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Producing high-quality NEGATIVES from ERTS black-and-white TRANSPARENCIES

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Abstract: A method has been devised for producing high-quality black-and-white negatives quickly and efficiently from dense transparencies originating from Earth Resources Technology Satellite imagery. Transparencies are evaluated on a standard light source to determine exposure and processing information needed for making negatives. A "System ASA Rating" was developed by testing and selecting combinations of film, light sources, and developer. Changes in film density and contrast of negatives owing to reciprocity effects are controlled by calculating adjustments in exposure and development. The method described can be used in relatively small darkrooms without expensive equipment. Its usefulness was demonstrated in a high-altitude photo mission over the Black Hills National Forest, South Dakota.

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A major benefit expected from the Earth Resources Technology Satellite (ERTS) was a synoptic view of large areas taken in four separate wavebands from more than 550 miles in space. ERTS imagery provides the land manager an up-to-date photo map of an 85,000-acre area at different times (seasons) of the year. Heller[1] reported that this imagery offers promise in forest management and inventory work over extensively forested areas, although the results to date are experimental and not ready for immediate use.

This experimental satellite was launched on July 23, 1972, by the U.S. National Aeronautics and Space Administration (NASA). It records scene information by means of a multispectral scanner and relays electronic signals to ground facilities. The signals are converted to conventional photographic film images in the form of positive 70-mm. transparencies by an electron beam recorder.

Copies made from the archival transparencies can be obtained from NASA in the form of third-generation 70-mm. black-and-white positives and negatives. Most of the positives have been of good quality, but the negatives have been extremely dense. Consequently, the negatives have a high fog level, a reduced density range of the gray scale, and a loss of image contrast. The gray scale shown on each 70-mm. transparency has 15 steps, but only seven or eight can be discriminated on the dense negatives.

The remote sensing research unit of the Pacific Southwest Forest and Range Experiment Station is using ERTS imagery to study forest resources. The unit's photographic staff has found it difficult, however, to make satisfactory enlargements (10X to 30X) from the NASA-produced negatives for field and other uses. And much vital information has been lost because the negatives were overexposed. I knew of no darkroom technique for restoring this information—even by using instructions from NASA on processing methods for ERTS negatives.[2]

Long exposure is needed to make enlargements from the dense negatives. A 4X enlargement, for example, requires an exposure of 10 to 15 minutes. Even higher magnification requires unreasonably long exposure—and this can have adverse effects on the finished print, such as loss of critical detail.

I have developed a technique for producing high-quality black-and-white negatives from ERTS transparencies. This method insures that the same quality is maintained from one pass (orbit) to the next as well as from season to season. It can also be used to make negatives from any transparencies—black and white or color. The method can be followed in a small darkroom without any large investment of money.

MATERIALS AND METHOD

Each ERTS transparency is evaluated on a light source to determine the correct exposure and processing information. I use either channel 5 (0.6 to 0.7 μm) or channel 7 (0.8 to 1.1 μm) for making copy negatives. Through a series of tests, a "System ASA Rating" was derived for a particular film emulsion. This was done in conjunction with both the illumination provided by the evaluating light source as well as the exposing light source. Once these light sources have been established they should remain as standards. Changes in film density and contrast, due to the reciprocity characteristics of the emulsion, are controlled by use of the Reciprocity Effect Compensation Table *(table 1)*. Use of the table helps eliminate all preliminary testing.

Equipment

Any light meter can be used to read the over-all density (light value) of the test transparency. The light source used to evaluate the test transparency is the standard to which all transparencies will be compared in the future. This standard can be a light table, transparency illuminator or viewer, contact printer, or even a homemade light box consisting of a lamp and a diffusion screen. But the standard must remain unchanged.

An enlarger was used as a source of illumination to contact expose the negative image from the ERTS transparency. The selection of an enlarger over other printing equipment was due to its versatility. Desirable features of an enlarger permit variations in exposure time, aperture opening (f stop), distance between lamphousing and easel, and the use of neutral density filters. Neutral density filtration of 100 (color compensating filters—cyan, magenta, and yellow) was used to control exposure time. The unexposed film and the positive transparency are placed on the enlarger base and held flat with a piece of optically flat glass.

Table 1—*Steps to be used for compensating for reciprocity effect in processing film*[1]

If indicated exposure time (seconds) is . . .	Use . . . *Either* this lens aperture adjustment	*Or* this adjusted exposure time	*And,* in either case, use this development adjustment . . .[2]
	Stops	*Seconds*	*Percent*
1/2	1 more	1	25 less
1	1 more	3	30 less
5	1-2/3 more	20	35 less
10	2 more	55	35 less
15	2 more	85	35 less
50	2-1/3 more	370	40 less

[1]Source: film data sheet for Kodak Ektapan Film-4162, March 1969.
[2]Apply the percent adjustment to correct the developing time selected in *table 2*.

Processing the exposed sheet film can be handled in either a tray or a tank, depending on the number of sheets to be handled at one time.

Films, Developers

Several films and developers were tested for use in making negatives from ERTS transparencies. I found that Kodak Ektapan Film (Type 4162)[3] was the best for this task. Ektapan film is a medium-speed (ASA 100), very fine grain, extremely stable (Estar base), panchromatic film. A high-quality negative was produced by processing Ektapan film in Kodak Microdol-X film developer. Microdol-X Developer has the characteristics of low graininess coupled with maximum sharpness and renders a low fog level.

"System ASA Rating"

To use the light meter, a light standard, an enlarger (illuminator), Ektapan film, and Microdol-X Developer in the right combination, I had to first find a usable ASA rating. This was done by a series of test exposures. The film exposure time was kept constant and the enlarger lens aperture (f stop) setting changed (e.g., 10 sec @ f.8, 10 sec @ f.11, 10 sec @ f.16). The test film sheets were notch-coded for identification, and all exposure variables were recorded. They included: exposure time and f stop; lens used; distance from lens to base (easel); diameter of light beam on easel (focus control); variable enlarger settings; and neutral density filtration—if used.

Before developing the test exposures, it is necessary to compensate for reciprocity effect. Reciprocity

Table 2–*Developing times*[1] *based on 1/100 second Ektapan Sheet Film and Microdol-X Film Developer,*[2] *by solution temperature*

Developing method	65° F.	68° F.[3]	70° F.	72° F.	75° F.
	Minutes				
Tray (continuous agitation	12	10	9½	8½	7½
Tank (agitation at 1-minute intervals)	16	13	12	10	9

[1]*Must* adjust for reciprocity effect by using adjustment figures in *table 1*, column 4.
[2]Kodak Ektapan Film-4162 data sheet, March 1969.
[3]Most often used temperature.

failure can occur at exposure times exceeding 1/10 second because of the characteristics of the emulsion. To compensate for changes in density and contrast, use *table 1* and *table 2. Table 1* shows that the 10-second test exposures required 35 percent less development. The tray method (temperature of developer –68°F) requires a developing time of 10 minutes *(table 2).* Because of the long exposure, however, the adjusted developing time for the test exposures processed under these conditions was 6½ minutes (i.e., 35 percent of 10 minutes = 3.5 minutes; therefore, 10 minutes less 3.5 minutes = 6.5 minutes).

After the film was processed and dried, the negatives were examined for over-all density, contrast, gray scale, fog level, and detail. Contact prints were also made from the test negatives and evaluated. A negative was selected that had a good range of gray levels, a minimum fog level, and the sharpest detail.

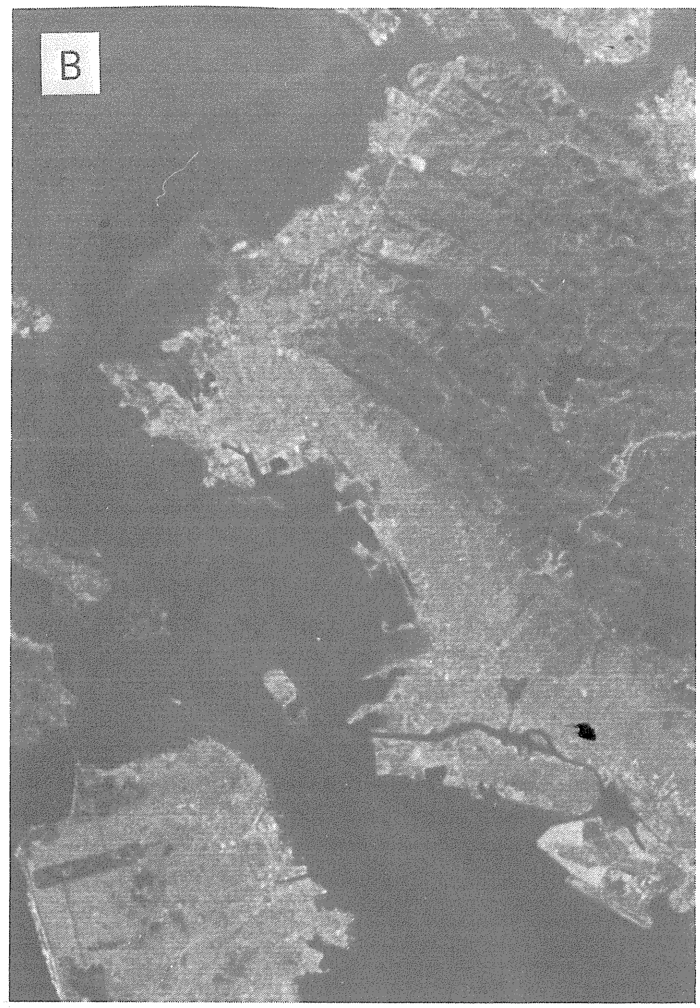
After the test and the evaluation were completed, these known values were used to determine the "System ASA Rating": (a) exposure time (seconds); (b) aperture setting (f stop); (c) lens aperture adjustment (column 2 of *table 1*); and (d) light value of transparency (obtained with meter, transparency, and standard light source). By using a light meter, we can calculate the "System ASA Rating." For example, the best test negative selected was exposed at f.8 for 10 seconds. Since *table 1* showed a lens aperture adjustment of 2 stops more, the calculated exposure used in working backwards to arrive at a film speed computes to be f.16 for 10 seconds. With the light meter set on a light value of 9 (measured from the transparency on the standard light source), the dial was rotated until f.16 was aligned with 10 seconds. The number that appeared in the ASA window of the computer was the new "System ASA Rating." ASA 2 was the rating arrived at for this particular system.

The technique classified here is unique in that it is composed of specific pieces of equipment and one particular film type. Others using it must go through this procedure with their own equipment to arrive at their own "System" rating. A different "System ASA Rating" was established for making enlarged negatives from the 70-mm. ERTS transparencies.

STEP-BY-STEP PROCEDURE

With the new "System ASA Rating" known, a fast, efficient method is available for producing negatives from ERTS transparencies by following these steps:

1. Obtain a light meter reading for the transparency on a standard light source.



2. Find an exposure setting (f stop and time) with the light value and "System ASA Rating."

3. Use *table 1* for adjusting exposure for Reciprocity Compensation—adjust aperture or time, but not both.

4. Set enlarger in the same configuration as the one used when test exposures were made.

5. Expose negatives according to the adjusted exposure settings (from step 3).

6. Set up for processing by either tank or tray method and prepare chemicals (developer, stop bath, and fixer).

7. Just before processing, take temperature reading of developer and find developing time in *table 2.*

8. Reduce the developing time *(table 2)* by the percent development adjustment called for in *table 1.*

9. Process the film according to the instructions received in the film package, except for adjusted developing time.

Enlargements

If extreme enlargements are required, portions of the ERTS transparency can be enlarged onto Ektapan film. This method will permit larger blowups over that attainable with a contact negative. The advantage of an enlarged negative (2X or 3X) over a contact negative is a reduction in the noticeable granularity (the graininess of developed image) in the final enlarged print. A different "System ASA Rating" will need to be determined for making the enlarged negatives.

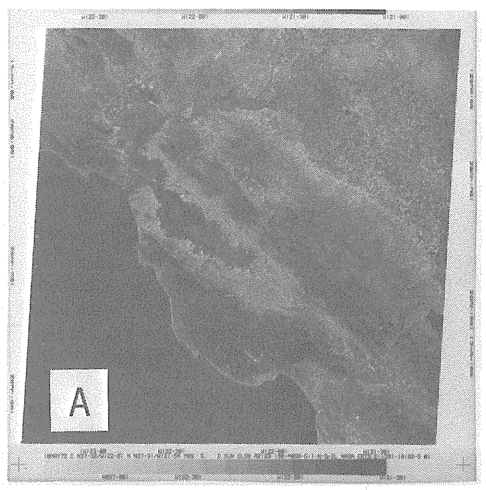
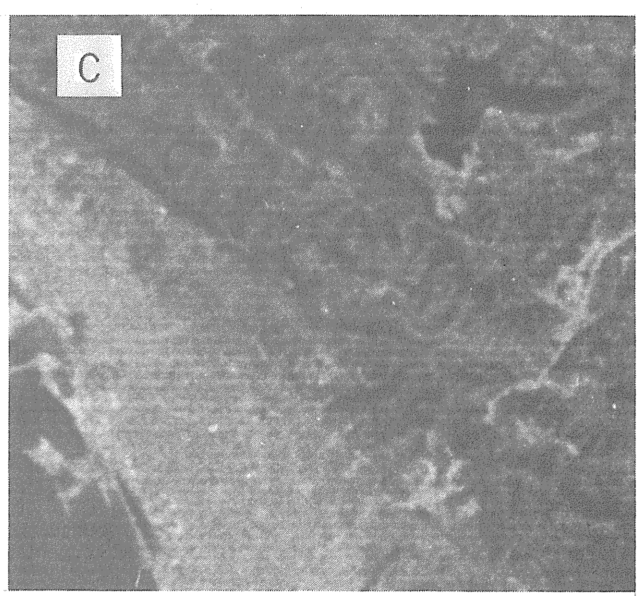
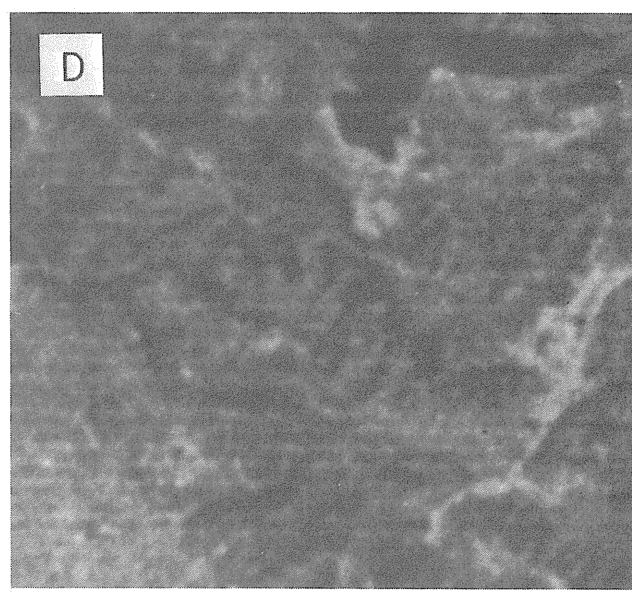


Figure 1—Prints made from a Forest Service-produced negative: **A**, contact print (1:1); **B**, 10X enlargement; **C**, 20X enlargement; **D**, 30X enlargement. The negative was made from an ERTS transparency (ID 1291-18182-5) that shows the San Francisco Bay area. Scan lines become more noticeable as magnification increases. Imagery is from Multispectral Scanner band 5 (red, 0.6 to 0.7 μm), May 10, 1973.





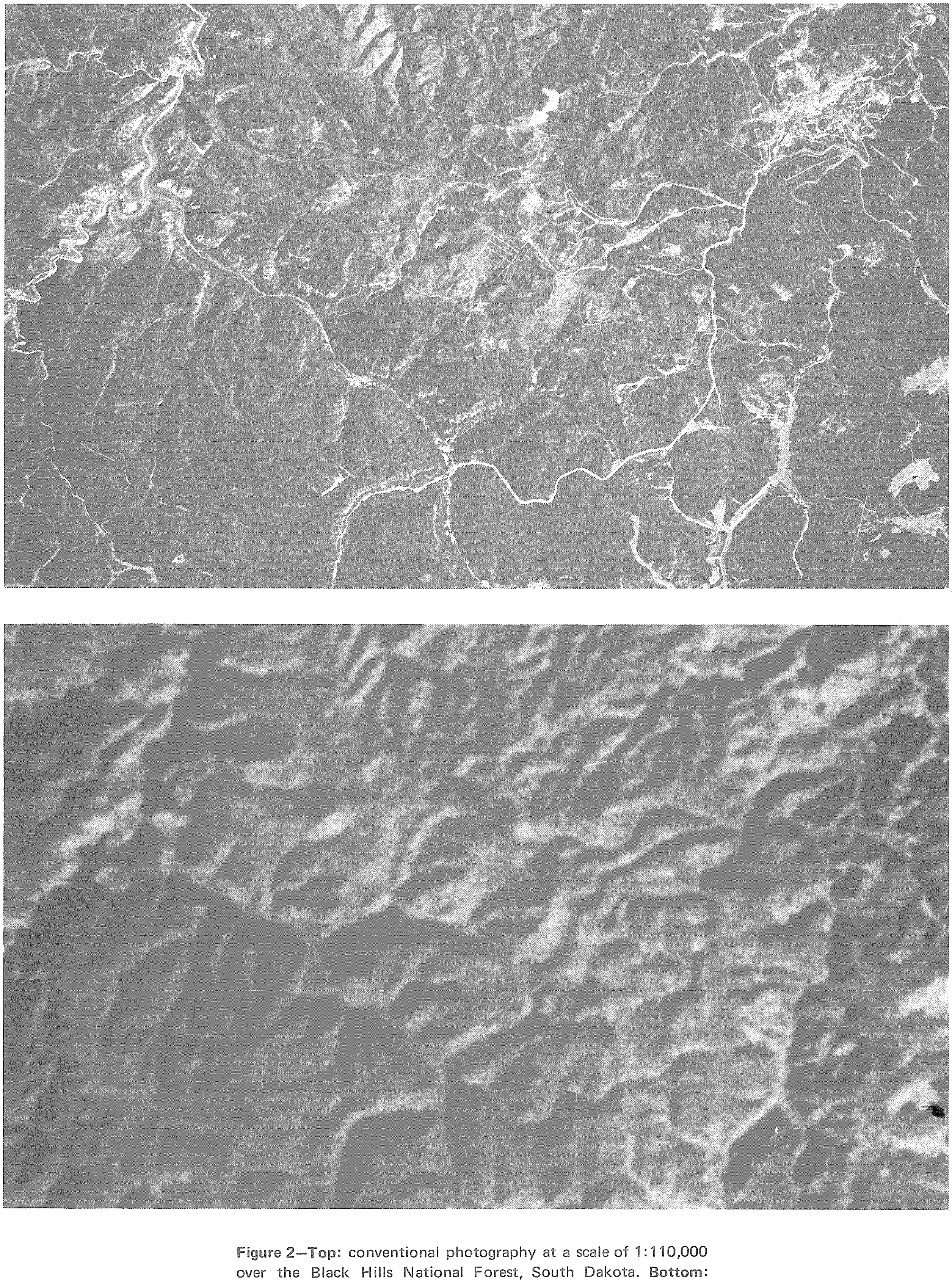


Figure 2—Top: conventional photography at a scale of 1:110,000 over the Black Hills National Forest, South Dakota. **Bottom:** ERTS image (ID 1172-17123-7) enlarged about 30X for comparison; ERTS image is channel 7 (0.8 to 1.1 μm), January 11, 1973.

Prints

Enlargements can be made on variable contrast photo paper and the over-all contrast controlled by means of filters. Polycontrast Paper or Polycontrast Rapid Paper developed in Dektol Developer is a good combination.

With a good negative, prints can be made ranging in size from contact (1:1) to 30X or even beyond *(fig. 1). Figure 2* illustrates 30X enlargement made from a negative produced by the method described and shows how it compares with conventional photography taken by high-flying aircraft. A variety of scales can be achieved by enlarging the negative to match existing maps, aeronautical charts, or high-altitude aerial photography. The particular scale desired can be produced by superimposing the negative image (in enlarger) onto the map, chart, or aerial photo placed on the easel.

A practical use of prints made from the negatives produced by this method was demonstrated on a recent high-altitude photo mission over the Black Hills National Forest in South Dakota. Existing Forest Service maps at a scale of ½ inch = 1 mile (1:126,700) lack the type of detail and information that is helpful for photo navigation. An ERTS image was enlarged and scaled to the National Forest map and flight lines transferred to the photos. The photo crew found these photos to be far superior to the maps that had been used in the past.

NOTES

[1]Heller, Robert C. *ERTS imagery–problems and promises for foresters.* 1973. (Paper presented at Meeting of Remote Sensing Subject Group, Intern. Union of Forest Research Organizations, Freiburg, West Germany, Sept. 19, 1973.)

[2]U.S. National Aeronautics and Space Administration. *Processing methods for ERTS negatives.* ERTS Investigators' Bull. A(13): 1-4. 1973.

[3]Trade names and commercial products and enterprises are mentioned solely for information. No endorsement by the U.S. Department of Agriculture is implied.

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