Utah State University

DigitalCommons@USU

Aspen Bibliography

Aspen Research

2009

Assessing aspen using remote sensing

Randy Hamilton

Kevin Megown

Jeff DiBenedetto

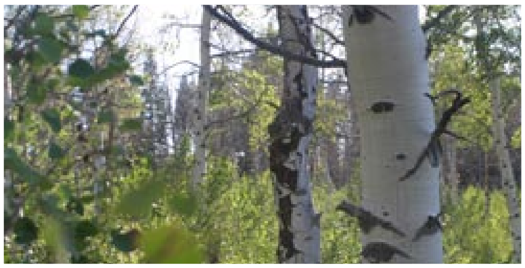
Dale Bartos

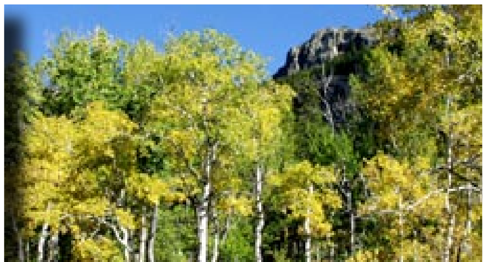
Anne Mikeck

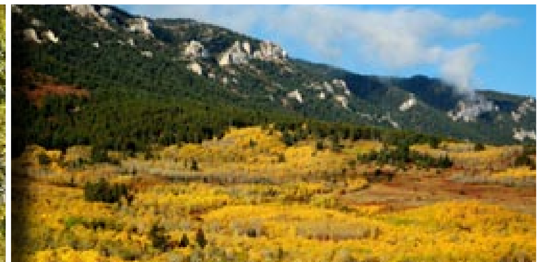
Assessing Aspen Using Remote Sensing

February 2009

RSAC-0110-RPT2







United States Department of Agriculture

Forest Service

Geospatial Management Office

Remote Sensing Applications Center

Abstract

Large areas of aspen *(Populus tremuloides)* have disappeared and continue to disappear from western forests due to successional decline and sudden aspen decline (SAD). This loss of aspen ecosystems negatively impacts watersheds, wildlife, plants, and recreation. Much can still be done to restore aspen if timely and appropriate action is taken. However, land managers often lack fundamental information on the location, quantity, and status of aspen stands. This information is needed to plan, implement, and defend aspen restoration activities, but it is often difficult and costly to obtain. Advances in remote sensing technologies can provide cost-effective ways to obtain spatial and quantitative information about aspen to support restoration activities at multiple scales. With sponsorship from the U.S. Department of Agriculture Forest Service Remote Sensing Steering Committee, the Forest Service Remote Sensing Applications Center conducted three pilot studies to develop remote sensing methods for obtaining key information about aspen. Efforts were focused primarily on developing a method to create a stratified probability map of aspen cover from Landsat Thematic Mapper (TM) satellite imagery for a study area located in the Custer National Forest. Photo-interpreted samples of the strata yielded estimates of the aspen cover present in each stratum. This product can greatly increase the efficiency of planning restoration activities and collecting associated field data. Pilot studies were also conducted to develop remote sensing methods to map SAD across large areas and map small, isolated aspen patches for restoration planning.

Keywords

aspen, *Populus tremuloides,* sudden aspen decline, successional decline, Custer National Forest

Authors

Randy Hamilton is an entomologist and remote sensing specialist working at the USDA Forest Service, Remote Sensing Applications Center, and employed by RedCastle Resources in Salt Lake City, Utah.

Kevin Megown is a senior project leader and biometrician also working at the Remote Sensing Applications Center and employed by RedCastle Resources.

Jeff DiBenedetto is a landscape and vegetation ecologist working at the Forest Service Custer National Forest in Billings, Montana.

Dale Bartos is an ecologist working at the Forest Service, Rocky Mountain Research Station in Logan, Utah.

Anne Mileck is a vegetation manager and certified silviculturist working at the Modoc National Forest in Alturas, California.

Hamilton, R.; Megown, K.; DiBenedetto, J.; Bartos, D.; Mileck, A. 2009. Assessing aspen using remote sensing. RSAC-0110-RPT2. Salt Lake City, UT: U.S. Department of Agriculture Forest Service, Remote Sensing Applications Center. 8 p.

Table of Contents

Introduction

Quaking or trembling aspen *(Populus tremuloides)* is the most widely distributed tree species in North America (Lieffers and others 2001; Preston 1976). It is prized aesthetically for its golden fall foliage and bright green summertime leaves contrasted against the deep green of conifers (figure 1). Aspen is considered a keystone species because of the great diversity of plants and animals it supports (Campbell and Bartos 2001). Aspen protect watersheds, supplying more water than similar conifer-dominated watersheds (Bartos and Campbell 1998b). They provide abundant forage for wildlife and livestock and are prized in recreational areas (Bartos and Campbell 1998a; Shepperd and others 2006).

Figure 1—Aspen in the High Uinta Mountains.

Aspen in the west regenerate almost exclusively by suckering from parent rootstock and are generally dependent on more-or-less regular and frequent disturbance or dieback for suckering to occur (Burns and Honkala 1990; DeByle and Winokur 1985). In the absence of disturbance (especially fire), aspen populations (except some climax aspen communities) gradually decline and are replaced by conifers, sagebrush, or other shrub dominated communities (DeByle and Winokur 1985). From the time of European colonization, this replacement of aspen by other species, or successional decline, has claimed much of the aspen cover type in the western United States. In Utah, for example, dominant aspen populations have been reduced by 60 percent (Bartos 2007; Bartos and Campbell 1998a). The decline is attributed primarily to fire reduction or elimination, overuse by ungulates that feed heavily on new sprouts and prevent new cohorts from becoming established, and climate change (Bartos 2007; Bartos and Campbell 1998a; Rogers and others 2007).

More recently, mature aspen stands have succumbed to what has become known as sudden aspen decline (SAD). SAD is characterized by rapid death (1–2 years) of typically mature aspen clones, with no new suckers surviving (Bartos 2008; Worrall and others 2008). It generally begins in epicenters, spreading rapidly throughout a stand; however, not all clones may be affected in a particular area (Bartos 2008). The causes of SAD are not fully understood. However, Worrall and others (2008) reported that in Colorado, mature, low density stands on southern aspects and at low elevations were predisposed to decline. Key inciting factors of the decline included recent, acute drought and hotter than normal temperatures. Factors contributing to the decline consisted primarily of secondary biological agents such as canker fungi, wood-boring insects, and bark beetles.

Successional decline and SAD threaten aspen populations throughout the western United States, placing watersheds and wildlife habitat at risk. Fortunately, much can still be done to restore aspen if timely and appropriate action is taken. However, land managers often lack key information needed to plan, implement, and defend aspen restoration projects. The needed information, including where decline has occurred and the location, quantity, and status of existing stands, is often difficult and costly to obtain.

Advances in remote sensing technologies can provide cost-effective ways to obtain spatial and quantitative information about aspen to support aspen restoration activities at national, regional, forest, and field management levels. Spatial information, in the form of maps, documents the location of aspen and decline. Quantitative numerical information, derived from statistical samples, quantifies aspen occurrence and decline.

With sponsorship from the U.S. Department of Agriculture Forest Service Remote Sensing Steering Committee, the Forest Service Remote Sensing Applications Center (RSAC) conducted three pilot projects to develop remote sensing methods to obtain information about aspen. Developmental efforts focused primarily on obtaining information about existing aspen at the mid-scale mapping level (1:60,000–1:250,000 scale) because this level of information is the most widely used by land managers for planning management activities (Brohman and Bryant 2005). In particular, methods were implemented to create a probability map of aspen cover from moderate resolution satellite imagery, NAIP (National Agriculture Imagery Program) imagery, and topographic data. These methods are discussed in detail in this document. Remote sensing methods were also developed for mapping SAD across large areas, and mapping small, isolated aspen patches for base-level restoration planning. These applications are discussed in appendices A and B.

Mid-Level Aspen Cover Assessment

Aspen within the Greater Yellowstone area, which encompasses parts of Idaho, Montana, and Wyoming, has declined in vigor, occurrence, structural diversity, and geographic extent compared to historic conditions (USDA Forest Service, Northern Region 1998; Parmenter and others 2003). Montana's Comprehensive Fish and Wildlife Conservation Strategy lists mixed broadleaf forests, including woody draws and aspen galleries, as one of several community types of greatest conservation need (Montana Fish, Wildlife and Parks 2005). Land managers are interested in preserving biodiversity and restoring natural ecological processes associated with aspen (Montana Fish, Wildlife and Parks 2005). However, they lack key information about the current abundance, extent, and condition of aspen in this area. Current mid- and base-level maps portray existing vegetation cover types, but the aspen component lacks sufficient detail for use in aspen restoration project planning.

To assist land managers with their informational needs, RSAC developed a stratified aspen-cover layer from moderate resolution satellite imagery, NAIP imagery, and topographic data for the study area. The strata represented different proportions of aspen canopy cover. A photo-interpreted sample of aspen canopy cover within the strata yielded estimates of the proportion of aspen cover by strata and for the entire study area.

Study Area

The pilot project area, located 65 miles southwest of Billings, Montana, is situated in the Beartooth Ranger District of the Custer National Forest and encompasses 240,000 acres of forested land (figure 2). Elevations within the project area range from 4,800 to 10,800 feet.

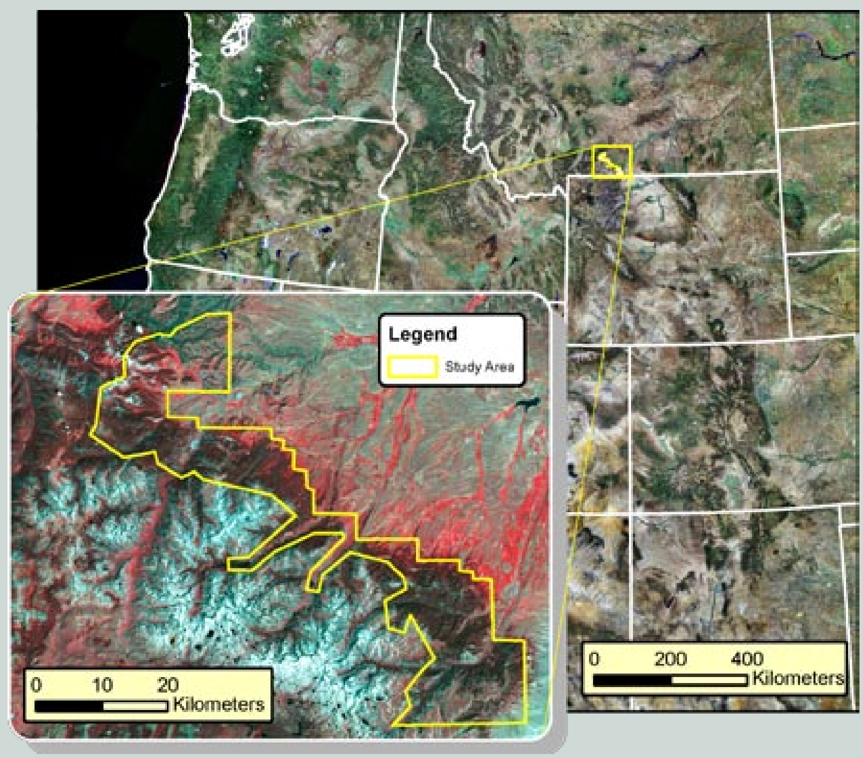


Figure 2—Pilot study area located in the Beartooth Ranger District of the Custer National Forest. The inset shows a close-up view of the study area with Landsat satellite imagery displayed in color infrared.

Methods

A regression tree classifier was used to map seven aspen and four other landscape classes within the study area (table 1). Orange, a freeware product consisting of a library of machine-learning algorithms, performed the classification (Demsar and others 2004). The reliefF splitting algorithm was used for the attribute selection criterion of the classifier (Kira and Rendell 1992; Kononenko 1994). Input data layers for the classifier included two dates of Landsat 5 Thematic Mapper (TM) imagery, derived indices, topographic data, and texture layers derived from color infrared digital orthophoto quarter quads (DOQQs) acquired through the National Agriculture Imagery Program (NAIP) (table 2).

Training for the classifier was obtained by photo-interpreting the land cover from 1-meter spatial resolution, color infrared NAIP imagery (acquired in 2006). Interpretation was performed within 30-by-30-meter grid cells that were aligned with the Landsat pixels. To avoid potential errors due to misregistration between the NAIP and Landsat imagery, samples were drawn, as much as possible, from cells surrounded by at least a 30-meter buffer of similar land cover. Approximately 20 spatially separated samples were obtained per class. For the aspen classes, samples were selected purposively, targeting the seven distinct classes. The aerial cover of aspen was assessed using a digital dot grid consisting of 9 dots per 30-by-30-meter cell (405 dots per acre) (figure 3). Dot grids were created using Digital Mylar, Image Sampler, an extension for ArcGIS (USDA Forest Service 2005). The number of dots intersecting aspen canopy was tallied and divided by the total number of dots to arrive at the proportion of the cell occupied by aspen. Training samples for the non-aspen classes were obtained by photo interpreting a random selection of grid cells. After sampling these cells, underrepresented classes were augmented with nonrandom samples.

Table 1—Land cover classes into which the study area was divided by a regression tree classifier

Stratum Number	Stratum Description
	Aspen (percent cover)
0	0–16
1	17–38 (the non-aspen component is predominantly conifer)
2	17–38 (the non-aspen component is predominantly grass/forbs)
3	39–61 (the non-aspen component is predominantly conifer)
4	39–61 (the non-aspen component is predominantly grass/forbs)
5	62–83
6	84–100
7	Conifer
8	Grass/forbs
9	Rock/bare earth
10	Water

Table 2—Data layers *(30-meter spatial resolution)* used in a regression tree classifier to map aspen and other land cover classes

Landsat 5 TM imagery (two dates)
21 July 2005
7 September 2005
Indices (both dates of TM imagery)
Tasseled cap brightness[a]
Tasseled cap greenness[a]
Tasseled cap wetness[a]
NDVI (normalized difference vegetation index)[b]
NDMI (normalized difference moisture index)[c]
Topographic data
DEM (digital elevation model)
Slope
Aspect (fully illuminated hillshade)
Texture
Standard deviation of NAIP red band within 30-meter cells
Standard deviation of NAIP NIR band within 30-meter cells
3-band texture from focal standard deviations (3 kernel sizes) of the NAIP first principle component

[a]Part of the tasseled cap transformation (see Crist 1985).
[b]NDVI=(B4-B3)/(B4+B3) where B3 and B4 are respectively Landsat 5 TM bands 3 and 4.
[c]NDMI=(B4-B5)/(B4+B5) where B4 and B5 are respectively Landsat 5 TM bands 4 and 5 (Wilson and Sader 2002).

After running the regression tree classifier to create a classified map of the study area, twenty randomly selected 30-by-30-meter grid cells were photo-sampled within each class or stratum. Aspen plots were sampled by dot grid in the same fashion as the aspen training samples. Non-aspen plots were simply attributed with their corresponding class. An estimate of aspen cover for each stratum was calculated based on the samples. Analysis of variance and a Student Newman-Keuls (SNK) multiple comparison test were performed to identify statistical differences in aspen canopy cover among the classes (PROC GLM, SAS Institute 2004). Strata with similar aspen cover were merged. Using the strata areas as weights, weighted mean aspen cover was calculated for the merged strata along with a 95 percent confidence interval.

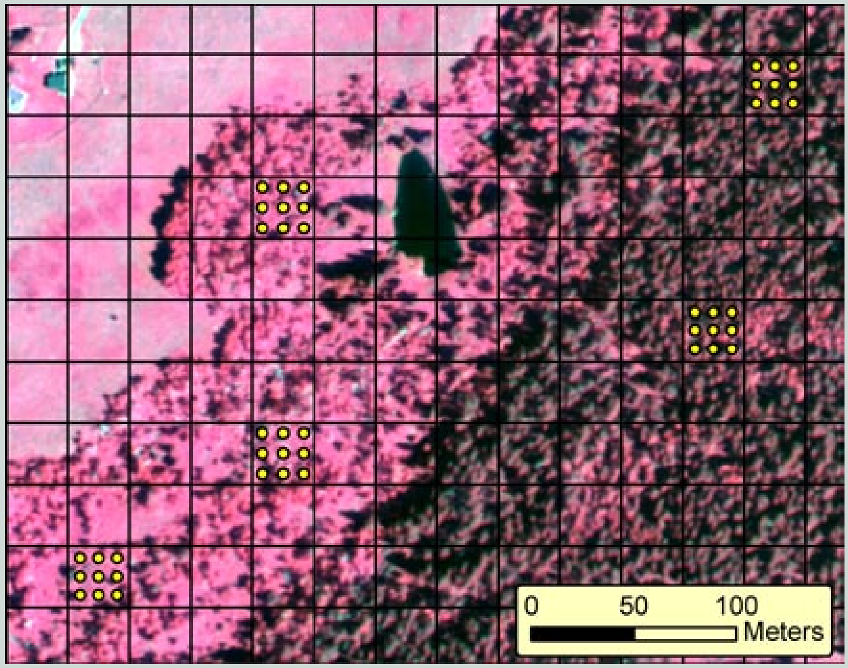


Figure 3—Aspen cover was sampled using a digital dot grid consisting of nine dots within a 30-by-30-meter grid cells. In this color infrared photo, aspen are bright red; conifers are a deeper red.

Table 3—Area, sample size, percent aspen cover, and standard error for each stratum based on randomly selected photo interpreted samples

Strata	Area (Acres)	Sample Size (n)	Percent Aspen Cover*	Standard Error
0	28,404	20	1.67 d	0.012
1	14,964	20	0.00 d	0.00
2	7,921	20	11.67 c	0.053
3	13,796	20	9.44 c	0.380
4	3,509	20	19.44 b	0.059
5	3,160	20	23.89 b	0.070
6	1,620	20	32.16 a	0.088
7	94,169	20	0.00 d	0.00
8	62,367	20	1.11 d	0.011
9	8,799	20	0.00 d	0.00
10	1,632	20	0.00 d	0.00

*Mean percentages followed by the same letter are not significantly different (SNK multiple comparison test).

Results

The regression tree classifier yielded a classified (stratified) map of the study area (figure 4). An estimate of aspen cover within each stratum was calculated based on the photo plot samples (table 3). Strata with statistically similar aspen cover were merged and new weighted estimates computed (table 4, figure 5). The ten original strata were collapsed into five. Based on the sample, the aerial cover of aspen within the study area is 2.23±1.40 percent (excluding the water stratum).

Discussion

The regression tree classification used to stratify the landscape is only one of many viable approaches. Other potential stratification methods could include an unsupervised classification with any number of classes, a random

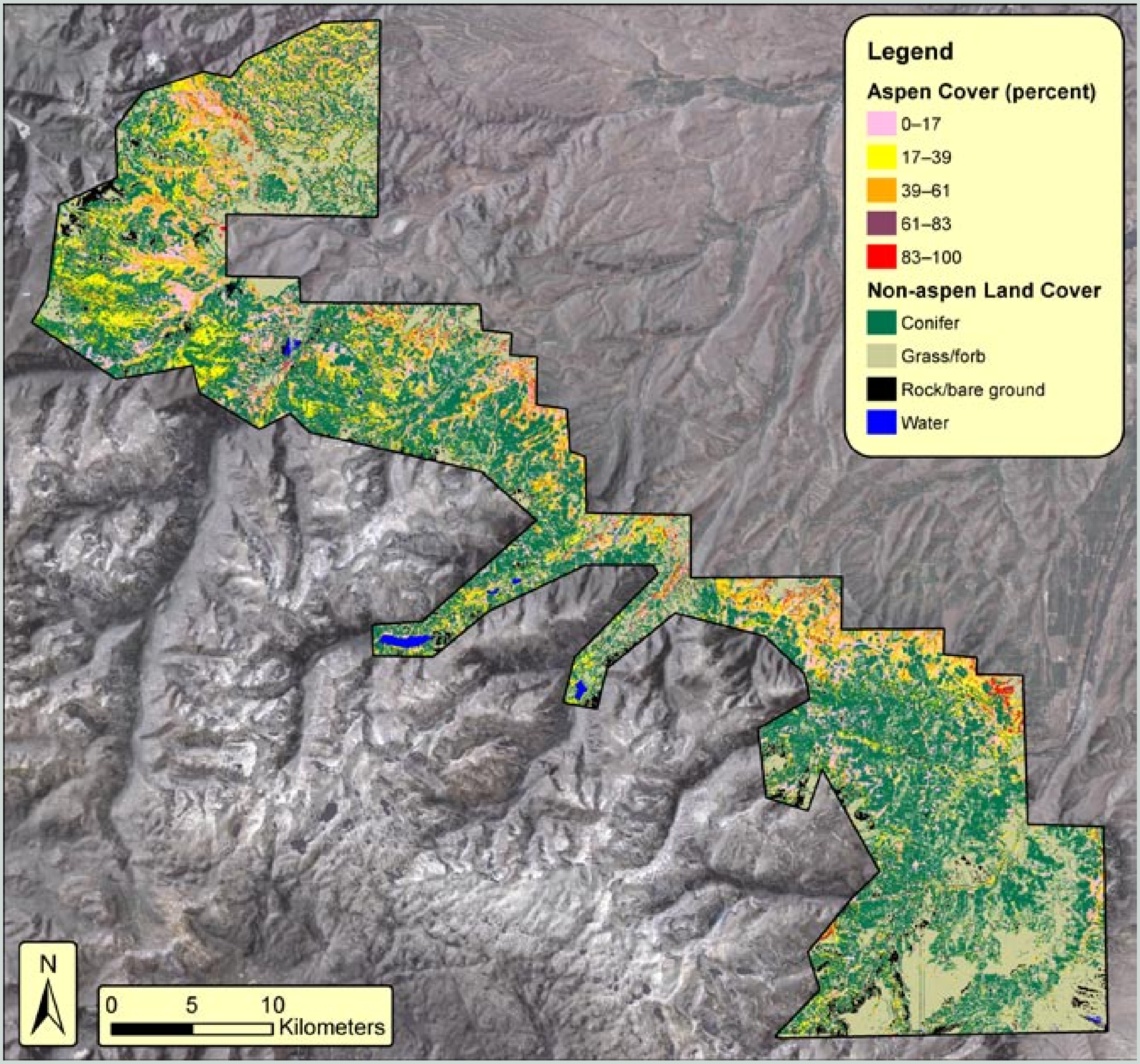


Figure 4—Classification of the study area showing aspen canopy cover strata *(with target percentages of cover indicated)* as well as other land cover types within the study area in southern Montana. These strata were sampled to estimate true aspen canopy cover.

Table 4—Merged strata by SNK-grouping, sample size, percent aspen cover with 95 percent confidence interval, and area. Strata in grouping 'd' *(very little to no aspen)* showing some aspen cover is separated from strata with no aspen cover.

SNK-Grouping	N	Percent Aspen Cover ± 95% CI	Area (acres)
a	20	32.16 ± 18.4	1,620
b	40	21.55 ± 9.1	6,669
c	40	10.25 ± 6.2	21,717
d	60	1.28 ± 1.2	90,771
d	60	0.00 ± 0.0	119,564

forest classification, or a classification based on spectral mixture analysis. The key point to remember is that the land cover within strata should be as homogeneous as possible, with respect to aspen cover, to reduce the cost and the variability of the estimates. Reducing within-strata variability also increases the value of the stratified map product when used to locate potential sites for restoration.

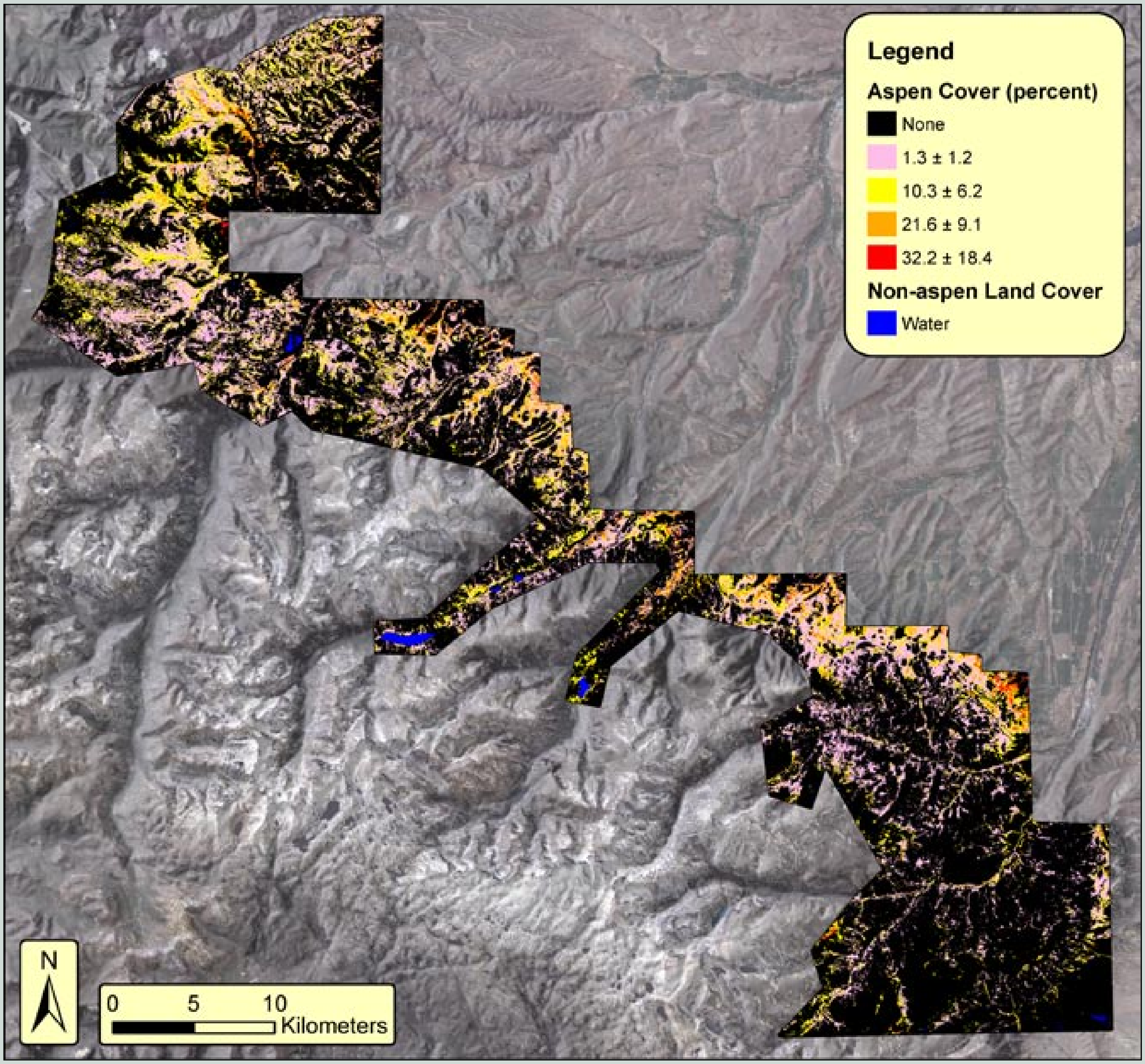


Figure 5—Final stratification of the study area after merging strata with similar proportions of aspen canopy cover. The legend provides sample-based estimates of true percentages of aspen canopy cover for the strata.

This pilot study demonstrated that a forested landscape can be stratified using Landsat satellite imagery and sampled by interpreting high-resolution photo plots to derive an estimate of the true amount of aspen cover within the strata. For implementation beyond the pilot project, additional steps should be taken to increase the precision of the aspen cover estimates and to integrate the stratified map into a mid-level vegetation map for use in project planning.

To increase the precision of the aspen cover estimates, the variance of the mean aspen cover estimates should be computed after acquiring a limited number of photo plot samples (e.g., 10 to 20). Based on the variance of these samples, the sample size required to achieve a desired level of precision can be determined using standard statistical techniques. After collecting additional random photo samples to achieve the desired precision of the estimate, the strata means can be compared using a means separation test. Similar strata can be merged. If additional accuracy, or more detailed information not visible on the aerial photo (e.g., tree size class or disease presence), is desired, field samples can be acquired using existing field inventory methods.

Once similar strata have been merged, they can be intersected with and summarized within mid-level vegetation map segments using a weighted average. As part of the mid-level vegetation map, the data on aspen cover can be used for aspen restoration or other project planning.

Table 5—Time costs to stratify a forest *(of variable size)* by aspen cover and photo-sample within strata to estimate the aspen cover

Expense Item	Cost (person days)	
	Technician	Analyst
Project management	2–4	5–10
Image/data preparation	5–10	1–2
Training sample collection (10–15 classes with 30–50 samples per class; assumes 20–30 samples collected per day)	10–38	1–2
Stratification	0	3–5
Random sample collection (10–15 classes with 50 samples per class; assumes 40–50 samples collected per day)	10–19	1–2
Estimate compilation	0	1–2
Reporting, including metadata compilation	0	2–4
Total	27–71	14–27

Costs

The cost to stratify a landscape by aspen cover and estimate the aspen canopy cover within the strata will vary depending on the availability and quality of imagery, the skill level of the remote sensing technician and analyst, and the desired level of precision of the estimates. For this study, Landsat and NAIP imagery were obtained free of charge. The NAIP imagery was of sufficient quality to allow photo-interpretation of aspen cover. Therefore, the only cost incurred was that of the remote sensing analyst and photo interpreter (technician). Excluding time spent testing and developing the methodology to stratify the study area, we estimate that an experienced remote sensing analyst and photo interpreter could complete a similar project for a National Forest in 41 to 98 full-time person days (table 5). The wide range of the estimate accounts for the factors mentioned above that impact the time required to complete this type of project. The size of the project area has comparatively little impact on the time requirement as long as the spectral appearance of aspen in the imagery is similar throughout the area.

References and Suggested Reading

Bartos, D.L. 2007. Aspen. In Hood, S.M; Miller, M., eds. Fire ecology and management of the major ecosystems of southern Utah. Gen. Tech. Rep. RMRS-GTR-202. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 39–55.

Bartos, D.L. 2008. Great Basin aspen ecosystems. In Chambers, J.C.; Devoe, N.; Evenden, A. eds. Collaborative management and research in the Great Basin—examining the issues and developing a framework for action. Gen. Tech. Rep. RMRS-GTR-204. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 57–60.

Bartos, D.L.; Campbell, R.B. Jr. 1998a. Decline of quaking aspen in the Interior West—examples from Utah. Rangelands. 20: 17–24.

Bartos, D.L.; Campbell, R.F. Jr. 1998b. Water depletion and other ecosystem values forfeited when conifer forests displace aspen communities. In Potts, D.F. ed, Proceedings of AWRA Specialty Conference, Rangeland Management and Water Resources. American Water Resource Association. Herndon, Virginia. TPS-98-1. 427–434.

Brohman, R.; Bryant, L. eds. 2005. Existing vegetation classification and mapping technical guide. Gen. Tech. Rep. WO-67. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff. 305 p.

Burns, R.M.; Honkala, B.H. 1990. Silvics of North America: Volume 2. Hardwoods. Agricultural Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. 877 p.

Campbell, R.B.; Bartos, D.L. 2001. Aspen ecosystems: objectives for sustaining biodiversity. In Shepperd, W.D.; Binkley, D.; Bartos, D.L.; Stohlgren, T.J.; Eskew, L.G., comps. Proceedings of symposium, Sustaining aspen in western landscapes, June 13–15, 2000, Grand Junction, Colorado. RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 299–307.

Crist, E.P. 1985. A TM tasseled cap equivalent transformation for reflectance factor data. Remote Sensing of Environment. 17: 301–306.

DeByle, N.V.; Winokur, R.P. eds. 1985. Aspen: ecology and management in the western United States. Gen. Tech. Rep. GTR-RM-119. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 283 p.

Demsar, J.; Zupan, B.; Leban, G. 2004. Orange: from experimental machine learning to interactive data mining, White Paper. Faculty of Computer and Information Science, University of Ljubljana, Slovenia [online]. Available: www.ailab.si/orange [February 6, 2009].

Kira, K.; Rendell, L. 1992. A practical approach to feature selection. In Sleeman, D.; Edwards, P. eds, Proceedings of the 9th International Conference on Machine Learning, Aberdeen, Scotland, United Kingdom. Morgan Kaufmann Publishers. 249–256.

Kononenko, I. 1994. Estimating attributes: Analysis and extensions of RELIEF. In Bergadano, F.; De Raedt, L. comps. Proceedings of the European Conference on Machine Learning, Catania, Italy: Springer-Verlag: 171–182.

Lieffers, V.J.; Landhausser, S.M.; Hogg, E.H. 2001. Is the wide distribution of aspen a result of its stress tolerance? In Shepperd, W.D.; Binkley, D.; Bartos, D.L.; Stohlgren, T.J.; Eskew, L.G. eds. Proceedings of symposium, Sustaining aspen in western landscapes. June 13–15, 2000, Grand Junction, CO. RMRS-P-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 311–323.

Montana Fish, Wildlife and Parks. 2005. Montana's comprehensive fish and wildlife conservation strategy. Helena, MT [online]. Available: http://fwp.mt.gov/specieshabitat/strategy/compstrategy.html [February 6, 2009]. 658 p.

Parmenter, A.W.; Hansen, A.; Kennedy, R.E.; Cohen, W.; Langner, U.; Lawrence, R.; Maxwell, B.; Gallant, A.; Aspinall, R. 2003. Land use and land cover change in the Greater Yellowstone Ecosystem: 1975-1995. Ecological Applications. 13: 687–703.

Preston, R.J. 1976. North American trees. Ames, Iowa: Iowa State University Press. 399 p.

Rogers, P.C.; Shepperd, W.D.; Bartos, D.L. 2007. Aspen in the Sierra Nevada: regional conservation of a continental species. Natural Areas Journal. 27: 183–193.

SAS Institute. 2004. SAS/STAT 9.1 User's Guide, Cary, NC: SAS Institute Inc.

Shepperd, W.D.; Rogers, P.C.; Burton, D.; Bartos, D.L. 2006. Ecology, biodiversity, management, and restoration of aspen in the Sierra Nevada. Gen. Tech. Rep. RMRS-GTR-178. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 122 p.

USDA Forest Service. 2005. Digital mylar—image sampler. Washington, DC: U.S. Department of Agriculture, Forest Service, Remote Sensing Applications Center [online]. Available to Forest Service intranet users: http://fsweb.geotraining.fs.fed.us/tutorials/digmylar/ [February 6, 2009].

USDA Forest Service. 1998. Northern Region overview detailed report. USDA Forest Service, Northern Region. Missoula Montana [online]. Available to Forest Service intranet users: http://fsweb.r1.fs.fed.us/em/new_site/assess_analyses/overviews/pdf_detailed_report_012599.pdf [February 6, 2009]. 192 p.

USGS 2006. MRLC 2001 Image processing procedure. U.S. Department of the Interior, U.S. Geological Survey [online]. Available: http://www.mrlc.gov/pdf/image_processing.pdf [February 18, 2009].

Wilson, E.H.; Sader, S.A. 2002. Detection of forest harvest type using multiple dates of Landsat TM imagery. Remote Sensing of Environment. 80: 385–396.

Worrall, J.J.; Egeland, L.; Eager, T.; Mask, R.A.; Johnson, E.W.; Kemp, P.A.; Shepperd, W.D. 2008. Rapid mortality of *Populus tremuloides* in southwestern Colorado, USA. Forest Ecology and Management. 255: 686–696.

For additional information, contact:
Brian Schwind
Remote Sensing Applications Center
2222 West 2300 South
Salt Lake City, UT 84119

phone: (801) 975-3750
e-mail: bschwind@fs.fed.us.

This publication can be downloaded from the RSAC Web sites: http://fsweb.rsac.fs.fed.us

Appendix A: Mapping Small, Isolated Aspen Stands in Google Earth

In the Modoc National Forest, located in northeastern California, existing quaking aspen stands are rare, generally small, sparse, and isolated. These stands, like aspen in other areas of the west, are threatened with elimination by conifer encroachment. In this environment, it is critical that single or a few isolated aspen stems in priority areas be mapped so that resource managers can prioritize and plan restoration efforts to achieve the greatest benefit with limited funds.

Mapping small, isolated stands automatically with digital image processing techniques can be difficult without high quality, very high-resolution digital imagery. Unfortunately, this type of imagery is generally not readily available to most forests, including the Modoc National Forest. Therefore, an alternate method to locate critical stands was developed using high resolution imagery available in Google Earth (GE). By chance, the imagery available in GE for parts of the Modoc National Forest was acquired during the peak of aspen fall color change, making it highly visible in the imagery.

To take advantage of the imagery available in GE, a grid of five-acre cells was created in ArcMap and imported into GE. The cells were then examined systematically for the presence of aspen. When aspen was present, a placemark was added to the cell. After examining all cells, the placemarks were transferred from GE to ArcMap, where they were used to attribute those grid cells containing aspen. Detailed instructions for doing this are provided below.

Grid Preparations in ArcMap

1. Determine the desired cell size. Five acres was chosen for the Modoc National Forest. A more refined product could be achieved using smaller cells such as 1.0 or 2.5 acres, but assessing smaller cells will also require more time.

2. Download and install Hawth's Tools from http://www.spatialecology.com/htools/. This free extension for ArcMap provides a suite of useful sampling tools, including a tool to create systematic grid cells of a user-specified size. After installing Hawth's Tools, a new toolbar should appear in ArcMap. If not, or if the toolbar is present but the tools fail to launch, check to see if the extension is active (Tools—>Extensions…) and that the toolbar is visible (View—>Toolbars).

3. For Hawth's tools, you will need to compute the length of a cell's side using the following formula:
   cell side length (meters) = √*cell size (acres)* *4,046.825
   (see also table A.1).

4. Create a shapefile grid of cells for your area of interest with Hawth's Tools (Hawth's Tools—>Sampling Tools—>Create Vector Grid (line/polygon)).

   a. In the popup window, define the area of interest using either a shapefile boundary file defining the area of interest or by manually enter coordinates to define the area.

   b. Specify the spacing between lines (i.e., the cell side length in meters)

   c. Specify an output location and shapefile name.

   d. Set the projection definition to Geographic WGS 1984 (Geographic Coordinate Systems—>World—>WGS 1984.prj). This is the native projection that GE uses.

   e. Click "OK" to execute.

Helpful Tips. . . Creating Grid Cells
Hawth's Tools provides an easy way to create grid cells; however, they can also be created with other scripts or extensions that are available for download from ESRI's Website (http://arcscripts.esri.com/). Search the arcscripts using the key word "sampling" to find them.

Table A.1—Cell side lengths for square cells of various acreages

Side length (meters)	Acreage
63.6	1.0
90.0	2.0
100.6	2.5
142.2	5.0

5. Convert the shapefile grid to a GE .kmz file

    a. If not already visible, show the ArcToolbox window in ArcMap.

    b. Launch the "Layer To KML" tool in the 3D Analyst Tools toolbox (3D Analyst Tools—>Conversion—>To KML—> Layer to KML) to create a .kmz file.

    c. Select the grid file and specify an output file and layer output scale (e.g., 5,000), then click "OK."

Assessment in Google Earth

1. Launch GE. If not installed, get administrator privileges and download and install it from http://earth.google.com/

2. In GE, navigate to your kmz file and open it (File–>Open). The grid should appear on the screen, with the name of the original shapefile in the "Temporary Places" folder of the Places panel (figure A.1).

3. Modify the display style of the grid

    a. Right click on your grid folder and select "Properties."

    b. Click the "Style, Color" tab.

    c. Click "Share Style" on the "Style, Color" tab.

    d. In the "Area" dropdown menu, select "Outlined."

    e. Under "Lines," change the color and/or width of the gridlines if desired.

    f. Click "OK" to close the dialog.

4. Zoom to one corner of the grid, then systematically pan through the imagery, examining each cell for the presence of aspen.

5. If aspen are found in a cell, add a placemark to it (figure A.2).

    a. Create a new folder in "My Places" to hold your placemarks.

        i. Right click "My Places" and select Add—>Folder.

        ii. Add a name in the popup window and click "OK."

    b. With the new folder selected (highlighted in the Places Panel), click the Placemark button  on the main toolbar (NOTE: If the toolbar is not visible, make it visible by selecting Toolbar from the View menu [View—> Toolbar]).

Helpful Tips . . . Shapefiles to .kml
If the 3D Analyst extension is not available, Forest Service users can access a KML wizard, which is a free ArcGIS extension that converts shapefiles to .kml files, which can also be read by GE. The KML wizard and documentation are available at ftp://ftp2.fs.fed.us/incoming/rsac/KML_Wizard/

Helpful Tips…Customizing "My Places"
If you want GE to store your grid so that it is available next time you launch the software, move it into the "My Places" folder. You can do this by:

1. Clicking, dragging, and dropping it in "My Places" or
2. Right clicking on the grid and selecting "Save to My Places"

You can create and name folders in "My Places" to store your files. To do this, right click "My Places" and select Add Folder.

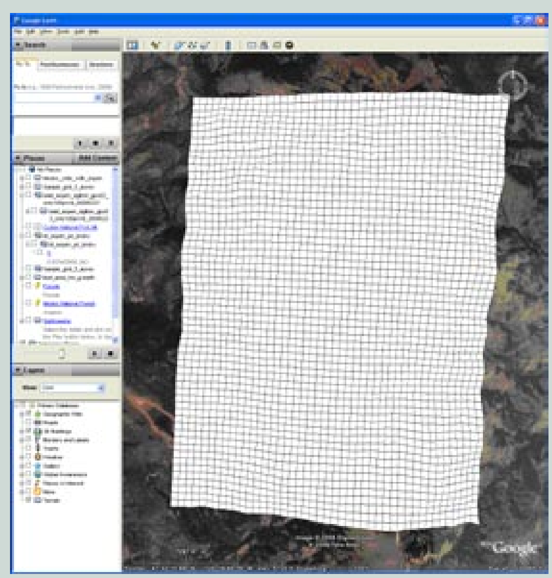


Figure A.1—Five-acre grid cells draped over the Google Earth terrain.

Helpful Tips…Panning in Google Earth
If you click in the GE viewer, hold, drag, and release while still dragging, GE will begin panning across the imagery in the direction of the drag and at a speed corresponding to the speed of the drag. To stop this automatic panning, just click anywhere in the GE viewer.

c. In the popup window, either accept or change the default name. If desired, you can name the placemarks to reflect the amount of aspen in the cells (e.g., Aspen10, or just 10 to indicate 10 percent aspen cover). When the placemarks are imported into ArcMap, the names will be preserved as attributes in a shapefile.

d. Click the marker button to the right of the Name box to select and modify the style of the placemark marker.

e. You can further modify the appearance of the placemark and its label by using options available in the tabs of the placemark window.

f. Click, hold, and drag the placemark to the desired location (you may need to move the placemark window out of the way to see the placemark).

g. Click "OK" to close the placemark window.

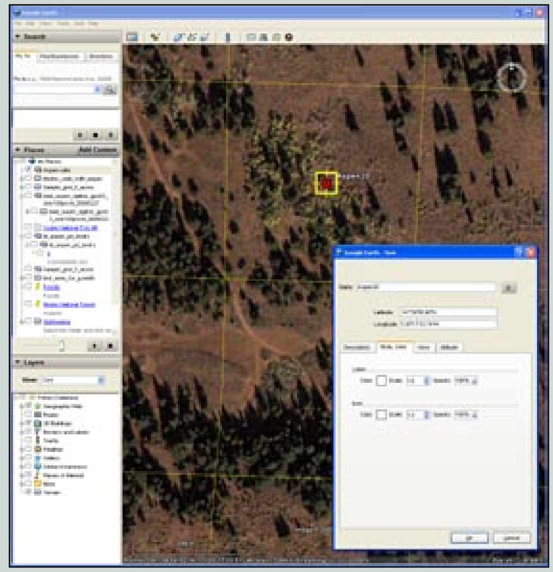


Figure A.2—Placemarks are added to cells containing aspen.

6. Export the placemarks.

a. After marking all cells containing aspen with a placemark, right click the folder containing them and select Save As…

b. In the Save File popup window, select .kml in the Save as type… dropdown menu.

c. Navigate to where you want to save the file, enter a filename, and click "Save."

Import kml Placemarks into ArcMap

1. Download and install the XTools Pro extension for ArcMap. This extension is available to all Forest Service users and can be downloaded from Region 3's intranet site along with licensing information (http://fsweb.r3.fs.fed.us/eng/gis/software.html).

a. In ArcMap, enable the XTools Pro extension (Tools—>Extensions…) and make the toolbar visible (View—>Toolbars).

2. Import the kml placemarks from GE into ArcMap using XTools Pro (XTools Pro—>Import Data from KML).

a. In the popup window, select the placemarks kml file for the input file and enter an appropriate output file name.

b. Click "OK." XTools will import the placemarks and add them to your ArcMap project as a shapefile.

Helpful Tips…Editing Placemarks

Move. If you need to move a placemark after closing the placemark window, right click on the placemark in the viewer window and select Properties. The placemark window will reappear and you can move the placemark.

Delete. To delete a placemark, right click on it and select Delete.

Helpful Tips…Converting kmls to Shapefiles

Several free scripts developed by the ESRI user community are available for download at http://arcscripts.esri.com/ that convert kml files to shapefiles. Search with the keyword kml. Unfortunately, these scripts do not always perform reliably.

Attribute the Grid File with Aspen Locations in ArcMap

1. Add a new field to the grid shapefile, which will indicate presence or absence of aspen.

2. Use the select by location function in ArcMap (Selection—>Select By Location…) to select grid cells containing a placemark (figure A.3).

3. With cells selected, use the Field Calculator to attribute only the selected cells with an attribute indicating the presence of aspen.

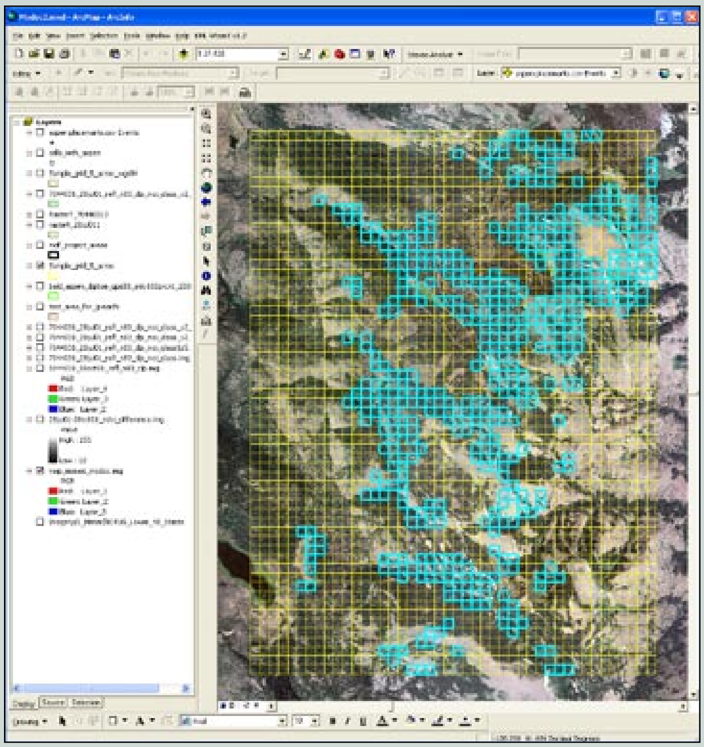


Figure A.3—Grid cells containing aspen are selected by placemarks imported from Google Earth.

Appendix B: Mapping Sudden Aspen Decline Across Large Areas

In recent years, aspen stands throughout the western United States and into Canada have succumbed to sudden aspen decline (SAD). The rapid onset of SAD and its wide distribution make it difficult for resource managers to fully comprehend the extent and magnitude of the problem. Current information about the distribution and severity of SAD is needed to guide management decisions at national, regional, and local levels.

To assist land managers with their informational needs, RSAC conducted a pilot project to develop methods to map SAD from moderate resolution satellite imagery using a change detection technique. Methods were developed and a product was produced for the study area; however, due to budgetary and time constraints, the product was not validated. This document describes the methodology developed to map change in aspen as well as possible methods for validating and using the map.

Study Area

A pilot project area was selected on Cedar Mountain, located just east of Cedar City, Utah (figure B.1). This area has a large (mostly stable) aspen population which has experienced some of the heaviest SAD in the state (figure B.2). The project area encompasses one full Landsat 5 TM scene (path 38, row 34) (figure B.1).

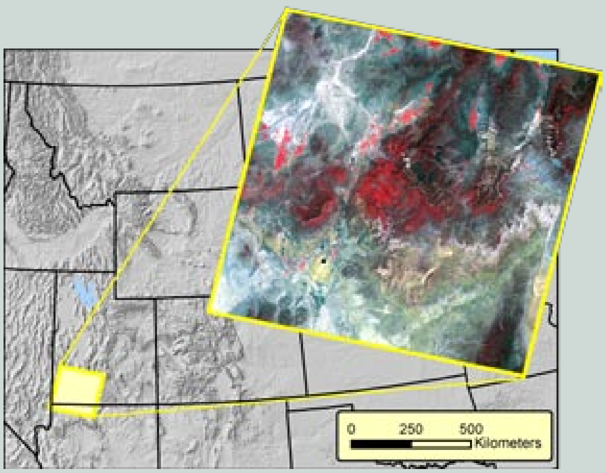


Figure B.1—Study area encompassing one full Landsat satellite scene centered over Cedar Mountain *(southern Utah)*. The inset shows a 2007 Landsat scene for the study area displayed in color infrared.

Figure B.2—Aspen stands throughout the Cedar Mountain area *(southern Utah)* have experienced extensive sudden aspen decline, as shown in this 2002 photo.

Methods

On Cedar Mountain, the greatest amount of SAD occurred between 2000 and 2007, with some decline occurring before 2000 (personal communication, Dale Bartos, 2008). Two Landsat 5 TM scenes spanning this interval (21 June 2000 and 25 June 2007) were selected for the study area. The imagery was obtained through the Multi-Resolution Land Characteristics Consortium (MRLC) and was geometrically and radiometrically corrected using standard methods at the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Data Center using the National Landsat Archive Production System (NLAPS) (USGS 2006). Both scenes were converted to signed 16-bit data format. The National Land Cover Database (NLCD) deciduous and mixed deciduous forest classes, which are dominated by aspen in this area, were used to create an analysis mask to restrict all analyses to these two land cover types.

The normalized difference vegetation index (NDVI) and normalized difference moisture index (NDMI) were computed and summed for each Landsat scene. The summed indices of 2000 were then subtracted from those of 2007 (figure B.3). Low values in the differenced raster represent a decrease in green vegetation, intermediate values no change, and high values an increase in green vegetation.

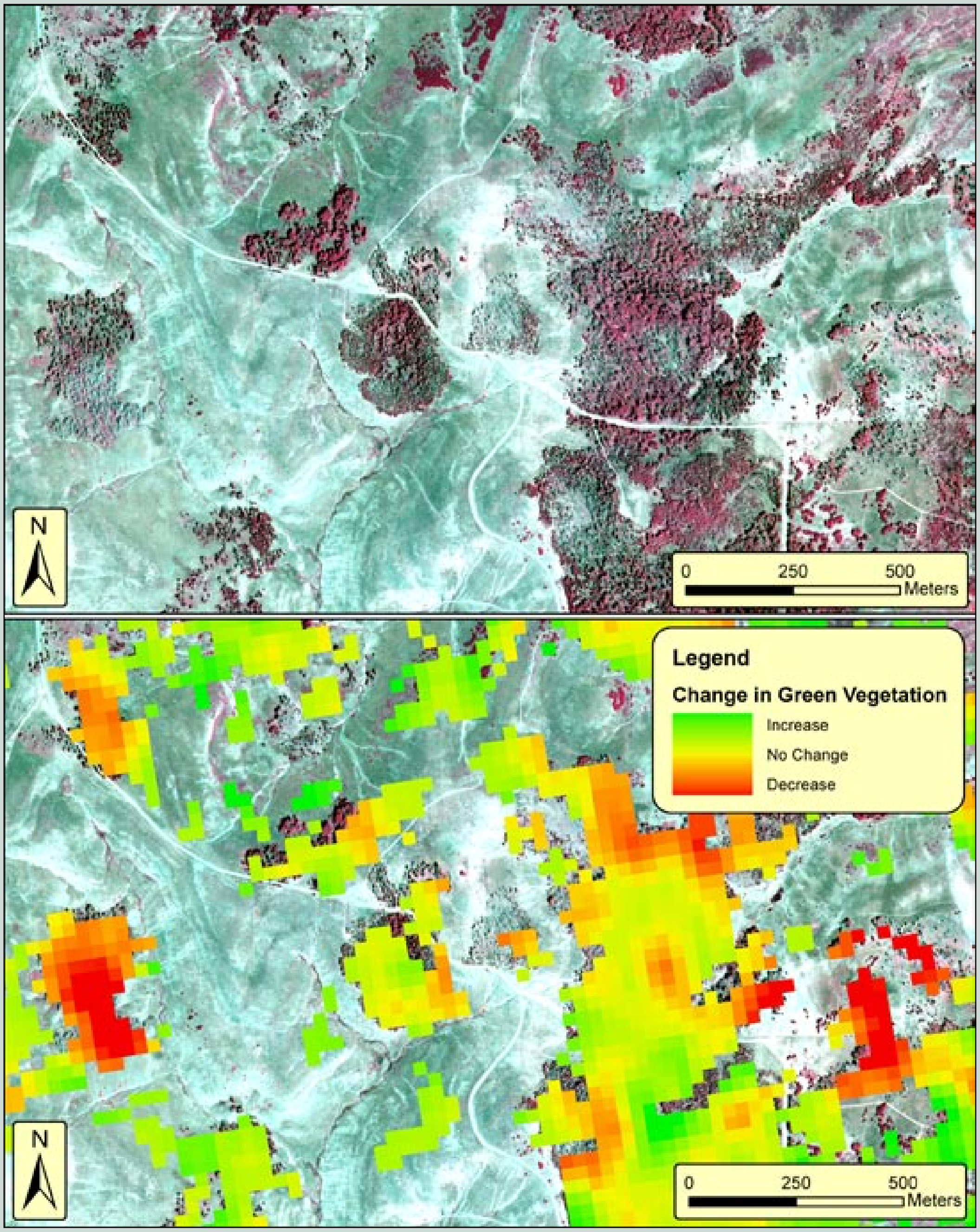


Figure B.3—*A)* Color infrared NAIP from 2005 showing aspen cover in the Cedar Mountain study area, including areas of SAD. *(B)* Difference image for the same area, draped over NAIP imagery, showing relative change in green vegetation between 2000 and 2007.

Calibration and Use of Change Map

To utilize the change map, it must be calibrated or related to actual change that has occurred on the ground. This can be accomplished in many different ways. One method is to divide the values of the change map into several (e.g., 5 to 15) equal interval groups. Each of these groups (or strata) can be randomly sampled with field- or photo-interpreted plots to derive an estimate of the amount of decline that has occurred. This approach is similar to that described in the body of this document for obtaining mid-level information about existing aspen populations. Another approach is to acquire field- or photo-interpreted samples from areas typifying the varying types of change that have occurred. These samples are then used as training for an image classifier to derive a classified image representing degrees of aspen decline.