Y. Dodson

80-19

Mike:
Didn't know
if you had
this one
Don

HOPEFULLY HELPFUL GUIDE

FOR THE

LANDSAT ANALYST

or

How to Convince Others You Think

You Know What You're Talking About.

by

R. Bruce Bonar

July, 1980

I. Basic LANDSAT Characteristics

A. A LANDSAT image is scanned in the green, red, and photo infrared wavelengths of the spectrum. The data from each band is converted to a black and white negative chip. A color negative is made by exposing color film to blue light filtered through the green negative, green light filtered through the red negative, and red light through the photo infrared negative. This color negative is used to make transparencies and paper photo products.

B. Basic Colors for Things (real and otherwise)

Water- Water appears blue to black. The cleaner and deeper the water, the darker the blue color. Lighter colors are usually the result of high turbidity, not due to temperature.

Cities and Other Urban Areas- Cities appear light blue-gray to bright blue. Concrete is usually white or very light blue. Asphalt is very dark blue or black. (See the Beltway on the Washington,D.C., area. The Maryland beltway is asphalt from the Cabin John Bridge to Georgia Avenue. From Georgia Ave. to the Woodrow Wilson Bridge, the pavement is concrete.)

Clouds- Clouds are white. The shadows should be black, and have the same shape as the clouds they are next to. Distances from the clouds to their respective shadows should be similar for all clouds in a given area.

Bare Soil- Soil colors vary greatly.They can be shades of green,gray, blue, or brown. Moist soils are darker than dry soils. Bare rock is often brighter than more developed soils. Granite in the High Sierras (California) is light blueish white. Different soil types have different signatures.

Vegetation- Growing, green vegetation reflects photo infrared very well, hence its bright red appearance on LANDSAT. As plants grow, ripen, and die; their signatures change. More about this later.

C. Color Variations

In the photo process involved in making paper enlargements, there can be a substantial amount of color variation. This can even occur in 2copies of the same scene, same date. Examine scene edges, clouds, beaches,etc., to determine if color is accurate.

Additional color variations can occur across a single scene. Local recent rainfalls in a dry period will make soils darker(moister) and vegetation redder(greener.)

All this means no single color key will work for all scenes, for all dates. Only water(including snow and clouds) is somewhat consistent.

D. Other Problems

Distortion- In the photo enlargement process, there is some distortion in the print; the distortion being greatest near the corners and edges of the print. When using landmarks for locating reference points, try to use ones closer to the center of the scene.

In addition, early 1980 scenes(and possibly some late 1979scenes) have a distortion as a result of a satellite problem. Overlays made from earlier scenes may not line up with 1980 scenes.

II. Native Vegetation

Very large areas (usually greater than 5 square miles) lacking obvious field patterns are likely to be native vegetation. Color and texture will be similar throughout the area, but close inspection will usually reveal a somewhat mottled appearance.

A. Marshes- Marshes are found in lowlands, along streams and rivers. They generally appear deep, dark red. A red vegetation signature is mixed with a dark water signature to produce a darker color than that of dryland vegetation. Areas with a dense tree canopy will appear brighter red (like a forest), mottled with deeper red marsh signatures. Salt marshes and land frequently inundated (wetlands) will be very dark, with very little red.

B. Forests and Brushland- Forests also appear red in summer. In areas of sufficient rainfall, forests will be found in uplands and mountains. Terrain often makes these areas unsuitable for agriculture, unless population pressure large enough to press marginal land into cultivation. In more arid regions, forests are limited to stream valleys where moisture is available. Brushland is usually found in sub-climax ecosystems (like abandoned fields) or at the fringes of forests in arid regions, where moisture is not sufficient for trees.

Forests appear a deep red due to shadows from tall trees. Evergreen forests may be distinguished from deciduous forests by looking for "green-up" (turning red) of the deciduous trees in the spring. Evergreen trees should appear red throughout the winter, deciduous trees will be gray-brown after leaves drop in the fall.NOTE: If an evergreen understory is present (mountain laurel, etc.), there will still be some red in the winter. However,it should not be as bright as a summer red.

Natural stands of trees should have a mottled appearance. Shade from large trees suppresses growth of new trees, resulting in a large crown, surrounded by less dense vegetation. As large crowned trees die, growth of surrounding vegetation increases. This creates a mottled appearance.

Extremely dense, homogeneous red forests in smaller areas are possible tree crops. It is unlikely such a homogeneous texture would occur without some kind of cultivation. These trees may either shade crops below (coffee), or produce fruit (bananas).

C. Grasslands- Praries and grasslands are usually flat or rolling areas in regions too arid for a climax forest to develop. Grass should also appear red in summer, but not as dark as forests (due to forest shade). Native grasses should have a senescence similar to cultivated crops such as wheat, oats, and barley. These cultivated crops will be brighter due to fertilization, irrigation, and pesticide use to increase productivity. They will also show a soil signature sometime during the year, in preparation for planting.

Unimproved pasture will appear much the same as native grasses. Pasture fields will usually remain pasture for several years or more. Look at scenes in different years to locate pasture by its consistent appearance.

Improved pasture includes those fields fertilized or irrigated, and those planted to hay crops for forage. These improved pastures will be a brighter red than unimproved pasture and native grassland. Hay may be planted for forage, or it may be cut and baled. Up to three hay crops may be cut per year in North Carolina and Georgia. Hay is green when cut, it should have no ripening signature before harvest.

D. Beaches- Beach sand appears bright white. Backdune vegetation(dune grass, sea oats, etc.) appear mottled browns and reds. Few cultivated crops are sufficiently salt tolerant to grow if these areas. Areas further in from the ocean will support growth of pines, appearing red and mottled red brown.

III. Crops

A. Basic Crop vs. Non-Crop- Crops can be distinguished from non-crops by the following:

1. Field Patterns- Large fields and pivot irrigation show field patterns well. The western United States , in particular, shows field patterns extremely well, compared to native vegetation. It is very difficult to find individual fields when field size is less than 100 acres. Field size can be deceiving. Many small fields separated by narrow, dirt trails may appear similar to large fields.

2. Planting- A soil signature should be present at least once during the year, if an annual crop is planted. Soil signature should be visible from field preparation before planting, through planting, until plants have emerged sufficiently to obscure the soil signature.

3. Crop Senescence- Annual crops have different signatures as they grow, ripen, and are harvested.

B. Crop Senescence

Most annual crops go through the same 7 stages in growth and harvest. The colors for the stages vary from crop to crop; due to physical characteristics of the plant, cultural practices, soil types, physical and climatic conditions. Unfortunately, colors for each stage also vary for the same crop in different locations on the same scene. How healthy a crop is will affect its physical appearance, giving a different signature.

Those factors which affect the signatures of soil and native vegetation

can also vary the signatures of crops in different stages of their senescence. These 7 stages are:

1. Plowing- Field work in preparation for planting results in a dark soil signature. Freshly plowed soil will be moister than soil which has been exposed to the sun for several days. Most fields are plowed sometime before planting.

2. Pre-Emergence- The plant is beginning to emerge from the soil. The appearance is still a soil signature, but lighter than that of fresh plowing. The plant has not developed enough leaves to obscure the soil signature.

3. Emergence- The plants are now getting taller, spreading out. The result is a mixture of soil and plant signatures. The color is usually a pink or tan. As leaves spread out into a canopy over the soil, the soil signature will disappear.

4. Growing- Healthy, growing plants reflect photo-infrared like there is no tomorrow. All crops are some shade of red when in their prime. The bright reds are most common. Variations in color can be due to row spacing, crop height (shadows cause a darker red), health of the plant, rainfall,etc.

5. Ripening- As crops ripen, growth begins to decrease. Some crops yellow as they ripen, some drop their leaves; the result is a decrease in the red color. In addition, the dead leaves add a bright tan color, and soil signatures may also become visible again. A mottled appearance develops as the red color decreases.

6. Dead Ripe- When the crop is standing dead ripe in the field, it no longer has a red signature. It has lost all its green leaves, and reflects

no photo-infrared. The appearance is a mixture of soil and dead vegetation signatures.

7. Harvest- The color of the harvest and post-harvest signatures depend a great deal on the local cultural harvesting practices. A light tan or white signature will result if stubble and stalks or leaves are left strewn over fields after harvest. Wheat is a good example of a crop with a white post- harvest signature.(See IV A. "Wheat.") If a minimal amount of dead plant material is left in the fiedls. the soil signatures will be more dominant.

Look at scenes during harvesting time to find fields with harvesting in progress. Wheat is the best example of this. The patterns of combining wheat is the U.S.A. show up very well on LANDSAT, primarily because the field sizes are usually quite large.

After harvest, fields may be replanted with another crop, planted to hay or other ground cover, or simply left idle. Post-harvest stubble may be plowed under, or the stubble may be left standing to be grazed by cattle or hogs. (In the U.S. Corn Belt, hogs eat corn stubble after harvest.)

IV. Some Specific Crops

A. Wheat- The following are "Bob Payne's Colors for Wheat":

1. Plowing- Brown (soil)
2. Pre-Emergence- Light green to white
3. Growing- Deep red
4. Ripening- A yellowing green, growing greener
5. Dead Ripe- Dark green or olive
6. Harvested- white or light tan

Winter wheat is easy to separate from summer crops by its harvest date. Partially harvested fields are easily identified during the harvest

season.

It is not possible to separate wheat from barley with visual analysis of LANDSAT. Oats will also be very similar in appearance.

Because of their respective growing seasons, wheat can be rotated with soybeans in the same field during one year. This is practiced a great deal in the major soybean area of Brazil. In this area, the post-harvest stubble of the wheat crop is not plowed under after the harvest. Soybeans are planted directly into the wheat stubble. Since some dead wheat straw is still on the fields during planting, the soil signature may not appear as dark as would be expected.

B. Soybeans- Soybeans are grown on bushy plants. The beans form in pods hanging from the plant. They are grown in larger, flatter fields like those of wheat. Soybeans are harvested by combine, much like the harvesters for wheat. With modifications, the same harvester can be used for both crops.

Soybean senescence signatures are very similar to those of wheat. Soy is bright red at peak growing period. It turns greener as it ripens, and gets deeper green as it drops leaves. The plant drops all its leaves prior to harvest.

Look at the planting and the harvesting dates to separate soybeans from corn. Corn is planted earlier, ripens and is harvested earlier. Corn should show a ripe (greenish) signature while soybeans should still be bright red.

C. Corn- Corn senescence signatures are also much like those of wheat, and of soybeans. Because corn plants are taller than soy plants, the shadows give corn a darker red during the growing season.

In the U.S.A., corn can be planted in large fields and harvested by

combine, like soybeans and wheat. Corn can also be planted on small hillside fields and hand harvested. In Brazil, we expect to see corn in the smaller, hilly fields; wheat and soy in the larger, flat fields in the valleys.

Post-Harvest signatures for corn can vary. If the stubble is gathered for silage, the post-harvest signature should be darker, with mostly a soil signature. If the stubble is left in the field for grazing, the signature will be lighter, getting progressively more like that of a soil signature as the stubble is eaten. Looking at harvest dates may help identify corn.

D. Rice- Rice requires fresh water for irrigation to flood the fields. Fields must be flat (or terraced) to hold the water. Good growth requires high temperatures in the growing season. Flooded fields are drained before harvest, and harvest is usually by combine in mechanized areas. (In the Far East, rice can be harvested while fields are flooded,by approaching the plants in low,open boats.the farmers beat the heads of the plants inside the boats, shaking the rice kernels into the floor of the boat.

Rice fields should appear dark (water) in pre-emergence. Dark signatures from water will be subdued when a canopy of rice plants covers the water. As the flooded fields are drained before harvest, the plants should take on a typical ripe crop signature. Typical harvesting and post-harvest signatures can also be expected.

Irrigation requirements make it necessary to locate rice fields near sources of water. In Brazil, numerous small reservoirs with a small number of fields downstream are found. There is a good probability these fields are rice. Rice is also found in delta areas where land is flat and fresh water is abundant.

E. Tobacco - Tobacco is limited to small field sizes. Of all tobacco fields, 95% are planted 4 rows, skip 1 row. In addition, tobacco can also be in alternating strips with other crops in the same field. The result will be a mottled appearance. Flue cured and cigar wrapper tobaccos are harvested by cutting the leaves individually as they ripen. The red growing signature should become fainter as the leaves individually ripen and are picked. Other ~~tobaccos~~ are harvested by cutting the stalk and removing all the leaves at once. Post-harvest will show a soil signature, since there is no dead vegetation covering the soil.

Hand labor requirements (and other considerations) restrict tobacco to small fields. This small field size, and planting other crops in fields with tobacco, should make it very difficult to distinguish individusl fields of tobacco. In North Carolina, harvest starts July 1, and is completed around August 30. County data on the amount and type of tobacco grown would be essential in trying to locate tobacco fields. LANDSAT coverage for the first days of September should ~~show bare soil~~ for all tobacco in North Caroilna. Corn is the only other crop to begin harvest this early, but the majority of the corn should appear ripening or dead ripe.

Good coverage of planting and harvesting dates should enable separation of tobacco areas from crops other than corn.

F. Cotton- The size of cotton plants depends upon the climate. In tropical conditions, cotton plants grow into trees. At the northern edge of the Cotton Belt, the plants are much smaller.

Cotton should have typical signatures for planting and growing stages. Plants are defoliated before harvest. Plants must still be green when they are defoliated, so the chemical will circulate through-

out the plant. This means cotton should have a bright red signature right up until spraying the defoliant. This usually occurs September 21 to Sept. 25 in North Carolina. Leaves should die and drop soon after spraying, showing a mixture of soil signatures covered with dead vegetation signatures. Crop harvest begins October 5 in N.C. Harvest signatures should be a typical tan-brown, with not much white present.

Cotton and corn have the same planting and harvesting dates. Look at scenes before September 21, before October 5, and shortly after harvest. Corn should be ripening before September 21, while cotton will still be bright red. Both crops will have a somewhat similar appearance during harvest; but the dramatic, quick change in the color of cotton should separate it from the gradually changing corn.

G. Coffee- We believe most most coffee is grown on hillsides, under a canopy of shade producing trees. These coffee plantations will probably appear as large areas (often over a square mile) with somewhat well defined edges. These areas will have an extremely homogeneous color (deep, dark red, or a shade thereof), and an unnaturally even texture. The appearance should be different than that of the nearby native vegetation. The actual coffee crop should not be visible, except in those areas where coffee is grown without a shade canopy.

H. Bananas, and Other Tree Crops- Bananas, and other broadleaf evergreen tree crops, will appear much like that of coffee grown under shade. An extremely even texture and homogeneous color usually indicate some form of cultivation, as native vegetation would have a more mottled appearance. Such tree crops would be very difficult to separate from one another.

It may be possible to locate deciduous orchards and citrus crops by looking for rows of trees. If grass is planted between rows of trees,

winter scenes should still show some pink signatures, with leafless trees appearing as darker spots in rows in the pink fields.

V. ...On Being An Analyst

A. Think like an analyst. (Make others think you know what you're talking about.)

When trying to identify crops, think about what those crops look like on the ground. How dense is the canopy over the ground? Is the soil visible between rows? Consider factors which may alter the typical signatures for the different stages of crop senescence. Gather as much ancillary data as possible. Such data should include:

-Cultural information on how the crops are planted and harvested.

-County crop data telling how much of which crops are grown in an area.

-Crop calendar showing the planting and harvesting dates of all crops in the area.

-General climatic data for the dates of scenes being studied. This will tell you which way to shift the crop calendar dates as a result of local weather.

-Topographic data showing general elevations and relief. Suspected "soil" signatures often appear as small towns on topographic maps. Do not be fooled. The usefulness of old, outdated maps may be marginal, as swamps may be drained, rivers dammed, and forests cleared and planted.

In trying to identify separate crops, determine from the crop calendar if dates are sufficiently different to identify crops by key date coverage, if such key date coverage is available.

Become familiar with harvesting winter wheat. Wheat is usually grown in large fields, particularly in the western United States. During the

harvest, this large field size enables us to see fields in the process of being harvested. Combines harvest fields in a number of different patterns, but most common are parallel rows on a circling spiral pattern from the edge to the center. These patterns appear with a bright wheat post-harvest signature around the edges, with a dead ripe signature in the center where the remainder of the crop is still standing. In a large wheat producing area; if you can locate one field being harvested, there will probably be more fields being harvested nearby. In a highly mechanized farming area, large areas can be planted in a short time. This means most of the crop will be rip at the same time. Teams of several combines work together in harvesting large fields. It is not unusual to fine three or four combines in formation , harvesting a field three abreast. Not only is this an excellent method for confirming wheat (or barley), it provides an excellent "Gee Whiz" factor with which to amaze and impress your friends and co-workers. Know your wheat.

B. Limitations- It is indeed unfortunate, but a number of practical limitations exist in trying to apply all of these nice theoretical techniques.

The greatest problem is the availability of truly complete multi-temporal coverage. It is essential to have enough scenes in a single year to follow different crops through their senescence. But unless coverage exists for those specific key dates during harvest time, it may be impossible to do more than separate summer crops from winter crops, and crops from non-crops. Coverage for the same months in different years will be helpful in separating native vegetation and permanent pasture from crops.

Since farmers often change crops from one year to the next, it will be very difficult to identify different summer crops if coverage is spread out over several years.

The ideal signatures of crops in different stages can be altered by a number of factors. Grass growing in the fields under crops, strip cropping, rocks and trees in the middle of fields, etc., can cause great confusion and disagreement among analysts.

The accuracy of ancillary data and crop calendars can sometimes be highly dubious. We like to assume the county data in the United States is somewhat accurate, foreign data may not be. If it makes no sense to you, there may be some reason (besides you.)

We would like to think growing summer crops could be separated on the basis of differences in signatures caused by differences in the physical appearancees of the different crops. However, the following is from "Pilot Study of the Potential Contributions of LANDSAT Data in the Construction of Area Sampling Frames (October, 1977)";

"In Tulare County (California) at the time of the July 12th satellite pass, the spectral signatures of the LANDSAT data for cotton, alfalfa, and grapes were not highly separable."

Cotton is a large bush, alfalfa is a grass (like wheat), grapes are grown on vines on wire arbors. These three crops have very little in common in terms of their physical appearance. Do not expect to be able to separate corn from soybeans in July because corn is taller, and should have a darker red signature. It may be beyond one's capabilities to attempt to do so.

Use of LANDSAT to identify crops, and summer crops in particular, is most feasible in areas with predominantly large field size. It is difficult to isolate the signature of a single crop when field size is smaller than a quarter-mile aquare. Signatures of very small fields become mixed with the signatures of the brush, woods, roads and trails

which surround the fields; as far as visual analysis is concerned. It may be possible to improve the resolution to acre size by computer analysis of the data for the individual pixel elements. This resolution is beyond our capabilities with the equipment and materials available.

It will be very difficult to separate crop from non-crop, and to identify specific crops, in areas of relative poverty which rely heavily on subsistence farming. Field sizes are likely to be very small, with mixed crops. Irrigation and fertilization may or may not be present. If not, such small fields with mixed crops may appear similar to native vegetation in the surrounding area. Harvesting may be done by hand, progressing more slowly than mechanical harvesting. These small subsistence farms, with hand labor, would be able to utilize land unsuitable for larger, more mechanized farms.

Separating deciduous forests from evergreen forests would seem to be a simple matter of comparing winter and summer scenes of the same area. Well, it isn't quite that simple. The presence of, and the type of understory, as well as the type and amount of forest floor covering, will affect the signature of the deciduous forest in the winter scenes. The U.S. Forest Service tried to identify hardwoods vs. softwoods in the western United States. After study of LANDSAT and several field checks by helicopter of the studied sites, it was determined their accuracy was only 50%, as in flipping a coin. (Information from Dale King.)