#2309

Pergamon

Applied Geography, Vol. 16, No. 4, pp. 265–277, 1996

0143-6228/96 $15.00 + 0.00

S0143-6228(96)00018-5

Regarding research as a land use

LHARRIN@KSU.KSU.EDU

L M B Harrington

Department of Geography, Dickens Hall, Kansas State University, Manhattan, KS 66506–0801, USA

Although missing as a land use category in all or most land classification systems, many land designation systems recognize research as the primary use of specific land areas. Research lands may be extensive and take up large areas; they may also be widespread systems of smaller designated sites that cover a significant total area. They are designated at the scale of international, national, subnational and smaller systems. New Mexico and Oregon, USA, illustrate extensive designation of lands for research purposes, including the variety of types and scales of research lands. In New Mexico, over a million hectares of land have been designated for research. This amounts to about 3.3 per cent of the state's area. Recognition of research as a land use, and of lands designated for research or scientific purposes, opens up many topics for further investigation. Copyright © 1996 Elsevier Science Ltd

As human beings increase in numbers and in their ability to manipulate and change their surroundings, patterns of land use around the world change. Among other changes, we have seen a growing tendency for governments and other institutions to select land areas and set them aside for particular purposes or uses seen as beneficial to society. One such use is research, including science and technology development. For example, as research lands and land systems have developed in the USA during the past century, they have undergone changes in focus, alternating between practical applications/technology development, and basic science and preservation purposes (Harrington, 1992). Through these changes in focus, diverse land systems have developed with research comprising at least part of their *raisons d'ètre*. Although research lands are significant in spatial extent and in potential effects on local economies and national scientific development, there has been little recognition of research as a distinct land use.

Research is, admittedly, a broad area of activity, with dictionary definitions like 'scientific or scholarly investigation', and 'diligent and systematic inquiry or investigation into a subject in order to discover or revise facts, theories, applications, etc'. However broad, it still is an identifiable human activity, and as such it requires a physical base. A wide variety of basic and applied research is conducted in both rural areas and urban centres. This research includes such diverse subjects as archaeology, geology, plant and animal ecology, climatology, astronomy, and even weapons development.

This paper documents the widespread application of land designation for research use, with emphasis on the USA. Research lands include widespread systems made up of many sites, from <1 ha to tens of thousands of hectares in size, as well as single research sites with special designations. Although the scale of individual sites and of research land systems varies, the total amount of land involved can be significant. To illustrate this phenomenon, a general description of types and scales of research land systems precedes a more detailed documentation of land areas set aside for research purposes. New Mexico and Oregon serve as specific illustrations of the possible extent and character of research lands.

While research can be pursued virtually anywhere, this discussion is limited to land areas that are specifically designated for, or associated with, research activities. Research lands are considered to be lands used for on-site investigations. This can include land utilized as the resource base for research (that is, lands used for studies requiring field work—Experimental Forests, for example), and lands occupied as the spatial base for research activities (that is, the location of research facilities not necessarily dependent on the specific land-based resources). The National Aeronautical and Space Administration and National Oceanic and Atmospheric Administration are agencies with some large research facilities, although much of the research associated with these facilities is not land-resource based; it is not dependent on the particular site. Examples of research lands in this latter category include the National Space Technology Laboratory (Missouri), the Goddard Space Flight Center (Maryland), the National Center for Atmospheric Research (Colorado) and the National Severe Storms Lab (Oklahoma). There may be overlaps between land used as the resource base for research and land occupied as the spatial base for research activities. The emphasis of this paper is on lands that comprise the base for research, although examples of lands that are principally occupied by research facilities are included because they can be significant in areal size. Identification of research as a use of land becomes clear when specific land areas designated for research or scientific use are tallied.

Types and scale of research lands

Numerous land reservation and designation systems set aside lands for research specifically, or for multiple uses that may include research. The scale of research lands may be considered in two contexts: first, in the context of the range of systems and coverage that can be identified at international, national, state, and non-governmental levels and, secondly, the relative scale of specific types of research lands. Certain types of research reserves tend to be very large (with few areas); others tend to be small, but are often more numerous. The following discussion describes research lands at various scales of designation, with some reference to possible individual areal coverage. Due to data availability, the focus is on the USA.

International research land designation

At the international scale, areas that are important for research, conservation and education/training are designated as Biosphere Reserves through the UNESCO Man and the Biosphere Programme (MAB). By 1993 the global network of Biosphere Reserves included 314 areas in 80 countries (see IUCN, 1994). Biosphere Reserves tend to be some of the largest areas set aside for research (and other) purposes; a number are over one million hectares in size. Several countries each have a single Biosphere Reserve; the largest number of these areas are listed for the USA (47, totalling over 27 million ha). The Biosphere Reserve designation overlaps with designations determined at the national level, such as National Parks and Experimental Forests. The most noticeable clustering of Biosphere Reserves occurs in Europe.

The UN list of protected areas recognizes several categories, including category I, 'Strict Nature Reserve/Scientific Reserve', and category II, 'National Park' (areas having 'significance for scientific, educational, and recreational use'). However, UN categorization (including Biosphere Reserve designation) does not give us a reliable indication of actual designation of land areas for scientific or research use. For example, US Wilderness Areas are generally category I because of their 'strict nature reserve' status—research is a secondary use or benefit—and National Estuarine Research Reserves are considered category IV—'Managed Nature Reserves'—in spite of the research designation. For this reason, UN categories are not used as a guide to research areas in this paper. It is interesting to note, however, that a number of countries have more than 2 per cent of their national territory in category I areas. When both category I and category II areas are considered, more than 4 per cent of the national territory of many countries is involved. (For some countries inclusion of marine reserves may inflate apparent proportions to 15 per cent or more.)

Research lands at the national level

Obviously, there are numerous land reservation systems in place around the globe, including such areas as national parks, nature reserves and national forests. At the national level, too, there are designation systems for areas that explicitly recognize research or scientific purposes: in New Zealand, Egypt and Iceland there are Scientific Reserves; in Australia, Scientific Areas and Scientific Purpose Reserves; in the UK, Sites of Special Scientific Interest; the Dominican Republic has designated Natural Scientific Reserves; and *Zapovedniki* in Russia and other post-Soviet Union countries can generally be regarded as research reserves.

Nationally, the USA has a number of designations and land management systems where research is a primary or secondary land use. They can be broadly divided into two major types: experimental reserves, where experimentation and environmental manipulation play a significant role; and non-experimental (natural) reserves, where research is generally non-manipulative and based primarily on observation. Harrington (1992) found that establishment of experimental and natural research reserves has been cyclic. The most recent bursts of experimental/technological research area designations in the USA were apparently associated with second world war and post-war military and energy (nuclear) development. Although the establishment of natural research reserves goes back to the earlier part of this century, the designation of larger numbers of these reserves, especially during the 1970s and 1980s, seems to have been related to heightened environmental interests during the 1960s and 1970s.

One fairly widespread type of non-experimental natural reserve used primarily for research is the Research Natural Area (RNA). These areas are administratively designated by a number of federal agencies, particularly the US Forest Service, the Fish and Wildlife Service, and the Bureau of Land Management. RNAs have also been established by other agencies, such as the Department of Energy (DOE) and the Department of Defense. Development of the RNA system began in 1927 (Federal Committee on Ecological Reserves, 1977) and now includes hundreds of areas. They are unevenly distributed, are generally not publicized, and the availability of information regarding their existence and attributes is extremely variable. In the early 1980s, it was reported that 'at last count' about 440 RNAs existed, administered by eight federal agencies (Burns, 1984). RNAs continue to be designated, however, and many areas proposed but not yet established are managed as RNAs. Relatively extensive information is available for Washington and Oregon, where there are over 125 RNAs administered by six agencies (see Franklin *et al.*, 1972 and supplements; Greene *et al.*, 1986; Lincoln, 1996). Some non-experimental research areas are important for archaeological and historical research, as well research in the natural sciences.

Experimental reserves include Long Term Ecological Research sites, or LTERs (sometimes referred to as Long Term Ecological Reserves); US Department of Agriculture Experimental Forests, Ranges and Watersheds; and other areas. In California alone there are 10 Experimental Forests and Ranges (totalling approximately 17 785 ha). Such areas are established by the Chief of the US Forest Service 'to provide outdoor laboratories and to serve as sites for pilot testing' (Berg, 1990). In his review of experimental watersheds, Farrell (1995) emphasized the importance of such areas to the understanding of water resources and the field of hydrology, also describing these sites as 'outdoor laboratories'—a repeated theme among descriptions of research lands.

Long Term Ecological Research sites are recognized and funded by the National Science Foundation. The system is unique in promoting long-term studies, even over the course of decades to a century (Magnuson, 1990), at a time when short-term studies and rapid publication are frequent goals in a 'publish-or-perish' research community. Research at different spatial scales is also promoted by the system, from more traditional small study sites to regional or continental levels of data collection (Swanson and Sparks, 1990; see Franklin *et al.*, 1990, for an overview of the LTER programme). Global change studies are of particular interest in the LTER network. With the establishment of the Antarctic Marine LTER (Palmer Station) in the early 1990s, the system has grown to 18 sites owned and operated by a variety of agencies. Work on extending the LTER idea internationally, to an ILTER network, has begun.

Some military installations, as well as a number of DOE reserves, may also be included as experimental reserves. Very large military installations with research and testing components include White Sands Missile Range (New Mexico) and the Deseret Test Center/Dugway Proving Grounds/Wendover Range complex (Utah). Large DOE areas include Hanford (Nuclear) Reservation (Washington), the Nevada Test Site (Nevada) and the Idaho National Engineering Laboratory (Idaho).

State and corporate research lands

Beyond the more or less nationally based systems, there are also numerous areas used for research that are designated and operated at the state level, and areas that are operated by non-governmental professional and conservation groups. For the USA, these include state Agricultural Experiment Stations, university-owned and -operated lands, and areas controlled by professional and other non-governmental organizations (such as the Society of American Foresters and The Nature Conservancy). (The boundary between national and state-based systems is somewhat unclear with respect to Agricultural Experiment Stations, but they are included here because they are attached to state universities.) Some states explicitly recognize scientific or research values and uses in their development of natural areas systems. Washington State, for example, has established a Natural Area Preserves System for research and educational uses. Many other states recognize scientific values in their state land designation systems.

California provides an outstanding example of state-level research lands. The University of California established a Natural Reserve System in 1965 to protect areas for the purposes of field research and teaching (Kennedy, 1984; Gustafson, 1985; Ford and Norris, 1988). There are now 32 sites in the system (Felixson and Stephens, 1996), ranging from 3 to 22 051 ha in size. The University of California owns a part of this land; other ownerships are included in the system through a variety of use and management agreements with other organizations, agencies and private individuals (Gustafson, 1989).

Additionally, there are business-associated research areas. For example, in the US cornbelt research plots associated with agricultural businesses dot the countryside. In the highly productive agricultural areas of Illinois, these research areas may be quite small—a few hectares or less—or the size of a small to medium-sized working farm. Test plots are for such products as plant varieties/hybrids and agricultural chemicals. These areas are in addition to (although they often serve double-duty as) 'demonstration plots' for farmers interested in comparing the performance of products they may wish to purchase in the future. Professional organizations, museums and scientific/educational organizations also maintain research stations.

Research lands: state-level case studies

While it is evident that research lands exist on a global scale, information for such areas is extremely limited and, due to the variety of research lands and the lack of data, any attempt to summarize systems at the international or national level would be overwhelming. It is more useful to illustrate the variety of research lands and the extent of such areas by focusing on research lands at the state scale. New Mexico and Oregon were chosen for this purpose because data about research areas is relatively more available for these states, and because they illustrate well the possible extent and mixes of research lands. Because of the greater diversity of identified research areas in New Mexico (*Figure 1*), its research lands are described in more detail; Oregon (*Figure 2*) is used for additional illustration and comparison.

Lands designated and used for research in New Mexico include military, Department of Energy, university, Forest Service, and Agricultural Research Service areas. White Sands Missile Range is by far the largest research area in New Mexico; it is, in fact, the largest military installation in the country. In spite of its name, White Sands is a research and testing facility with a variety of projects concerning, for example, climate and environmental investigations, simulations, clothing analysis and, obviously, missile tests. The installation has been characterized as 'just one huge laboratory' (Eckles, 1989).

The US Department of Energy operates several research facilities in New Mexico, including Sandia and Los Alamos National Laboratories. Los Alamos National Laboratory, established during wartime in the early 1940s, covers approximately 11 250 ha. Research activities continue to include nuclear weapons design and testing, but a wide variety of other types of research are also pursued, including investigations in the areas of archaeology, biology, chemistry and physics. Los Alamos is one of five designated DOE National Environmental Research Parks (Bildstein and Brisbin, 1990). Los Alamos County in New Mexico was carved out of adjoining counties in response to the establishment and growth of the laboratory. Essentially, it is a 'research county'. Because of recent global and national political (and funding) changes, the national laboratories are now considering new focuses for their research activities, including increased cooperation with the private sector and decreased emphasis on weaponry. The DOE also operates smaller research sites, such as the Southwest Region Solar Experiment Station in Las Cruces and the Waste Isolation Pilot Plant in southeastern New Mexico, where research is being conducted in conjunction with development of a possible low-level nuclear waste disposal site.

Although university lands, because of their multiple-use focus, cannot strictly be regarded as research lands, this part of their function and the existence of university lands/facilities that focus on research should not be discounted. Areas operating with a focus on resource-based or site-dependent research are of particular interest here. Related to the research function of universities, New Mexico's Agricultural Experiment Station sites are tied to New Mexico State University. The Hatch Act of 1887 created the US system of State Agricultural Experiment Stations, which provide for agricultural research cooperation between the federal government and state universities. New Mexico's network of sites totals over 46 000 ha, ranging individually from 28 to over 26 000 ha (*Table 1*). The largest component of the system is the New Mexico State University (NMSU) College Ranch, which is federally owned but university managed. In comparison, Oregon's Agricultural Experiment Station network totals 10 524 ha (*Table 2*).

The Jornada Experimental Range is a large federal research area under the administration of the USDA Agricultural Research Service (ARS). In the USA, ecologically similar Biosphere Reserves are sometimes paired, with observational research in one area and manipulation of portions of the ecosystem in the other (see Franklin, 1979). As an

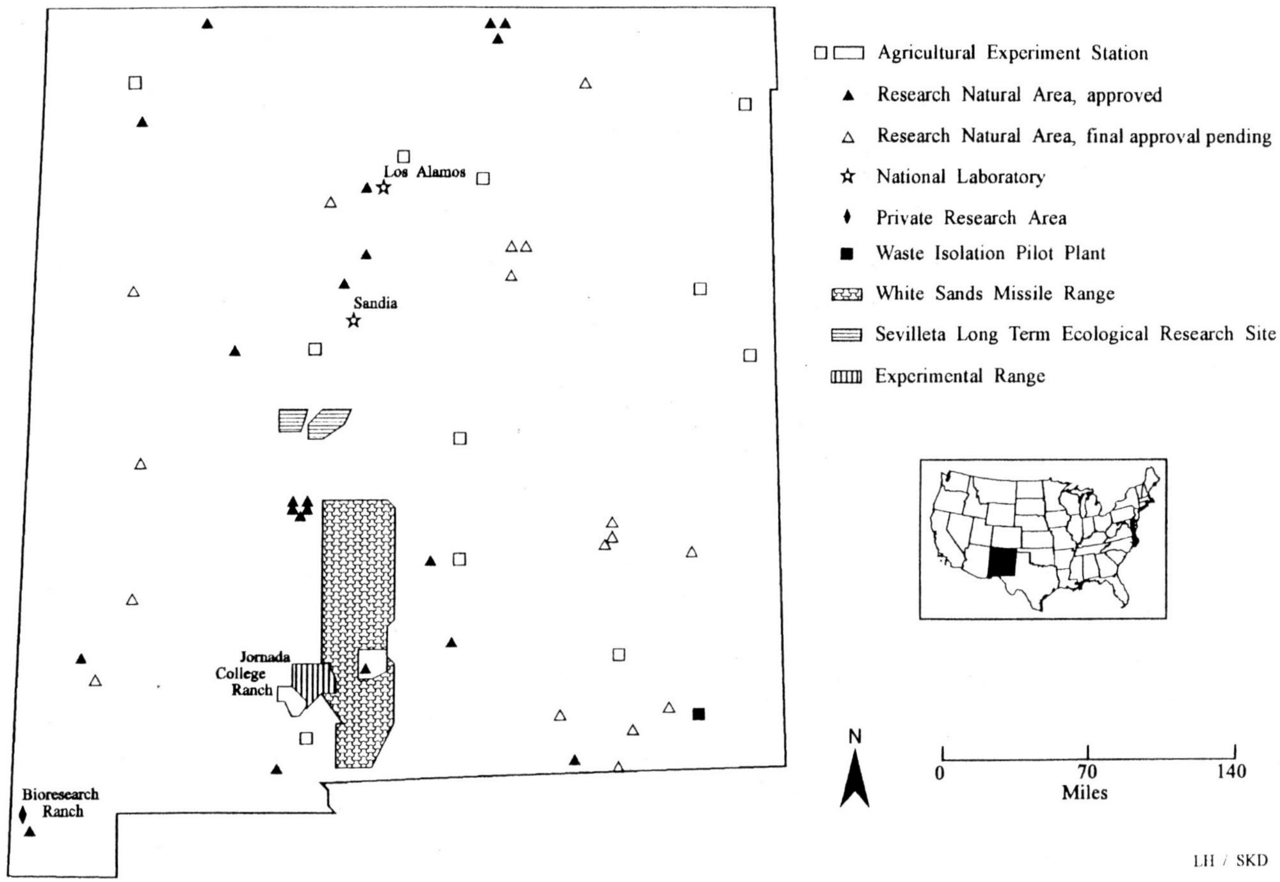

Figure 1. Research areas identified in New Mexico (see also notes to *Table 3*)

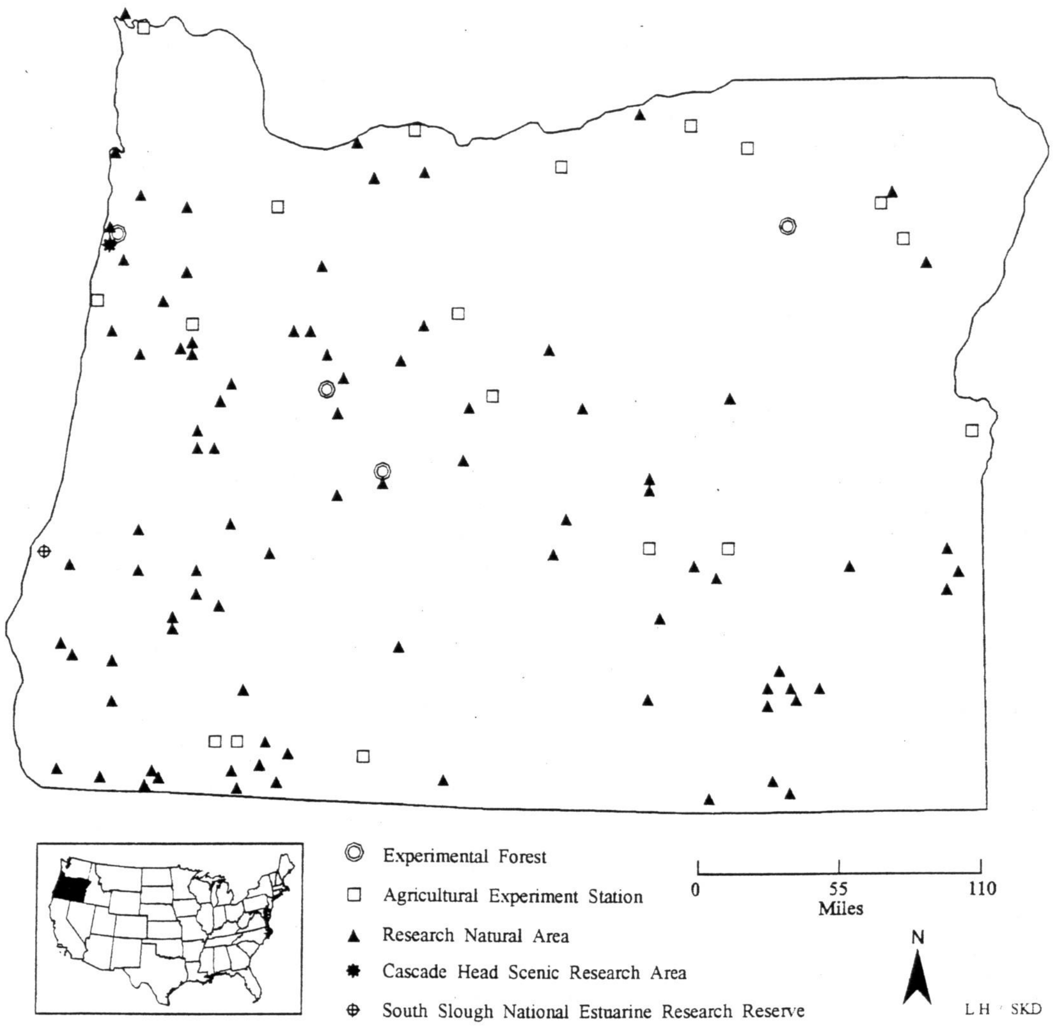

Figure 2. Research areas identified in Oregon (see also notes to *Table 4*)

'experimental' Biosphere Reserve, the Jornada (from 'Jornada del Muerto', or 'Journey of Death') is paired with another Chihuahuan desert reserve, Big Bend National Park in Texas. Some research projects/sites on the Jornada have been established for decades and include meteorological stations and research sites established in the 1920s and 1930s. The ARS and NMSU cooperate on research use of the College Ranch and the Jornada: both are included in the Jornada LTER site (Brenneman and Blinn, 1987).

In Oregon, there are four Experimental Forests and/or Experimental Ranges. These are administered by the US Forest Service. Cascade Head Experimental Forest overlaps with the Scenic Research Area, also administered by the Forest Service. Cascade Head National Scenic Research Area in Oregon is a rare instance of legislative recognition of the value of a specific area for research/scientific purposes. The Experimental Forest and Range areas, with Cascade Head Scenic Research Area, total about 24 000 ha. Two areas, H J Andrews Experimental Forest and Cascade Head Experimental Forest/Scenic Research Area, have been designated as Biosphere Reserves. H J Andrews is also an LTER site.

Research Natural Areas are scattered across both New Mexico and Oregon. In New Mexico, four federal agencies are involved in RNA designation: the US Forest Service

Table 1 New Mexico Agricultural Experiment Station network

Station	Area (ha)
Alcalde	28.3
Artesia	64.8
Clayton	129.5
Clovis	63.1
Corona	8 741.4
Farmington	102.8
Fort Stanton	10 522.1
Las Cruces (College Ranch = 26 184.5)	26 295.0
Los Lunas	81.7
Mora	54.6
Tucumcari	194.3
Total	46 277.6

Source: Briggs (1989)

(USFS), the Bureau of Land Management (BLM), the Fish and Wildlife Service (FWS) and the National Park Service. In Oregon, five agencies, including the USFS, BLM, FWS, Department of Defense and Army Corps of Engineers, designate and manage RNAs. New Mexico contains 26 established RNAs (about 18 800 ha) and 13 potential USFS additions (over 3200 ha), which are managed as RNAs. Oregon's RNA total is much higher, with at least 94 established sites (about 65 500 ha), and a number of proposed sites. A variety of natural features and biotic communities have thus been recognized and protected in both New Mexico and Oregon, with little direct human use other than research.

Table 2 Oregon Agricultural Experiment Station network

Station	Area (ha)
Astoria Station	0.3
Corvallis Farm, Ranch and Vineyard sites[a]	2 078.1
Hall Ranch	809.0
Hanley Station	32.9
Hermiston Station	110.4
Hood River Station	19.7
Kings Highway Station	8.9
Klamath Station	32.3
Madras Station	33.2
Malheur Station	48.8
Moro Station	93.1
Newport Station	124.5
North Willamette Station	63.3
Pendleton Station	59.1
Powell Butte Station	32.4
Section 5 Station	254.9
Squaw Butte Station	6 480.0
Union Station	243.1
Total	10 524.0

[a]14 sites; shown with a single symbol on *Figure 2*
Source: Fausett (1996)

Table 3 New Mexico research lands[a]

Research Lands	Area (ha)
Agricultural Experiment Stations	46 277.6
Jornada Experimental Range (Biosphere Reserve)	78 265.5
Sevilleta LTER	92 270.3
White Sands Missile Range[b]	783 233.5
Waste Isolation Pilot Plant (WIPP)[c]	14.2
Los Alamos National Laboratory	11 650.0
Sandia National Laboratory[d]	9 469.9
Bioresearch Ranch, Inc.[e]	1 024.7
Research Natural Areas (existing and pending)[f]	22 016.5
Total	1 044 222.2

[a]Conservative estimate based on identified research lands; excludes many university and multiple-use areas. Bildstein and Brisbin (1990) gives Los Alamos as 12 500 ha, and Jornada and Sevilleta LTERs as 104 166 and 100 000 ha, respectively
[b]Excluding joint-use Jornada lands (33 148.5 ha)
[c]Secured area; WIPP site boundary totals 4144.1 ha; mined experimental area is 4.9 ha (US DOE 1989, 2–3, 2–4, S–4)
[d]Includes DOE-owned lands and lands operated by agreements with other government entities (Adams, 1989)
[e]Bioresearch Ranch includes Central Peloncillo RNA and totals about 2023.5 ha (Scholes, 1989); Central Peloncillo is included as an RNA and is not included in the Bioresearch Ranch area
[f]RNA sources: Peterson and Rasmussen (1986), Dunmire (1989, 1991), Alden (1993), Barnes (1995), Overbaugh (1995) and Fletcher (1995)

The total area of sites in New Mexico that are *clearly* designated for research purposes (*Table 3*) comprises a significant part of the state. With a conservative accounting of these sites, well over 1 million ha, or a total of about 10 442 km^2, of land with research designations can be identified. This excludes many university-owned lands and other lands that may have significant research use in conjunction with other 'multiple' uses, but

Table 4 Oregon research lands[a]

Research lands	Area (ha)
Oregon Agricultural Experiment Station lands	10 524
Cascade Head Experimental Forest and Scenic Research Area (Biosphere Reserve)[b]	2 380
H J Andrews Experimental Forest (Biosphere Reserve)	6 400
Pringle Falls Experimental Forest	4 477
Starkey Experimental Forest and Range	10 935
South Slough National Estuarine Reserve	2 502
Research Natural Areas (established)[c]	65 545
Total	102 763

[a]Conservative estimate based on identified research lands
[b]Cascade Head Experimental Forest totals about 4815 ha and Cascade Head Scenic Research Area is 3916 ha; the two areas overlap, however, with approximately half of the Scenic Research Area also in the Experimental Forest (Greene, 1996). The figure given is an estimate based on Experimental Forest size + half the Research Area, and subtracting the area of Neskowin Crest RNA (476 ha) (included elsewhere)
[c]There also are a number of proposed RNAs. Data on some established RNAs are missing
Sources: Greene *et al.* (1986); Parsons *et al.* (1991); Skovlin (1991); IUCN (1993); Youngblood (1995); Fausett (1996); Greene (1996); Lincoln (1996)

that are not as clearly identified with research purposes and activities as those named here. The area of identified research lands in New Mexico accounts for 3.3 per cent of the state's territory. In comparison, urban and transportation land use accounts for about 4 per cent of the national territory, and only 1.1 per cent of New Mexico's (US Bureau of the Census, 1995: 225, 228). Because there are no large military or DOE research reservations in Oregon, the area of research land is less than for New Mexico (*Table 4*). Proportionate to state size, identified research lands account for 0.4 per cent of Oregon's surface area. Although not so dramatic as New Mexico, the total of 1028 km^2 of research lands identified in Oregon is significant.

Although New Mexico and Oregon have been used as examples here, research lands may be found in every state. For some states, such as New Mexico, Nevada, Maryland, Utah, Washington and Idaho, research lands (including experimental and test facilities) occupy a significant area. The activities associated with some of these areas account for major sources of income and employment. Los Alamos National Laboratory, for example, employs about 7670 people; its fiscal year 1993 budget was US$1118 million. Sandia National Laboratory in New Mexico is actually part of a network of laboratories and test facilities of the same name in New Mexico, California, Nevada and Hawaii, with a fiscal year 1993 budget of US$1400 million (US DOE, 1994).

Discussion

This paper has indicated the extensive nature of research lands and there is considerable scope for analysing the impacts of research as a land use. Although this paper makes no attempt at a quantitative assessment of the environmental or economic effects that may be associated with reservation or use of land for scientific purposes, economic effects of research sites may be significant. Some estimates of the local economic effects of certain federal research installations may be available, but for many areas both the extent of use and the associated economic effects remain unknown. Certainly, the income associated with facilities like Sandia and Los Alamos makes it difficult to overstate the importance of research dollars to the economy of the State of New Mexico.

Research lands offer geographers a new and rewarding area of investigation. Future studies of research as a land use may, for example, be directed toward: (1) determining the extent of research use of particular lands; (2) assessing the local economic role of research use of specific lands; (3) evaluating the scientific and social benefits of such use; (4) examining conflicts associated with designation and/or use of research lands; or (5) analysing the distribution of research lands. As more pressures are placed upon land for a variety of uses, it will be increasingly important to document the benefits of using some areas for research. Comparisons among individual areas or between regions may be particularly revealing in future considerations of possible research land designations and the funding of research activities.

It is often difficult to clearly identify lands designated for research use, and therefore more thorough documentation of these lands at a variety of scales, from subnational regions to globally, would be valuable. Researchers are often unaware of such areas. Conversely, researchers often make use of reserved areas without notifying managers either of the use or of research results. Protection of research sites and improved management of research and other lands would be enhanced by heightened awareness of research as a land use and more accurate knowledge bases that emerge with this use.

Several studies have addressed aspects of research lands. Determination of research output along the lines of Burnett (1986), Butler and Roberts (1986), Harrington and

Roberts (1988) and Wright and Hayward (1985) may be useful, particularly for comparative purposes. These projects relied on counts of documented research projects in various natural areas (reserves in three African countries, US Wilderness Areas and US National Parks). Another possibility is to determine researcher-hours spent on projects dependent upon the use of a particular area. It may also be possible, through this type of analysis, to determine the relative use of multiple-use areas in terms of person-hours spent in research activities as opposed to recreational pursuits, or by some other measurement to determine research use as opposed to other uses.

Studies of the local economic role of research use of specific lands may involve determining the money associated with researcher time spent, outside funding for projects in a particular area (see, for example, Woods and Barrett, 1988), and local effects of researcher salaries and spending. A recent LTER report states that an average of 56 per cent of research money is spent in local communities around the field stations. LTER sites are typically funded at just under US$600 000 annually, but LTER activities then leverage 'an average 2.1 dollars from each [National Science Foundation] grant dollar' (Hayden, 1996) by, for example, bringing in research grants from other sources. In the international context, some attention has been given to travel by members of scientific and professional organizations, and the economic effects of scientific activities in certain countries (Laarman and Perdue, 1987).

Future research may also address less obvious benefits accruing as a result of research activities in an area. Burnett (1986) compared the citations of research works from three parks. The premise of citation analysis is that more important work will be cited more frequently than scientifically less important work. Although there are problems with using this method, Burnett asserts that 'our best route to understanding the contribution of parks to scientific research remains ... the reputation of the research which they have produced'. In rare instances, it may be possible to document extraordinarily important discoveries arising from land-based research, such as a new, medically valuable drug or an early warning of climatic change and environmental response.

Conclusion

Land use has long been a central area of interest for geographers. Although research is a very important activity today, and occurs in extensive land areas, land managers and academics have failed to recognize it as a land use. Despite evidence that research is indeed a land use, there is a tendency to think of it only as something that scientists *do*, and not as an activity that makes *use* of land resources and may even be in conflict with other land uses. As an activity central to both development and resource management, it is surprising that the place of research in the landscape has received so little attention.

A land use that involves multiple systems of designation and management, internationally, and areas reserved at various scales with significant total land involvement, deserves attention. In many instances, areas designated for research use are protected from other uses, thus serving preservation and biodiversity concerns as well as providing sites for research activities. At other times, research is just one of the multiple accepted uses of designated areas; better understanding of the interaction of uses/users and the benefits that accrue from research are also needed. Through the years ahead, research lands will continue to make up a significant proportion of some regions of the globe, especially of rural land areas in more developed regions. Although growing slowly at the current time, they continue to expand. The scale, use and impacts of research lands will increasingly be deserving of research attention themselves.

Acknowledgements

The information supplied by a number of persons cited in the text is greatly appreciated. Comments from several colleagues during the development of this paper have also been valuable, particularly J A Harrington, Jr, D E Kromm, C Mather and R Schein, as well as reviewers' comments. The cartographic work of Sharon Davern and support of Kansas State University Department of Geography are also appreciated.

References

Adams, M L (1989) Personal communication (Sandia National Laboratory)

Alden, E (1993) Personal communication (USDA Forest Service, Rocky Mountain Experiment Station)

Barnes, C (1995) Personal communication (BLM Recreation Specialist, Farmington District)

Berg, N H (technical coordinator) (1990) *Experimental Forests and Ranges: Field Research Facilities of the Pacific Southwest Research Station* USDA Forest Service, Pacific Southwest Research Station, Berkeley, CA

Bildstein, K L and Brisbin, I L Jr (1990) 'Lands for long-term research in conservation biology', *Conservation Biology* 4, 301–308

Brenneman, J and Blinn, T (eds) (1987) *Long-Term Ecological Research in the United States: A Network of Research Sites* 4th edn, Oregon State University Forest Science Department, Corvallis, OR

Briggs, D (1989) Personal communication (New Mexico State University/New Mexico Agricultural Experiment Station)

Burnett, G W (1986) 'The scientific production of parks: an evaluation of three central African reserves', *Parks* 2, 11–14

Burns, R M (1984) 'Importance of baseline information to the Research Natural Area program', in Johnson, J L, Franklin, J F and Krebill, R G (coordinators) *Research Natural Areas: Baseline Monitoring and Management* USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT, pp 50–52

Butler, L M and Roberts, R S (1986) 'Use of wilderness areas for research', in Lucas, R C (compiler) *Proceedings: National Wilderness Research Conference: Current Research* USDA Forest Service Intermountain Research Station, Ogden, UT, pp 398–405

Dunmire, W (1989)(1991) Personal communications (Nature Conservancy, New Mexico)

Eckles, J (1989) Personal communication (White Sands Missile Range)

Farrell, D A (1995) 'Experimental watersheds: a historical perspective', *Journal of Soil and Water Conservation* 50, 432–437

Fausett, L (1996) Personal communication (Oregon Agricultural Experiment Station)

Fletcher, R (1995) Personal communication (USFS Southwest Region, Regional Ecologist)

Federal Committee on Ecological Reserves(1977) *A Directory of Research Natural Areas on Federal Lands of the United States of America* USDA Forest Service, Washington, DC

Felixson, C and Stephens, T (1996) 'Stunt Ranch Reserve joins NRS as post-fire recovery continues', *The NRS Transect* 14(1), 1–2

Ford, L D and K S Norris, K S (1988) 'The University of California Natural Reserve System: progress and prospects', *BioScience* 38, 463–470

Franklin, J F (1979) 'The conceptual basis for selection of U.S. Biosphere Reserves and features of established areas', in Franklin, J F and Krugman, S L (coordinators) *Selection, Management and Utilization of Biosphere Reserves* USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR, pp 3–27

Franklin, J F, Hall, F C, Dyrness, C T and Maser, C (1972) *Federal Research Natural Areas in Oregon and Washington: A Guidebook for Scientists and Educators* USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR

Franklin, J F, Bledsoe, C S and Callahan, J T (1990) 'Contributions of the Long-Term Ecological Research Program', *BioScience* 40, 509–523

Greene, S E (1996) Personal communication (USDA Forest Service)

Greene, S E, Blinn, T and Franklin, J F (1986) *Research Natural Areas in Oregon and Washington: Past and Current Research and Related Literature* USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR

Gustafson, S (1985) *Natural Reserve System: The First Twenty Years* University of California Natural Reserve System, Berkeley, CA

Gustafson, S (1989) Personal communication (California Natural Reserve System)

Harrington, L M B (1992) 'Research as an alternative land use', in Bowler, I R, Bryant, C and Nellis, M D (eds) *Contemporary Rural Systems in Transition, Volume 1: Agriculture and Environment* CAB International, Wallingford, UK, pp 195–205
Harrington, L M B and Roberts, R S (1988) 'Wilderness research: effects of administering agency', *Society and Natural Resources* 1, 215–225
Hayden, B P (1996) 'An LTER profile', *Network News* 19, 1
IUCN (1994) *1993 United Nations List of National Parks and Protected Areas* IUCN, Gland, Switzerland
Kennedy, J A (1984) 'Protected areas for teaching and research: the University of California experience', in McNeely, J A and Miller, K R (eds) *National Parks, Conservation, and Development: The Role of Protected Areas in Sustaining Society* Smithsonian Institution Press, Washington, DC, pp 538–545
Laarman, J G and Perdue, R R (1987) *A Survey of Return Visits to Costa Rica by OTS Participants and Associates* Southeastern Center for Forest Economics Research, Research Triangle Park, NC
Lincoln, B (compiler) (1996) *Research Natural Areas in Washington and Oregon* Bureau of Land Management, Oregon State Office, Portland, OR
Magnuson, J J (1990) 'Long-term ecological research and the invisible present', *BioScience* 40, 495–501
Overbaugh, W (1995) Personal communication (BLM, New Mexico state office)
Parsons, G L *et al.* (1991) *Invertebrates of the H. J. Andrews Experimental Forest, Western Cascade Range, Oregon. V: An Annotated List of Insects and Other Arthropods* General Technical Report PNW-GTR-290, USDA Forest Service, Pacific Northwest Research Station, Portland, OR
Peterson, R S and Rasmussen, E (1986) *Research Natural Areas in New Mexico* USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO
Scholes, R T (1989) Personal communication (Bioresearch Ranch, Inc)
Skovlin, J M (1991) *Fifty Years of Research Progress: A Historical Document on the Starkey Experimental Forest and Range* General Technical Report PNW-GTR-266, USDA Forest Service, Pacific Northwest Research Station, Portland, OR
Swanson, F J and Sparks, R E (1990) 'Long-term ecological research and the invisible place', *BioScience* 40, 502–508
US Bureau of the Census (1995) *Statistical Abstract of the United States, 1995* 115th edn, US Department of Commerce, Washington, DC
US Department of Energy (1989) *Draft Supplement Environmental Impact Statement: Waste Isolation Pilot Plant* Vol 1, US DOE, Washington, DC
US Department of Energy (1994) *Technology Transfer 1994* US DOE, Washington, DC
Woods, P E and Barrett, G W (1988) 'NSF funding trends in response to the eruption of Mount St. Helens', *Bulletin of the Ecological Society of America* 69, 18–20
Wright, R G and Hayward, P (1985) 'National parks as research areas, with a focus on Glacier National Park, Montana', *Bulletin of the Ecological Society of America* 66, 354–355
Youngblood, A (compiler) (1995) *Research Publications of the Pringle Falls Experimental Forest, Central Oregon Cascade Range, 1930 to 1993* General Technical Report PNW-GTR-347, USDA Forest Service, Pacific Northwest Research Station, Portland, OR

(Revised manuscript received 12 July 1996)