12-Step Guidance for NPS Vegetation Inventories

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Executive Summary

The Vegetation Inventory is a cooperative effort between the NPS I&M Program and the Geological Survey to classify, describe, and map vegetation communities in more than 270 national park units across the United States. As one of the 12 basic inventories funded by the NPS I&M Program, the Vegetation Inventory produces high-quality, standardized maps and associated data sets of vegetation and other land-cover occurring within parks in order to fill and complement a wide variety of resource assessment, park management, and conservation needs.

This 12-step guidance document and its associated documents, databases, and “good examples”, is an attempt to capture the “best management practices” and key lessons learned from our more than 15 years of experience in developing, delivering, and using the vegetation maps and associated data sets and products. The guide is intended to be a working document that will continually be improved as our NPS user community and cooperators and contractors gain additional experience and provide good examples of ways to effectively and efficiently complete the inventory for the remaining parks. These guidelines do not apply to the parks in Alaska, which because of scale and remoteness and logistical issues, must be mapped at lower resolution using a different approach.

The 12 steps that all NPS staff, cooperators, and contractors must follow as part of developing and delivering the products of this inventory are as follows:

1. Review Existing Data and "Best Practices" to Develop a Brief Proposal (1-5 pages) to Develop a Park or Network Vegetation Inventory Study Plan
2. Planning and Scoping to Gather the Detailed Information Needed to Develop the Study Plan
3. Develop and Submit a Detailed Study Plan for Approval of Funding
4. Field Plot Data Collection (for the Ecological Classification)
5. Develop Vegetation Classification, Vegetation Type Descriptions, and Field Key
6. Develop Mapping Model (Calibration)
7. Acquire and Prepare Imagery
8. Imagery Analysis / Imagery Classification
9. GIS Project Preparation
10. Validation of Thematic Accuracy of Map Products
11. Formal Accuracy Assessment (AA)
12. Deliver Final Reports, GIS Database and Required Products

12-step Guidance for Completing the Vegetation Inventory

Step 1: Review Existing Data and "Best Practices" to Develop a Brief Proposal (1-5 pages) to Develop a Park or Network Vegetation Inventory Study Plan

- For most parks, the completion of the Vegetation Inventory and the delivery of the resulting vegetation map, reports, GIS database, imagery, and other products, will be an expensive, multi-step endeavor spanning multiple years and multiple cooperators and contractors. To ensure that we take advantage of the "best practices" that we've developed from more than 15 years of experience with this inventory, and that we provide the best possible products to the remaining parks that meet minimum standards and fit within our funding constraints, the I&M Program now requires that a detailed Study Plan be developed and approved for each park before funding will be provided for field work, imagery acquisition and processing, mapping, and subsequent work.

- To initiate the process, a **Brief Proposal** should be submitted to the Vegetation Inventory Program Manager (karl_brown@nps.gov) describing how the park(s) will conduct Steps 1-3, who will develop the detailed Study Plan, and how much is requested from the I&M Program to complete the first 3 steps. The Brief Proposal can be submitted at any time during the year, but decisions on funding allocations for the following fiscal year are usually made in late July and early August, so August 1st is the recommended due date. The recommended format for the Brief Proposal is available at http://science.nature.nps.gov/im/inventory/veg/docs/VI_Brief_Proposal_Format.doc

- A mockup-up example of a Brief Proposal that shows the level of detail that is needed is available at http://science.nature.nps.gov/im/inventory/veg/docs/VI_Brief_Proposal_Template.doc.

- Although the I&M Program does not have enough funding to initiate the Vegetation Inventory for all of the remaining parks, a park or network may still want to complete the first three steps of this process and develop a detailed Study Plan. The development of a study plan may be a good strategy for seeking funds from other sources and increasing the likelihood of getting some of the work started earlier using end-of-year money or other opportunities.

- The person developing the Brief Proposal should first review the guidance and examples in this 12-step document and on the Vegetation Inventory website, and then call or email Karl Brown or one of the other Vegetation Inventory staff to get feedback and advice on developing the proposal.

Step 2: Planning and Scoping to Gather the Detailed Information Needed to Develop the Study Plan

- This planning and scoping step will gather most of the information that is needed to produce the detailed Study Plan described in Step 3. The planning and scoping for the inventory includes a thorough review of existing data, guidance, and "best practices" by the person(s) who will develop the study plan, and a series of emails, conference calls, meetings, and workshops with park and network staff, cooperators, contractors, and other stakeholders.

- The initial work should include a detailed review of the guidance and good examples that are available on this website, followed by a series of phone calls and emails to determine what data exists and what is already known for the park(s), and who the key stakeholders are. Caution: Be careful to rely only on the recently-developed guidance and examples, as most of the vegetation mapping projects done in the past do not incorporate the latest standards and updated policies and "best practices", and the guidance posted on the USGS website is outdated.

- The initial "office work" will be used to plan and organize a face-to-face workshop that would include key stakeholders such as park managers and natural resource staff, I&M network staff, national Vegetation Inventory Program staff, and collaborators. Topics to be discussed at the workshop would include the following:
  - Roles and responsibilities of the project lead, and the various park, I&M network, and national program staff.
  - Potential partnerships and cost-leveraging, including in-kind assistance, expertise available at the park or network, and logistical support.
  - Review of existing guidance, program standards and policies, and required products.
  - Summary and evaluation of existing data discovered to date (e.g., vegetation plot data, species lists, existing classification data, existing imagery, maps).
  - Agreement on the area to be described and mapped (see below).
  - Discussion of compliance and permitting issues, including permissions needed for access to study areas.
  - Logistical and safety considerations, and other challenges specific to the project area.
  - Discuss options for completing the various steps of the inventory, including potential cooperators and contractors.
  - Discuss the proposed schedule for the work, including best times of the year for imagery and field work, and discuss the workflow for classification, mapping and GIS database development, accuracy assessment, and final product delivery.

- The policy of the I&M Program is to complete inventory projects to legal park boundaries. Inventories may be conducted beyond park boundaries if there is no additional cost (e.g., geologic resource maps are done by quad sheet, and it would actually be more expensive to clip to park boundaries), or if additional funding can be obtained from other sources to cover the incremental costs of conducting inventories in those additional areas. Written approval from the I&M Program Leader is needed to extend inventories beyond park boundaries except in cases where there is no additional cost to the I&M Program. See page 33 of the Inventory Strategic Plan.

- Suggestions on how to evaluate legacy data sets is available at the Vegetation Inventory Program's Technical Guidance website: http://science.nature.nps.gov/im/inventory/veg/docs/VI_Legacy_Data.pdf

- An example memo to call a scoping meeting is provided at http://science.nature.nps.gov/im/inventory/veg/docs/Scoping_Memo.pdf. This memo includes scoping meeting background, purpose, and suggested meeting topics.

Step 3: Develop and Submit a Detailed Study Plan for Approval of Funding

- The information from the planning and scoping done in Steps 1 and 2 is used to develop a detailed Study Plan that must be approved before the I&M Program will fund any subsequent work on the inventory.

- For the recommended content and organization of the Study Plan, and links to "good examples", see: http://science.nature.nps.gov/im/inventory/veg/Study_Plans.cfm

- The study plan should include at least a brief discussion of how the locations of the vegetation plots will be determined, but a more detailed description of where the field crew should collect the plot data can be included in Step 4.

- To provide flexibility and to take advantage of end-of-year funding and other opportunities that may become available, it is a good idea to include various “modules” or options in the study plan that could be implemented each year depending on how much funding is available from the I&M Program and other sources.

- The draft Study Plan should be submitted to the Vegetation Inventory Program Lead (karl_brown@nps.gov). The plan will receive the appropriate level of peer review, and may require revisions. The final Study Plan must be approved by the Vegetation Inventory Program Lead and the National I&M Program Leader (steven_fancy@nps.gov) before I&M funding is provided for Steps 4-12 of the process.

- The draft study plan can be submitted for review at any time during the year, but decisions on funding allocations for the following fiscal year are usually made in late July and early August, and at least one month should be allowed for peer review and revisions before the study plan is finalized.

Step 4: Field Plot Data Collection (for the Ecological Classification)

- Classification plot data serve two purposes: (1) to serve as the raw data from which to build the park ecological classification, and thus, the map classification, and (2) as a permanent record of the floristic characteristics of each vegetation type. The digital vegetation map, GIS Database, interpretive report, metadata, and imagery are all important products of the inventory, but it is important to also recognize the value of the detailed plot data, which may have numerous management and scientific uses now and in the future. The plot data and type descriptions will in many cases be more detailed that what can be mapped based on imagery and other data, but the map itself is only one of the valuable products that are generated by this inventory.

- An initial classification plot sampling plan should be designed. Factors to be considered when deciding where to place the vegetation plots may include park size, terrain features, heterogeneity of vegetation types, logistical and safety considerations, and the cost of getting to different areas of the park. The sampling plan needs to be flexible so that field crews can make adjustments based on the conditions they find when they arrive at the proposed sampling sites. Guidance on sampling design options that may be useful are available in the following document that has been excerpted

from the 1994 guidance developed for this inventory: http://science.nature.nps.gov/im/inventory/veg/docs/Chpt_5_Field_Methods.doc

- At the beginning of the field season, the crew that will be collecting plot data in a particular park should meet with the appropriate park staff to review the work that will be done and to discuss logistical and safety issues (e.g., vehicles, radio frequencies, keys to gates, access to particular areas of the park, compliance issues, safety issues). Where necessary, field logistics, research permits, and backcountry travel need to be facilitated by the park. The project lead or field crew leader should coordinate with the park backcountry office early to reserve campsites, travel zones, and capacity management to not adversely affect visitor services.

- All projects are required to use the NPS Plots database for entering and managing field plot data. The I&M Program will not fund the development of customized databases for this need. Existing alternative customized databases may be used, but must be exported to PLOTS 3.0 and submitted at the beginning of Step 5 and as one of the final products described in Step 12 (Version 3.0 is the current version and is recommended). The Plots database and user guide can be downloaded from: http://science.nature.nps.gov/im/inventory/veg/plots.cfm

- It is important to allow adequate time for PLOTS data entry and quality control.

- The location of the plots will be determined by the sampling design developed as part of the study plan (see Step 3). If no pre-existing plot data are to be used in the analysis, the sampling effort should strive for about 5 plots per vegetation type. In more complex parks, it is often efficient to plan on at least two field seasons, and to sample the full gradient of vegetation in the first season, and use this knowledge to understand the amount of additional data needed to describe and diagnose vegetation types more fully.

- Local NPS authorities (parks and/or networks), advised by local cooperators, as needed, are responsible for identifying sensitive data issues in the PLOTS data and resolving them so that the maximum amount of vegetation and location data can be released to the public. It is recommended that sensitive data be identified before the field season begins and that crews avoid including sensitive data with non-sensitive data when in the field (e.g., avoiding placing plots on rare plant species locations in cases where the species is too rare to be important to the classification).

- Decide on a consistent naming convention for digital field photos collected along with vegetation plots. The naming convention chosen should correspond to a plot number or other plot identifier. This also holds true for photos collected as part of the accuracy assessment. The photos collected during field work will be combined in the GIS Database. Our experience has shown that the field photos are a valuable resource to the current and future natural resource management of the park.

- A number of field crews have used PDAs (personal digital assistant) in the field to collect field data, rather than using paper data forms. The following website has been set up where we can post documents from field crews to summarize their experience and recommendations with various types of PDAs and plot data collection methods

(Keep checking back: we are soliciting documents from recent field crews, and will post them as they are submitted): http://science.nature.nps.gov/im/inventory/veg/FieldDataCollection.cfm.

Step 5: Develop Vegetation Classification, Vegetation Type Descriptions, and Field Key

- The completed PLOTS database must be sent to I&M Quantitative Ecologist Tom Philippi (Tom_philippi@nps.gov) for the computation of the # of map classes the I&M Program is willing to fund. Anything above this estimated number of map classes will be allowable only with permission from the I&M Program. The purpose of this step is to avoid overly "lumped" or overly "split" classification treatments and to better balance the ecological classification units (types) with the resolution of map classes. To estimate the # of maps classes, alpha and gamma diversity metrics (Whittaker 1960) are used as independent variables in a multiple linear regression formula derived from previous NPS projects. Additional types that are not represented in plots (primarily semi-natural and cultural types) may be recognized from observation, if they are substantially distinct from those represented by plots.

- Using quantitative classification methods (e.g., cluster analysis) as grouping guidance, arrange field plot data into groups that represent locally recognized vegetation types.

- The best ecological classification practice is to "classify locally and crosswalk globally." Vegetation types should be recognized first from patterns in local plot data, with each type preferably being represented by multiple plots.

- Develop local type descriptions for each type, using the floristic and ecological data from the group of plots assigned to that type and/or supplemental observations, as necessary. For a recommended format of vegetation type descriptions, see: Example_VegType_Descriptions.pdf

- The I&M Program will fund new development of one set of vegetation type descriptions. The network and park may negotiate on whether this will be local descriptions or an update of global descriptions (the latter option ordinarily would require that a more extensive (regional) data set be readily available to the project.

- Match each local type to a type recognized by the current provisional content of the National Vegetation Classification. [See http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol. The [existing] global information may be added to the vegetation type description. See: Example_VegType_Descriptions.pdf

- If no type in the NVC appears to match the local vegetation type, a National Park Service provisional type may be proposed. (These will have no global description).

- Develop and test field keys during the taxonomic classification step. This product should be completed before image analysis and mapping starts. [See BestPracticesFieldKey.doc, ASISNewFieldKey2009.doc and VICKFieldKey2.doc].

Step 6: Develop Mapping Model (Calibration)

- The mapping model translates the ecological classification model to a spatial classification model (a map database) that is as equivalent (1:1) as possible. The translation may be done by the ecological classification team, the mapping team, or [preferably] both.

- In a relative minority of cases (e.g., in some wetlands and riparian areas), vegetation types that may normally occur at scales less than the minimum mapping unit or are thematically difficult to distinguish may need to be mapped as classes representing multiple vegetation types.

Step 7: Acquire and Prepare Imagery

- Acquiring the appropriate imagery for the project is fundamental to the success of the mapping. This step requires several actions. First, the specifications for the imagery need to be defined. Second, a search for existing imagery needs to be performed. If existing imagery is found, it needs to be evaluated to assure that it is appropriate for mapping the pre-defined vegetation units. If no suitable imagery exists, new imagery must be acquired and prepared for interpretation.

- The imagery that will be interpreted and used to create the map of the distribution of the vegetation units must contain the information that is necessary for that interpretation. Specifically, the image properties (color, tone and texture) that allow the vegetation units to be distinguished by the analyst must be present in the imagery. The analyst (or team) that is responsible for the interpretation needs to be actively involved in the selection of the imagery in order to assure that the quality of the imagery is adequate for successful mapping. The specifications for the imagery will relate to the dates of acquisition, the scale of the imagery and the spectral qualities (emulsion for photographs or bands for digital imagery). If stereo imagery is required, specifications for endlap and sidelap of imagery will also apply.

- The specifications for the imagery should be based on discussions between the ecologists and the imagery interpreters. The ecologists can determine the plant species (or combinations of species) or other characteristics (substrate qualities, soil color, bedrock, moisture) that are diagnostic for the specific vegetation units and would be expected to be visible in the imagery. This information can be used to determine the appropriate dates for acquisition (based upon plant phenology), scale of imagery and or minimum mapping unit (mmu; based upon the physical size of the features to be identified), and the spectral qualities necessary to identify these features.

- Acquiring new imagery can be expensive, and the development of contract specifications can be complicated. It is important to use existing imagery if available and appropriate for these projects. Existing imagery can often be found from previous park projects, USFS archives, state Department of Transportation (DOT) projects, and a variety of other sources. There may be areas where processed imagery from other programs such as the National Agricultural Imagery Program (NAIP) is available and appropriate. The NPS I&M Program has already acquired most of the NAIP imagery covering park units and quads of interest. A list of photo sources compiled by the

Intermountain Region is provided as an example:
IMR_AerialPhotography_websites.doc

- If appropriate imagery cannot be found, new imagery must be acquired. Options for acquiring new imagery include: contracting through NPS or cooperators, use of existing contracts (USGS, USDA, etc), or partnering with others (USFS, BLM, etc). Examples of contracts for aerial photo acquisition can be found at: VOYA_Spring08_SOW.doc, SLBE_Spring2007_SOW.doc, US_Border_GGI_SOW.doc Contact information for existing USGS and USDA contracts can be found here Contracting_imagery_through_other_agencies.docx

- If a park decides to contract the imagery, they must also be prepared to evaluate the imagery when it is delivered in order to assure that it meets the stated specifications.

- Further guidance can be found at the technical guidance page on the Vegetation Inventory Program website. See "Imagery Guidance" at http://science.nature.nps.gov/im/inventory/veg/Guidance.cfm

- From past experience, the optimal scale for imagery for vegetation inventories has been between 1:8,000 and 1:15,840. Most projects will require Color Infra-Red (CIR) film, but there are instances where natural color is more appropriate (some desert environs with sparse vegetation and more exposed soil can saturate the IR portion of the sensor). Maximum "greenness" can often cause confusion between vegetation classes. It is often better to acquire imagery early in the season when the vegetation is beginning to "leaf out" or late in the season when some of the vegetation is beginning to senesce. The spatial resolution of the imagery is closely related to scale and film type for traditional camera systems. For digital systems the spatial resolution (or pixel size) needs to be appropriate for capturing the spatial detail required for vegetation identification (15 cm – 1 meter). Other pertinent imagery specs will reference the amount of sidelap and endlap for stereo photography, flying height and or focal length, and lens filters.

- Traditional cameras and roll film seem to be less available than in the past. More contractors are providing imagery from digital camera systems. If stereo imagery is required by the image analyst, make sure that a digital system is capable of providing stereo coverage. The Interagency Digital Imagery Working Group (IDIWG) is in the process of developing standards for digital imaging systems. Please contact the program manager for further details.

Step 8: Imagery Analysis / Imagery Classification

- This is the 'mapping' step that converts the signature of individual stands of vegetation into polygons or grids and attaches the ecological classification as attributes to those features. This process has many variations and methodologies, but the final product is a GIS database that has vegetation types in linked tables.

- The signatures of vegetation types in the imagery are recognized based on an informed understanding of the ecological model, including the floristic attributes and environmental settings of the types. Generally, the ecological class: map class ratio

should be near 1:1, with most exceptions involving aggregates of types that typically occur together in patches that are less than the minimum mapping unit in size. There are a variety of methods for image analysis and interpretation and for ecological modeling (including both objective and subjective approaches), but the best results usually are obtained by a reliance on image analysis and ecological modeling, rather than one of the approaches alone. Both approaches benefit from relating a number of geo-referenced ground observation points that, minimally, (1) have been typed to the ecological classes in the field, and (2) have been accurately located, so as to inform the image analysis. More mapping observation points than classification plots may be needed to inform mapping, but much less data need be collected at each mapping observation point. A mapping collaborator is free to propose and utilize any method that will develop a product that meets the product specifications. No specific technique is required or favored in the image analysis or image classification step. Additional guidance is under development, see http://science.nature.nps.gov/im/inventory/veg/Guidance.cfm. Please contact the program manager for further details.

- The minimum mapping unit is 0.5 ha, and the use of point data and the capture of “park specials” are typical. This practice is very helpful to the park, but does not authorize a finer scale mapping effort. Image analysis and classification will need to produce a final product in NAD83 UTM, at a scale of 1:24,000. The final cartographic scaled output for display will vary. Typically, the effort may be in an appropriate E plot scale for viewing and display. The final product specifications can be reviewed at: http://science.nature.nps.gov/im/inventory/veg/docs/Product_Specifications.pdf As described in Step 12, follow the Final Product Guidelines for the development of the project DVD for project close-out.

- The project may utilize a variety of methods to do this; you may utilize photo interpretation, digitizing and/or machine logic to capture map type line work for GIS. You may use any technique suitable for the product that meets product specifications. Variable scale and line density can be adjusted for back-county and high traffic park areas. The NPS vegetation inventory program will consider a finer resolution (larger scale) for high traffic park areas and a coarser resolution (smaller scale) for backcountry areas of large parks receiving less direct management.

- Create individual stand boundaries, represented as polygons or grids in the GIS database. It is often desirable to create a vector (polygon) version of grid databases.

- For small and accessible parks (e.g., less than 1,500 acres), with fewer vegetation types, a reliance on field attribution at the individual polygon level may work well, and lower resolution imagery may be sufficient (e.g., 1:10-12K or NAIP). In these cases, accuracy assessment (at the minimum mapping unit scale, rather than the polygon scale) is still required.

- Attach attributes to signatures for the draft map; this is a freely exchanged intermediate product and should not be constrained by USGS or other agency peer review or agency embargos prior to distribution. The NPS vegetation inventory does not distribute draft maps without first discussing with the mapping cooperator. The park or network can decide which collaborators or cooperators should have access to the draft

materials, including non-disclosure agreements prior to completion. Many parks have experienced difficulty from draft maps being used out of context.

- Image spectral classification may work, but this approach has performed poorly in previous efforts. They have typically not resulted in adequate map accuracy, and have required far more test points than available to calibrate the classification algorithm. The analysis step should yield a map in sufficient detail and of sufficient quality to apply reasonable validation efforts to make the final map. Due to backcountry travel, high cost factors, and limited plant growth calendar windows, capturing “training” data can be very expensive and may be far more difficult on NPS lands than on other public lands.

- Field verification of the correspondence of the map classes and the field keys to the ecological classification models should be planned for. The production team should feel confident that overall accuracy will be acceptable and should ensure that individual problem classes receive sufficient additional attention prior to submitting the map for validation (Step 10) and accuracy assessment (Step 11).

Step 9: GIS Project Preparation

- With the draft map complete and verified as part of step 8, combine the draft map with associated GIS files (imagery, PLOTs, DEM, etc) to create a GIS Project file (e.g., ArcGIS .mxd file and .lyr file).

- As with the draft map, the GIS Project should be available to appropriate collaborators and cooperators as a freely exchanged intermediate product (it should not be constrained by USGS or other agency peer review or agency embargos prior to distribution). Many parks have experienced difficulty from draft maps being used out of context.

- Distribute the GIS Project to the park or network for evaluation. Provide some training if needed on navigating through the GIS Project. Verify the vegetation type classes with park(s) through the draft map and draft legend development. Allow park management to provide guidance on vegetation types of major interest and types of lower or minimal interest. If confused class signatures pose an issue, discuss this with the park management staff.

- We suggest the mapping team discuss an appropriate time-frame for gathering review comments and suggestions back from the park or network.

- Adjust and correct the draft map based on the reviews by the park or network. The map should be ready for validation and formal accuracy assessment. Note: A GIS Database (i.e. Geodatabase) will be created as part of the final GIS Database product included in Step 12.

- This step is funded as a part of the map development budget, not as part of the accuracy assessment.

Step 10: Validation of Thematic Accuracy of Map Products

- Validation is an external product evaluation step that is independent of the mapping process (as opposed to internal quality assurance measures, such as verification). Its purpose is to assess whether the map, as a whole, has met minimal thematic accuracy requirements and should be accepted as a final product by the NPS. It does not serve as a per-class accuracy assessment.

- As an independent assessment, validation must be done by the NPS or by a neutral 3rd party designated by the NPS. It must be done in a timely manner, in order to allow the producer to plan more work or (in the case of a contractor) to understand when final payment may be forthcoming.

- Validation is required for projects done under contract, where the contract stipulates minimal thematic accuracy targets. It is strongly recommended for most projects conducted under a cooperative or interagency agreement. For very small parks (e.g., those with an accuracy assessment workload of fewer than 150 observations) that are conducted under agreement, NPS may allow the accuracy assessment to serve as a validation, understanding that the accuracy assessment must be redone if the results indicate that a revision of the map is necessary in order to meet minimal accuracy requirements. In such cases, the observations made in the initial attempt at accuracy assessment may be "recycled" as observations to improve the map.

- A minimum accuracy rate of 60% (point estimate of the mean for all observations, pooled across the project) at the finest resolution of map classes is the default threshold for thematic accuracy. A lower rate may be acceptable at the option of the NPS (as approved by the NPSVI). If the products fail to reach a minimum level of thematic accuracy, they are returned to the producers for more work (remapping, adjustment of field key, etc.). In such a case, the validation observations may be used ("recycled") by the producers to do this work. If the products pass this minimum threshold level, the project moves on to the formal per-class accuracy assessment.

- Validation is conducted much as with accuracy assessment (see below) in that the design should be statistically rigorous (within reasonable travel restrictions). The amount of data collected may be as minimal as in the accuracy assessment, but it is suggested that enough be collected to isolate the error source, in case of dispute over product acceptance. The purpose of this Validation step is to accept or reject the overall product before the map and GIS database are finalized, and we recommend that a sample of 30-50 observations be made across the entire map, stratified across map classes. The formal Accuracy Assessment, in contrast, is intended to inform the user of map limitations for individual map classes. It is important to define the terms of validation to the producers when issuing or negotiating the contract to minimize or avoid disputes over the results. See GRCA_Validation_Methods.doc

Step 11: Formal Accuracy Assessment (AA)

- The purpose of the formal accuracy assessment is to evaluate the final map product in order to understand the reliability of the total map and the individual map classes. A

map (such as the Vegetation Map) is an abstract model of the distribution of vegetation types and is made possible by generalizing some of the conditions. These generalizations lead to some error in the mapping. A formalized accuracy assessment allows these errors to be quantified so that the potential users of the map products can better understand the limitations of the map. A formal accuracy assessment consists of several parts. First, a sampling scheme needs to be developed that adequately represents the map. The sample sites then need to be visited in order to determine the vegetation type that is actually at that physical location. The results of the sampling are then entered into a database in order to create a contingency table (confusion matrix) that can be used to calculate the per-class and overall accuracy of the map. Finally, a report that describes the accuracy assessment process and the results of the analysis will be required.

- The detailed theory and guidance for assessing the accuracy of maps from the NPS I&M Vegetation Inventory efforts was developed at the beginning of the efforts in 1994. They are well documented and can be found at Thematic Accuracy Assessment Procedures (2010)

- The standards call for using a stratified random sampling scheme for developing the sampling locations. The sampling is stratified by map class and each class will typically require 30 accuracy assessment plots.

- You may use planning tools such as NPS Alaskapak, ARC Macro Language (AML) for ESRI tools, or similar toolsets to plan the map class sample points. Select appropriate numbers of samples depending on the class frequency, e.g., 30 sample points for common types. In most cases, the assessment can be limited to vegetation that is considered natural or semi-natural (i.e., cultural vegetation or non-vegetated map classes are usually omitted). Logistics of large parks or of parks where travel is otherwise difficult or time-consuming will usually require that the areas considered for sampling (inference population) be buffered for reasonable access (i.e., a cost surface). In balancing representation against time (cost), it is recommended that at least 30% (representation consideration) of each map class fall within this population, but that at least 8 points per field day (cost consideration) be collected.

- The size of the accuracy assessment plots is equal to the size of the minimum mapping unit specified for the map class (usually, 0.5 hectare). The entire polygon is not being evaluated, just a point that is the size of the mmu. These plots do not require gathering detailed information as is done for the vegetation characterization plots in Step 4, and the field crew should be able to evaluate the plot and record the vegetation class in 5-10 minutes at each point. These points include a GPS location, and involve keying the vegetation to the appropriate type for the minimum mapping units viewed in that map class. There is no shortcut for small parks, but the shorter travel distances result in lower cost.

- In the interests of maintaining the accuracy assessment as an independent assessment of the reliability of the map, the best practice procedure is to not engage the production team (project field ecologists and/or project mappers) in the design or analysis of the accuracy assessment. Hire field crews who are qualified to interpret the vegetation key and taxonomic classification and for negotiating the travel challenges in

the park(s). Depending on the number of map classes, the size of the park, the difficulty of access and travel, and the number of observers, the field campaign can take from several days to a full season or more.

- At the beginning of the field season, the crew that will be collecting plot data in a particular park shall meet with the appropriate park staff to review the work that will be done and discuss logistical and safety issues (e.g., vehicles, radio frequencies, keys to gates, access to particular areas of the park, compliance issues, safety issues). Where necessary, field logistics, research permits, and backcountry travel need to be facilitated by the park. The project lead or field crew leader shall coordinate with the park backcountry office early to reserve campsites, travel zones, and capacity management in order to minimally impact visitor services.

- Crews will navigate to the predetermined AA observation points and identify vegetation at the scale of the MMU. Typical production ranges from 8 to 25 points per day, depending on travel distances from roads and trails. With 50-60 map classes, the AA may involve 1500-1800 sample points. Vegetation polygons and AA points plotted on digital ortho-imagery make great field maps.

- Report the results. A contingency table (confusion matrix) should be presented along with a description of the effort. An example of a good accuracy assessment report can be found on the VI program's *Good Examples and Best Practices* website. See "Accuracy Assessment Report" at: http://science.nature.nps.gov/im/inventory/veg/Best_Examples.cfm

- If verification has been adequately done, few adjustments in classes should be needed, but map and/or ecological classes for some highly and mutually confused types might be further lumped and the pooled results reported. On the other hand, as long as the overall (all classes pooled) accuracy objectives for the project are met, there is no minimum accuracy requirement per class.

- Some projects in the past have used this formal accuracy assessment as a means to collect additional field data similar to the initial characterization plots. This is not the purpose of the accuracy assessment phase and the I&M program will not cover these additional costs. An example AA Field Form can be found on the VI program's *Good Examples and Best Practices* website. See "Accuracy Assessment Field Form" at: http://science.nature.nps.gov/im/inventory/veg/Best_Examples.cfm

- This process is not intended to be used to go back and revise the map. If this happens, the "new" final map will not have an accuracy assessment and the I&M Program will not fund additional revisions.

- In order to maintain consistency in the various projects, the actual accuracy results from the contingency table will be reported. Multiple contingency tables that show the accuracy results at various levels of the National Vegetation Classification hierarchy may be presented, but results derived from project-specific fuzzy logic criteria are not acceptable for I&M funding.

Step 12: Deliver Final Reports, GIS Database and Required Products

- The list of required products and final product specifications is available at: http://science.nature.nps.gov/im/inventory/veg/docs/Product_Specifications.pdf

- Spatial data should be delivered in a GIS Database (e.g., geodatabase). To draft the GIS Database, combine the PLOTS field database with the final vegetation polygon map and build appropriate relationships between the vegetation field data and the vegetation polygons. You can enhance the features of the GIS Database by linking the field photos to the vegetation plots as hyperlinks in GIS. The GIS Database should have the vegetation polygons, point locations of vegetation plots, relationships to the plots data, and hyperlinks to field photos. The GIS Database needs to be thoroughly checked for errors prior to delivery.

- The Northern Colorado Plateau Network has created a GIS database that we consider the best example for storing and retrieving vegetation spatial data and associated relationships with classification PLOTS data. To download the template, see the "GIS Database" link at http://science.nature.nps.gov/im/inventory/veg/Best_Examples.cfm

- The park or network team and collaborators are responsible for assembling a project DVD of all final products, including: the final project report, GIS datasets, photos, PLOTS Database, AA analysis results, and associated metadata. If an independent team is responsible for the AA reporting, coordination among the various cooperators is critical. A project manager should be selected for coordinating the various pieces of the final products.

- This step takes more time than many cooperators plan for, so please be sure to review the final product guidelines and plan for the necessary time to pull the project DVD together. A project is not considered "complete" until the program receives the project DVD.

- The report that is produced should be peer reviewed and published in the NPS Natural Resource Report series. Guidance for submitting reports to the series and for completing the peer review is available at: http://www.nature.nps.gov/publications/NRPM/index.cfm. The project leader for the park or network is responsible for finding a Peer Review Manager and arranging for (and paying for, if necessary) peer review.

- The final products will be made available to NPS staff, and to the scientific community and general public, through the NPS IRMA data system (http://nrinfo.nps.gov/Home.mvc). A limited number of hard copies will be delivered to park managers and key NPS staff. All products will be digital, including the final archiving of field forms, datasets, imagery, and map layouts.

- The products from past inventories will eventually be migrated to the NPS IRMA data system (http://nrinfo.nps.gov/Home.mvc), but they can currently be found through the following website: http://science.nature.nps.gov/im/inventory/veg/products.cfm

- Follow the Final Product Guidelines for the development of the project DVD for project close-out. http://science.nature.nps.gov/im/inventory/veg/docs/Product_Specifications.pdf

- As part of delivering the final products to the park, the park managers and inventory team may want to schedule a meeting so that inventory team members can describe the products and answer any questions from park managers and staff. For an example agenda and suggestions for the planning the meeting, see “Helpful Examples for Planning a Project Close-out Meeting as: http://science.nature.nps.gov/im/inventory/veg/Best_Examples.cfm

Literature Cited:

Whittaker, R. H. 1960. Vegetation of the Siskiyou Mountains, Oregon and California. Ecological Monographs 30: 279-338.