Legislative Analyst's Office
Supplemental Report of the 2007 Budget Act
2007-08 Fiscal Year

Item 3600-001-0001 Department of Fish and Game

*This particular report is a requirement in Senate Bill 85, August 2007, which added Section 1940 to the Fish and Game Code (see attached), and included the following supplemental language:***:**

(c) The department shall submit a report to the budge committee of each house of the Legislature no later than January 10, 2008, providing its mapping standard and advising how the department will ensure that its standard will be updated to reflect changing technology and serve as the state's center of expertise on vegetation mapping.

DEPARTMENT RESPONSE:

FY 2007-08 – Vegetation Mapping Standard for the State of California

Senate Bill 85, Chapter 178, Statutes of 2007, added Section 1940 to the Fish and Game Code that requires the Department of Fish and Game (Department) to develop a vegetation mapping standard for the State of California. It also requires a report to be submitted to the Budget Committee of each house of the Legislature, "providing its mapping standard and advising how the department will ensure that its standard will be updated to reflect changing technology and serve as the state's center of expertise on vegetation mapping."

This report discusses the basic underpinnings of this standard and the steps the Department has undertaken to develop the standard in collaboration with stakeholders. The report includes the following five components:

1. Discussion of the published state-wide standard for vegetation classification

2. Methods for field data collection, image interpretation, and digital map production and attribution

3. Required training manuals and materials, tools, and database structures

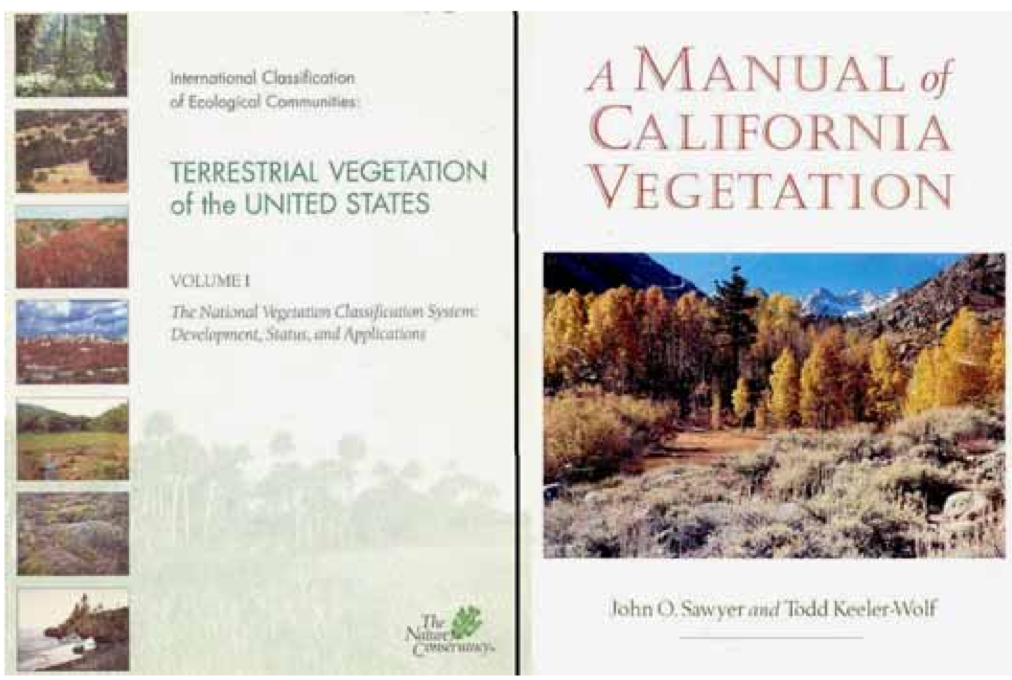
4. Post- project accuracy assessment and public review

5. Method of induction of new and updated map products into the state system

1. State Vegetation Classification Standard

The standard for the California vegetation classification results from the work of a consortium of state, national, and international scientists and natural resource professionals. The state classification is the California expression of the National Vegetation Classification System (NVCS). As a result of collaboration between vegetation scientists and working groups of agency and non-governmental organizations (NGO)\ users, the state and National Vegetation classification systems have developed in consort over the past 15 years (***Figure 1***). The first publication of the state vegetation classification system as a result of this effort came in 1995 with "A Manual of California Vegetation" by Sawyer and Keeler-Wolf.

Figure 1: *The National Vegetation Classification (left) and California's Vegetation Classification (right) are linked and standardized through the functions of the NGO, NatureServe and are bound to standards set by the Ecological Society of America's Vegetation Panel (http://www.esa.org/vegweb/panelMembers.php).*



This book was a synthesis of all existing information on quantitative vegetation classification up to that time and was the product of a multi-year collaboration between a committee of state experts composed of scientists, managers, and other users of vegetation information. It was based on a draft National Vegetation Classification system (NVC) using defensible quantitative definitions of vegetation placed within a hierarchy of seven levels. This hierarchical classification system was first published in 1998 (Grossman et al. 1998). The NVC was adopted by the Federal Geographic Data Standards Committee (FGDC) as the National Standard for Vegetation Classification to be used for all Federal Vegetation assessments including mapping; (FGDC vegetation website: http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation/index_html).

Since the FGDC acceptance of the NVC, a committee of local California users, under the aegis of the State Executive Biodiversity Council has formed. This committee is comprised of 11 state and federal agencies and NGOs that are directly involved in mapping and/or classifying vegetation in the state. It has become known as the Vegetation MOU Committee. In 2000, the Committee developed a Memorandum of Understanding (http://ceres.ca.gov/biodiversity/vegmou.html) outlining the agreement among the major users and producers of the state vegetation classification system. This agreement included several specific objectives:

- Develop common standards for data content, data capture methods, field procedures, accuracy assessment and documentation.

- Complete a hierarchical vegetation classification system adaptable to varying goals of the signatories and improve vegetation and habitat classification and crosswalks between systems

- Complete and maintain a vegetation map of all public and private lands in California on a regional basis through interagency cooperative efforts as the basis for vegetation inventories and assessments of habitats, including detection of changes.

Among the first completed objectives of the MOU Committee was agreement that the NVC, as outlined in Grossman et al. (1998; http://www.natureserve.org/library/vol1.pdf) and as updated for California use by the Vegetation Classification and Mapping Program of the Department, would serve as the state standard (minutes of MOU committee October 1, 2002, http://ceres.ca.gov/biodiversity/Meetings/Special/Notes_10.01.02.pdf).

Since that time, the Department's Vegetation Classification and Mapping Program (VegCAMP) has maintained an updated classification database based on new scientific information, (http://www.dfg.ca.gov/biogeodata/vegcamp/natural_comm_list.asp).

This classification complies with the National Classification, which is in turn regularly updated by the NGO NatureServe (http://www.natureserve.org/explorer/servlet/).

NatureServe and VegCAMP maintain a regular relationship of updating and refinement of the vegetation classification.

Currently, the California Vegetation Classification is reaching its second major milestone in the publication of the second edition of the Manual of California Vegetation. The manuscript has been accepted for publication by the California Native Plant Society, following extensive peer-review, and will be published in 2008. This publication embodies all work in the 12 years since publication of the first edition. This includes integrating the new formal definition and description of over 225 individual alliances (doubling the number in the first edition) and over 1,000 new plant associations. It includes a complete discussion of the relationship between the National and California classifications and formally defines and describes almost 500 alliances. Revision of this classification is addressed within the VegCAMP program using periodic updates following scientific analysis and review of new quantitative data, much as new

species are evaluated as they are discovered by science. These updates are fed periodically to the NatureServe National Vegetation database, which maintains the National Vegetation Classification.
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2. Standard Methods

A complex and integrated process, vegetation assessment for the entire state requires a standardized methodology to collect, process, analyze, depict, update, and distribute information. This multi-step process has been refined by VegCAMP and its cooperators over the past several years, the result of work on more than 20 individual projects ranging from a few thousand acres to over 10 million acres.

2 a. Field Data Collection and Analysis: Field data collection is the basis for all vegetation mapping and classification. All vegetation data are collected from natural assemblages of plants called “stands” (***Figure 2***).

Figure 2: *Stands of vegetation delineated from a field view showing some associated animal species*

(Western Riverside County).

A stand is the fundamental unit of vegetation. It is composed of a uniform group of individual plants growing together as a result of their shared ecological and physiological tolerance. Stands are arrayed in repeating patterns across the landscape. In the methodology supported by DFG, stands viewed from the field should also be, as much as possible depicted in the vegetation map.

Field data collection includes the selection, sampling, and recording of data from representative stands. This includes plant composition, stand size and structure, environmental characteristics, site history, and recent historical effects. This suite of characteristics is amassed in a standardized way for all projects using two basic protocols developed by a consortium of experts convened through the California Native Plant Society's (CNPS) Vegetation Committee. These protocols, described on the CNPS and DFG websites (http://www.dfg.ca.gov/biogeodata/vegcamp/ or http://www.cnps.org/cnps/vegetation/), are known as the Rapid Assessment and the Relevé protocols. Depending upon the business needs of specific users, these two techniques can be easily modified or augmented to collect further information on such things as fire and fuels data, or additional wildlife habitat information. However, taken alone, they provide all basic information needs to support standardized mapping and classification of vegetation.

The Rapid Assessment (RA) technique is the foundation for collecting field samples to support the classification, general ground-truthing, and accuracy assessment of most large mapping projects. This technique is valuable because it melds all required categories of information (species, cover, structure, site history, environmental characteristics) in a single page field form that can be quickly learned and efficiently completed. RA has proven to be adequate for sampling types of vegetation in the state including deserts, grasslands, scrub, woodland, forest, and alpine habitats. Because vegetation classification and mapping requires many repeated samples of each type of vegetation to ensure high accuracy in the classification and its mapping, the great value of the RA technique is its relatively short sampling time, enabling more than twice as many samples taken in a given period than other typical approaches.

The other basic technique is the Relevé (French for "abstract" or "summary"), a widely accepted method (Muller-Dombois and Ellenberg 1974) that is used as the basis for most descriptive work on vegetation classification worldwide. The Relevé approach collects the same basic information as the RA but requires a complete species list and estimates of cover in a measured area of uniform size. It typically requires about twice as much time per sample as the RA, but has great value when specific information is needed for diverse vegetation that has not been well described before, or for detailed comparative monitoring projects. Most projects include a combination of RA and relevé sampling, as most projects require a combination of many replicate samples and a set of samples that substantiate new types of vegetation and that form the basis for permanent monitoring plots.

Sample selection for all large area projects is undertaken using a three-tiered approach. First, physically and legally accessible areas are identified and a suite of existing GIS information on geology, climate, and topography are quantitatively analyzed. These landform data are broken into categories that equate to natural landscape units likely to contain differing types of vegetation. Secondly, a subset of the most accessible and representative landform units is selected for sampling by field teams. Finally, following at least a full sampling season, sites that have, by physical inspection, been found to contain additional vegetation not sampled in the first pass are selected for sampling.

Data are analyzed using standard statistical software developed specifically for vegetation classification. A detailed sequence of steps includes error checking, removal of outlier samples, and statistical comparisons of similarities of all of the samples. This information is used to determine how to formally divide the sampled groups into individual vegetation types (called plant associations). Descriptions following standard and widely accepted reporting techniques are written along with technical keys used to identify each type of vegetation. This information is essential to determine the accuracy and utility of the final mapping project.

2b. Image Interpretation: All vegetation maps that cover reasonably large areas are the result of expert interpretation of aerial photography, satellite, or airplane-born digital imagery. An important part of the standards for state vegetation mapping is the uniform treatment and application of this imagery. Without standards set for the scale and quality of the base imagery and the scale and quality of the interpretation of this imagery, no reliable integrated state-wide map would be possible. Over the life of this program, it is inevitable that today's standards for base imagery and the techniques used to interpret it will change as a result of technological improvements. The program acknowledges this and will adopt a flexible approach to such standards. Such standards are likely to be agreed upon through the regular meetings of the vegetation MOU committee (discussed in Section 1). The unchanging factors that will guide any new approaches are the basic units of vegetation and their natural size and distribution across the landscape.

The standard imagery for the first state wide mapping will be that provided by the National Agricultural Imagery Program (NAIP). This nationally mandated program (NAIP website: http://165.221.201.14/NAIP.html) is a federally supported program that provides uniform scale and quality digital aerial photography for all of the United States on a five year repeat timeline. The resolution of the imagery is 1 m, which translates to an approximately 1:39,000 scale image. The imagery is available in both true color and in color infra-red formats, providing a wide array of possibilities for detailed interpretation. The most recent NAIP imagery was flown in the summer of 2005. New imagery flown in 2010 will replace the existing data set in projects undertaken in following years.

The imagery is produced using nationally accepted standards for spatial accuracy and can be loaded onto computer workstations to be processed and interpreted through standard Geographic Information Systems (GIS) analysis. The NAIP imagery may be augmented by other locally available high quality and high resolution imagery, but to assure uniform, seamless representation, will be the accepted base imagery used for all mapping conducted during the first full state-wide mapping effort throughout the state.

Uniformity of image interpretation is established by relying upon:

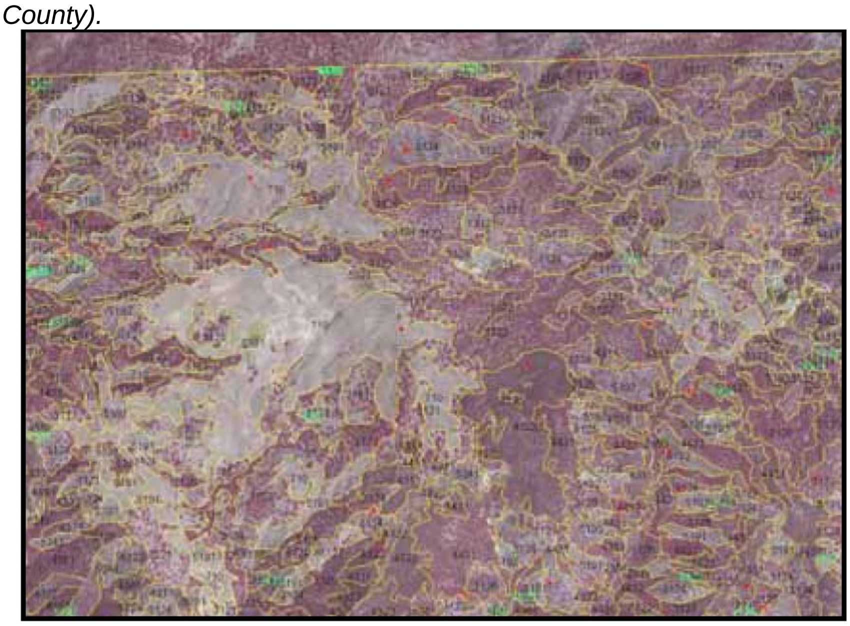
1) the national vegetation classification hierarchy, and
2) a standard minimum mapping unit size of one acre (0.471 ha) for wetlands and riparian and two acres for upland vegetation.

Vegetation types distinct on the ground, but indistinct at the above scales of imagery interpretation are aggregated using standardized rules that include a uniform application of the NVCS hierarchy and plurality rules for inclusions of minor types into larger regularly mappable classification units. A set of mapping standards has been produced through the Vegetation MOU Committee

Available at the following website:
http://ceres.ca.gov/biodiversity/Meetings/Special/mapping_standards2.pdf).

These will be adhered to and when new technology and needs arise, will be modified with the cooperation of the Committee.

Figure 3: *Example of detailed mapping effort overlain atop digital color infra-red orthophoto, showing coastal oak woodland, grassland, and chaparral matrix. Numbers are vegetation codes, red dots are field sample locations (eastern San Benito County).*



2 c. Digital Map Production: Mapping proceeds within a project area following the completion of the field classification and the refinement of the classification into consistent mapping units. The process of delineation of map units follows a series of steps. These include:

1) rough characterization of the vegetation by basic life-form (for example, woodlands are differentiated from shrublands, and grasslands),

2) refinement of polygons based on specific interpretation of type, cover, and other structural qualities, and

3) final modification of polygons following map accuracy assessment.

Step 1 is commonly undertaken using learning-based computer programs that can reliably segment a digital aerial photograph into polygons. However, the final phases of production are undertaken by highly trained and calibrated image interpreters who rely heavily upon their expertise, field data, and classification data. Following the completion of Step 2, the map is subjected to an independent test of its accuracy using standardized techniques (discussed in the next section). As a result of the accuracy assessment phase and review by users of the map, the final map of each project area is produced, incorporating all corrections and agreed-upon modifications.

2 d. Map Attribution: The GIS format of the map products enables the thousands of individual polygons to be tagged with a number of useful attributes beyond simply the name of each type of vegetation.

The standard set of attributes has been agreed upon by the State Vegetation Committee (Standard vegetation map attributes table 2003: http://ceres.ca.gov/biodiversity/Meetings/Special/map_attributes_5.pdf).

In many ways, this is the crux of the broad utility for these map products, enabling them to be used for predicting species' habitat, fire and fuels modeling, timber productivity, and other conservation values. The suite of attributes include categories for vegetation height, vegetation cover (separate values for distinct layers of trees, shrubs, and herbs; conifer and broadleaf cover, etc.), and translations to other commonly used map classifications (for example CalFire's and Forest Service's CALVEG, or Wildlife Habitat Relationship's classification). Additional attributes for human-mediated impact (such as development, roads, trails, invasive exotic plant cover) are categorically ranked.

3. Required Training Manuals and Materials, Tools, and Database Structures

A series of training protocols have been developed, categorically describing each of the vegetation sampling techniques outlined in Section 2a. These have been taught through a series of trainings by Department and CNPS staff over the past 10 years. Mapping standards are similarly described for specific projects accessible via the BIOS portal (http://bios.dfg.ca.gov/). Mapping training materials have also been developed for a series of mapping workshops co-taught by staff from Department and CNPS and the private consulting firm Aerial Information Systems. These include example delineations, specific processing steps, and calibration tools for coding height, cover, checking on minimum map size, and disturbance categories.
All data, whether collected in the field, or recorded as attributes for the vegetation maps, are entered in standardized databases that are developed as part of the corporate biological data structure in the Department of Fish and Games BIOS format (http://bios.dfg.ca.gov/). Database development includes built-in error checking features for all scientific names, codes, and numeric values. Data updating is regularly undertaken for both the GIS maps and for the field data collection. Data downloading and uploading is accomplished through a series of tools that are web-compliant. This allows users to access all basic data and provide comments on specific interpretations that may be in question by qualified users. All fields and data structures are supported by standardized metadata formats accessible for all projects via the BIOS portal.

4. Post- Project Accuracy Assessment and Public Review

The value of the map and associated data is only as good as its proven accuracy. Thus, each product undergoes an accuracy assessment. Mapping accuracy is tested by collecting an independent set of field data using the Rapid Assessment Protocol (described above in Section 2a). The basis for accuracy assessment relies upon two main premises. First, the mappers have a general feel of how confident they are about each mapping unit used in the project. This can be estimated and acts as a means to determine how many independent checks of polygons of a specific category should be collected. Second, there is a statistically valid method of collecting and independently evaluating these data. Formulae are developed for each project that account for the estimated accuracy for each type of vegetation mapped and the certainty expected, based generally on the value that at least 80% of the time each mapping unit is correctly mapped for type, structure, and other valuable attributes (Meidinger et al 2003). Although it may seem surprising to see figures as low as 80% depicted as being acceptable, detailed mapping with fine levels of classification and delineation is never 100% accurate unless every map polygon can be visited and observed. The National Park Service vegetation mapping program, the most exacting and detailed so far, also has a standard of 80% minimum accuracy.

Figure 4: *Example of Accuracy Assessment Summary Table from the Legal Delta Mapping Project (blue indicates types that did not meet standards for accuracy and should be refined).*

Veg Code	Map Unit Name	number samples	samples used	average % score
1382	Salix gooddingii - Populus fremontii - (QuLo-SaEx-RuDi) association	26	26	94.6
3461	Salix lasiolepis - Mixed brambles (RoCa - ViTi - RuDi) MU	24	21	91.4
4511	Scirpus acutus Pure association	21	20	93
4514	Scirpus acutus - (Typha latifolia) - Phragmites australis association	18	18	92.2
4513	Scirpus acutus -Typha latifolia association	17	16	85
4710	California Annual Grasslands - Herbaceous MU	13	11	94.5
6211	Brazilian Waterweed Egeria -Myriophyllum Submerged	12	7	91.4
4701	Ruderal Herbaceous Grasses & Forbs	12	11	85.5
3481	Salix exigua - (SaLa - RuDi - RoCa) association	11	11	100
3442	Cornus sericea - Salix lasiolepis / (PhAu) association	11	11	80
1380	Black Willow (Salix gooddingii alliance)	10	10	96
3460	Arroyo Willow (Salix lasiolepis alliance)	10	8	77.5
3410	Blackberry (Rubus discolor alliance)	10	10	76
9300	Exotic Vegetation Stands	9	9	97.8
1360	Fremont Cottonwood (Populus fremontii alliance)	8	8	87.5
4502	Mixed Scirpus / Floating Aquatics (Hydrocotyle-Eichhornia) MU	7	7	100
2230	Valley Oak (Quercus lobata alliance)	7	7	85.7
1321	Alnus rhombifolia / Salix exigua (Rosa californica) association	7	6	73.3
4503	Mixed Scirpus/ Submerged Aquatics (Egeria-Cabomba-Myriophyllum spp.) MU	6	6	90

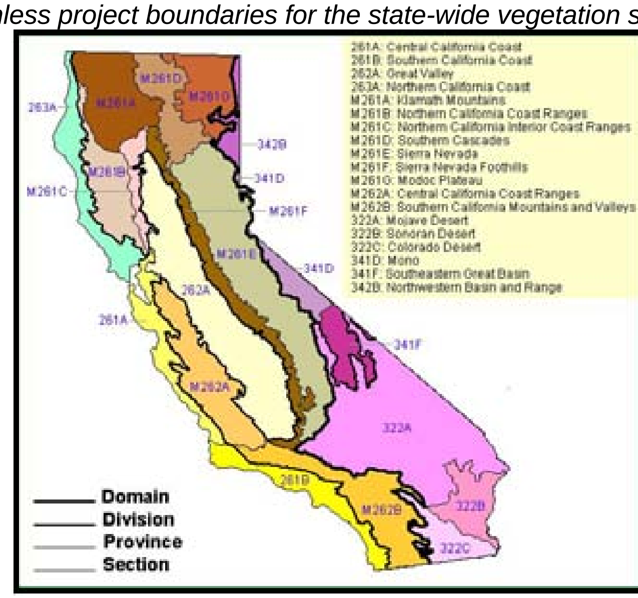
Due to the cost of collecting statistically valid sample sizes for accuracy assessment, compromises may be necessary. In many cases, full accuracy assessment may account for 1/3 of the cost of the entire project, if it is even logistically feasible. In some cases, there aren't enough individuals of certain types to get a valid sample. In addition, many of these samples may be difficult to access (for instance, they occur on private land). Thus, partial accuracy assessment (better known technically as "Quality Assurance") will be necessary. Under these circumstances, clear information will be provided to the public about the accuracy of the units assessed, and likewise, the reduction of certainty on other map categories. At a minimum, accuracy of the core attributes determined for each project area will be assessed. These would include type, cover, height, and size of the vegetation for which it is logistically feasible to amass a significant sample size, and those types that are of particular importance to users of the data (determined case by case by the users groups).

5. Induction of New and Updated Map Products into the State System

The process of statewide vegetation mapping and classification is naturally iterative. A great deal of new information will be provided when areas are mapped for the first time. Once the entire state is mapped, the vegetation will continue to change, requiring regular updates.

As each portion of the state is mapped, an edge-matching process will take place to provide seamless continuity between individual mapping areas. A key first step in this process is determining how the areas will be chosen to minimize overlap and to ensure complete representation. This will be accomplished by using ecological section boundaries rather than political boundaries (***Figure 5***). There is great value to collecting and attributing data in ecologically defined units, within which are shared similar vegetation, climate, biological processes, and accessibility issues. This process also ensures greater efficiency in long-range planning, because the resources and time needed for upcoming projects can be planned well in advance, and are effectively divorced from possible political adjustments that could reduce planning, lower efficiency, and raise costs.

Figure 5: *Ecological sections of California as defined in Miles and Goudey (1997). There are 19 main sections, further divided into 208 subsections. The sections and subsections serve as the basis for establishing seamless project boundaries for the state-wide vegetation survey.*

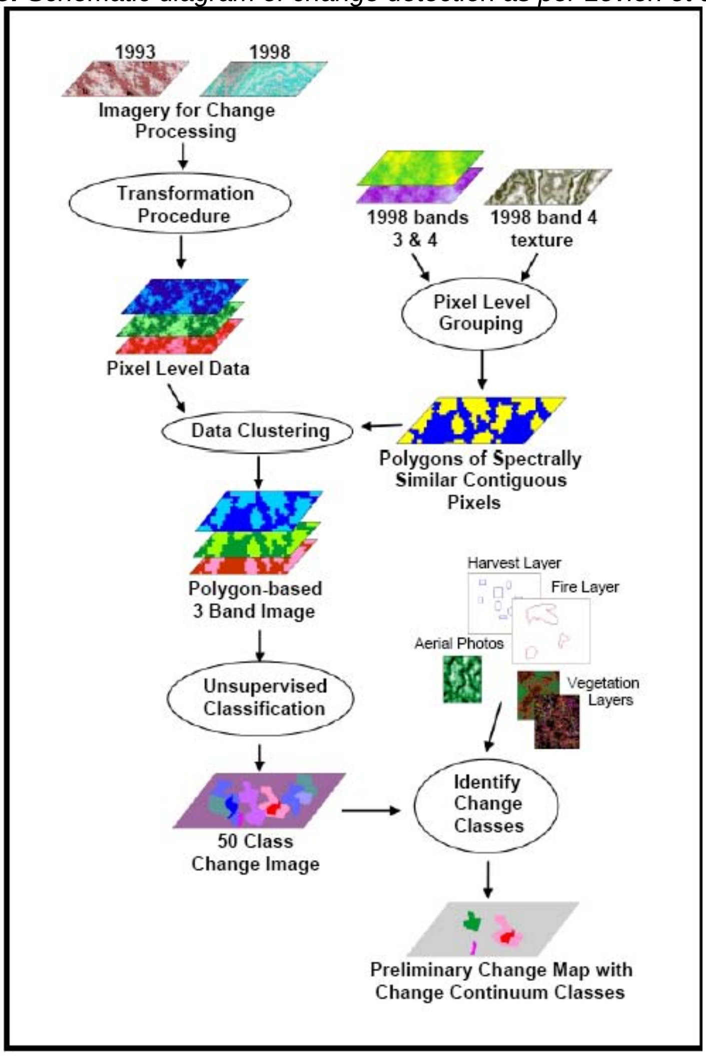


The physical border-matching between ecological sections will be aided by the standard imagery used throughout the state, standard rules for delineation and map unit creation, and detailed training and calibration of all image interpreters.

Building a data framework that accounts for the interweaving of new and updated information from the map and from the field work is a necessity. Flexible database structures have been built that accommodate new information as separate updated categories. For example, individually revisited sample points can record multiple sets of data for each field each time they are sampled. Tools can be developed to summarize statistical changes between visits. Likewise, mapping updates are also accommodated using geo-databases that can accommodate both thematic shifts (changes in vegetation type or density, for example) and spatial shifts (changes in the shape and size of the polygon).

Change detection processing has been well developed by the U.S. Forest Service (Levien et al. 1999) and is a two-step process. Gross regional change is first assessed using algorithms to identify spectral changes in regional imagery.

Figure 5: *Schematic diagram of change detection as per Levien et al. (1999)*



Following this process, the areas detected as changed are further delineated using the Step 2 under Section 2c described above. This process will be enacted as each area of the state is re-visited maintaining a schedule based on the five year updates of the NAIP imagery and upon prior experience of detectable rates of vegetation change averaged throughout the state. All mapped and field inventoried change will be entered into the standardized databases and regular reports summarizing these changes will be produced on an annual basis.

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