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LAND USE ANALYSIS OF U.S. URBAN AREAS USING

HIGH-RESOLUTION IMAGERY FROM SKYLAB

by

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Skylab Earth Resources Experiment Package

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NOTE

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request.

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ABSTRACT

High-resolution S-190B color imagery from Skylab-3 has been evaluated in the Census Cities Project of the U.S. Geological Survey. These 1973 data were employed in making land use interpretations at 1:100,000 scale for parts of the New Haven, Conn., Washington, D.C., and Phoenix, Ariz. test sites. Land use change maps were also produced for these sites by comparing the Skylab imagery with 1:100,000 scale 1970 RC-8 infrared photographs from RB-57 aircraft.

The spatial resolution of the S-190B imagery approached that of the RC-8 infrared imagery, especially in built-up areas. Among the sites, 25 separate land use categories were identified. Residential and Transportation classes were particularly distinct and could be divided into subcategories. Industrial, commercial, and institutional land uses were also visible on the S-190B imagery, although the precise boundaries of these areas were commonly difficult to delineate. Construction sites were highly visible. Of the less intensively used land areas, water, wetlands, beaches, and extractive operations were easily detected from the Skylab-3 data. Forests and agricultural land could only be delimited at a generalized level of detail. The use of infrared rather than color film in the S-190B sensor would possibly allow the detection of greater land use detail in both urban and non-urban areas. Using infrared film, combined with repetitive seasonal sensor coverage, would aid in making the S-190B sensor a more effective tool for land inventory purposes.

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INTRODUCTION

The USGS Geography Program, in cooperation with NASA, has conducted
land use investigations using remote sensor data from aircraft and
orbiting satellites. Part of this program, the Census Cities
Experiment, has evaluated land use and land use change for selected
urban areas in the United States (Wray, 1970). The initial Census
Cities project, begun at the time of the 1970 Census, produced land
use maps interpreted from high-altitude aircraft imagery acquired by
NASA in 1970 (Simpson, et.al., 1972; USGS, 1974: USGS, 1975). It
also produced maps of land use change derived from similar aircraft
imagery acquired by NASA in 1972. The products generated and the
techniques employed in their production have served as standards
for evaluating sensor data from LANDSAT (formerly ERTS) and Skylab.

The Census Cities Skylab project (Skylab/EREP Investigation No. 469)
began using S-190B multispectral imagery from Skylab-2, acquired in
June 1973. Initial research compared the interpretability of land
use from this multispectral Skylab imagery, and similar LANDSAT-1 data,
with the interpretability of land use from RC-8 color infrared aircraft
imagery for a part of the Phoenix, Arizona test site. This research
demonstrated that, using manual interpretation techniques, a generalized
level of land use detail can be detected from the multispectral
satellite imagery in an urban environment (Milazzo, 1974). Interpreta-
tion of the higher resolution color S-190B (Earth Terrain Camera)
photographs, produced during the manned Skylab-3 mission in August and
September, 1973, permitted the detection of higher levels of land use
detail. Further study of S-190B sensor data for a variety of urban
settings sought to determine the types of post-1970 land use changes
that could be detected using this high-resolution sensor.

Of the original urban test sites considered for further study, Tucson
and Cedar Rapids were eliminated because of imcomplete S-190B coverage.
Pontiac and Pittsburgh were eliminated due to heavy cloud cover.
Parts of the New Haven, Washington, Phoenix, and San Francisco test
sites were ultimately selected because of the availability of cloud-
free S-190B imagery for these areas. This report describes the land
use interpretation and the detection of land use change for parts of
New Haven, Washington, and Phoenix. A similar study of the San Francisco
test site is being conducted by Dr. Dulio Peruzzi. It includes an
evaluation of density slicing of the multispectral data to classify
land use in an urban area.

IMAGE INTERPRETATION

A series of 20 X 20-km land use map sections for a prototype Atlas of Urban and Regional Change (Wray, 1972) had been produced from the 1970 aircraft imagery for New Haven, Washington, and Phoenix. Universal Transverse Mercator (UTM) grid lines were employed as map boundaries for individual 20 X 20-km sheets within each test site. For the evaluation of Skylab-3 data, one 20 X 20-km section from each of the three sites was chosen for analysis. For New Haven, Sheet 560-660 was selected. This 400-km^2 area includes all of New Haven, West Haven, and Milford; as well as portions of East Haven, North Haven, Orange, Hamden, and Ansonia. This area is part of an older, densely poplulated urban area in a forested setting. The S-190B high-resolution color photograph used for the New Haven study is Frame 88-276, September 19, 1973. For Washington, Sheet 320-310 was chosen in order to monitor land use activity on the urban fringe. This site lies in Montgomery County, Maryland. Frame 83-166, August 5, 1973, was employed for the suburban Washington analysis. For Phoenix, Sheet 700-400 was selected. This area includes portions of downtown Phoenix as well as urban fringe areas around Scottsdale and Paradise Valley. The S-190B image used for this site is Frame 86-011, September 6, 1973.

For each site, a 1:100,000 scale color transparency for use as a plotting base was produced from the original 1:960,000 scale S-190B image. The photographic enlargements were overlain with 1-kilometre grids which corresponded to those appearing on the 20 X 20-km map sections. Drafting film overlays were then taped to the grids, and boundary lines for the test sites were drafted on these overlays. The original S-190B color imagery was studied with 18- and 30-power microfiche viewers. Land use polygon boundaries were then compiled on the overlays for discrete land parcels measuring four hectares or larger (figures 1, 2, and 3).

LAND USE CLASSIFICATION

The land use classification used in this study is derived from a multilevel land use classification system developed for use with remote sensor data (Anderson, et.al., 1972). In this system, Level I contains the more generalized land use categories, such as Urban and Built-up. Level II refers to a more detailed breakdown of a Level I category, such as Transportation. A Level III category (Anderson, et.al., 1975) refers to a still more detailed land use type, such as a Rail Road Facility. Since many Level III land use categories are detectable from the S-190B imagery, all land use codes appearing in the legends on the land use interpretations (figures 1, 2, and 3) are expressed in a 3-digit, Level III format. Capital letters representing the 3-digit codes are used in the land use polygons for the sake of readability. Not all land use categories observed from the S-190B imagery are of Level III detail. The presence or absence of 0's in a given 3-digit land use code indicates the hierarchical level of the

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land-use category represented by that code. Forests, for instance, are detectable only at Level I detail and are coded as 400. A Level II land-use category, such as Industrial, would be coded as 130. The code for an actual Level III land-use category, such as 112 (Multi-Family Residential), contains no 0's.

URBAN LAND USES

Residential

Residential land in each of the sites can be identified on S-190B imagery and subdived into single and multi-family categories. The signatures differ somewhat among the sites, and within individual sites, due to variations in roof reflectance, vegetation and time of year, lot sizes, and block arrangements.

In the New Haven area, older single-family residences display rectangular roofs of approximately 10 m X 15 m, set against heavily vegetated lots of about 20 m X 30 m. Individual streets are not visible although gaps in the roof aptterns indicate the presence of rectangular blocks measuring about 60 m X 200 m. Older residential areas in the Washington site display similar roof and vegetation signatures, although the houses tend to be distributed in the curved patterns typeical of suburban street arrangements. In Phoenix, older single-family residential areas are represented by bright roofs measuring about 10 m X 15 m arranged in long blocks measuring some 60 m X 400 m (figure 4a). There are few trees in the Phoenix area to obscure the roofs and lawns, which contrasts markedly with both New Haven and Washington

New single-family housing is generally distinctive in all three test sites, since begetation associated with the houses has not matured enough to obscure the roofs. In the New Haven and Washington areas, however, some new residential areas containing dark roofed houses are represented by gray-green composite signatures of roofs, lawns and streets (Lins and Alexander, 1974). The visible newer houses are larger than those in the older residential areas. Roofs measure approximately 10 m X 20 m with lot sizer approaching 30 m X 50 m. Some of the lots in the Paradise Valley area of the Phoenix site measure one hectare or larger. The block and street patterns for new housing in the Washington and New Haven suburbs are curvilinear (figure 4b). In the portion of the Phoenix suburbs examined here, developers have generally retained the long, rectangular blocks characteristic of older residential areas, and derived from the system of land survey.

Multi-family housing is the more difficult of the two major residential types to delimit. In the New Haven area, the most common type of multi-family housing is the older, inner city apartment. These buildings are visible as long, narrow, closely spaced buildings with the narrow ends facing the streets. Some of these buildings appear to be attached row houses. This housing lies in an arc around the New Haven business district and in the part of West Haven that overlooks New Haven Harbor.

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Population and housing statistics reveal that the buildings in these
areas contain between 2 and 50 units, although the small size of the
structures suggests that most fall within the lower part of this
range (U.S. Bureau of the Census, 1972). Small inner city multi-
family structures are less discernible from S-190B imagery than from
aircraft photographs.

Larger apartment buildings are more easily identified. These are
usually arranged in distinct clusters of rectangular elements, each
ranging in size from 15 m X 30 m to about 20 m X 75 m. The buildings
lie parallel or at right angels to each other, separated by lawns and
parking areas. In New Haven, a large group is visible in the inner
city north of the Yale University campus. In all three sites, however,
most of the larger apartment complexes are located in suburban areas
close to major arteries and commercial centers. In New Haven, several
apartment complexes lie between Orange Avenue and the Connecticut
Turnpike in West Haven and Milford. In the Phoenix site, the largest
concentration of apartment buildings clusters around the Scottsdale
commercial area. Apartment complexes in the suburban Washington
region are concentrated near interchanges of the Capital Beltway and
along major highways such as Rockville Pike and Georgia Avenue (figure 4c)

Commercial and Services

Several types of commercial areas may be observed. These include
central business districts, strip developments, and suburban shopping
centers. Central business districts (CBD's) appear in the New Haven
and Phoenix sites. In New Haven, the CBD is a cluster of large,
closely spaced buildings lying south and east of Yale University. In
Phoenix, the CBD is located in the southwest corner of sheet 700-400
(figure 3). Viewed on the S-190B imagery, this area is characterized
by large, bright roofs set against a pattern of small blocks (figure 5a).
In both New Haven and Phoenix, the CBD's appear in distinct contrast to
adjacent residential areas which display more vegetation.

Strip commercial developments in all three urban sites extend along
major roads, and are usually flanked by residential areas. Strip
developments reflect bright roofs against darker parking areas and
usually extend no more than one block in depth on either side of a
road (figure 5b).

Suburban shopping centers are present in all three sites. They are
visible along major suburban highways or at the intersections of two
or more of these routes (figure 5c). They are identified by their
large, brightly reflected roofs and are surrounded by extremely large,
black-topped parking lots. Often measuring more than 20 hectares,
these complexes are among the most easily identifiable features visible
on the S-190B imagery.

Industrial

The largest industrial areas observed are located within the New Haven
test site. Much of this industrial development is clustered around the

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mouths of the Quinnipiac and Mill Rivers, facing New Haven Harbor
(figure 6a). This area appears as a crowded mixture of large buildings,
fuel tanks, and rail sidings. The fuel tanks display especially
bright signatures, measuring between 30 m and 50 m in diameter. Similar
areas are located in West Haven, North Haven and along the West River
in New Haven. Several indistrial areas were observed in the Phoenix
site. The largest consits of large rectangular buildings clustered
around a railroad yard near downtown Phoenix. Some industrial areas
in the Phoenix area are of the light-industry variety, oriented toward
road transportation. These facilities resemble shopping centers except
that several large buildings are present and the parking areas are not
arranged to allow convenient access to the buildings (figure 6b).

Industrial and Commercial Complexes

Along major highways in the New Haven and suburban Washington sites
lie mixtures of industrial and commercial land uses, sometimes referred
to as "industrial parks." Viewed from Skylab-3 imagery, however,
these areas exhibit none of the features associated with heavey in-
dustry, such as fuel tanks, rail sidings, and piles of raw materials.
Instead, these complexes resemble suburban commercial centers, except
that there are several large buildings present, with extensive land-
scaping around the buildings and parking areas (figure 6c). Previous
field evaluations conducted by personnel in the Geography Program
have demonstrated that these areas encompass a variety of economic
activities including light assembly, regional distribution, and research
and development activities.

Transportation

The S-190B imagery proved to be of great value in delineating various
types of transportation facilities. Major highways and interchanges
are clearly visible due to their bright, linear signatures (figure 7a).
Many lesser roads may also be observed, although residential streets
tend to be obscured by vegetation.

Railroad yards were easily detected, primarily in the New Haven and
Phoenix sites. Individual tracks are not visible, but the dark
composite signature of many parallel tracks is quite distinct. The
largest railroad facility in ant of the sites lies adjacent to a wet-
land area in North Haven, Connecticut, covering several hundred hectares
(figure 7b).

Major airports are observable from Skylab-3 in all three sites. The
most visible is the Sky Harbor Airport in Phoenix (figure 7c). Smaller
airstrips, however, are more difficult to detect, except in the Phoenix
area where the dark runways appear in sharp contrast to the arid range-
lands surrounding them.

Utility corridors are visible only where they pass through forests. In
these instances, the rights of way are seen as linear patterns approximately
30 m X 50 m in width. Utility corridors are not visible in the arid
Phoenix site.

Marine craft facilities could be detected only in the New Haven Harbor
area. Shipping piers and quays are visible, along with associated

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buildingsn and storage tanks. It is difficult, however, to separate
port facilities from nearby industrial complexes.

Institutions

Some institutions appear in all of the test sites and consist primarily
of educational facilities and large medical complexes. Viewed on the
S-190B imagery, institutions appear as groups of long, connected
buildings surrounded by extensive vegetated areas, parking lots and,
in some cases, athletic fields. Yale University, in central New Haven,
is the largest institution observed, although its precise boundaries
are not easily determined from the Skylab-3 imagery. In the portion of
the Washington area examined, institutions occupy smaller plots and
consist mainly of schools isolated amidst residential developments.
Many smaller institutions in all test sites are indistinguishable from
adjacent commercial areas, but this interpretation problem is not unique
to S-190B imagery.

Improved Open Space

This category includes golf courses, cemeteries, parks, and vacant lots
in urban settings. The fairway patterns of golf courses stand in sharp
contrast to their surroundings, especially in the Phoenix site. Cemeteries,
non-forested parks, and vacant areas exhibit similar signatures on the
S-190B imagery and are more easily differentiated from infrared aircraft
photographs.

NON-URBAN LAND USES

Agricultural Land

Agricultural land is visible form Skylab-3, although no clear distinctions
can be made among cropland, pasture, and orchards. On the urban fringe,
small parcels of agricultural land and improved open space display
identical signatures. The natural color film generated by the S-190B
sensor is responsible for the blurring of these distinctions. It is
possible that the use of infrared film woud aid in identifying different
agricultural types and in distinguishing between agricultural and other
land use classes in urban fringe areas. The only other agricultural category
visible from Skylab-3 was a large feedlot in the Phoenix area.

Shrub-Brushland Range

Shrub-brushland range is the dominant natural land cover in the Phoenix
area. It appears in distinct contrast to the urbanized areas and irrigated
agricultural land. Although individual plants connot be observed from
Skylab-3, concentrations of this vegetation are visible as dark linear
patterns lying along intermittent watercourses. The shrub-brushland range
areas exhibit darker signatures than areas of bare sand.

Forest Land

Forested areas are visible on the S-190B imagery covering the New Haven and Washington sites. No forested areas were observed in the Phoenix test site. Forests are uniformly dark green and cannot be subdivided into deciduous and coniferous categories using the S-190B imagery. The signatures of forested areas are often sufficiently dark to obscure adjacent cultural features, especially housing areas. The use of infrared film would possibly sharpen the contrast between forests and buildings and aid in distinguishing between deciduous and coniferous forest types.

Water

Water bodies are generally interpretable from S-190B imagery although dark vegetation patterns sometimes conceal the precise boundaries of these features. Bays, estuaries, and streams are easily differentiated, but it is often difficult to distinguish between natural lakes and reservoirs. The Washington and New Haven sites both contain numerous water bodies. As might be expected, the Phoenix site contains few water areas.

Wetland

Wetland areas were observed from the Skylab-3 imagery only in the New Haven site. These areas display mottled blue-green signatures and lie beside several meandering streams that flow into Long Island Sound. The largest wetland area, mostly nonforested, lies along the Quinnipiac River in North Haven. Covering some 500 hectares, this area is studded with ponds and exhibits numerous parallel linear patterns, probably drainage canals. There are some sparsely forested areas on the fringes of the wetlands.

Beaches and Mudflats

These areas, mostly beaches, were observed in the New Haven site only. The beaches and mudflats lie at the shorelines facing New Haven Harbor and Long Island Sound. These areas are easily observed due to their shining white signatures, which indicate the presence of sand.

Strip Mines, Quarries, and Gravel Pits

Extractive areas are visible from the S-190B imagery in the New Haven and suburban Washington sites. These areas are characterized by their bare, distrubed appearances and are usually isolated from residential areas. Quarries and other extractive sites commonly contain small ponds, created by digging through aquifers. Extensive extractive areas are visible along the Quinnipiac River in North Haven, Connecticut. It is not possible to determine what is being extracted from these operations in any of the test sites.

Transitional Land

This category refers to land under construction. Viewed from S-190B imagery, the transitional areas are distinctive due to their bright, barren signatures. Some of these areas appear as extensions to existing commercial or industrial centers. Highway construction is highly visible due to the linear nature of the construction scars. In areas undergoing residential construction, street patterns are commonly visible. Transitional Land is evident in all three urban sites.

CHANGE DETECTION

Upon competion of the interpretation and classification phases of the Skylab project, a study was begun to detect, classify, and measure post-1970 land use changes in the three urban test sites by comparing the 1973 land use interpretations generated from S-190B imagery with 1970 aircraft data. Because of the variations in the formats and classification schemes of the 1970 land use maps (Simpson, and others, 1972; USGS, 1974: USGS, 1975), it was decided that the 1:100,000 scale 1970 color infrared RC-8 photography from NASA Missions 128B and 128D would be used as the 1970 data base. For each test site, RB-57 photography covering that site was overlain with the appropriate 1:100,000 scale Skylab-3 land use interpretation. A drafting film overlay was attached to the land use map and test site boundaries were then drafted onto this overlay. Next, a visual comparison was made between the 1970 photography and the 1973 Skylab-3 land use interpretation for each sq. km. in the test site. Areas of possible change were further examined on the S-190B imagery, using 18- and 30- power microfiche readers. If an actual land use category change was detected its boundaries were then drafted onto the film overlay and coded with an appropriate 2-letter, from-to code representing the Level III numerical codes appearing in the legend. This process resulted in the production of a land-use change polygon map for each of the three urban test sites (figures 8, 9, and 10). The legends appearing on these change illustrations reflect actual land use change situations appearing in the individual sites. The change polygons in each site were measured in hectares using a dot planimeter. Percentages of the total amount of change in a site were then computed for each change category appearing in the site (tables 1, 2 and 3)..

New Haven

Changes detected between 1970 and 1973 were few and small in size in the New Haven area. Of the 102 hectares of change delimited in this site, nearly one-fourth involved transitional land changing to single-family residential (table 1). There were a few additions made to existing industrial and commercial areas. The draining of several small ponds accounted for an additional 19 hectares of change (table 1). Another type of change detected involved the significant expansion of several storage tank areas in East Haven (figure 11a). Since these storage tanks may be individually observed and measured on the S-190B imagery, it is reasonable to surmise that similar remote sensor data could be

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used to monitor increases in the fuel storage capacities of various regions. Such information could prove to be of critical importance during national or regional fuel shortages.

Washington

In the site, 1597 hectares of post-1970 land use changes were delimited from the S-190B imagery. More than 23 per cent of this total involved agricultural land changing to single-fimily residential (table 2; figure 11b). An almost identical amount of agricultural land came under construction during the same period. Substantial areas of forest and improved open space also underwent construction between 1970 and 1973 (table 2). These changes reflect an expansion of the Washington suburbs into previously non-urban areas and a filling-in of open space within the urban area.

Phoenix

The changes detected in the Phoenix area primarily involve large parcels of shrub-brushland range being built-up in residential uses or generally undergoing construction (figure 11c). More than 68 per cent of the land use change in the Phoenix site falls into these categories (table 3). Much of this activity is occurring on the urban fringe around Scottsdale and Paradise Valley. In downtown Phoenix, a long narrow strip of older residences was seen to have been demolished since 1970, leaving a barren linear scar easily observed from the S-190B imagery. This pattern undoubtedly heralds the construction of a long-proposed expressway through the central business district and serves as a vivid example of the type of activities that may be monitored using Earth Terrain Camera data.

CONCLUSIONS AND RECOMMENDATIONS

The S-190B imagery from Skylab-3 permitted the detection of higher levels of land use detail than any satellite imagery previously evaluated using manual interpretation techniques. The resolution of this imagery approaches that of 1:100,000 scale infrared aircraft photography, especially in ·
regard to urban phenomena. Non-urban land uses, however, are less distinct. Forests, for instance, exhibit a uniformly blurred green appearance on the natural color S-190B imagery and tend to obscrue res-idences and other cultural features. Also, forests and agricultural land connot be subdivided into more detailed classifications using S-190B imagery. It is possible that · repetitive seasonal sensor passes combined with the use of infrared film in the Earth Terrain Camera would aid in solving these interpretation problems.

The S-190B imagery allows the monitoring of land use change if a suitable earlier inventory is available for use as a data base. Possessing such an inventory, compiled in 1970, the Census Cities staff was able to use S-190B data to detect post-1970 land use changes in the New Haven, Washington, and Phoenix test sites. Large parcels of agricultural land, forest, and rangeland were observed to have undergone construction since 1970. These observations demonstrate the possible role of similar sensor data in agricultural inventories, forest surveys, and related environmental assess-ments. Analysis of the Skylab-3 data also revealed considerable residential construction. This information could be useful to planning and public ·
service agencies for population estimates and studies of the impact of new housing construction on the allocation of community services. Other change information derived from the S-190B imagery, concerning highway building and storage tank construction, has definite implications in the areas of transportation analysis and fuel allocation.

In order for this information to be useful in decision making, however, it must be rapdily available to potential users. Manual interpretation of sensor data causes an inevitable delay in making the resulting products availabe to users. Manual interpretation of high-resolution photography is perhaps most useful in establishing a detailed, carefully controlled data base, which could be rapidly updated using machine processed digital sensor data.

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Table 1.   New Haven Land Use Change from Skylab-3, S-190B, Sheet 560-660.

1970 - 1973	Hectares	% of total
(L) 170 - (A) 111	6	5.89
(L) 170 - (C) 120	3	2.94
(L) 170 - (D) 130	10	9.80
(L) 170 - (K) 160	5	4.90
(R) 520 - (V) 620	14	13.73
(S) 530 - (V) 620	15	14.71
(Y) 760 - (A) 111	25	24.51
(Y) 760 - (B) 112	4	3.92
(Y) 760 - (C) 120	8	7.84
(Y) 760 - (D) 130	8	7.84
(Y) 760 - (K) 160	4	3.92
TOTAL	102	100.00

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Table 2. Washington Land Use Change from Skylab-3, S-190B, Sheet 320-310.

1970 - 1973	Hectares	% of total
(C) 120 - (Y) 760	23	1.44
(E) 141 - (Y) 760	16	1.00
(L) 170 - (A) 111	56	3.51
(L) 170 - (B) 112	45	2.82
(L) 170 - (C) 120	6	.38
(L) 170 - (J) 150	31	1.94
(L) 170 - (K) 160	14	.88
(L) 170 - (Y) 760	104	6.51
(M) 210 - (A) 111	378	23.67
(M) 210 - (B) 112	12	.75
(M) 210 - (C) 120	9	.56
(M) 210 - (D) 130	5	.31
(M) 210 - (K) 160	9	.56
(M) 210 - (Y) 760	364	22.79
(P) 400 - (A) 111	99	6.20
(P) 400 - (B) 112	46	2.88
(P) 400 - (C) 120	52	3.26
(P) 400 - (Y) 760	222	13.90
(Y) 760 - (A) 111	106	6.64
TOTAL	1597	100.00

Table 3. Phoenix Land Use Change from Skylab-3, S-190B, Sheet 700 - 400.

1970 - 1973	Hectares	% of total
(A) 111 - (Y) 760	70	2.46
(C) 120 - (Y) 760	12	.42
(L) 170 - (A) 111	4	.14
(L) 170 - (C) 120	8	.28
(L) 170 - (K) 160	8	.28
(M) 210 - (A) 111	106	3.72
(M) 210 - (B) 112	44	1.54
(M) 210 - (C) 120	6	.21
(M) 210 - (K) 160	21	.74
(M) 210 - (L) 170	40	1.40
(M) 210 - (S) 530	7	.25
(M) 210 - (Y) 760	206	7.22
(O) 320 - (A) 111	897	31.46
(O) 320 - (C) 120	8	.28
(O) 320 - (K) 160	34	1.19
(O) 320 - (L) 170	92	3.23
(O) 320 - (S) 530	6	.21
(O) 320 - (Y) 760	1050	36.83
(Y) 760 - (A) 111	172	6.03
(Y) 760 - (B) 112	31	1.09
(Y) 760 - (C) 120	15	.53
(Y) 760 - (K) 160	14	.49
TOTAL	2851	100.00

1973 LAND USE INTERPRETATION FROM SKYLAB-3, S-190B
NEW HAVEN, CONNECTICUT

4560 kmN.

660 kmE.   UTM Grid Zone 18

0 .... 5 10
Kilometres

EXPLANATION

A—111, Single-Family Residential
B—112, Multi-Family Residential
C—120, Commercial & Services
D—130, Industrial
E—141, Highways
F—142, Railroad Facilities
G—143, Airport Facilities
H—144, Utility Rights of Way
I—145, Marine Craft Facilities
J—150, Industrial & Commercial Complexes
K—160, Institutions
L—170, Improved Open Space

M—210, Cropland, Pastures & Orchards
P—400, Forest Land
Q—510, Streams & Canals
R—520, Lakes
S—530, Reservoirs
T—540, Bays & Estuaries
U—610, Forested Wetland
V—620, Nonforested Wetland
W—720, Beaches & Mudflats
X—750, Strip Mines, Quarries &
       Gravel Pits
Y—760, Transitional Land

Figure 1.--Level III land use for New Haven test site (Sheet 560-660).
     Compiled at 1:100,000 scale from NASA Skylab-3, S-190B
     imagery (September 19, 1973).

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1973 LAND USE INTERPRETATION FROM SKYLAB-3, S-190B
WASHINGTON, D. C.

EXPLANATION

A—111, Single-Family Residential
B—112, Multi-Family Residential
C—120, Commercial & Services
D—130, Industrial
E— 141, Highways
G—143, Airport Facilities
H—144, Utility Rights of Way
J— 150, Industrial & Commercial Complexes
K—160, Institutions

L— 170, Improved Open Space
M—210, Cropland. Pastures & Orchards
P—400, Forest Land
Q—510, Streams & Canals
S—530, Reservoirs
X—750, Strip Mines. Quarries & Gravel Pits
Y—760, Transitional Land

Figure 2.-- Level III land use for Washington test site (Sheet 320-310).
Compiled at 1:100,000 scale from NASA Skylab-3, S-190B
imagery (August 5, 1973).

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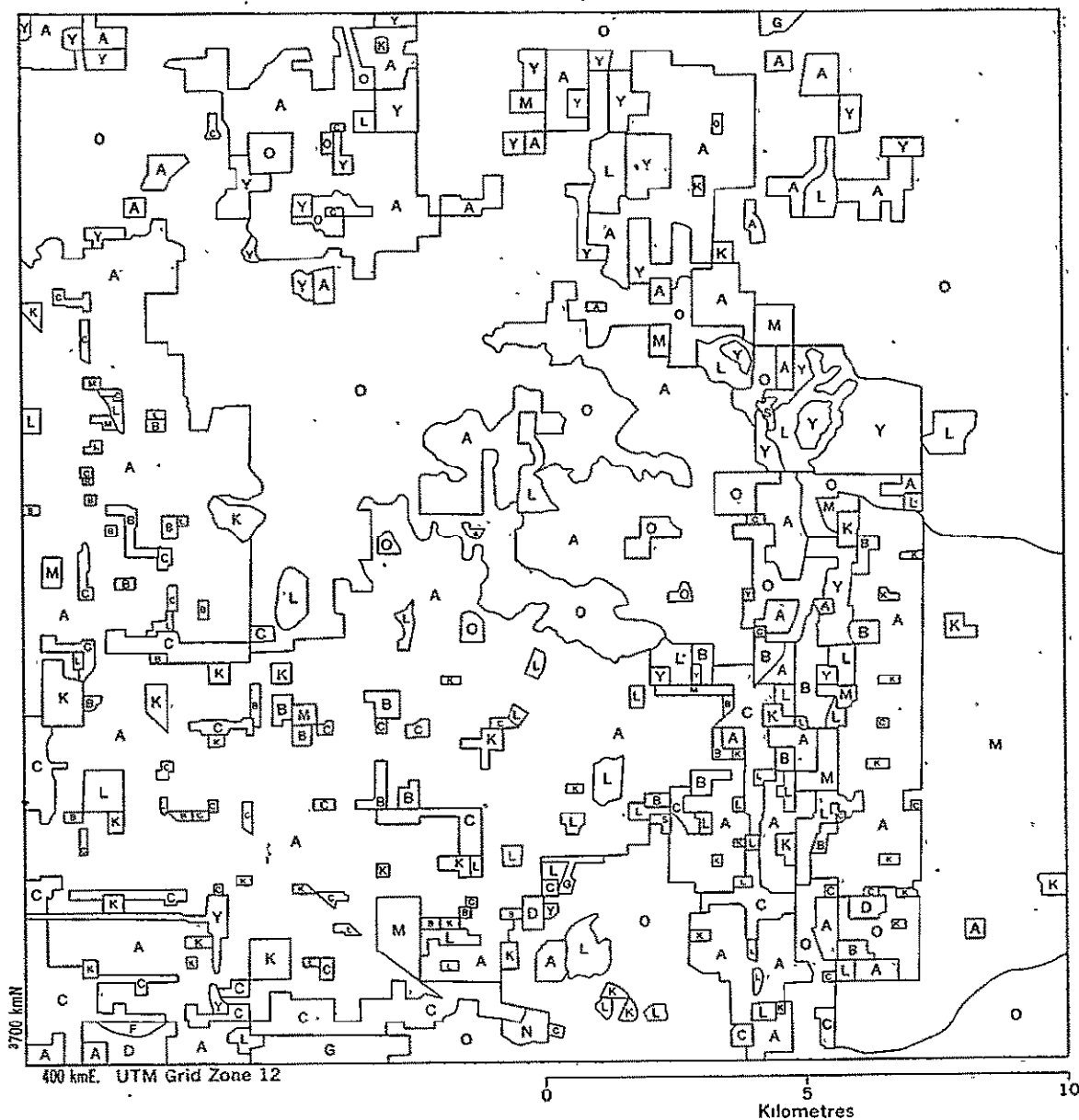
1973 LAND USE INTERPRETATION FROM SKYLAB-3, S-190B
PHOENIX, ARIZONA

400 kmE. UTM Grid Zone 12

Kilometres

EXPLANATION
A—111, Single-Family Residential
B—112, Multi-Family Residential
C—120, Commercial & Services.
D—130, Industrial
F—142, Railroad Facilities
G—143, Airport Facilities
K—160, Institutions
L—170, Improved Open Space
M—210, Cropland, Pastures & Orchards
N—230, Confined Feeding Operations
O—320, Shrub-Brushland Range
S—530, Reservoirs
Y—760, Transitional Land .

Figure 3.—Level III land use for Phoenix test site (Sheet 700-400).
Compiled at 1:100,000 scale from NASA Skylab-3, S-190B
imagery (September 6, 1973).
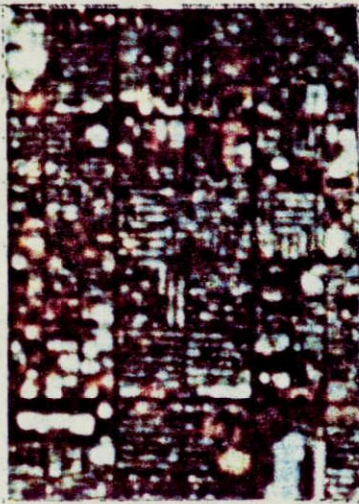
A) Phoenix Site. Older single-family housing in
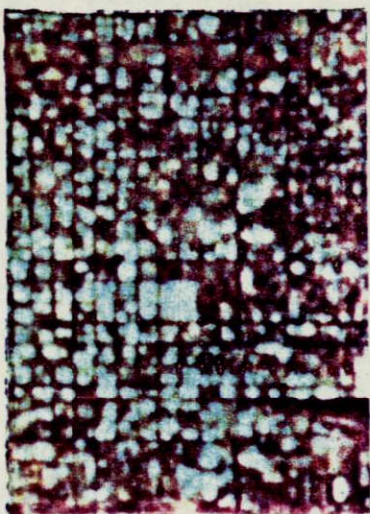eastern Phoenix, Arizona (center).

B) New Haven Site. Newer single-family housing in
Milford, Connecticut.

C) Washington Site. Apartment complexes along
Georgia Avenue near Wheaton, Montgomery County,
Maryland (center).

Figure 4.--Examples of residential land uses observed from Skylab-3,
S-190B imagery in the Phoenix, New Haven, and Washington
test sites. Photographic reproductions are at 1:40,250 scale.
EDC-010109.

A) <u>Phoenix Site</u>. Central business district in Phoenix, Arizona.

B) <u>New Haven Site</u>. Strip commercial development in Milford, Connecticut.
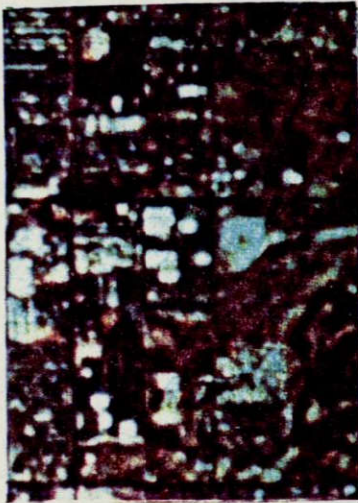
C) <u>Washington Site</u>. Suburban shopping center in Wheaton, Montgomery County, Maryland.

Figure 5.--Examples of commercial land uses observed from Skylab-3, S-190B imagery in the Phoenix, New Haven, and Washington test sites. Photographic reproductions are at 1:40,250 scale. EDC-010110.

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A) New Haven Site. Industrial area overlooking New Haven Harbor, Connecticut.

B) Phoenix Site. Light industrial area in eastern Phoenix, Arizona (center).

C) Washington Site. Industrial and commercial complex in Montgomery County, Maryland.

Figure 6.--Examples of industrial, and industrial-commercial complexes observed from Skylab-3, S-190B in the New Haven, Phoenix, and Washington test sites. Photographic reproductions are at 1:40,250 scale. EDC-010111.

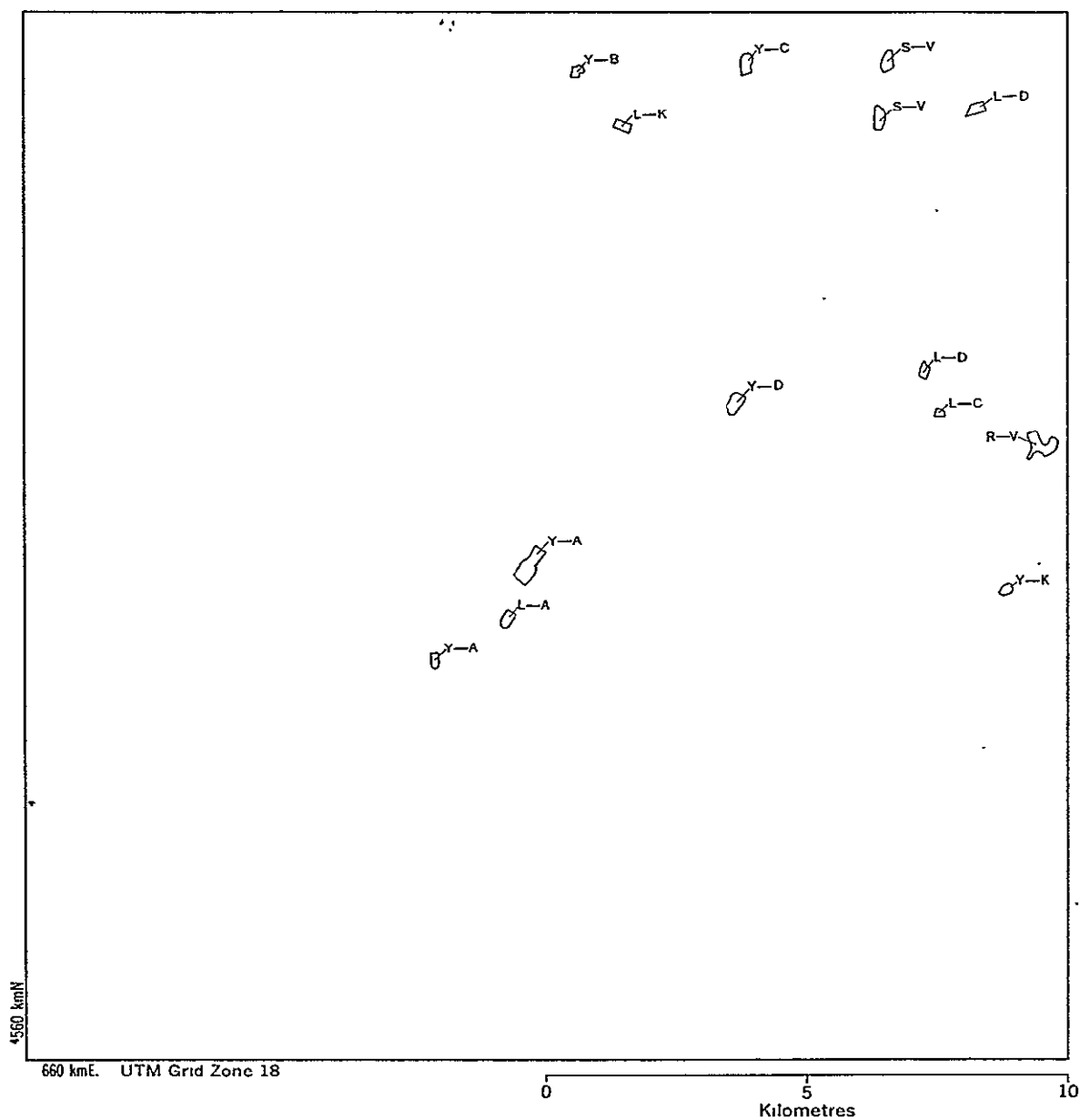A) Washington Site. Highway interchange in suburban Maryland.

B) New Haven Site. Railroad yard west of Interstate Route 91, North Haven, Connecticut.

C) Phoenix Site. Airport runways and terminal buildings in Phoenix, Arizona.

Figure 7.--Examples of transportation land uses observed from Skylab-3 S-190B imagery in the Washington, New Haven and Phoenix test sites. Photographic reproductions are at 1:40,250 scale. EDC-010112.

Y—B Y—C S—V

L—K S—V L—D

L—D

Y—D L—C

R—V

Y—A

L—A

Y—A Y—K

4560 kmN

660 kmE. UTM Grid Zone 18

0 5 10
Kilometres

EXPLANATION

L—K

LAND USE CHANGE
*First letter indicates 1970 land-use
interpretation, second letter indicates
1970–73 change in land use*

A—111, Single-Family Residential
B—112, Multi-Family Residential
C—120, Commercial & Services
D—130, Industrial
K—160, Institutions
L—170, Improved Open Space
R—520, Lakes
S—530, Reservoirs
V—620, Nonforested Wetland
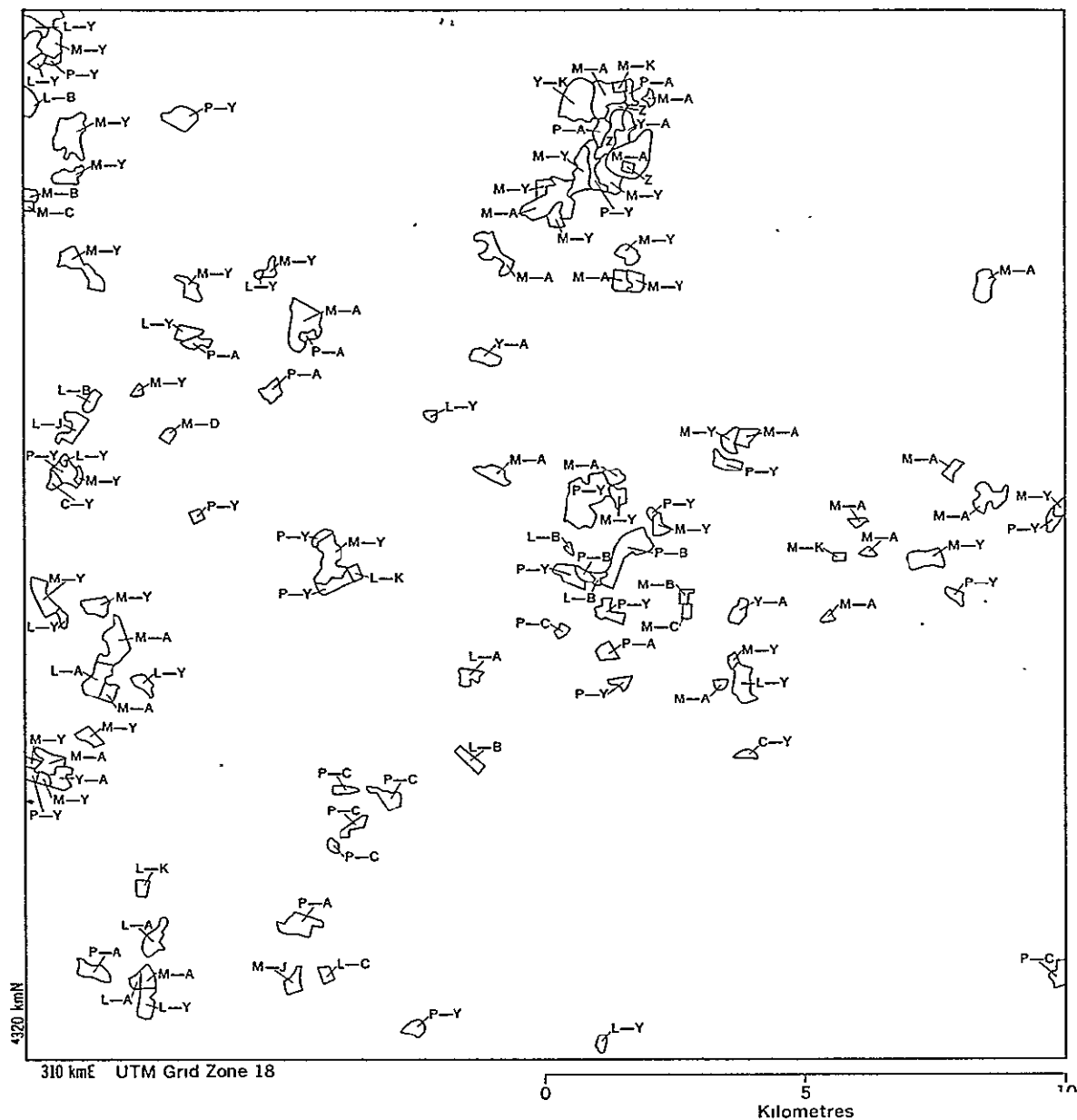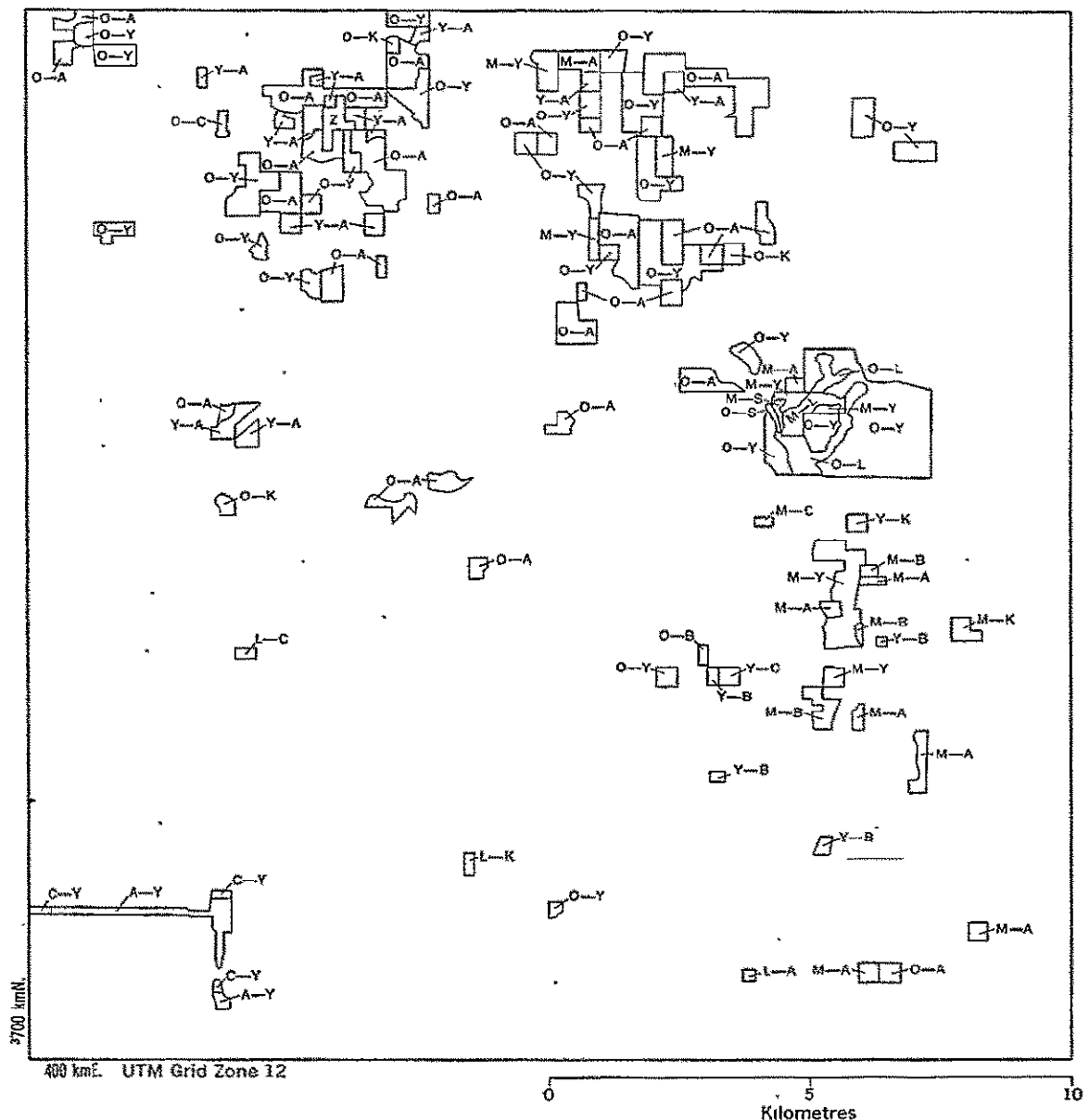Y—760, Transitional Land
Z   No Change in Land Use

Figure 8.—Level III land use change for New Haven test site (Sheet 560-
660). Compiled at 1:100,000 scale by comparing 1973
Skylab-3 land use interpretation with NASA RC-8 imagery
(June 28, 1970).

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310 kmE UTM Grid Zone 18

4320 kmN

0   5   1͏0
Kilometres

EXPLANATION

A—111, Single-Family Residential
B—112, Multi-Family Residential
C—120, Commercial & Services
D—130, Industrial
E—141, Highways
J—150, Industrial & Commercial Complexes
K—160, Institutions
L—170, Improved Open Space
M—210, Cropland, Pastures & Orchards
P—400, Forest Land
Y—760, Transitional Land
Z   No Change in Land Use

LAND USE CHANGE

First letter indicates 1970 land-use
interpretation, second letter indicates
1970–73 change in land use

Figure 9.—Level III land use change for Washington test site (Sheet
320–310). Compiled at 1:100,000 scale by comparing 1973
Skylab-3 land use interpretation with NASA RC-8 imagery
(June 28. 1970).

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1970-1973 LAND USE CHANGE DETECTION FROM SKYLAB-3, S-190B
PHOENIX, ARIZONA

Figure 10.-- Level III land use change for Phoenix test site (Sheet
700-400). Compiled at 1:100,000 scale by comparing 1973
Skylab-3 land use interpretation with NASA RC-8 imagery
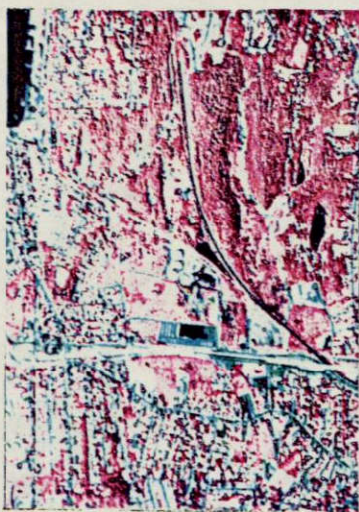(May 22, 1970).

A) New Haven Site. Storage tank construction in East Haven, Conn. area (center).

B) Washington Site. Single family residential construction near Olney, Montgomery County, Maryland.

C) Phoenix Site. Rangeland under construction in Scottsdale, Arizona.

Figure 11.—Comparative remote sensor sets illustrating land use change in the New Haven, Washington, and Phoenix test site. Photographic reproductions are at 1:40,250 scales. EDC-010113.