 12/day to assist in PI efforts, and to check interpretation accuracy. These were collected in the field by members of the vegetation sampling crew.
- Issues of access due to topography and/or private land-owners may reduce the number of plots in some plant communities.

Table 23. Proposed Level of Effort for Field Data Collection (in days).

Data Collection Topic	NWM or similar	Costs	Discussion
Plot and Observation Points	45 days	90,150	Work was contracted to NWM in 2006
Total (days)	**45 days**	**$90,150**	--

Task Deliverables: All plots and observation points representing the vegetation communities at CRMO will be delivered to UCBN. Data will be delivered in either paper or digital form.

TASK 5.0 Vegetation Classification, Alliance/Association Descriptions and Field Key

Following vegetation plot data collection and data entry ICDC staff will analyze the data and classify it into the National Vegetation Classification System (NVCS) (Grossman et al. 1998). The NVCS as developed by The Nature Conservancy and currently maintained by NatureServe represents a national system containing seven classification levels with the finest being the plant association.

Following entry into the Plots database, species foliar cover values for each plot will be exported into a spreadsheet format and arranged into a plot by species data matrix. Several of the species recorded in the Plots database, primarily trees and shrubs, may occupy more than one stratum within a particular plot. Such layers provide valuable information regarding the structural diversity of the association and potential successional trends. To incorporate this information into the matrix, the code names for species occurring in more than one layer should be subscripted with a strata code (e.g., T1, T2, S1, S2, S3). The matrix will be used in exploratory analyses with the objectives of summarizing the compositional and structural characteristics of the communities and assessing possible spatial patterns related to environmental gradients.

Following procedures described by Grossman et al. (1998) and McCune and Mefford (1999), the data matrix would be analyzed as necessary using TWINSPAN, Cluster Analysis (relative Euclidian distance measure with Ward's method of group linkage), and DECORANA (an ordination technique). The matrix can be edited prior to analysis by first removing all species that had total cover values (summed over all plots) of less than or equal to 1 percent to keep the influence of minor species at a minimum. Raw foliar cover scores should be used in all data analysis procedures. The data matrix will then be subjectively evaluated for plots that demonstrated exceptionally low similarity to the remaining plots (outliers). Outlier plots are common in relatively large data sets and occur because of disturbed, heterogeneous, or otherwise unusual sites, or because of gaps in sampling (Gauch 1982). Removing outliers would likely increase the efficiency of the analysis and substantially improve the interpretability of the results.

Draft vegetation classification efforts would be reviewed by ICDC, CRMO staff and UCBN in terms of regional data and existing classification. NPS ecologists would discuss and incorporate suggested revisions, as necessary. After the data has been classified local and global descriptions for each association will be created. Local descriptions of vegetation associations or alliance if associations can't be determined (as they occur throughout CRMO) will be drafted by ICDC ecologists with input from the field crews. Local descriptions will focus on the park-wide variation including the unique characteristics of the association. Generally, three to four

local descriptions can be written in one day depending on the complexity of the vegetation type. The global descriptions for the associations will be modified and up-dated using these local descriptions.

After the data has been classified an illustrated field key will be created that will have dichotomous breaks. This key will walk an average person familiar with the vegetation at CRMO through the associations/alliances in a stepwise fashion. During construction members of the field data collection team should be used to help provide information for the key and to test it once completed. For consistency, this key will be used by the ecologists collecting accuracy assessment points to record the correct field classification. This task would require preparation of a plant association field key, annotation of each couplet in the key with diagnostic field descriptions, and illustration of the key with color slides or digital photos taken in the field at vegetation plot sites. This key will also be invaluable for future researchers, interpretive specialists, and visitors interested in vegetation distribution.

Assumptions:

- It is assumed that approximately 45 plant associations will be determined for CRMO.
- An ecologist familiar with CRMO vegetation will prepare the illustrated plant association field key.

Table 24. Proposed Level of Effort for Classification and Descriptions (in days)

Task Topic	ICDC	Costs	Discussion
Final classification	-	-	Statistical analyses performed by ICDC with NatureServe.
Local Descriptions	5 days	$2,400	Local Descriptions for the associations/alliances at CRMO
Global Descriptions	5 days	$2,400	NatureServe review of the descriptions and incorporation into the NVCS
Field Key Prep.	1 day	$613	Obligated (**Attachment B**)
Total (days)	**16 days**	**$5,413**	--

Task Deliverables: A preliminary list of associations and alliances will be delivered to UCBN prior to the scoping meeting. A comprehensive, classified list of plant association/alliances will be created in the NVC using the plot and observation data. Local descriptions for all associations/alliances will by used to update the global descriptions. An illustrated field key will be created for the vegetation associations/alliance at CRMO prior to the start of accuracy assessment data collection.

TASK 6.0 Aerial Photointerpretation and Segmentation

Delineation and mapping of the vegetation at CRMO will include a combination of automated image segmentation using eCognition or similar software and traditional photointerpretation (PI). Segmentation will be used to delineate easily observed features and features with high contrast such as open water, roads, and bare rock using the existing NAIP imagery. Once completed this initial map will be further refined though PI using the new photos acquired in 2007. PI will use the standard photo signature characteristics (tone, texture, color, shape, etc…) and ancillary data (slope, elevation, aspect, etc…) to further delineate the final detail of the map classes. Map classes will strive to maintain a 1:1 ratio of map class to plant association. The final mapping scheme will be determined by at a meeting or conference call between the NPS and contract staff. Typically the map classes in these project cover three basic considerations, 1) incorporating the NVC associations/alliances, 2) recognizing the limitations of the imagery (i.e. can you reliably see the plant association on the photo), and 3) covering the management needs of CRMO. The final mapping product will also include all necessary attribution consisting of the vegetation map classes, general height and density modifiers and links to the NVC. It is anticipated that approximately 45 plant associations/alliances and up to 20 land use/bare ground/geology types will be considered as potential map classes. One reconnaissance field trip to ground-truth and obtain photo-signature information by the photo interpreters will be conducted annually during the project.

Photointerpretation is most effectively accomplished when an initial classification has been performed, limiting the amount of cross-walk necessary between interpreted map units and the final classification (developed with the input of NatureServe). The individual responsible for PI should also provide input into the GIS process and review the final GIS layer for quality and consistency. An accurate, descriptive photointerpretive key will be created to allow all future researchers to understand the interpretive cues used to delineate polygons, which may help to refine the process for future efforts. Typically photo interpretation for these efforts proceeds at about 1000/acres per day.

Assumptions:

- PI work will be conducted at 1500 acres/day. These rates may require adjustment during the process, as photointerpretation proceeds.
- Level of effort will be calculated based an approximate 50,000 acre project area.
- The PI investigator will assist the GIS technician to produce a photointerpretive key.

Table 25. Proposed Level of Effort for PI (in days)

PI Topic	CTI	Costs	Discussion
Photointerpretation	600 days	$288,000	--
Quality Check of GIS	10 days	$4,800	Check draft vegetation plots back to interpreted photography.
Photointerpretation key	5 days	$2,400	Provide representative signatures to the GIS technicians to document PI work for future database users.
Field Recon	10 days	$10,000	Includes time and travel costs for trip.
Total (days)	**625 days**	**$305,200**	--

Task Deliverables: A preliminary vegetation map to the formation level will be created using segmentation techniques. Final detail will be created on aerial photo overlays.

TASK 7.0 Digital Database and Vegetation Map Preparation

Once all of the image processing and PI is completed the final digital database and vegetation map will be created and populated. This will include creating a spatial GIS layer using ArcGIS software. One seamless GIS layer will be created for CRMO by transferring the PI and segmentation information onto the NAIP imagery. Steps required for this task include: digitizing the linework, rectifying it to the basemap, edge-matching, performing a thorough cleaning and weeding process and finally attributing all of the polygons with the necessary vegetation information.

Quality control cannot be overstated in the automation of interpreted vegetation data. One of the more useful practices is to review draft digital data (hard-copy map), usually a quarter-quadrangle at a time, back to the interpreted aerial photograph. GIS quality checks are most effectively performed by the PI specialists. In addition, it is a common practice for producers of a digital database to perform an accuracy check or vegetation map field validation check following initial transfer, digitization, and quality checking. The map validation field check allows a visual review of PI work versus plant associations and land use types. Some observation points may be recorded to more adequately define confusing plant association signatures.

Assumptions:

- GIS automation and preparation of the final database will include a hybrid combination of scanning, on-screen digitizing, and image processing/segmentation techniques to delineate and automate interpreted data.
- GIS database building – geo-referencing, attributing, edge matching, and quality checking will occur at a rate approximately one-half that of the PI effort.
- Appropriate metadata files will be created as the GIS process proceeds.
- All GIS products will meet or exceed FGDC and USGS/NPS Map Accuracy Standards for 1:12,000-scale maps.

Table 26. Proposed Level of Effort for Digital Database and Vegetation Map Preparation

Task Topic	CTI	Costs	Discussion
Data automation, georeferencing	167 days	$80,123	Includes scanning Mylar overlays and georeferencing.
Attribution and edge matching	25 days	$12,000	--
Quality checking	20 days	$9,600	Provide hard-copy plot to PI technician for field verification.
Metadata	2 days	$960	This task could include training, metadata development, and metadata review.
Total (days)	**197 days**	**$102,683**	

Task Deliverables: A final vegetation digital GIS layer for CRMO will be created. This will include all necessary attributes. FGDC-standard metadata will be created for this layer.

TASK 8.0 Accuracy Assessment

Requirements for the NPS Vegetation Mapping Program specify an 80% accuracy for each vegetation class that is mapped (map unit) which infers an 80% accurate vegetation map. In terms of spatial accuracy, the data are expected to meet national map accuracy standards and typically this assumed by the use of standard basemap such as the NAIP orthophotography. The AA procedures employed should be able to determine whether the vegetation map meets these requirements. The following recommendations have been made for AA efforts (TNC, NCGIA, and ESRI 1994):

- The AA should be independent of the mapping process;
- The AA should be point based with an observational unit equivalent to or larger than the minimum mapping unit;
- The recommended number of AA samples per map class should reflect the abundance of each map class in the project area;
- Thematic accuracy should be expressed using contingency matrices adjusted for chance agreement with a Kappa index (Foody 1994);
- AA should ideally capture all components of uncertainty associated with vegetation mapping; and
- AA procedures should be tested operationally to determine if methodology would need to be refined.

Randomly pre-selected accuracy assessment (AA) point coordinates would be plotted on a coded base map by the GIS group/agency responsible for producing the vegetation map. This plot will be used in the field as a point distribution guide, and would be most useful with polygon lines (but not attributes) in place. An ecologist would navigate to the coordinates using a global positioning system (GPS) receiver, use the plant association classification key to determine the appropriate type, and record data for an area the size of the minimum mapping unit around the point, on a modified observation point form. Two representative photos of the site will be taken to document the vegetation. **Attachment E** presents a sample accuracy assessment data collection form that could be modified for UCBN use.

Sample sizes for the AA would be calculated from analysis of the electronic database prepared from the PI. Abundant vegetation types would be sampled at least 30 times, relatively abundant and relatively rare types at least 20 times, and rare types at least 5 times. Very rare types would require visits to all polygons (TNC, NCGIA, and ESRI 1994).

It is anticipated that 1000 - 1500 randomly located AA points will be used. Ten to 20 AA points can typically be recorded by an ecologist per field day (8 hours), considering the limitations of navigating to individual GPS coordinates present in CRMO. It is estimated that the accuracy assessment point collection would take approximately 10 researcher days (average of 20 AA points per day). Upon completion all of the data will be entered into the UCBN Plots database. These will reviewed by UCBN staff for quality and accuracy.

Following collection of AA points in the field, the points are overlain on the map and error matrix or contingency table is created. The error matrix reports both the user's and producer's error (i.e. errors of omission and commission) and represents the AA points label vs. the map label. Once completed the error matrix will be presented at a meeting or conference call to the UCBN and CRMO staff. Any deficiencies in the map will be addressed by either aggregating similar types to achieve the 80% standard or agreeing to live with the lower accuracy. Upon approval

of the accuracy statistics for each map class will be calculated and the map modified accordingly.

Assumptions:

- Two contracted AA field team (two researchers each) would be used.
- All GPS units for field navigation will be supplied by the contracted field crews.
- Approximately 40 days will be needed to collect the AA data.
- The AA contractor will be responsible for entering the data into the UCBN database.
- All field maps and target points will be supplied by the GIS contractor.
- All analyses will be performed by the GIS contractor and reported as appropriate error matrices.

Table 27. Proposed Level of Effort for Accuracy Assessment (in days).

AA Topic	CTI and NWM	Costs	Discussion
Select random AA points and create maps	3 days	$1,440	Selection would be conducted by the GIS staff.
Collect field data	40 days	$72,000	Includes 4 ecologists for 20 days each and travel.
Analyze field data	7 days	$3,360	Preparation would be performed by GIS staff.
Modifications to the map	3 days	$1,440	Any changes will be updated in the GIS layer by GIS staff.
Total (days)	**53 days**	**$78,240**	

Task Deliverables: Approximately 1200 completed field forms, to be entered into the UCBN database will be collected at CRMO. An overlay exercise will produce a preliminary contingency table of map accuracy to be used in an AA meeting. The results of the AA meeting will be published as detailed meeting minutes. All AA methods and results will be included in the final report.

TASK 9.0 Final Report and Deliverables

Several elements are required for a comprehensive report including the National Vegetation Mapping Program summation and methodology; general site information that can affect or be affected by vegetation (e.g., climate, topography, geology, soils, hydrology, historic land use, etc.); current land uses (particularly important for the environs); CRMO and UCBN management goals, and the methods and results for field data that were collected and analyzed. A detailed discussion of results related to the classification and PI work is also necessary to improve understanding by and provide guidance to CRMO and UCBN managers and other database users. These are aided by illustrations of the park landscape and plant associations and by illustrated keys to aerial photography signatures. In addition, it is important for users to understand the assessment of accuracy and its implications when using the base vegetation map. The report will also contain a discussion on future recommendations, how to improve the products and possible add-on projects.

Along with the report other deliverables include a final paper map and layout to highlight the vegetation layer. All digital data will be contained on a CD-Rom or DVD including copies of the report and map layout. All graphics included in the report will also be included. Typically a draft of all the deliverables will be created and presented to CRMO and UCBN staff for review and input. CTI will be responsible for the final editing and formatting. All material supplied by other contractors and agencies will be edited by CTI and included in one final comprehensive report.

Assumptions:

- NWI or similar contract ecologists will provide the methodology and summation of the field research; CTI will provide the methodology for the interpretive effort; GIS methodology and digital database production; and ICDC will provide the classification documents.
- UCBN will provide the desired outline of site-specific report topics, if they differ from traditionally written reports and map layouts.
- CTI will be responsible for editing and producing the final report and other deliverables.

Table 28. Proposed Level of Effort for Report Production (in days)

Report Topic	CTI	Costs	Discussion
Draft Report	15 days	$7,200	Two days each assumed for UCBN and CRMO review.
Final Map	3 days	$1,440	Includes minor expenses for report production (CDs, copies, etc.)
Final Report	15 days	$7,200	
Total (days)	**33 days**	**$15,840**	Minor expenses for report production (CDs, copies, etc.)

Task Deliverables: A final report covering all methods, results and discussions used in the vegetation mapping at CRMO will be created. A final map highlighting the vegetation will be created. All documents will be provided to CRMO and UCBN as paper and electronic versions.