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Testimony of
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before

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Commerce, Science, and Transportation

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I. Introduction

Thank you for the opportunity to testify on S. 2297, the ***Land Remote Sensing Policy Act of 1992*** and other issues related to land remote sensing.

I strongly endorse the proposed ***Land Remote Sensing Policy Act of 1992*** as summarized in S. 2297. The proposed legislation should allow the United States to recapture its lead in land remote sensing. I will identify very specific reasons why I endorse the "de-commercialization" of the Landsat program and make specific recommendations to the committee which I hope can be considered.

II. The United States Has Lost Its Technological Leadership in Land Remote Sensing Sensor Systems

In the opening remarks to Congress on February 27th, 1992, Mr. Pressler stated that the goal of Senate bill 2297 was to

> "...maintain its leadership in land remote sensing by providing data continuity for the Landsat Program...".

I agree that remote sensing scientists in the United States are the recognized leaders in the world today in understanding how to capture, analyze and model land remote sensing data using analog and digital image processing techniques to provide valuable environmental information. *Unfortunately, the current (Landsat 4 & 5) and proposed (Landsat 6) sensor systems deployed are antiquated. Therefore, I believe the United States is no longer the leader in satellite land remote sensor technology.* Commercialization of the Landsat system has brought the United States to this point.

I am not the only academic who feels this way. For example, Estes and Jones (1992) recently conducted an indepth survey of academic geographers in the United States on their feelings about Landsat commercialization (academic geographers conduct the majority of the remote sensing teaching in the U.S. and a substantial amount of the research). Out of 299 questionnaires sent, 167 were returned. When asked "has commercialization of remote sensor data had a positive or negative impact on remote sensing research?", 77% felt it was negative or very negative (Figure 1). When asked "has commercialization of remote sensor data had a positive or negative impact on remote sensing education?", 74% said negative or very negative (Figure 2). Finally, when asked "how strongly would you support the federal government taking over the operation of the Landsat system?", an overwhelming 86% registered either support or strong support, while only 4% were opposed (Figure 3). Thus, there is a tremendous groundswell of support among some academics for federal government *de-commercialization* of the Landsat program.

IIa. Landsat 4 & 5 and Even Landsat 6 (1993) Sensor Systems are Almost Obsolete

Landsat 4 with its Thematic Mapper (TM) and Multispectral Scanner (MSS) sensor systems was launched on July 16, 1982 and Landsat 5 on March 1, 1984. These were magnificent sensors systems for their time, representing the best land remote sensing systems in the world in terms of spatial, spectral, temporal, and radiometric resolution (Table 1). They were placed in orbit while the United States government was in charge of the land remote sensing program. EOSAT signed the contract to begin commercialization in September, 1985. At that time it was hoped that EOSAT inconjunction with the federal government would devote considerable resources to the continued development of improved Landsat remote sensor technology. Unfortunately, under commercialization from 1985 to May 6, 1992, we have not seen any improvement in the spatial, spectral, and temporal characteristics of the Landsat system. Even when Landsat 6 is launched in January, 1993 we will see only modest improvement which will still be based on antiquated 'scanning mirror' technology.

Basically, the United States gave up its lead in satellite remote sensing when the French launched the Le Systeme Pour l' Observation de la Terre (SPOT) on February 21, 1986 (and SPOT 2 in 1990). It is instructive to review the characteristics of the Landsat Thematic Mapper we currently have and compare it to what the French SPOT satellites provide (Tables 1 and 3). It is also useful to identify the proposed Landsat 6 and SPOT 4 sensor systems (Tables 1 and 3) to determine if the United States can regain its leadership in land satellite remote sensor technology. Finally, an opinion about the optimum Landsat 7 sensor system configuration is provided (Table 2)

IIb. Remote Sensor Detector Hardware

Landsat: Landsat 4 (1982), Landsat 5 (1984), and even Landsat 6 (1993) are based on 'scanning mirror' technology (Jensen, 1986; Fischal, 1992). The moving mirror in a mechanical scanning sensor is subject to wear, has variable speed of movement across the image causing across-track geometric distortion, and contributes to instability of satellite orientation (Campbell, 1987). Furthermore, the scanner technology often yields substantial 'stripping' which is especially troublesome when performing water quality research (Jensen et. al., 1989).

SPOT: Conversely, the French SPOT High Resolution Visible (HRV) sensors use 'pushbroom' scanning technology based on charge coupled devices (CCDs) that can simultaneously image an entire line of data (in the cross-track axis) without mechanical movement. SPOT linear arrays consist of some 6,000 detectors for each scan line in the focal plane; the array is scanned electronically to record brightness values in each line. The absence of moving parts provides greater reliability, more uniform scanning speed across the image swath, and greater stability of the satellite, thereby assuring higher geometric accuracy (Campbell, 1987). *Future Landsat sensor systems should be based on this type of linear or area array technology.*

IIc. Spectral Resolution

Landsat: From 1982 until the launch of SPOT 1 on February 1, 1986, Landsat 4 & 5 TM sensor systems had the best spectral resolution in the world (Table 1; Figure 4). The three visible, near-infrared, and two mid-infrared bands have been of significant value to a tremendous variety of environmental problems. The thermal infrared band has only been of marginal value, due primarily to its poor spatial resolution (120 x 120 m) and often excessive stripping. These same bands plus a panchromatic band from .5 - .9 um will be used on Landsat 6 in 1993. Unfortunately, the bandwidth of the new Landsat 6 panchromatic band was not selected by rigorous scientific experimentation. Its selection was based on an in-house simulation study (Fischal, 1992) using an aircraft mounted ITRES sensor system acquiring data at 7.5 x 7.5 m spatial resolution (later resampled to 15 x 15 m pixels). No one knows the scientific utility of the new TM panchromatic band compared to the proven success of the SPOT panchromatic band (.51 - .73 um) which was selected based on 40 years of applications using panchromatic aerial photography in the same spectral region. They bypassed the scientific/academic community in the selection of what appears to be the most important new component of the Landsat 6 system.

Landsat 6 has another significant 'spectral' problem. While they tout the fact that Landsat 6 will have a new panchromatic band, it can only be acquired at the expense of valuable information in other bands. In fact, the user community only has three data acquisition choices: a) obtain data using the original 7 TM bands (no new improvement of technology here), b) obtain data from the panchromatic band, band 4, band 5, and band 6, or

c) panchromatic, band 4, band 6, and band 7. Thus, there is no way to get the original 7 TM bands plus a panchromatic band! While users of SPOT panchromatic and multispectral (XS) data are allowed to purchase the entire data stream, users of Landsat 6 data must purchase two complete data streams (if possible) to obtain the bands they will need for most applications. This is totally unsatisfactory for state remote sensing applications as has been summarized in a letter from South Carolina state agencies (Sommers, 1992).

Fischal (1992) states that these limited data streams are the result of being constrained to $\leq$85 Mbits/second to minimize the impact on foreign ground receiving stations. Why wasn't the United States user community consulted on what might have been deleted, such as the seldom used thermal channel or perhaps one of the mid-infrared bands? Instead, the 'new technology' of Landsat 6 cannot even be used to create standard natural color or color-infrared composites which are so helpful in most research endeavors (Chavez et al., 1990) without purchasing two complete data sets (if possible). Furthermore, it is widely known that when remote sensing vegetation (agriculture, forestry, wetlands) it is best to include a band from the visible, the near infrared, and the mid-infrared in addition to the panchromatic data (e.g. bands 3, 4, 5, and pan) (Jensen et al., 1990). This most important data stream is not even an option under the proposed Landsat 6 system! This is another example of not consulting closely with the United States remote sensing scientific community before making decisions.

SPOT: The SPOT 1, 2, and 3 (1994) HRV instruments record energy in green, red, near-infrared and panchromatic wavelengths (Table 3). Users of SPOT panchromatic and multispectral (XS) data are allowed to purchase the entire data stream, not just subsets of it. The lack of mid- and thermal infrared bands has not stifled the purchase of SPOT scenes as most environmental remote sensing applications can be adequately performed using these four bands. Furthermore, the SPOT system can acquire across-track stereoscopic coverage which is so important for the creation of small scale planimetric maps and digital elevation models. Much of the digital image processing industry in the United States (ERDAS, Intergraph, R-Wel, I^2S etc.) recently developed 'soft-copy photogrammetry' software to derive digital elevation models from such data which often represent the heart of local and regional geographic information systems.

SPOT 3 (identical to SPOT 1 & 2) is built and ready to be launched. SPOT 4 is being constructed and is tentatively scheduled to provide a new mid-infrared band plus 4 to 5 new, yet-to-be-determined bands designed to collect 1 km x 1 km vegetation information (Figure 3). This 'veg' information will be obtained over the entire earth once per day if desired. Thus, SPOT Inc. is actively moving into the global vegetation monitoring marketplace with this new sensor system, while continuing to improve its high spatial and spectral resolution sensor systems.

SPOT 1, 2, and 3 (1994) data do have flaws. First, the panchromatic data must be registered to the multispectral data using digital image processing resampling techniques before a merged dataset can be analyzed (Jensen et al., 1990). However, all bands will be registered on SPOT 4 (1996). Second, a SPOT scene does not cover as much geographic area as a

Landsat TM scene (60 x 60 km versus 185 x 170 km, respectively). This can be a problem when studying extremely large areas.

IId. Spatial Resolution

Landsat: Landsat 4 & 5 TM data from 1982 to 1986 were the best in the world with 30 x 30 m spatial resolution for all bands except the thermal channel (120 x 120 m). Landsat 6 (1993) will have exactly the same bands and spatial resolution as Landsat 4 & 5 except for a new 15 x 15 m panchromatic band. Unfortunately, this 15 x 15 m panchromatic capability will still not be as good as the SPOT 10 x 10 m panchromatic data available since 1986.

SPOT: Since 1986, SPOT 1 & 2 HRV sensors have recorded multispectral imagery at 20 x 20 m spatial resolution and panchromatic data at 10 x 10 m. These spatial resolutions revolutionized land remote sensing from space because a) many studies of heterogeneous vegetation (e.g. wetland, forests, rangeland) require higher 20 x 20 m spatial resolution multispectral data, and b) many urban and suburban applications can be performed with panchromatic 10 x 10 m spatial resolution data. There has been a tremendous demand for the use of the panchromatic 10 x 10 m data where the rectified image data are used as a background layer in geographic information systems (GIS). SPOT 5 is to have 5 x 5 m panchromatic data capability, which will make Landsat 6 even more obsolete.

IIe. Temporal Resolution

Landsat: Landsats 4 & 5 have a repeat cycle of 8 to 16 days if both sensors are functioning. Landsat 6 will also be 'non-pointable'. This fixed temporal resolution means that Landsat data will always be difficult to acquire over relatively cloudy regions and that special off-nadir emergency acquisitions (e.g. Chernobyl, the Persian Gulf War) may not be acquired.

SPOT: From the beginning, the SPOT HRV sensors could be pointed off-nadir (the point directly below the spacecraft) to acquire data. Using the off-nadir viewing capability, SPOT can acquire repeat coverage at intervals of 1 to 5 days, depending upon latitude (Campbell, 1987). This results in significantly greater number of data acquisitions to be made of areas of interest when the sensors are not directly overhead. It is especially useful for obtaining imagery over areas with cloud cover problems. Furthermore, when an accident like Chernobyl or the Persian Gulf oil spill occurs, the SPOT system can be pointed to obtain data relatively quickly.

The United States land remote sensing system must become a 'pointable' sensor system.

IIf. Radiometric Resolution

The radiometric sensitivity of current and proposed Landsat TM data and SPOT data are sufficient for most earth resource applications. The data are quantized to 8 bits and provided on a variety of media (6250 bpi tapes, 8mm, and floppy disks).

IIg. Recommendations for a Landsat 7 Sensor System

Even when Landsat 6 is launched in January, 1993, we will continue to have sub-standard temporal (i.e. no pointability) and spatial resolution (i.e. only 15 x 15 m panchromatic and 30 x 30 m multispectral versus SPOT 10 x 10 m panchromatic and 20 x 20 m multispectral data). Furthermore, the utility of the Landsat 6 panchromatic spectral band may not prove as useful as expected because of a) its untested bandwidth, and b) the limited data streams available to the user community.

I serve on the SPOT 'Academic Advisory Committee'. I have also provided SPOT with my opinion on future SPOT sensor systems. Conversations with Clarke Nelson at SPOT suggest that SPOT 4 (tentatively scheduled to be launched in 1996) is expected to have a) a 10 x 10 m panchromatic band registered to the multispectral data, b) a mid-infrared band, and c) four or five new bands at 1 km by 1 km spatial resolution which will inventory the earth once every day for global science applications (Table 3). The President of SPOT Image Inc., Theodore Nanz says SPOT 5 ... "plans to go to five-meter resolution when it launches its privately funded satellite at the turn of the century" (Stephens,1991; Table 4). Thus, it is critical that the United States begin now to make Landsat 7 as good as possible if we are to regain our U.S. leadership in land remote sensing systems. *What really scares me is when people talk about making Landsat 7 a clone of Landsat 6.* For example, "Silvestrini said a Landsat 6 clone would only cost about $250 million." (EOSAT, 1991). *Therefore, a National Landsat Advisory Council should be established to a) receive input from university, public, and private industry remote sensing scientists, and b) direct new sensor system development. If this is not done, it appears we will fall further behind in land remote sensor technology.*

I suggest that the sensor system summarized in Table 2 be considered for Landsat 7. This is based on years of personal experience with Landsat MSS and TM data, SPOT XS and panchromatic data, aircraft multispectral scanning systems (e.g. Daedalus) and the conceptual sensor system design put forth by Light (1990) and Colvocoresses (1991). First, multispectral data should be acquired in the bands shown at 10 x 10 m spatial resolution. A panchromatic band from .51 - .73 um should collect data at 5 x 5 m spatial resolution. *All of the data stream should be available to the user community.* This would satisfy 90% of the earth resource applications. To satisfy planimetric and topographic mapping activities at $\leq$ 1:50,000 scale, a fore and aft panchromatic stereoscopic viewing capability is required which will yield 10 m contour intervals which meet national map accuracy standards. These data should be acquired using linear and/or area array remote sensor technology, not scanner technology. All sensors should be pointable, if possible. It is recognized that such a system will generate a significant data stream (266 Mbits/second) but that it 'is within the limits of current technology' (Light, 1990). *This type of remote sensing system should be deployed if the United States is serious about regaining its leadership in satellite land remote sensor technology.*

III. Landsat Data Are Too Costly, Cannot Be Shared, and are not Provided in a Timely Manner

IIIa. The Prohibitive Cost of the Landsat Data

The Landsat system has been managed by a) the EROS Data Center, b) NOAA, and c) EOSAT. The current price of Landsat MSS data are $1,000 per MSS scene (for those $\leq$ 2 years old) and $4,400 for a single Landsat TM scene (system corrected; October 1, 1991). This is outrageous. The exorbitant escalation in cost of both the photographic and digital products has resulted in a tremendous decrease in total items purchased [Figure 5; from Silvestrini (1991) and EROS Data Center (1991)]. The pricing structure has hindered the effective use of satellite data in the U.S. and the world for ecological applications (Roughgarden, et al. 1991) and is partially to blame for the feelings of many U.S. academics toward commercialization as summarized in Figures 1 - 3.

Foreign countries also have similar concerns (Voute, 1987; Lauer et al., 1991). For example, in the opening session of the meeting of Directors of National Remote Sensing Centers, sponsored by the United Nations Development Program's Economic and Social Commission for Asia and the Pacific (ESCAP), in Shanghai, People's Republic of China, in July, 1988, the Executive Secretary of ESCAP commented on the ..."widespread concern about the increasing cost of obtaining remotely sensed data," and the need to "...explore the possibility of assisting member countries to obtain such data at more reasonable prices" (Kabria, 1988). Then, one director after another included a statement in his or her annual report that condemned current pricing policies for Landsat and SPOT data. For Indonesia, it was "...the unfavorable price relating to satellite imagery" (Irsyam, 1988); for Pakistan, "... the commercialization of satellite remote sensing systems and the increasing cost of space segment services could have an adverse effect on the development of remote sensing programs" (Mehmud and Mirza, 1988); and from Sri Lanka, "paucity of funds has also limited the frequency with which air photography or satellite imagery could be obtained" (Berugoda, 1988). Even a recent report from the People's Republic of China noted that, if the costs of satellite imagery continue to remain high, China and other countries in the region may have to abandon satellite remote sensing technology and return to the sole use of aerial photography (He, 1989).

It is recommended that under the direction of NASA/DOD, the price of future Landsat data ***recover the cost of duplication only***. I hope this would be $\leq$ $300 for digital MSS data and $\leq$ $500 for digital TM data. The Landsat sensors were created, placed in orbit, and operated at considerable public expense. The public should not be charged an exorbitant fee for their own data. *I recommend this pricing policy be for everyone: scientists, educators, public institutions, and private industry.* This would eliminate the 'policing' which must accompany a multiple-tier pricing structure.

EOSAT has charged per scene 'data acquisition fees' and also levied a 'cloud cover service charge' for certain orders. *All Landsat 'data acquisition fees' and 'cloud cover service charges' must be eliminated.* It appears that these changes in policy may become effective

for the Landsat 6 processing era. Why did it take until 1993 to implement them? Common sense would suggest that these fees in addition to the extremely high cost of the raw data would keep many people from purchasing Landsat products.

I believe that if these price policies were instituted, the number of digital scenes purchased for land remote sensing research in the U.S. and abroad would be astounding.

IIIb. The Prohibitive Sharing Policy

For years, the Landsat Data Use Agreement has strangled remote sensing research at public universities and in state agencies. *I recommend that public universities, state agencies, and other non-profit groups be allowed to buy a single copy of the raw, unenhanced remote sensor data and then share it freely among academic departments (e.g. geography, marine science, agriculture) or public agencies (e.g. Water Resources, Land Resources, Fish & Wildlife, Coastal Council etc.).* It took EOSAT seven (7) years to learn this valuable lesson. Only in 1991 did EOSAT initiate a statewide data acquisition program (Burroughs, 1992). This type of thinking should be encouraged and continued. *Unenhanced Landsat data purchased by private companies for value-added profit taking should not be 'shared'.*

IIIc. The Timeliness of Data Delivery

Through the years, the EROS Data Center, NOAA, and finally EOSAT have had a notoriously bad reputation for remote sensor data delivery, although EOSAT has improved their performance during 1991-1992. *I recommend that if a purchase order is in place, the data should be delivered to the user within 14 working days.* Furthermore, I suggest that the transmission of the data over Ethernet lines from NASA/DOD to the user be investigated immediately. In many instances, this procedure would remove the hard copy handling and shipping, reduce cost, and speed up delivery. This is possible using 1992 technology, especially during late night hours.

IV. Landsat Data Must be Acquired and Archived to Supplement the Global Change Data Obtained by the Earth Observing System (EOS)

There is great interest in the Earth Observing System (EOS) sensors which will begin to be placed in orbit sometime in 1998 (Wickland, 1991). These sensors were designed with a great deal of thought and will provide a significant amount of information to model and monitor world-wide global change. It is anticipated that the Landsat archives which already contain a unique set of data stretching back 20 years will be heavily used to a) represent the only true longitudinal land use/land cover database for the cloud-free portions of the earth, and b) calibrate the new sensors that will fly as part of EOS. There are still major gaps in the 'basic data set' because Landsats 4 and 5 are only turned on selectively due to TDRSS link problems and there is the desire to conserve the sensors so that we don't have a 'data gap' before Landsat 6 is launched (Silvestrini, 1991; Harper, 1992). Nevertheless, a significant attempt should be made to obtain the worldwide Landsat global change 'basic data set' as soon as possible as suggested by Colvocoresses (1991).

V. While the Earth Observing System (EOS) will be of value to address global change problems, the local, county, state and federal agencies must rely on a quality land remote sensing system to meet their day-to-day environmental monitoring requirements: The South Carolina Example

The proposed EOS sensor systems, however, will probably have very little impact on the day-to-day data requirements of local, county, state, and even federal land remote sensing programs. While several EOS sensors record high spectral resolution information, most of them (except ASTER) acquire data with a spatial resolution more coarse than 30 x 30 m (Wickland, 1991). Thus, to perform the day to day monitoring of the natural resources in our individual states, we must have a reliable earth resource remote sensing system providing high spectral and spatial remote sensor data at reasonable cost and in a timely fashion. Below is an abbreviated summary of the type of land remote sensor data required by the State of South Carolina to monitor its resources into the 21st Century. We would hope the ***Land Remote Sensing Policy Act of 1992*** would articulate the creation of a United States program which will provide such remote sensor data.

Va. The State of South Carolina's Remote Sensing Requirements

1) **Made in the U.S.A.:** South Carolina desires to purchase remotely sensed data from the United States and not from a foreign country or private industry which charges exorbitant prices.

2) **Sensor System Requirements:** Ninety-five percent of South Carolina's land remote sensing data requirements could be fulfilled by a system which collects 5 x 5 m panchromatic and 10 x 10 m multispectral data in standard TM bandwidths. Ideally, the the sensor would be pointable allowing more frequent data acquisition which is a serious problem during South Carolina's cloudy growing season.

3) **Cost**: The remotely sensed data should be made available for the cost of data reproduction. No 'data acquisition' fee or 'cloud cover service charge' should be applied.

4) **Data availability:** South Carolina must have the ability to purchase a single copy of an image and share it among all state universities and agencies. The data should be delivered within 14 days from date of acquisition.

Thank you for the opportunity to present my views on the ***Land Remote Sensing Policy Act of 1992***. Please contact me if you have any questions at 803 -777- 5790.

Table 1. Landsat Thematic Mapper 4 (1982), 5 (1984), and 6 (1993) Sensor System Configurations
(Source: Jensen; 1986; EOSAT, 1992)

Sensor	Spectral	Spatial[3]	Temporal	Quantization
blue[1]	0.45 - 0.52 um	30 x 30 m	16 days	8 bits
green[1]	0.52 - 0.60 um	30 x 30 m	"	"
red[1]	0.63 - 0.69 um	30 x 30 m		
near-IR[1]	0.76 - 0.90 um	30 x 30 m		
mid-IR[1]	1.55 - 1.75 um	30 x 30 m		
thermal[1]	10.4 - 12.5 um	120 x 120 m		
mid-IR[1]	2.08 - 2.35 um	30 x 30 m		
pan[2]	**0.50 - 0.90 um**	**15 x 15 m**		

[1] These bands are found on Landsat TM 4, 5, and 6 (1993).

[2] This band will be found on Landsat 6 (1993).

[3] 185 km swath width.

Table 2. Proposed Future Landsat Sensor System (7 or 8) for Earth Science and Cartographic Mapping Applications at 1:50,000 Scale and Smaller to Regain U.S. Lead in Land Remote Sensing Technology (tentatively launched in 2000)
[Source: Light (1990); Colvocoresses (1991); author]

Sensor	Spectral	Spatial[2]	Temporal	Quantization
blue-green[1]	0.47 - 0.57 um	10 x 10 m	45 days or	8 bits
red[1]	0.57 - 0.69 um	10 x 10 m	pointable	"
near-IR[1]	0.76 - 1.05 um	10 x 10 m	"	
mid-IR[1]	1.55 - 1.75 um	10 x 10 m		
pan[1]	0.51 -0 .73 um	5 x 5 m		

[1] Linear Array push-broom , each band

[2] 64 km swath width.

Table 3. **SPOT 1, 2, 3 (tentative 1994) and SPOT 4 (tentative 1996) Sensor System Configurations**
(Source: Clark A. Nelson, 4/28/92)

Sensor	Spectral	Spatial	Temporal	Quantization
XS1[1]	.50 - .59 um	20 x 20 m	pointable	8-bits
XS2[1]	.61 - .68 um	20 x 20 m	pointable	"
XS3[1]	.79 - .89 um	20 x 20 m	pointable	
XS4 [2]	**1.58 - 1.75 um**	**20 x 20 m**	**pointable**	
Pan[1]	.51 - .73 um	10 x 10 m **registered**	pointable	
Veg [2]	**4-5 bands t.b.d.**	**1 km x 1 km** **2500 km swath** **daily coverage of Earth**	unknown	

Across-track stereo

[1] These bands are found on SPOT 1, 2, and 3 (built and ready to launch when SPOT 1 or 2 wear out)
[2] These additional bands will be on SPOT 4 (under construction).

Table 4. SPOT 5 Sensor System Configuration (tentative 2000)
(Source: Clark A. Nelson, 4/28/92; Nanz quoted in Stephens, 1991)

Sensor	Spectral	Spatial	Temporal	Quantization
XS1	t.b.d.	**possibly 10 x 10 m**	pointable	8-bits
XS2	t.b.d.	**possibly 10 x 10**	pointable	"
XS3	t.b.d.	**possibly 10 x 10**	pointable	
XS4	t.b.d.	**possibly 10 x 10**	pointable	
Pan	t.b.d.	**will be 5 x 5 m**	pointable	
Veg	t.b.d.	t.b.d.	unknown	

Along track stereo

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"IN YOUR OPINION, HAS COMMERCIALIZATION OF R.S. DATA HAD A POSITIVE OR NEGATIVE IMPACT ON REMOTE SENSING RESEARCH ?"

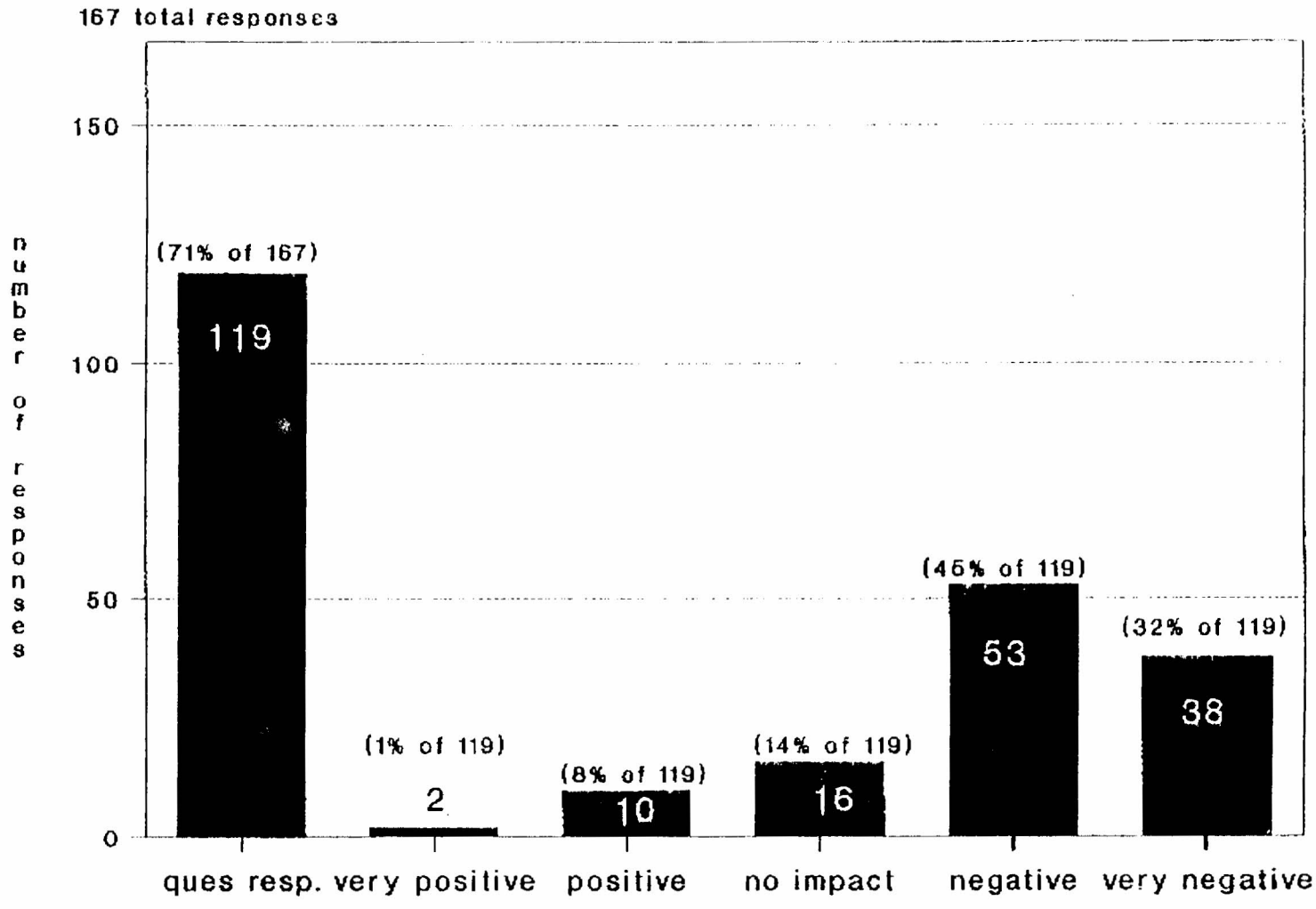

Figure 1. Results of a questionnaire administered by Dr. John E. Estes and David R. Jones, Department of Geography, University of California at Santa Barbara.

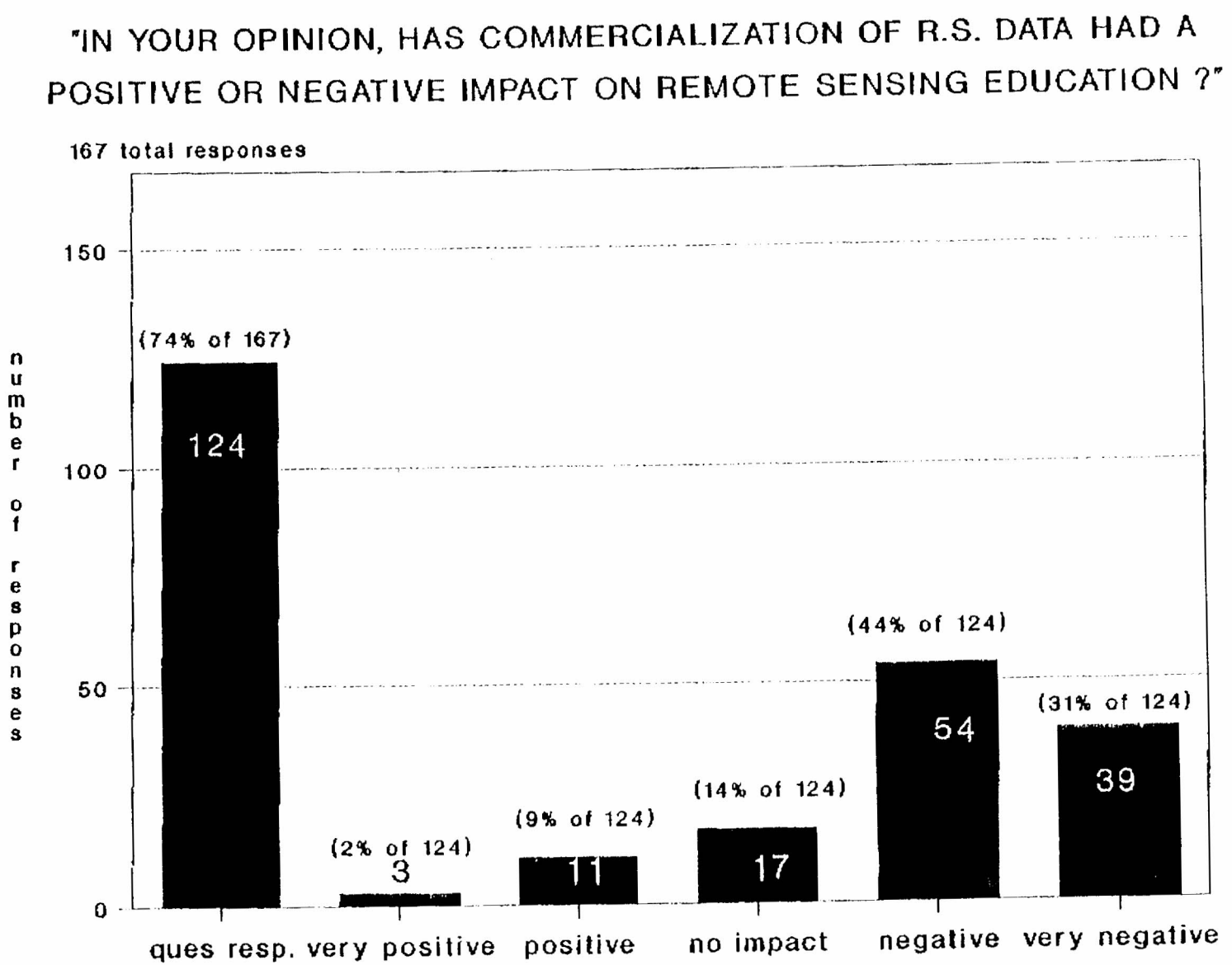

Figure 2. Results of a questionnaire administered by Dr. John E. Estes and David R. Jones, Department of Geography, University of California at Santa Barbara.

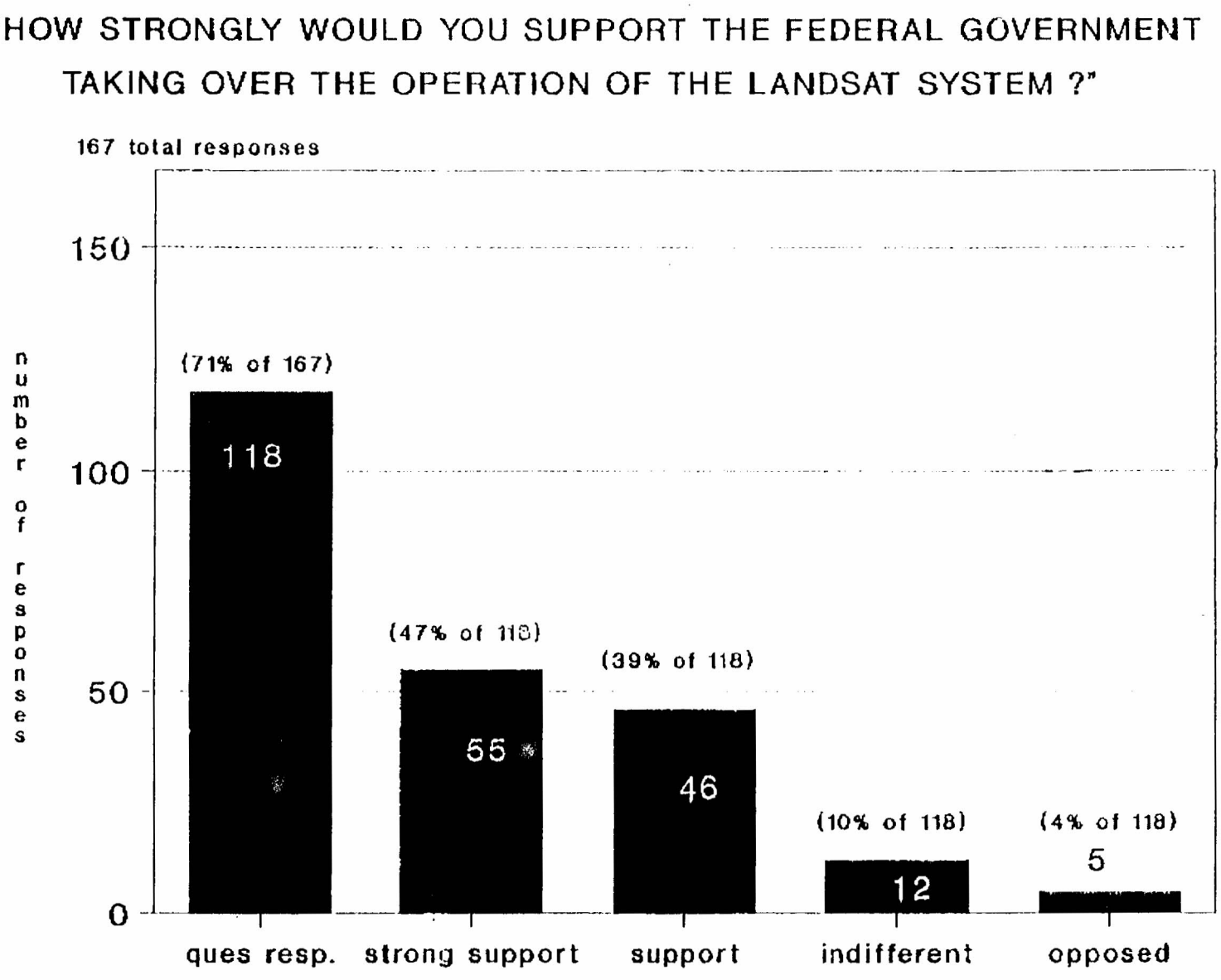

Figure 3. Results of a questionnaire administered by Dr. John E. Estes and David R. Jones, Department of Geography, University of California at Santa Barbara.

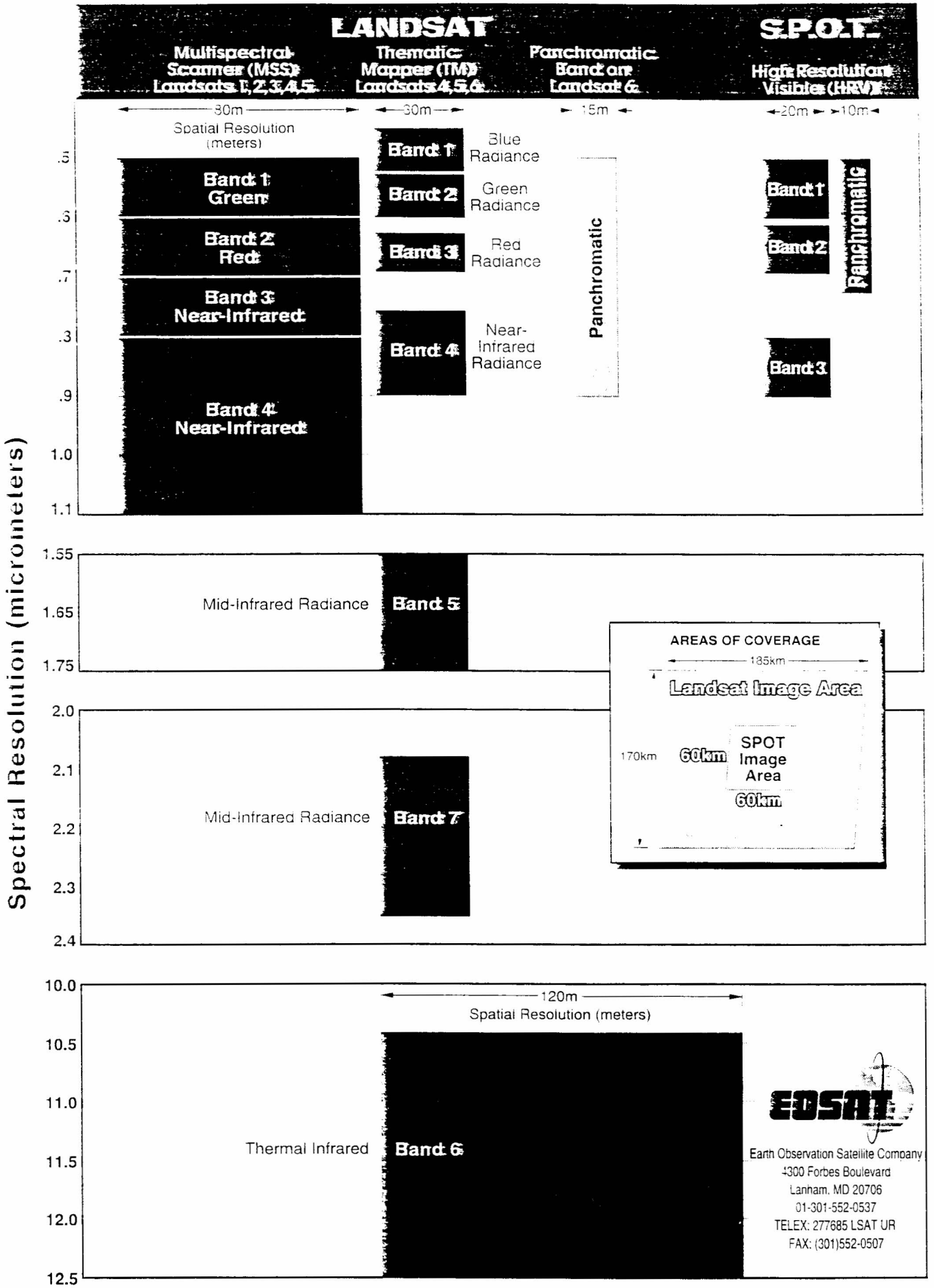

Figure 4. Summary of spatial and spectral resolution characteristics of Landsat Thematic Mapper (TM), Multispectral scanner (MSS), and SPOT High Resolution Visible (HRV) sensor systems (Source: EOSAT).

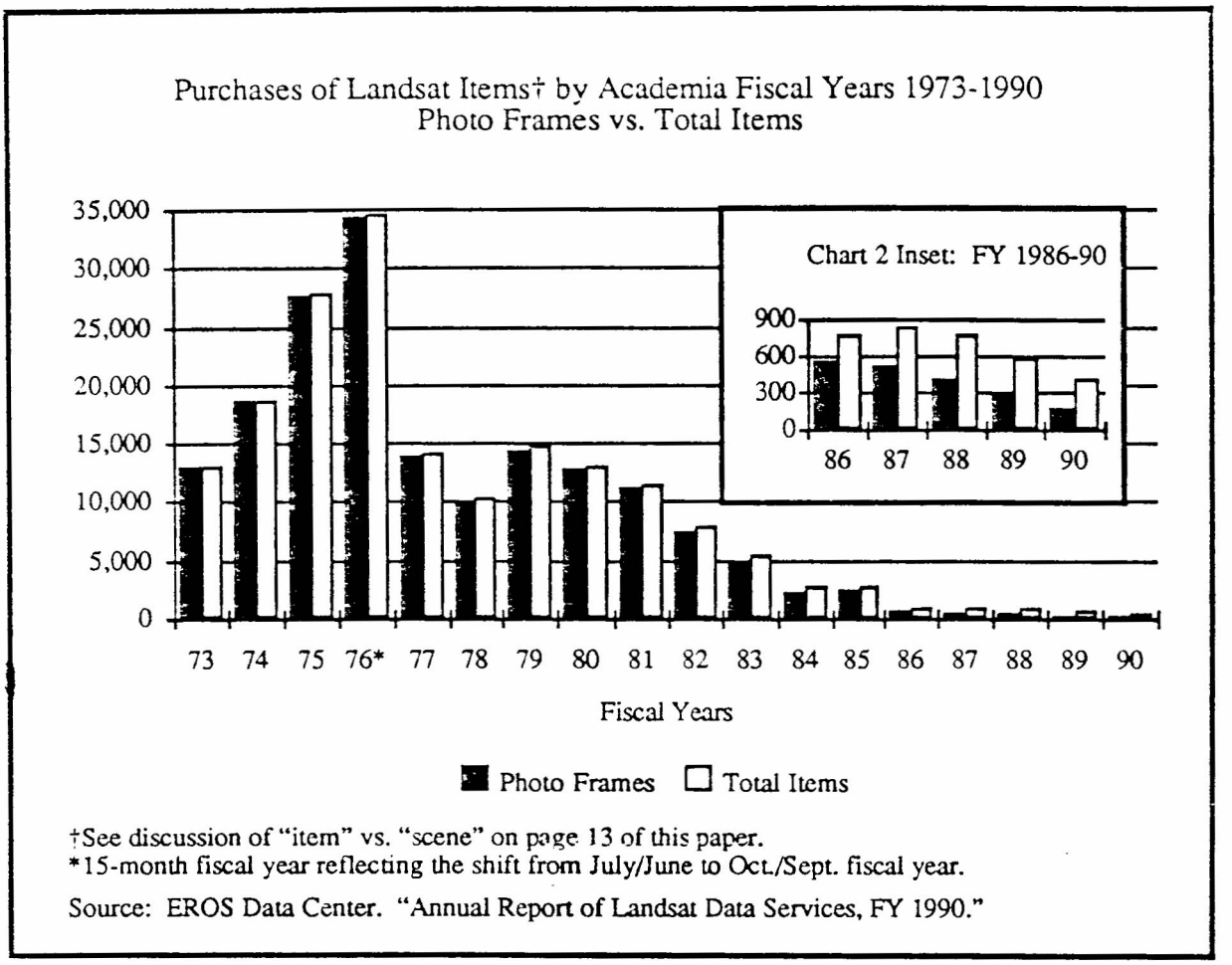

Figure 5. Purchases of Landsat items by academia for Fiscal Years 1973-1990 listing photo frames and total items (Source: Silvestrini, 1991; EROS Data Center "Annual Report of Landsat Data Service, FY 1990)