TR 1737-02 OBSOLETE

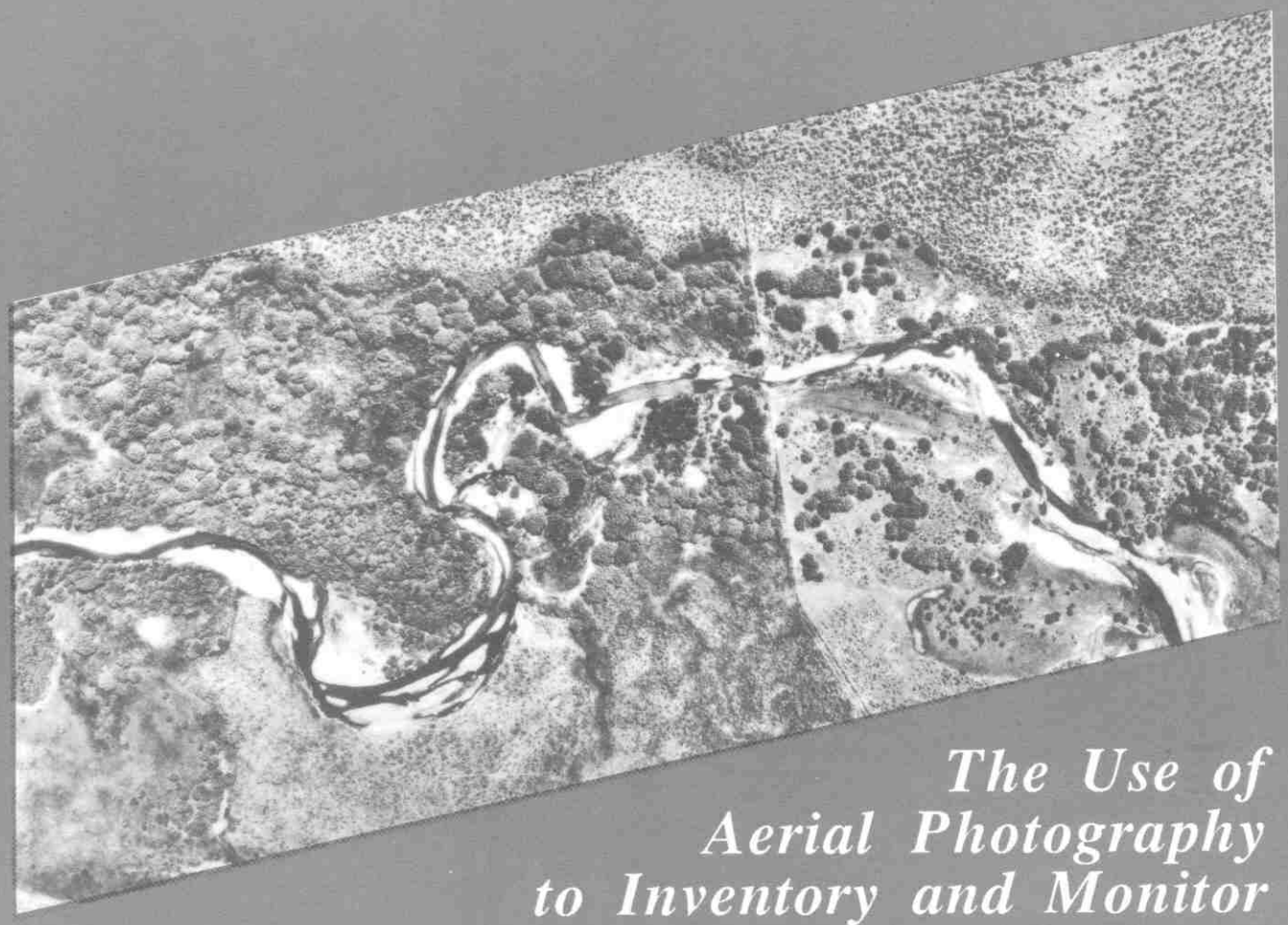
Use of Aerial Photography to Inventory & Monitor Riparian Areas

This Technical Reference has been updated replaced by TR 1737-10 – Using Aerial Photographs to Assess Proper Functioning Condition of Riparian-Wetland Areas, 1996, Revised 1999.

Note: Click Here to return to the Tech Reference Index

RIPARIAN AREA MANAGEMENT

TR 1737-2 1987



The Use of Aerial Photography to Inventory and Monitor Riparian Areas

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RIPARIAN AREA MANAGEMENT

The Use of Aerial Photography to Inventory and Monitor Riparian Areas

by

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Technical Reference 1737-2

August 1987

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THE USE OF AERIAL PHOTOGRAPHY TO INVENTORY AND MONITOR RIPARIAN AREAS

I. INTRODUCTION

The Federal Land Policy and Management Act of 1976 (FLPMA) requires the Bureau of Land Management to inventory lands and resources on a continuing basis. Methods for inventory and monitoring riparian areas have not been fully developed.

Recognition of the importance of riparian areas nationally has led to renewed interest in refining methods of assessing riparian lands.

Ground data collection of riparian areas can be accelerated and enhanced by the use of large-scale color infrared or natural color aerial photography. Canopy and ground cover, bare soil, and acreage can be calculated, and riparian plant communities delineated for mapping purposes on the large-scale photos.

Change in riparian areas can be visually assessed by comparing photography flown at a later date. Detailed vegetation maps can be developed for long-term management plans or information transfer to geographic information systems.

This Technical Note provides the reader with concepts and procedures required to plan, initiate, and complete a successful project utilizing large-scale aerial photography for the inventory and monitoring of riparian areas.

The BLM Service Center, Branch of Remote Sensing (D-473) can provide assistance in the design and accomplishment of projects to meet specific needs.

II. ESTABLISHING THE PHOTO-BASELINE DATA

A. Preplanning:

1. Area selection: Carefully select stream areas that are of primary concern. Be specific in identifying the beginning and end points but don't skimp on photo coverage. Once the aircraft is over the area, an additional two or three exposures do not add significantly to the overall cost of the project.

2. Season and time of day: Usually you will want the photography flown as near "peak of green" as possible. This is generally near the point where vegetation is growing vigorously and is at a full leaf stage. Only the local resource specialist knows when peak of green occurs. It should be determined before you decide what type of film you wish to use. Also, if deep canyons are in the area, the field specialist should specify the time of day to fly in order to minimize shadows.

3. Film type: The intended use of the imagery directly relates to the type of film you should require. Example: If you wish to outline and quantify (in acres) the extent of a riparian area, natural color film is adequate. If you wish to analyze vegetation composition (i.e., shrubs/trees/grasses), color infrared film is preferred.

4. Scale of photography: The intended use has a direct bearing on the scale requirements. Example: You can locate most riparian areas and make linear (mileage) measurements from 1:24,000 or smaller scale resource photography. However, to visually analyze, delineate, and measure areas to the community level for later comparison (monitoring), a scale of 1:2,400 to 1:3,000 is recommended for narrow strips of riparian vegetation. Wider riparian zones may require photo scales from 1:3,000 to 1:6,000 in order to photographically cover the area with a single strip.

5. Intended use and map base considerations: Prior to initiating actions to acquire photo coverage or collecting any supporting data, the user must clearly define the intended uses of the photographs. If information is to be portrayed as a map, certain considerations must be recognized from the start. An appropriate map base must be chosen. If the information is to be used only to calculate approximate acreages of riparian vegetation, an abbreviated procedure is feasible.

   These considerations are covered more fully in Section IlI.B.1. of this Technical Note.

B. Project Initiation: Start necessary paperwork 3 months in advance of expected flying date to allow time for preparing specifications, photolab work, securing bids, contract award, and prework conference.

1. Specifications for aerial photography acquisition: Technical specifications entitled Special Aerial Photography Specifications have been developed for photo scales 1:2,000 to 1:6,000 and copies are available through the BLM Service Center, Branch of Remote Sensing, D-473. These specifications incorporate the considerations and determinations listed under II.A. 1, 2, 3, 4 of this Technical Note in addition to many other requirements that are necessary to obtain quality imagery. The Specification Detail Sheet - Form 9672-3 (July 1984) is made a part of the specifications as an attachment. It provides space for specific information relative to the acquisition of the photography and any additional requirements not covered in the special aerial photography specifications.

2. Flight map preparation: Flight maps should be prepared from the largest scale topographic maps available, e.g., 1:24,000, 7-1/2 minute quad map. See Special Aerial Photography Specifications - Part II.F.1.a. for guidance in preparing the flight maps. Should assistance be needed in the preparation of flight maps, contact your State Office remote sensing coordinator or the BLM Service Center, Branch of Remote Sensing, D-473.

3. Procurement of photography: The method of contracting for photography is usually determined by the estimated size and cost of the project. Assuming the project cost is within the authority of your contracting officer, some options open to you for contracting the work are:

   a. Issue a formal **Invitation for Bid.** Usually this is done where large contracts are involved.

   b. Utilize negotiated procurement procedures. This usually applies to projects requiring special skills.

   c. Utilize **Standard Form 18** to obtain written quotations. This procedure allows sending specifications, maps, and other items that clarify the request for price quotations. Allow about 3 weeks turnaround time to receive bids.

   d. Employ the **Oral Quotations Form 1510-42** for supplies and services. This is generally used for small aerial photo contracts that can be described sufficiently to get a good price quote over the phone.

   e. Coordination of your project with that of another District or State may reduce the project cost. One of the major cost items is ferry time for the flight crew from the contractor's home base to the project site. If your project can be combined with another project in a nearby area, the ferry time charge will be minimized.

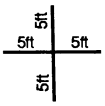
      YOU ARE URGED TO REQUEST TECHNICAL ASSISTANCE FROM THE SERVICE CENTER, BRANCH OF REMOTE SENSING, D-473, ON PHOTO PROCUREMENT MATTERS.

4. Ground targeting (paneling): Ground targeting is essential to let the aerial photography crew know where coverage is to begin and end. Also, the targets make it possible to calculate the actual photo scale. See item III.B.3.a.(2) for more details on the necessity of knowing the actual photo scale. The following is the recommended procedure for placing the targets.

   a. Two targets should be placed at the ends of each stream segment. On longer stream segments, place another set (2) at approximately 2-mile intervals (depending on access) along the stream or at the mid-point of the segment.

      (1) These target sets should be placed 200 to 500 feet apart within the photo coverage area and with one of the targets near the stream where ground data and photos will be taken. An accurate ground distance between the targets should be measured and recorded for later use in determining photo scale.

(2) Targets should be in the form of crosses (+). Each target panel should be 10 feet (ft.) long, and approximately 18 inches (in.) wide.



(3) Targets can be formed from butcher paper that is readily available from butcher shops or grocery stores. The butcher paper is biodegradable and does not require retrieving after the photography is completed. White plastic material may be used but should be retrieved after project completion since it will not degrade rapidly. Targets should be anchored with twine or rocks.

(4) Targets as described will suffice for photo scales of 1:2,400 to 1:6,000. The targeting should be done not more than one week prior to flying to avoid target loss from wind, animal disturbance, or vandalism.

5. Onsite data collection: Take color print 35-mm photographs of the stream/riparian area (upstream, across stream, and downstream) at the site where the photo targets are placed. Record the photo numbers on Form 6602-9, Riparian/Aquatic Information Summary. Collect stream inventory data for a 1/10-mile stream segment. Determine the dominant and subdominant herbaceous vegetation, shrubs, and trees, and the percent bare soil; enter this data on Form 6602-9. Take additional field notes that may assist in photo interpretation.

III. ANALYSIS AND USE OF DATA

A. Options for Performing the Analysis

1. Local BLM staff: Photo interpretation and data analysis should be performed at the local field office level by resource specialists familiar with vegetation and management activities on the site. The procedures outlined in the following sections of this Technical Note have been developed and tested with local analysis in mind.

2. Other BLM assistance: The BLM Service Center's Branch of Remote Sensing staff has considerable experience in this type of analysis and is available for counsel and advice on all aspects of riparian remote sensing. Facilities, interpretation equipment, and staff are available at the Service Center to assist field personnel with analysis.

   State or District level remote sensing expertise should also be called upon, when available, for assistance in planning and accomplishing a project.

3. Contracted analysis: Educational institutions, consulting firms, and other government agencies may offer interpretation and analysis capabilities. For instance, the EPA facility in Las Vegas, Nevada, has cooperated with BLM offices in the recent past. This type of cooperation has varied from performing the analysis and documenting the results to simply making their facilities available for a BLM work session.

B. Analysis Procedures:

1. Considerations: Prior to initiating analysis, several issues must be resolved. The most important one is to clearly define the intended use of the analysis data. Two optional procedures should be considered.

Procedure No. 1 - If the data is primarily to be used to create a map of riparian cover types and other parameters and may ultimately be used within a geographic information system (GIS), map base considerations are critical. For large riparian zones (1/4 mile wide or larger), a 1:24,000 map base (either orthophotoquad or topographic map) may be appropriate. However, on a vast majority of the BLM streams, the riparian communities are so small that they cannot be portrayed at a scale of 1:24,000. This presents a significant dilemma for the use of detailed riparian data within GIS. A possible solution may be to photographically create an enlarged base map from the continuous tone or half tone negative of an orthophotoquad. An orthoquad enlargement to scales of between 1:6,000 and 1:12,000 may be appropriate. If the riparian data is gathered at a photo scale of 1:2,400 a map transfer to 1:6,000 scale would involve a reduction of 2.5 times and is feasible. The riparian plant communities would be quite small, but data entry into GIS would be possible. This procedure is preferred for most applications since greater mapping accuracy can be maintained.

Procedure No. 2 - If the creation of a map is of little or no importance and the dominant use of the data is to gather tabular information concerning approximate acreages, a modified (abbreviated) procedure is feasible. If ground targeting is accomplished, photo scales are calculated and match lines are delineated on each interpreted photo, it is reasonable to tabulate acreages directly from the photos. It must be clearly recognized that the accuracy of the resulting acreage figures are approximations due to the lack of a controlled map base.

2. DESCRIPTION OF ANALYSIS PROCEDURE NO. 1:

TRANSFER INTERPRETED DATA TO MAP BASE AND CALCULATE ACREAGES (preferred procedure)

a. Photo Preparation

(1) **Delineation of match lines:** Match lines should be placed on each photograph in areas where the relief or elevation difference, in a 5-mile segment, is 500 to 1,000 feet. By doing this you will be using the most horizontally correct portion of the photograph and errors caused by relief displacement will be minimized.

Stream courses that have less relief or those that are in flatter terrain have less displacement and therefore, you may choose to use every other photo to put match lines on.

The procedure for placing match lines on photos is as follows:

Step 1 - locate photo centers by making a cross on each photo resulting from intersecting the four fiducial marks on the midpoints of the photo format. See Figure 1.

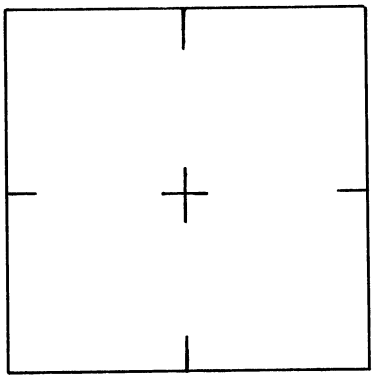


Figure 1

Step 2 - transfer the adjoining photo centers (conjugate principal points [CPP]) on to each photo. Figure 2.

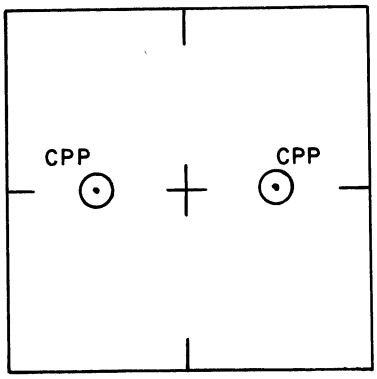


Figure 2

Step 3 - draw your match lines, by using a straight edge, on the first photo halfway between the photo center and the CPP and across the riparian area. Figure 3.

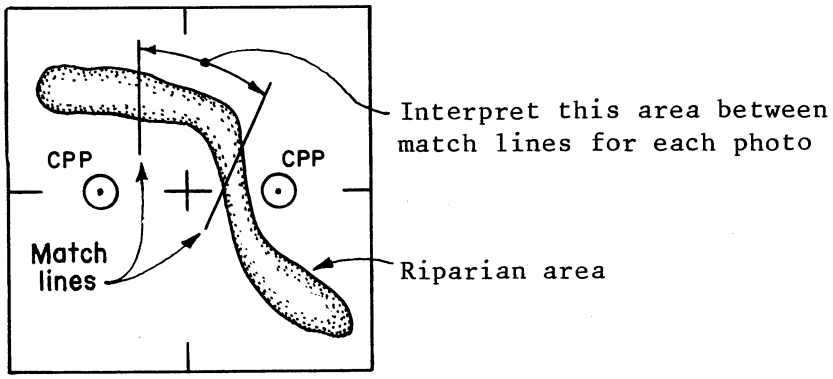


Figure 3

Step 4 - transfer the match lines to the next photo by visually locating high and low points along the match line. NOTE: This line may not be straight. Although this process will take a few hours, it greatly promotes efficiency and accuracy. It will help avoid duplication of interpretations and gaps (holidays) in the delineations.

(2) **Prepare overlays:** Clear acetate overlays (9 in. x 9 in.) should be placed on each frame to be interpreted. A fine point, permanent marking pen should be used. Delineate a line over each fiducial mark observed on the photo. Trace the photo number (e.g., 8-4-1) precisely over the lettering on the print. Trace the match lines precisely from the print. The interpretation overlay is now registered to either a particular transparency or its paper print. It can be removed from over the photo and replaced without fear of misregistration. Figure 4 shows an example of a properly prepared overlay.

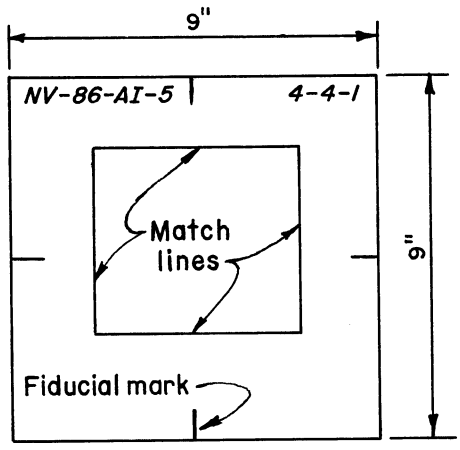


Figure 4

b. Photo interpretation - Prior to initiating photo interpretation, several determinations must be made. A minimum mapping unit (MMU) should be selected. This MMU will serve as a guide for all future delineation and mapping. For purposes of example, we have selected a 1 acre MMU. Although very small features and individual plants are discernible on the large scale aerial photos, a reasonable mapping unit must be selected. The interpreter must keep in mind that his/her delineations will be reduced in size significantly when the data is transferred to the mapping base. Clear boundaries of the polygons and appropriate labels must be transferred to the base map.

A Vegetation Analysis Framework should be developed prior to interpretation. This will describe the characteristics of the dominant and mixed riparian communities to be encountered and delineated. As interpretation proceeds, this framework can be modified as needed. Figure 5 illustrates an example of a vegetation analysis framework. It was used in 1986 during a work session in Nevada and found to be adequate for that environment. Resource specialists are urged to review this framework and create their own based on local requirements. Delineations should be confined to the riparian corridor and everything between the match lines on each photo interpreted. The interpreter should assure that type lines are edge matched with adjoining photos to aid in efficient map transfer.

Stereoviewing of the prints is helpful and photo interpreters should utilize stereoscopes, at least during the initial stages of the project. Stereoscopes are especially helpful in determining relative heights of tree and shrub species.

Although paper prints may be the primary interpretation and delineation medium, it is highly recommended that the color infrared film transparencies be available on a light table during the interpretation. Visually analyzing these transparencies under stereo magnification has proven to be of great value during the analysis process.

While performing the photo interpretation, it is best to proceed from the dominant or "purer" types (easiest) to the more difficult mixed communities. Use of supporting ground photography is encouraged as are visits to the field. Photo interpretation is a "confidence building" exercise and all available supporting data should be used.

Experience has shown that although the first several photos will take longer than normal, a photo interpreter will gain speed and efficiency rapidly once his/her confidence is gained.

VEGETATION ANALYSIS FRAMEWORK

Riparian Plant Community Photo Analysis Form (attach on back of photo when completed)

Stream Name_____ Photo Number_____

Today's Date_____ Interpreter(s)_____

Dominant Species Groups

1. Herbaceous Vegetation - Minimum mapping unit (MMU) is 1 acre. Herbaceous vegetation is dominant and comprises 75% or more of the ground cover. Shrubs and trees may be present but amount to less than MMU.

   1 _____ acres

2. Shrubs - MMU is 1 acre. Shrubs are dominant and comprise 75% or more of canopy. Trees and herbaceous vegetation may be present but amount to less than MMU.

   2 _____ acres

3. Trees - MMU is 1 acre. Trees 10 feet high are dominant and comprise 75% or more of canopy. Shrubs and herbaceous vegetation may be present but less than MMU.

   3 _____ acres

4. Riparian Vegetation scarce or absent - A linear measurement of the length of stream where there is an absence of riparian vegetation in MMU amounts. If less than 200 feet in length, disregard and include in other types (dominant or mixed).

   4 _____ miles

Mixed Communities

MMUs of mixed types are 1 acre. Tree, shrubs, or herbaceous vegetation less than 75% cover with a lesser amount of one or two other groups included in a mixed community.

5. Shrub/herbaceous vegetation 5 _____ acres

6. Tree/herbaceous vegetation 6 _____ acres

7. Tree/shrub 7 _____ acres

8. Tree/shrub/herbaceous vegetation 8 _____ acres

Total Riparian Acres _____

Figure 5

c. Map transfer/tabulation - Section III.B.1. - Considerations described the map transfer process. Prior to initiating the map transfer process, District or State Office cartographic staff personnel should be consulted. It is critical that proper procedures be followed, especially if GIS data entry is anticipated.

3. DESCRIPTION OF ANALYSIS PROCEDURE NO. 2:

CALCULATE APPROXIMATE ACREAGES DIRECTLY FROM PHOTOS (abbreviated procedure)

a. Photo preparation

(1) **Delineation of Match Lines:** Procedures used would be identical to those described in Procedure No. 1.

(2) **Calculation of Photo Scale:** The "nominal" or "contracted" photo scale (1:2,400 or 1:6,000) is not the actual photo scale. When severe elevation changes occur within any photo strip, the actual photo scale will vary considerably; therefore, the mensuration results are affected. The actual photo scale should be calculated utilizing the ground distance (obtained when targets were originally placed) between each target set and an average scale for the flight strip be determined for mensuration purposes.

The suggested formula for calculating photo scale is the ratio of photo distance (PD) to ground distance (GD). In order to ratio, like units of measure are necessary. Therefore, convert the ground distance to inches. Example: The ground distance between targets A and B is 400 feet. The photo distance between targets A and B is 2.0 inches. The formula is:

$$\frac{2 \text{ in. (PD)}}{400 \text{ ft. X } 12 \text{ in. (GD)}} = \frac{2 \text{ in. (PD)} \div 2 \text{ in.}}{4{,}800 \text{ in. (GD)} \div 2 \text{ in.}} = \frac{1}{2{,}400}$$

or the photo scale is 1:2,400. This means that 1 inch on the photo is equal to 2,400 inches on the ground or 1 inch on the photo is equal to 200 feet on the ground.

Should other scale calculations be needed, they can be obtained by measuring the distance between two photo and map identifiable points in the areas needed. Example: Map distance between two points is 1.2 inches. 1.2 inches X map scale (1:24,000) = 28,800 inches, which becomes ground distance at this point. Photo distance between the same two points is 5.7 inches. The ratio, therefore, is 5.7 inches :28,800 inches. To ratio photo distance to ground distance, simply divide 5.7 inches by 5.7 inches and 28,800 inches by 5.7 inches; or,

$$\frac{5.7 \text{ in.} \div 5.7 \text{ in.}}{28{,}800 \text{ in.} \div 5.7 \text{ in.}} = \frac{1}{5{,}052}$$

or 1:5,052 which is the photo scale.

(3) **Prepare overlays:** Procedures used would be identical to those described in Procedure No. 1.

b. Photo interpretation

In general the procedure as described in Procedure No. 1 also is appropriate for this effort. Even though this procedure calls for direct calculation of polygon acreages from photos, selection of an MMU is still important to assure efficiency and consistency in the acreage determinations. In addition, development and utilization of a Vegetation Analysis Framework is required.

c. Measurement/tabulation

After all polygons are completed, labeled, and edge-matched with adjoining photos, the measurement and tabulation phase can be initiated. Many field offices have access to digital planimeters (i.e., Numonics or equivalent) that allow direct calculation of acreages if a photo scale is entered. Small, portable digital planimeters can also be rented on a daily basis for a reasonable cost.

There is a considerable amount of development occurring at this time related to ways of automating the capture of polygon data. Some of these techniques utilize video cameras and "line-following" techniques. Resource specialists are urged to contact their district or state office remote sensing specialists or the BLM Service Center, Branch of Remote Sensing if they want to know the current capabilities and availability of this type of technology.

As the data is assembled, it should be recorded on an analysis form. (A form similar to Figure 5 can be utilized.) The data can be recorded by photo number and subsequent tabulation by other subdivisions (allotment, ownership, stream segment, etc.) is possible if desired.

IV. MONITORING

Initial large-scale aerial photography of a riparian area provides an overview of existing conditions in terms of the readily interpreted variables. Subsequent photos over time provide the means of detecting change in these variables. Subtle change due to the lack of or above normal precipitation may not be evident as compared to the catastrophic change caused by a 100-year flood.

The most easily detected change in a riparian area would be a reduction in foliar cover and an increase in bare soil. This change may be obvious upon inspection of the baseline (initial) photo compared with the monitoring photo taken 5 to 10 years later. The cause of the change may be answered only by on-the-ground inspection; thus the photos offer the opportunity to monitor the extent of change but not necessarily the cause.

A. Acquiring Rephotography: The same considerations outlined previously in Section II of this document (Establishing the Photo-Baseline Data) should be used to plan the rephotography for monitoring purposes.

1. Area selection: The area should be the same as originally photographed unless you no longer have a need to monitor and manage a section of stream.

2. Season and time of day: The season should be the same general time as the original photography. This will make the photography easier to interpret and the changes more obvious.

3. Film type: The film type should be the same as the original if the photography will be used for the same purpose.

4. Scale of photography: The photo scale should be as near the original photo scale as possible to enhance the change comparisons.

5. Specification for aerial photo acquisition: The technical specifications should be the same as the original photography.

6. Flight map preparation: The flight maps should be prepared using the same careful considerations as the original flights.

7. Procurement of photography: The same procurement procedures used for the baseline photography should be used again unless there is a major difference in project requirements.

8. Ground targeting: Ground targeting is just as essential to the rephotography as it was for the original photography. The targets will make it possible to calculate the actual photo scale for mensuration and will notify the flight crew where to begin and end photography.

B. Variables that can be Monitored:

Experience has shown that changes in the following variables can be determined via photo interpretation of large-scale (1:2,400) aerial photography.

Variable	May be Photo Interpreted or Calculated
Plant Species Composition	
Trees	Yes
Shrubs	Yes, some shrubs such as willow and baccharis
Grasses	No
Forbs	No
Ground Cover	
% Trees	Yes
% Shrubs	Yes
% Herbaceous Vegetation	Yes
% Bare Soil	Yes

(Cont.) Variable	May be Photo Interpreted or Calculated
Density	Yes, large trees and some shrubs, such as cottonwood and willow
Reproduction	Yes, young trees and shrubs but not seedlings
Condition Class	No
Trend	Yes, as related to change in the amount of ground cover and bare soil
Potential	No
Structure	Yes, height of trees and shrubs
Streambank Shade	Yes
Stream Width	Yes
Flood Plain Width	Yes
Streambank Stability	Yes
Streambed Silt	Yes
Stream Channel Stability	Yes

C. Analysis Procedure:

Step 1. Old and new photos over the entire stream section should be visually compared. Via this process, not only can critical key areas be evaluated but changes occurring on non-study areas can also be detected and documented. One of the important advantages of a photo-based monitoring system is the ability to expand the area that can be evaluated as compared to entirely ground-based study.

Step 2. It is anticipated that several key areas will already be selected prior to the acquisition of the rephotography. Closely evaluate these sites. Perform a reinterpretation on these key areas and compare results. Please keep in mind that the critical steps performed during the baseline interpretation (see III.B.2. or III.B.3.) are still essential for the reinterpretation.

In addition, if your visual comparison (Step 1) identified further areas of change, a reinterpretation may be appropriate.

Step 3. Once the photo interpretation and analysis have been completed, an onsite field visitation may be required to further quantify the changes and investigate the causes of change.

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

This Technical Reference describes technical considerations and procedures for acquisition and use of aerial photography for riparian area inventory and monitoring. Preplanning is crucial and considerations such as area selection, season and time of day to fly, film type and scale of photography are discussed. Also discussed are, when to begin the initial paperwork, specifications, and flight map preparations, leading to the procurement of aerial photography. Optional methods for the procurement are presented. Options for performing the analysis and step-by-step analysis procedures are described. Items are presented that should be considered prior to analysis, photo preparation, photo interpretation, and procurement of re-photography for monitoring. Variables that can be monitored are addressed.

17. Document Analysis a. Descriptors

Aerial photography 1405
Aerial survey 0802

b. Identifiers/Open-Ended Terms

Riparian area inventory
Riparian area monitoring

c. COSATI Field/Group

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