

Distribution of Pinyon-Juniper in the Western United States

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Abstract—The extent of pinyon-juniper woodlands in the Western United States, as determined from advanced very high resolution radiometer (AVHRR) data, has been appraised at approximately 55.6 million acres. There is presently no complete national inventory to which this total can be compared; however, Forest Service plot-based estimates and independent GAP predictions are consistent with the AVHRR acreage in Utah where adequate inventory data exist. An assessment by the Bureau of Land Management has yielded higher pinyon-juniper coverage for their own lands than that derived from AVHRR data. Spatial discrepancies remain between the AVHRR and GAP coverages, however. The importance of algorithms in classifying remotely sensed data is noted.

The Government Performance and Results Act (GPRA) of 1993 requires all Federal agencies, including USDA Forest Service and USDI Bureau of Land Management (BLM), to prepare recurring strategic plans. In order to carry out any strategic plan, agencies must have an adequate understanding of the conditions of lands under their jurisdiction. National assessments are used to provide the information needed for understanding the rangeland situation in the United States (Joyce 1989). Included in most assessments for land management agencies are estimations of the extent of and shifts in major rangeland cover types, including pinyon-juniper. In this paper, reference to pinyon-juniper includes both pinyon-juniper and juniper woodlands.

Given the relative disparities among previous appraisals of pinyon-juniper coverage in the Western United States (West and others 1975, USDA Forest Service 1989), we needed a better estimate of its distribution to support GPRA strategic plans due in the years 2000 and 2003. To do so, we used several data sources, including reports from Forest Inventory and Analysis (FIA) surveys, two different estimation methods utilizing advanced very high resolution radiometer (AVHRR) data, and GAP data to evaluate one AVHRR estimator of nationwide pinyon-juniper distribution. In addition, we compared these estimates to pinyon-juniper acreages provided by BLM for their lands.

In: Monsen, Stephen B.; Stevens, Richard, comps. 1999. Proceedings: ecology and management of pinyon-juniper communities within the Interior West; 1997 September 15–18; Provo, UT. Proc. RMRS-P-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

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Methods

We used a digitized forest type map, developed from AVHRR data by the Forest Service's Southern Forest Experiment Station in 1992, as a baseline estimator to assess the extent of pinyon-juniper woodlands, by Federal ownership categories, in the Western United States (Powell and others 1994). This classification (USFS-AVHRR) differed from an earlier one produced by U.S. Geological Survey (USGS-AVHRR; Loveland and others 1991) in three ways:

- It combined AVHRR and Landsat TM classifications to create a "forest density" map that filtered out non-forest pixels.
- It used thermal Landsat bands. The USGS classification used only composite maximum greenness time-series images to separate vegetation types—a process which may not have been effective in arid environments.
- It was validated by FIA plot-based data.

Using ARC/INFO, we partitioned an Albers (equal area) projection of the USFS-AVHRR pinyon-juniper distribution map by Forest Service, BLM, other Federal, and non-federal land ownership, and calculated the acreage in each category.

The Forest Service estimations for pinyon-juniper coverage, by state, were compared with FIA statistics for Utah and Nevada, where extensive FIA plot-based inventory data exist (O'Brien and Woudenberg, this proceedings). Although FIA state-level estimates include all land ownerships within the Intermountain region, for the most part National Forest Systems (NFS) provided the data for NFS lands. Data for forests and woodlands not on NFS lands, including most BLM lands, were collected by FIA. In 1991, FIA carried out a statewide inventory of all forest lands across all ownerships in Utah, including reserved (O'Brien 1999).

We also compared estimates of pinyon-juniper abundance on BLM lands, by state, with acreages reported by USDI Bureau of Land Management (1993).

Finally, we were interested in ascertaining how similar the USFS-AVHRR approximation for Utah was to the coverage of pinyon-juniper from the vegetation layer in the Utah GAP program (Edwards and others 1995). The Utah GAP program followed a complex vegetation classification system that used Landsat TM imagery at 30-m pixel resolution for a base map, but was modified by visual photo interpretation of aerial photography and digitizing of existing vegetation maps (Scott and others 1993). Thus, the two protocols would be based upon a substantially different pixel size, 1-km for USFS-AVHRR and 30-m for the GAP analysis.

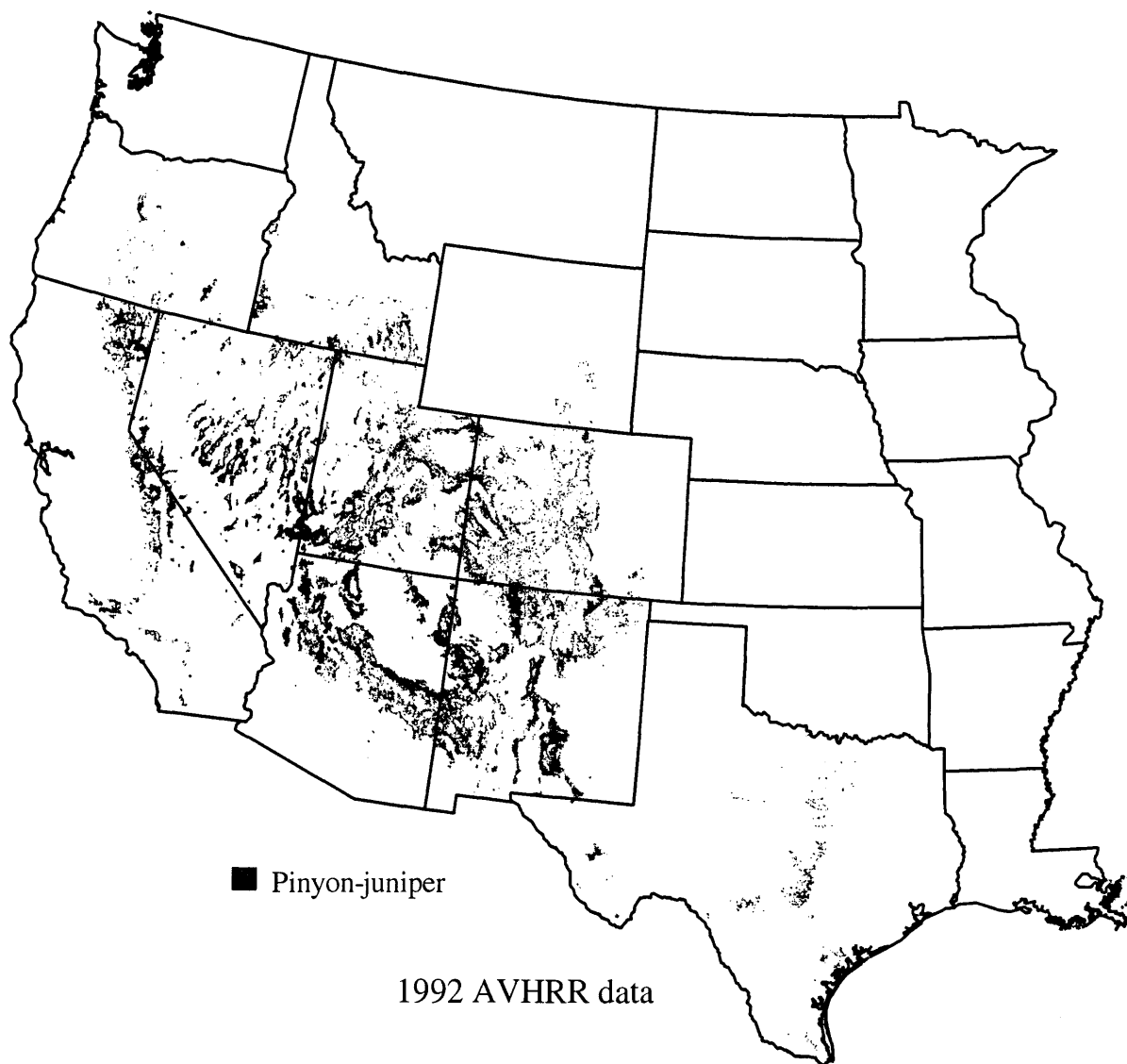


Figure 1—Distribution of pinyon-juniper woodland in the western United States (from Powell and others 1994).

Results

The Forest Service AVHRR estimate of national pinyon-juniper coverage is portrayed in figure 1 and is presented numerically in table 1 by state and land ownership. The five states of Nevada, Utah, Colorado, Arizona and New Mexico account for 46.3 million acres or about 83 percent of all U.S. lands dominated by pinyon and/or juniper. We estimate the total U.S. area occupied by pinyon-juniper to be 55.6 million acres.

Forest Inventory and Analysis plot data summarized in this document report that Nevada has 8.839 million acres of pinyon-juniper woodland with a standard error of 187,300 acres (O'Brien and Woudenberg, this proceedings). Likewise, Utah is estimated to have 9.149 million acres of pinyon-juniper woodland with a standard error of 279,500 acres. The AVHRR estimate for Utah of 9.439 million acres shown in table 1 is contained within an 80 percent confidence interval for the FIA estimate. For Nevada, the AVHRR

Table 1—Area of pinyon-juniper woodlands, by state and ownership, for 10 western states. From a Forest Service classification of AVHRR data (Powell and others 1994).

State	Acres (Thousands)				All lands
	USFS	BLM	Other Fed	Nonfederal	
Ariz.	3,634	964	3,322	1,708	9,628
Calif.	3,179	793	435	494	4,901
Colo.	2,248	1,827	500	2,021	6,596
Idaho	828	594	123	187	1,732
Nev.	2,754	4,635	414	303	8,106
N.M.	4,276	1,459	2,184	4,642	12,561
Ore.	350	134	117	186	787
Texas	0	0	85	1,562	1,647
Utah	3,696	4,064	551	1,128	9,439
Wyo.	125	12	0	66	203
Total	21,090	14,482	7,731	12,297	55,600

Table 2—Area of “woodlands” on BLM land by state for nine western states as reported by USDI Bureau of Land Management (1993).

State	Acres (Thousands)
Arizona	1,240
California	387
Colorado	3,534
Idaho	385
Nevada	6,210
New Mexico	1,721
Oregon	286
Utah	6,418
Wyoming	207
Total	~20,400

estimate of 8.106 million acres is not within the 80 percent confidence interval of 8.600 million acres to 9.079 million acres derived from FIA data (O’Brien and Woudenberg 1999) (table 1).

Table 2 portrays area of pinyon-juniper for BLM lands alone, based upon surveys from USDI Bureau of Land Management (1993). The BLM acreages greatly exceed the AVHRR estimates for lands under the jurisdiction of BLM except for California, Idaho and New Mexico (table 1). The largest dissimilarities are for Utah, Colorado and Nevada. One explanation for the somewhat high BLM estimates for Utah and Colorado would be their inclusion of oak-mountain mahogany woodlands within the woodland category (Küchler 1964).

A comparison of the two classifications of AVHRR data for the extent of pinyon-juniper in the state of Nevada is a pertinent example of how much variation can ensue from two algorithms that process the same raw data. The 1990 USGS protocol detected a total of 2.4 million acres of “western woodland” in Nevada, of which 319,000 acres was classified as pinyon-juniper woodland (fig. 2). The 1992 FS

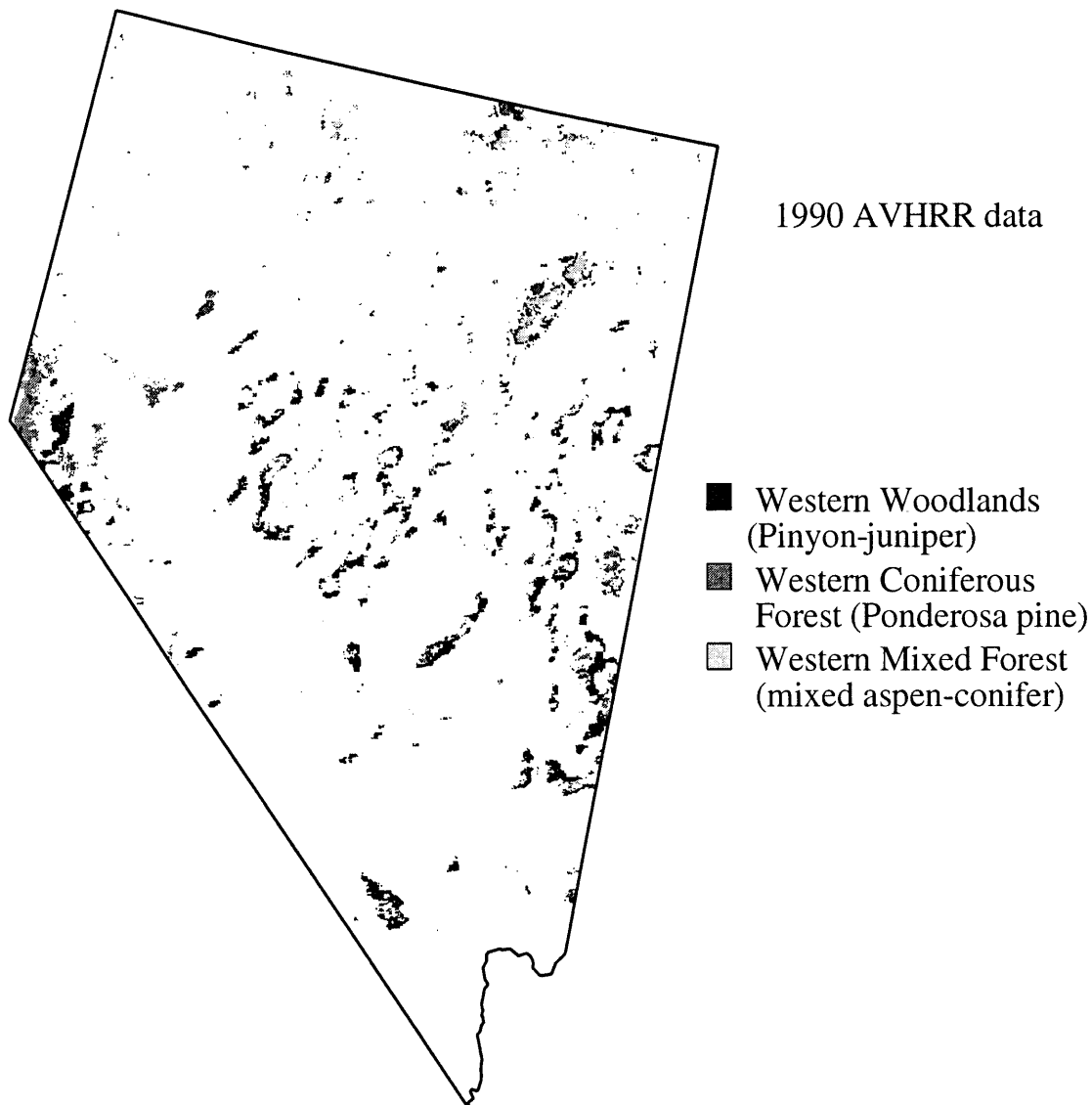


Figure 2—Distribution of pinyon-juniper woodland in Nevada, derived from a U.S. Geological Survey algorithm of AVHRR data (see Loveland and others 1991).

classification distinguished 8.1 million acres of pinyon-juniper woodland in Nevada, an estimate much closer to the 8.8 million acres obtained from FIA plot data (O'Brien and Woudenberg, this proceedings) (fig. 3).

The differences between the 1990 USGS-AVHRR and USFS-AVHRR estimates of pinyon-juniper acreages in Nevada can be visualized by examining a smaller area within the state. We arbitrarily selected an area just inside Nevada's border with Utah, primarily in White Pine and Lincoln Counties, to compare the visual effect of the two classifications. The results are obvious and profound (fig. 4 and 5).

The assessment for pinyon-juniper coverage in the state of Utah comparing USFS-AVHRR and GAP analysis is revealing. The two estimates for total cover are extremely close, 9.439 million acres to 9.596 million acres, respectively. Nonetheless, the spatial distributions are different in both

locale and density (fig. 6 and 7). We had expected the larger pixel size of the USFS-AVHRR map to result in a less fragmented portrayal of pinyon-juniper, but the opposite actually occurred. The indication of differences in locale can be seen by comparing stand distributions using county lines, particularly in the south-central part of the state.

To quantify this apparent lack of consensus between the USFS-AVHRR and GAP analysis maps, we tested for overlap of the pinyon and/or juniper polygons in the ARC/INFO vector files from the two respective approaches. Only 3.92 million acres in Utah were jointly classified as pinyon-juniper, pinyon or juniper by the two methods. That means each of the methods classified approximately 5.5 million acres as pinyon-juniper woodland that the other did not. In other words, the USFS-AVHRR and GAP analysis data collectively identified a total of more than 15 million acres as being dominated by pinyon-juniper, but less than 4 million of

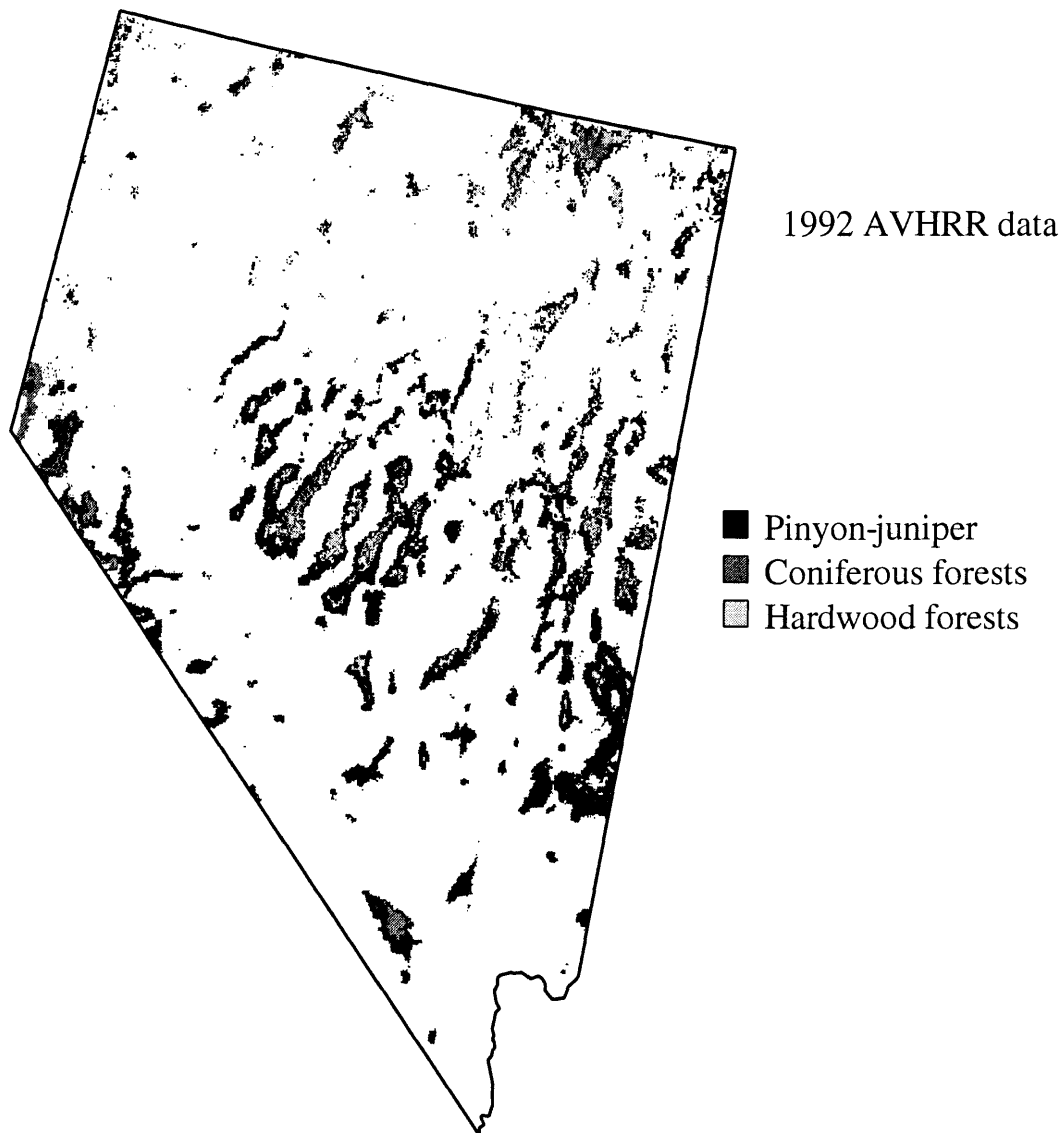


Figure 3—Distribution of pinyon-juniper woodland in Nevada, derived from a USDA Forest Service algorithm of AVHRR data (see Powell and others 1994).

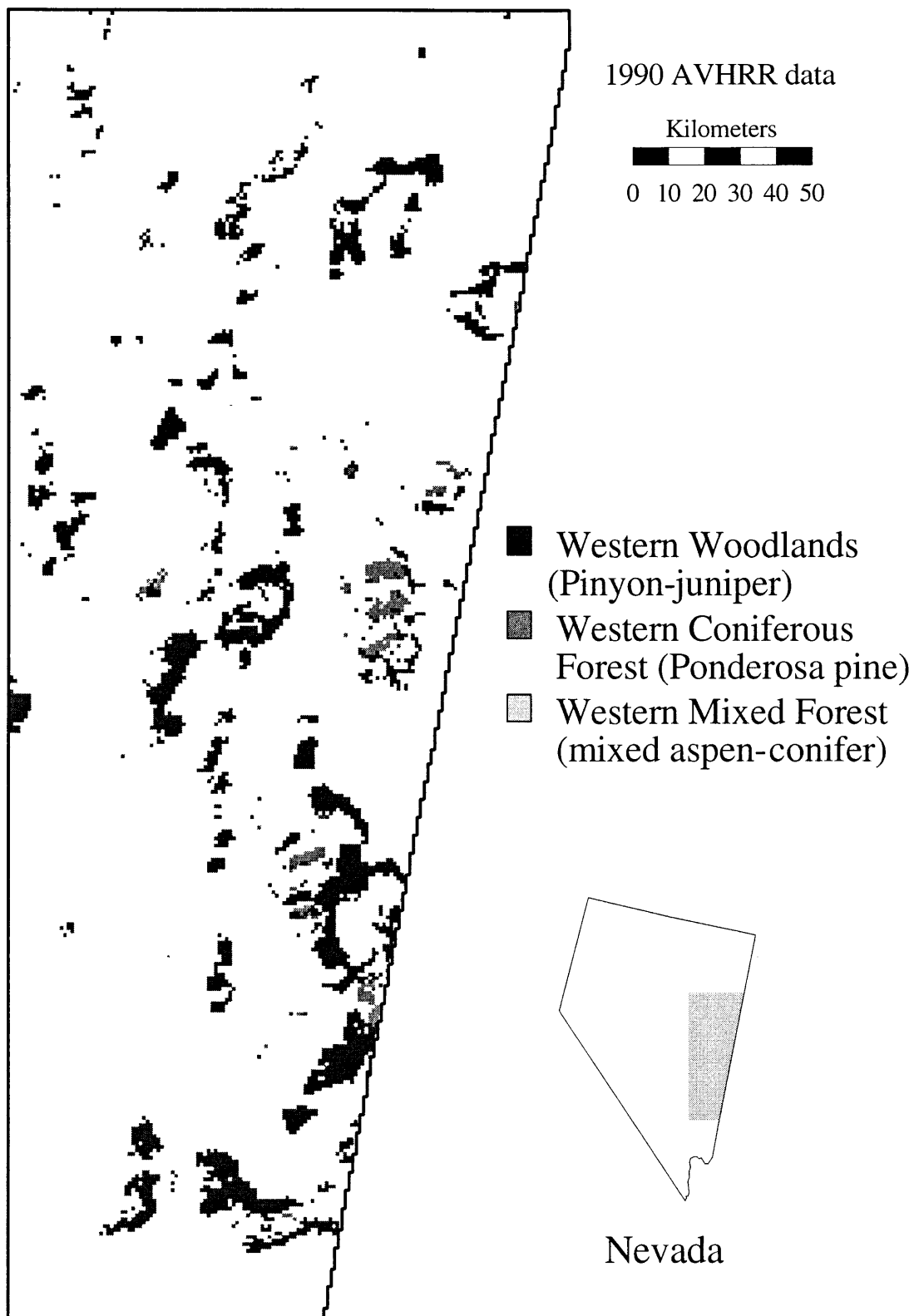


Figure 4—Distribution of various forest and woodland cover types in eastern Nevada, derived from a U.S. Geological Survey algorithm of AVHRR data (see Loveland and others 1991).

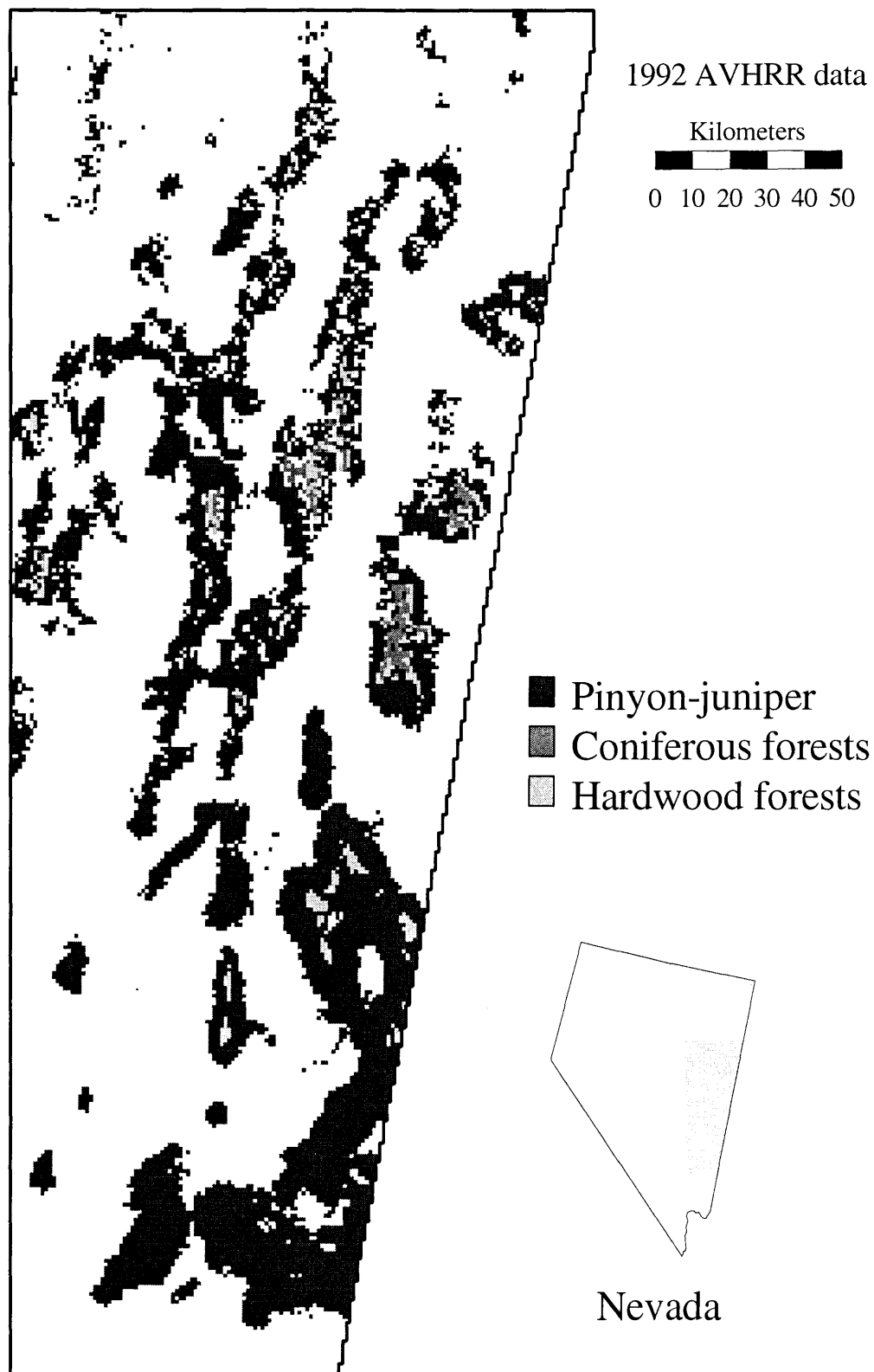
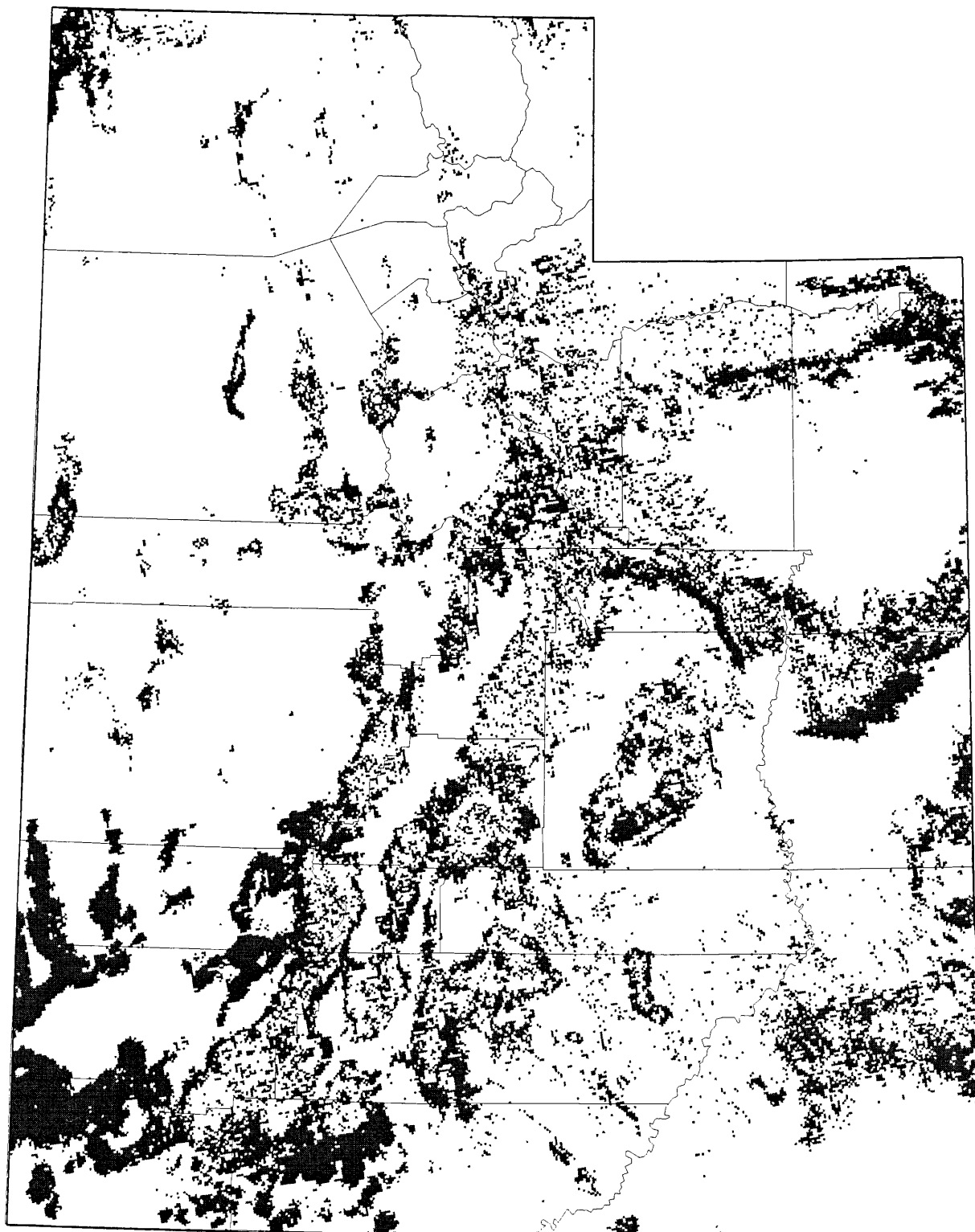


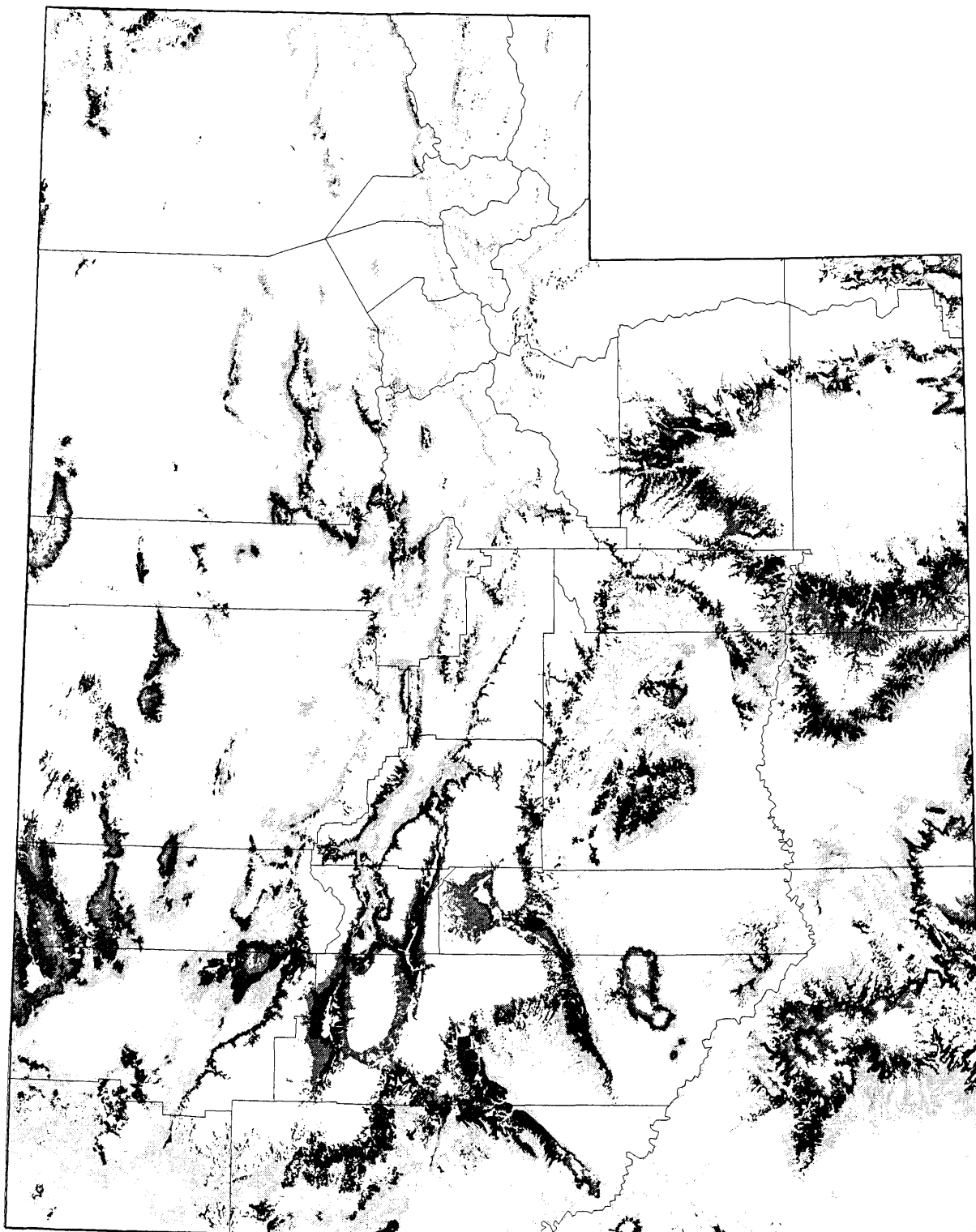
Figure 5—Distribution of various forest and woodland cover types in eastern Nevada, derived from a USDA Forest Service algorithm of AVHRR data (see Powell and others 1994).



Data Source:
1992 AVHRR data

Legend
 ■ Pinyon-Juniper □ County lines

Figure 6—Distribution of pinyon-juniper woodland in Utah using AVHRR data with a 1-km² pixel size (see Powell and others 1994).



Legend

- | | |
|------------------|----------------|
| ■ Pinyon Juniper | □ Juniper |
| ■ Pinyon | ▨ County lines |

Data Source:
USGS Biol. Res. Div.

Figure 7—Distribution of pinyon-juniper woodland in Utah using GAP data with a 900-m² pixel size (see Edwards and others 1995).

those acres were classified in that category by both methods. Based upon the close agreement among FIA, USFS-AVHRR, and GAP predictions for the extent of pinyon-juniper woodland in Utah, we conclude that the actual coverage is about 9.5 million acres. However, its precise spatial distribution remains inconclusive.

Discussion

Broad inconsistencies exist between the various sources of land-cover data for pinyon-juniper woodlands. In general, the BLM's estimates for their own land exceed that provided by remote sensing. The difference in total woodland area on BLM lands, 20.4 million acres versus 14.5 million acres from the AVHRR estimate, cannot be totally accounted for by considering woodlands not containing juniper. Moreover, the agreement between the FIA data and USFS-AVHRR maps for Utah imply that the BLM estimates may be somewhat high. FIA estimates tend to track the USFS-AVHRR totals for pinyon-juniper for those states where comprehensive plot data are available across major landowner categories.

The relationship between the USFS-AVHRR and Utah GAP estimates for pinyon-juniper land cover demonstrate the importance of scale (pixel size) and algorithms for defining land cover types when evaluating different protocols. Research is obviously needed to develop ways for rectifying incompatible attributes of regional and national monitoring systems.

The most efficient monitoring system for making national and regional assessments may incorporate both remotely-sensed data and data from a systematic structure of ground observations. At a minimum, a multi-stage sampling procedure involving plot data could more easily validate cover type misclassification of remotely-sensed data.

Acknowledgments

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