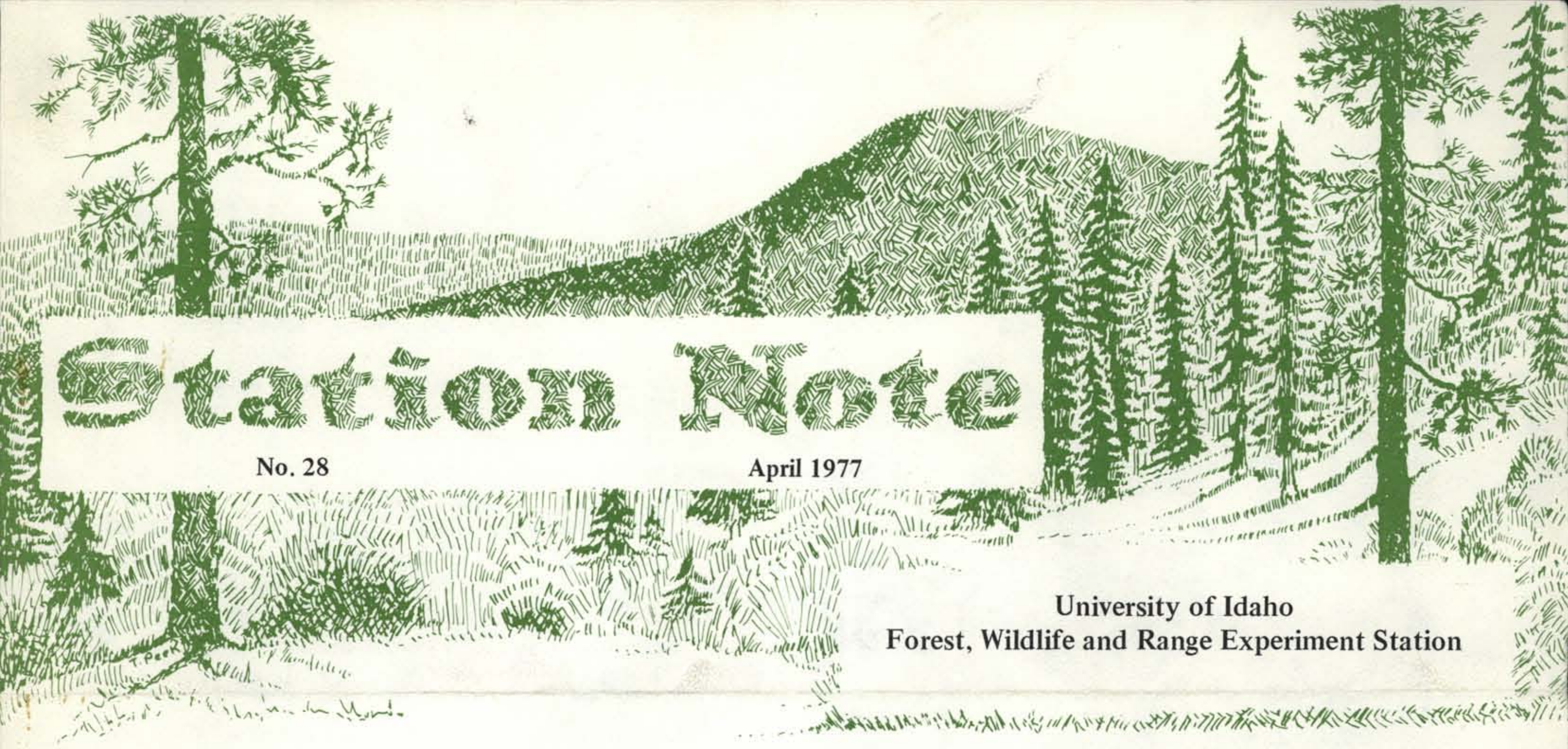

Idaho Land-Use Mapping From LANDSAT Transparencies

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INTRODUCTION

Visual interpretation of LANDSAT false-color composite imagery enabled the senior author to map land uses for the entire state of Idaho in two months' time during the summer of 1975. The mapping was part of the initial stage of the Pacific Northwest Regional Commission's Land Resources Inventory Demonstration Project; results are now published in the form of black-line overlays at scales of 1:250,000, 1:500,000 and 1:1,000,000.

METHODS

Compilation was done at 1:250,000 on acetate sheets taped to standard U.S. Geological Survey (USGS) maps of that scale, 20 of which cover the state. Penciled originals were retraced in ink on mylar, and the products sent to the Cartographic Laboratory of the Department of Geography, University of Oregon, Eugene, where they were generalized and reduced for reproduction at smaller scales.

The maps depict nine broad classes of use, those termed "Level I" by Anderson et al. (1972): water, urban and built-up land, agricultural land, nonforested wetland, rangeland, forest land, permanent snow and icefields, barren land, and tundra. In general, the first four types were mapped to a minimum area of 160 acres (one-eighth inch square at 1:250,000), and the remainder to a minimum of 640 acres (one-quarter inch square). No higher degree of land-use classification was believed achievable by visual interpretation from the imagery; this presumption was largely confirmed in practice.

The usual order of map compilation was reversed in this instance, in that "ground truth" information from Soil Conservation Service (SCS) county land-use maps was transferred to the acetate-overlaid 1:250,000 sheets before the LANDSAT images were interpreted. The SCS maps, drawn to a scale of 1:126,570, employed most of the categories of land use noted above. They were furnished by the Boise office of the SCS, U.S. Department of Agriculture.

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The Pacific Northwest Regional Commission has contracted for this undertaking and two similar projects in Oregon and Washington. Work described in this note was subcontracted from the University of Oregon. University of Idaho Forest, Wildlife and Range Experiment Station Contribution No. 65.

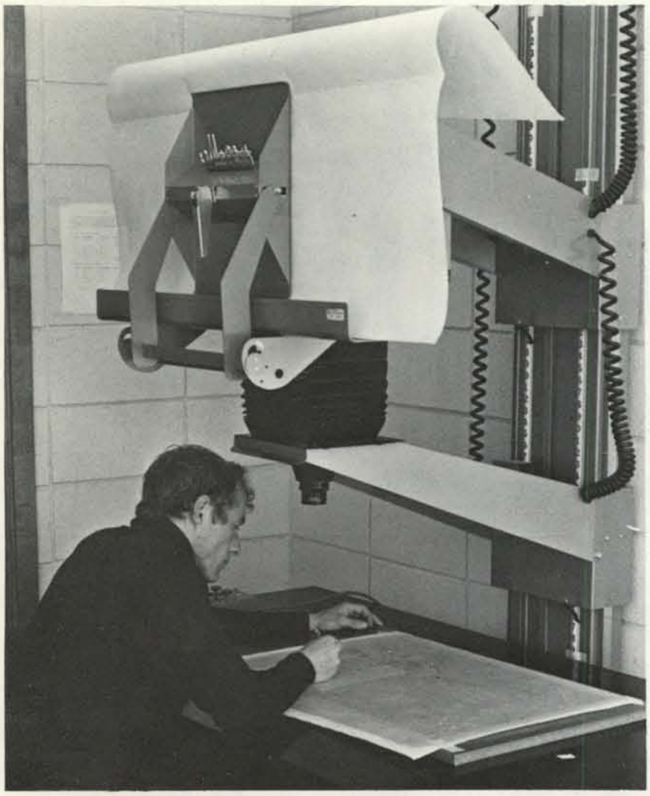

Fig. 1. A Map-O-Graph overhead projector was used to reduce Soil Conservation Service land-use map detail to the scale of the base maps.

Transfer was made by use of a Map-O-Graph Model 55 vertical overhead reflecting projector, which reduced the SCS map detail to the USGS scale and projected it onto the surface of a worktable (Fig. 1). The 11-inch-square dimensions of the Map-O-Graph's aperture window limited the extent of detail which could be transferred at once; detail had to be transferred to the acetate in successive patches, with a new registration of the projected image – 5.5 inches square – at each shift. Discrepancies between the SCS and USGS base maps necessitated frequent minor adjustments of scale; these incongruities, together with the instrument's optical properties, limited the area of accurate registration to a central zone about 4 inches square on the tracing table. Survey lines, roads, and watercourses were used for registration, since the SCS maps lacked topographic detail.

Registration was complicated by the fact that the projected Map-O-Graph image of a hand-colored SCS map was often too weak to be clearly seen against the bold USGS map detail. However, with the USGS map and its acetate overlay taped to a drawing board, it was easy to insert a sheet of white paper between map and acetate, so that the relevant portion of the USGS map could be hidden or made visible during registration and transfer. In registration, the paper could be manipulated to create a "flicker" effect, with USGS and SCS images alternately visible, as the drawing board was moved about to bring them into congruence; during transfer, the paper could be used to mask the USGS map as necessary, so that the SCS detail could be discerned and delineated easily.

The SCS land-use type boundaries were penciled in on the acetate, and the types coded with numerals 1 through 9. Inconsistencies in the SCS mapping, which turned up with some frequency at county boundaries, were left for later resolution through LANDSAT image interpretation.

The acetate-overlaid map sheets, with transferred SCS land-use detail, were then placed under a wide-base Bausch & Lomb Zoom Transfer Scope (ZTS), and LANDSAT false-color 1:1,000,000 7 x 7-inch transparencies were put into registry with them for intepretation (Fig. 2). A 1X map lens was employed. The eyepieces were focused on the map table, and the vertical stage carrying the transparency was moved into focus at a point within an inch of its limit of rearward travel. Magnification of about 4.5X, as registered on the instrument's scale-adjustment control knob, was then required to enlarge the transparency to map scale. At this magnification, the limits of resolution of the LANDSAT images began to be evident; further enlargement did not seem to improve interpretability enough to offset the accompanying reduction in field of view.

The 1X map lens of the ZTS allowed the interpreter a circular 7.3-inch-diameter field of view on the map, which corresponded to a 1.8-inch-diameter circle on the transparency. As with the Map-O-Graph at an earlier stage, detail transfer had to proceed patchwise; and, as before, fewer discrepancies between adjacent patches were encountered when the interpreter confined his work to a central circle of map about 5 inches in diameter, and did not try to delineate the entire visible area. This made it necessary to shift the field of view and realign the map and image more frequently.

Fig. 2. On the Zoom Transfer Scope, illumination controls at the operator's left allow him to view either the LANDSAT image (on the vertical stage), or the map, or both at once. Scale, orientation and stretch controls at his right permit matching of the two images.

The acetate-covered map was moved about on the table in the first stages of each registration; then it was taped down while final adjustments were made with the controls of the ZTS. In addition to the scale control, the instrument has X and Y screw adjustments for the map lens, an image-rotation fingerwheel, and a lever and finger-wheel which permit the operator to "stretch" the image in any direction to fit the map. The ability simultaneously to distort the LANDSAT image and to vary the direction of the distortion was invaluable in fitting image to map, even though the amount of stretch employed was always small. It was found advisable to zero the stretch controls with every shift of field, and then to make the best possible job of registration with the other controls before calling the stretch adjustments into play; it was equally wise to center the X and Y screws of the map lens before each change of field.

Roads, property lines, and topographic features were all used in registration; in mountainous terrain, ridges and drainages appearing on the LANDSAT images could be matched to base-map contours with precision. It was often helpful to vary the intensity of both direct lighting on the map, and "transillumination" through the transparency, during registration and detail transfer.

The following LANDSAT images were used:

ERTS-E-1035-17525	27 Aug 72
-1072-17580	3 Oct 72
-1272-18092	21 Apr 73
-1308-18095	27 May 73
-1342-17592	30 Jun 73
-1358-17465	16 Jul 73
-1358-17474	16 Jul 73
-1379-18041	6 Aug 73
-1380-18084	7 Aug 73
-1411-17404	7 Sep 73
-1411-17410	7 Sep 73
-1415-18022	11 Sep 73
-1415-18024	11 Sep 73
-1701-17451	24 Jun 74
-1701-17460	24 Jun 74
-1702-17512	25 Jun 74
-1703-17572	26 Jun 74
-1720-17495	13 Jul 74
-1720-17502	13 Jul 74

Because these images covered the state with limited overlap, there were few opportunities for direct comparison of imagery taken at different seasons. Some seasonal differences among images were obvious, however, and fall imagery was observed to confer some advantages, as noted later.

INTERPRETATION

Interpretation of the registered LANDSAT images allowed considerable redrawing and refinement of the SCS land-use type lines; this was especially the case in wildland areas, where SCS mapping had been done with a broad brush. Of course, the arrangement of the work, with LANDSAT interpretation super-imposed upon SCS mapping, allowed no assessment of what might have been accomplished by use of LANDSAT imagery alone and unaided. Further comments on LANDSAT interpretation are perhaps best arranged by land-use type.

Water

There was no mistaking open water on LANDSAT false-color composites. Clear, deep water was a dark blue-black, and shallow or turbid water a pastel blue; neither color resembled anything else. Where deeply-colored vegetation bordered on water, strong transillumination was necessary for adequate perception of edge detail.

Urban and Built-up Land

Settlements and industrial sites usually appeared mottled blue-grey, with occasional streaks of white or light yellow, and strips and patches of dull rose-red which denoted vegetation. Base maps usually indicated the positions of such sites. Topographic location provided other obvious clues; a barren mountaintop, however blue-grey, was not likely to be mistaken for any work of man.

Although high-intensity commercial, industrial, and residential areas were fairly easy to identify, urban borders were not always readily delineated; the interpreter who tries to draw a meaningful line through the maze of agricultural, range and low-intensity commercial/residential land surrounding a city like Boise, gains new respect for the aptness of the term "urban sprawl." Small towns tended to show more definite borders.

The devegetated zone surrounding the Kellogg smelter was conspicuous and easily delineated, and fell into this category of use both by definition (Anderson et al. 1972) and appearance.

Agricultural Land

Pattern, and to a lesser extent color, identified agricultural lands. The rectangular arrangement of farm fields was easily recognized, as were the disks which denoted center-pivot irrigation. There was a noticeable disparity between the small (often flood-irrigated) fields in regions of early settlement, and the larger (often sprinkler-irrigated) fields of the more recently developed regions. Fields appeared brilliant red when crops were growing, and yellow to white just before and immediately after harvest; fallow land and other patches of bare soil showed blue-grey.

As with urban land, the typical agricultural use pattern was strikingly obvious, but boundary areas often comprised intricately interwoven land uses which posed problems of definition as well as of delineation. It was difficult, for example, to decide at what point improved rangeland might qualify as agricultural land.

Nonforested Wetland

Topographic situation, evident both from the base map and from the imagery, was key in locating this use type; the difficulty lay in distinguishing it from wet meadowland, an agricultural type. Wetlands usually showed a dusky-pink color, the bright red of their vegetation muted somewhat by the darker water below, but this circumstance was subject to seasonal change. In general, broad expanses of low-lying land adjacent to water bodies and lacking regular agricultural patterns were interpreted as wetland.

Rangeland

This was the most variable of the land-use types, including essentially all wildland-bearing non-forest vegetation: unforested brushy slopes in the mountains, sage/grass foothills, and salt desert flats. Nothing was easier to find than rangeland on LANDSAT imagery of Idaho, yet to decide precisely at what point rangeland shaded into forest, or into barren land, or into agricultural land, demanded close attention and carefully framed definitions of each type.

Springtime imagery tended to obscure distinctions between rangeland and other vegetational types; all appeared in a similar fluorescent red. Such imagery might have improved discrimination between range and barren land, were it not that much of Idaho's barren land is under snow in the spring. Fall imagery was best for separating rangeland from forest; by September, range types on mountain slopes had turned grey-brown, while forests had retained a rusty-red hue.

Beyond the forested mountains, most desert land was classified as range. However, the most recent lava flows in the Snake River Plain, distinctly visible as dark-grey irregular patches against the browner rangeland, were classed as barren land. Outlines of rangeland fires were clearly visible; the burned areas appeared dark grey, like the color of lava flows, but much smaller in extent. Near the southern border of the state, distinctions between pinyon-juniper rangeland and forested land became difficult.

Forest Land

In most imagery, forest vegetation was distinguishable from other types by its dense, darker tone – a red of higher saturation and lower brilliance than that of agricultural land – and its topographic location. Fall imagery was best for separating forest land from interspersed range. Clearcut patches were easily distinguishable, but some sites deforested by fire may have been misclassified as rangeland.

Permanent Snow and Icefields

Only late summer and early fall imagery were adequate to support this interpretation. In imagery taken earlier in the year, snow blanketed barren land above timberline, and probably obscured some forest land as well. Snow and ice are brilliant white in color on LANDSAT imagery; they are distinguishable from clouds by their location and absence of shadow.

Barren Land

As noted earlier, this type exists at the extremities of the forest-range continuum. Barren land was identified in the lava flows (and bright, cream-white colored sand dunes) of the desert, and in the rocky slopes above timberline. In the latter case, image tone was usually that of bare soil and rock, light blue-grey to white.

Tundra

This type was delineated, with great hesitancy, in a few above-timberline areas that lay too high to be called range, and were too well vegetated to be called barren. In some images this type was doubtless hidden by snow; late summer imagery is necessary for any degree of accuracy in depicting this type.

AVAILABILITY

The published land-use overlays are available from Northwest Cartographics, 2945 Hilyard Street, Eugene, Oregon 97405. Base maps and four other kinds of thematic overlays, compiled from various sources and illustrating drainage, soils, land ownership, and energy features, were prepared during Phase I of the Land Resources Inventory Demonstration Project, and may be obtained from the same source at all three scales. The 1:250,000 overlays, printed on Cronaflex, cost $355 per set of 20; the 1:500,000 and 1:1,000,000 overlays – each covering the entire state in a single clear-film sheet – cost $81 and $63, respectively. Compatible maps and overlays of Washington and Oregon are also available.

LITERATURE CITED

Anderson, J.R., E.E. Hardy, and J.T. Roach. 1972. A land-use classification system for use with remote-sensor data. Geological Survey Circular 671, U.S. Department of the Interior. 16 pp.