Old-Growth Forests on National Park Service Lands: NPS Views and Information

Lucy E. Tyrrell

Great Lakes CPSU Report 91-1

October 1991

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Old-Growth Forests on National Park Service Lands: NPS Views and Information

Great Lakes CPSU Report No. 91-1

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October 1991

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Abstract

An informal survey was initiated to determine what information is now available on the extent, character and management of old-growth forests on lands of the National Park Service (NPS). In 1988 a questionnaire was distributed to NPS units that possibly contained this community type. The responses of all 58 units have been summarized. The working definitions of old growth differed widely among respondents. Attributes most frequently mentioned were lack of disturbance (lack of logging and an undisturbed character) and tree age. The amount of old growth is estimated at more than 1.97 million hectares (4,867,800 acres), located in 32 states and the District of Columbia, and in all 10 NPS regions. Species lists for old-growth stands are available for vascular plants in 53% of the NPS units and for birds in 35%. Many units (35%) did not have information on which species are strongly associated with old-growth forests. The most frequently reported disturbances affecting old-growth forests were logging, wildfire, windthrow events and fire suppression. More than half (54%) of NPS units reported no management plan specific to old-growth forests. Research efforts in these old-growth forests included current research projects (60% of NPS units), long-term data sets (63%) and permanent plots (35%). The old-growth forests on lands of the NPS are an extensive and valuable natural resource whose importance should be considered in plans for park management and research.

Acknowledgements

Many thanks are extended to the NPS Regional Chief Scientists, CPSU personnel and individuals associated with NPS units who have participated in this project, by providing information, whether by letter, telephone or survey form, and by lending photographs. Without this overwhelming response, this report would not have been possible. Appreciative comments are also due to Mike Adams, organizer of the seminar course "Ecology in the National Parks" offered in the fall of 1988 in the Botany Department of the University of Wisconsin-Madison. It was for a class presentation for this seminar that this project was initiated. The other seminar participants offered many interesting comments during a discussion of the preliminary results of this survey. Kandis Elliot, Sue Lietz and Claudia Lipke provided assistance with report preparation, and Ron Hiebert and Jim Bennett served as the coordinating liaison for the publication phase of this report. Jim Bennett, Cynthia Dott, Donald Field, Tom Givnish, Ron Hiebert, Kathryn McEachern, Dave Peterson and Tom Vale provided valuable comments on drafts of this report.

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Foreword

This report compiles the results from questionnaires and interviews of National Park Service (NPS) scientists and resource management specialists in NPS units that possibly contain old-growth forests, as determined by NPS Regional Chief Scientists. The document is not meant to be the definitive work for the Service and does not attempt to formulate a Servicewide definition of old-growth forests. Instead, it describes units perceived to possess old-growth forests; estimates the extent of these forests; and identifies common attributes of old-growth forests, factors that continue to affect these forests and current management efforts. It may also provide guidance for future research and resource management needs and provides suggestions for improving management.

One of the first questions asked when doing a survey such as this is "What is an old-growth forest?" In order to have an accurate survey, respondents must use definitions based on similar criteria. However, as the author points out, even definitions among the scientific community vary considerably. Definitions that are used within parks are even more variable. It appears that each park has its own definition dependent on factors relating to the parks' associated forest type(s). Identification of attributes most often used by NPS personnel in defining old growth is the first step in formulating standard criteria for the identification of old-growth stands. The following five concepts may help begin this process:

- The forest unit lacks factors commonly associated with disturbance, e.g., logging and natural disasters. Words like virgin, pristine, relict, original or undisturbed are often used to describe old growth.
- Dominant trees have reached a pre-determined minimum age in relation to their total life span.
- The stand has reached a specific successional (most often advanced) status.
- The stand possesses a specific species composition often associated with old-growth forests.
- The forest maintains structural characteristics commonly associated with old growth:
  - Closed canopy
  - Presence of a variety of age classes
  - Minimum tree height (often predetermined) has been reached
  - Presence of a large amount of woody debris

Although the basic philosophy of park management is to manage for the protection of all park resources as a whole, it may be wise to formulate a working definition of old-growth forests, as old growth (at the local or regional level) is fast becoming a rare and finite resource. The working definition the NPS pursues need not be an all encompassing one, but may be tailored to each physiographic region or forest type. However, it should possess a set of similar criteria for defining these valuable stands.

The identification of factors affecting or having the potential to affect old-growth stands today is crucial to their proper management. NPS respondents identified the following factors that continue to affect old-growth forests. Greater awareness of these factors may be helpful when formulating future research and resource management actions:

- Effects from logging activities prior to NPS status
- Fire (wild and human-caused) and effects of fire suppression efforts
- Windthrow events
- Exotic species
- Subsistence logging (specific to the Alaska Region)

Factors that have the potential to affect old-growth forests but not mentioned by NPS respondents include acid rain, global warming and greenhouse effects, and forest fragmentation.

This survey points out that current management efforts are concentrated in the following areas:

- General protection and preservation of the resource
- Restoration of forests affected by past lumbering activities
- Reintroduction of fire

- Control of exotic or problem native species
- Establishment of trails and/or interpretive programs

This report has identified specific research and resource management issues related to old-growth forests. These issues are not surprising or radically different from overall NPS research needs. However, the identification of issues is necessary to provide improved management. This is not to say that these research needs in other successional types are not important also. Suggested future research and resource management needs include the following:

- Acquiring baseline information
  - Compiling comprehensive species lists of all organisms using old-growth forests. Specifically, non-vascular plants, terrestrial invertebrates and soil biota.
  - Identifying organisms dependent on old-growth forests. The identification of these species is the first step towards preserving this important biological resource.
- Initiating studies designed to compare species occurrence and population density of organisms within old-growth units to those outside these areas.
- Maintaining long-term data sets already in use and initiate long-term data collection in sites not already doing so. Utilizing permanent plots to compare old growth and regrowth units to those outside these areas.
- Writing management plans that are specific to old-growth units.

Future management efforts directed towards solving the following problems would be beneficial to the management of old-growth forests.

- There are no standard NPS criteria for evaluating a potential site to determine if it is old growth.
- Some units do not use any definition for determining if a site is old growth.
- Existing NPS definitions of old growth are insufficient. They are often vague and can not be easily applied to the variety of NPS units and forest types (applicable only to specific sites or regions). Sufficient data are often lacking for determining stand age (which is often a criteria used by many old-growth definitions). Minimum tree age figures used are often arbitrary and can not be applied to the variety of forest types that exist in NPS units. In other instances some stands being considered for old-growth status have a frequent natural disturbance even though they do possess many of the other old-growth attributes. Finally, the definition presently used by park staff does not take into account the following factors: understory vegetation, structural variability, successional variability, effects of fire suppression and use by Native Americans and other permittees.
- More accurate estimates of acreage of old growth are needed.
- Specific management plans do not exist for old-growth units.

This report does not explore all the issues, problems or solutions to managing old-growth forests in the NPS. However it does provide guidance for further research and resource management and should be used as a catalyst for future debate and activities.

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Introduction

Old-growth forest inventories

The definition, ecology, preservation and sustainability of old-growth forests* are currently important issues for ecologists, foresters and resource managers. Two important sources of information help address issues related to the protection of old-growth forests (e.g., how much of the old growth remaining on public lands should be preserved?) and to their management (e.g., how does a park manage to ensure presence of structurally intact and fully functional old-growth forests in present and future landscapes?). These sources are (1) inventories (e.g., how much old-growth forests remains? where are the old-growth forests at present?) and research (e.g., what are the compositional, structural and functional features of old-growth forests? how do old-growth forests change successionally? how important are old-growth forests to the maintenance of biological diversity?). Thomas et al. (1988) present some of the interactions among inventory and research, and the ecological, management and conservation issues related to old-growth forests, especially on federal lands.

Although inventories of old growth are dependent on the definition being used, inventories and accumulating research data on forest successional patterns, structural diversity and ecological processes continue to help refine the concept of old growth. Increasingly, research provides evidence for the importance of old growth and the need for its protection.

As timber harvesting continues to reduce the amount of old growth, however it is defined, the extent, status and protection of old-growth forests still remaining on private and public lands is of increasing public concern (e.g., Daniel 1988, Heinrichs 1988, Stiak 1990). Inventories of old growth have been made in several states, including Maine (Maine State Planning Office 1983), Minnesota (Rusterholz 1989), New Hampshire (Carbonneau 1986), and Pennsylvania (Smith 1989). Information has been compiled for selected old-growth areas in the United States (Bolgiano 1989), and for specific regions or areas (Davis 1990 for the East, Greene 1988 for western Oregon and Washington, Habeck 1988 for the Rockies, Leopold et al. 1988 for Adirondack Park, Morrison 1988 for the Pacific Northwest, Parker 1989 for the Central Hardwood Region, and Roemer et al. 1988 for coastal British Columbia).

Objectives in compiling information on NPS old growth

Information about old-growth forests on National Park Service (NPS) lands has not been summarized previously. The idea for compiling this information was prompted by reading that a "projected inventory" had been compiled for old-growth forests in western Oregon and Washington, on lands of the NPS, Bureau of Land Management (BLM) and U.S. Forest Service (USFS) (Greene 1988). Based on this, a series of questions were formulated to "inventory" (by questionnaire only) what information (current perceptions of NPS personnel) is available on the definition, extent, characteristics and management of old-growth forests protected on NPS lands on a nationwide basis. The objective of this report is to bring together the information collected by informal survey from the NPS units perceived to have old growth, to provide regional perspectives on the old-growth issue and to make this compiled information available beyond the unit or regional level.

This type of summary can serve to generate productive discussions. It can raise such familiar or new questions as:

- What is old growth?
- To what forest types should the term be applied?
- Are old-growth forests in NPS units being given the priority of attention commensurate with their value as a national, natural resource?
- Is the size of old-growth areas protected within the boundaries of NPS units adequate to protect these forest resources?

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*The terms "old-growth" and "old growth" have been used in the literature. The convention appears to be to use both terms, using "old-growth" only as an adjective, as in "old-growth forest" or "old-growth ecosystem", and using "old growth" as an adjective-noun combination, as in "the concept of old growth" or "managing old growth" (e.g., Old-growth Definition Task Group 1986, Thomas et al. 1988, Barnes 1989, Spies et al. 1988). This format is used in this report. Others (e.g., Hunter 1988, Bolgiano 1989), however, have consistently used "old-growth" in all contexts.

- How does the NPS view its role as guardian and steward of old growth ?
- Is the current management of these old-growth forests achieving the desired results for future old growth?

This document does not intend to provide a definition of old growth, nor definitive answers on any aspect of old growth on NPS lands. It should be emphasized that the questionnaire was not intended to be a rigorous sociological study of perspectives of the NPS personnel (questionnaire respondents). Rather, when the questions were formulated, they were designed to elicit information known about biological or ecological aspects of NPS old growth. It was not anticipated that the information on old growth would be primarily perceptions of the respondents. At the time the survey was initiated, it was not realized that few data exist for old growth on NPS lands.

Greene (1988) recognized that the figures from the three agencies she consulted in Oregon and Washington (NPS, BLM, and USFS) were not always comparable because of a range of definitions of old growth used by these agencies, including 8 different Forest Service definitions. Despite this limitation, Greene (1988) provided some provisional summary estimates for old growth in that region (NPS—310,122 ha, BLM—193,320 ha, and USFS—1,354,420 ha). In the same way, old-growth definitions differ among NPS respondents, as summarized in this report. However, if the summaries can be viewed as preliminary, and only approximate quantitatively, they can still be viewed as a useful, provisional summary, to be modified, even as the ideas and concepts about old-growth forests continue to be refined within both scientific and management circles.

The concept of old-growth forests

The concept of old growth is an evolving one. The development of various working definitions for different forest types occurred in the late seventies and early eighties (summary by Thomas et al. 1988). In the Pacific Northwest, attempts to define old growth have been based on the work of Franklin and others. The Old-Growth

Alaska Region. Two of the major forest types in Wrangell-St. Elias National Park and Preserve are black spruce found on wet sites, and white spruce (shown here) found on much drier sites. Photo credit: Kathryn Beck / Wrangell-St. Elias National Park and Preserve.

Definition Task Group (1986) established old growth as an ecological concept and built on the earlier descriptions of Douglas-fir forests in the Pacific Northwest (Franklin et al. 1981) to develop a community-specific (Douglas-fir forests) interim definition of old growth. This definition is based on multiple criteria (live trees, canopy, snags, logs). For a stand to be old growth, minimal levels of these structural criteria must be met (e.g., >10 snags per hectare (4 snags per acre) that are >50 cm (20 inches) in diameter and >4.6 meters (15 feet) tall).

Spies and Franklin (1988) provided a good overview of the more recent insights into the structural and functional characteristics of old-growth forests, emphasizing that old growth is "more than just old or large trees". They admitted that the "gradual and variable nature of succession and stand development make the task of precisely defining old growth difficult". They suggested an index of "old-growthness" based on structural characteristics that change during forest succession, rather than a distinct cut-off between mature and old-growth stages of succession.

Thomas et al. (1988) agreed that "a single, all-inclusive definition of old growth is not feasible", but also commented that "definitions of old growth for specific forest types are possible and necessary for management purposes". In general, they viewed old growth as a stage of forest development, though the specifics of the composition, vegetation structure and minimum stand size of old growth differ in character depending on the region, forest type and local conditions.

Others have taken a similar approach to old-growth definitions in providing a general conceptual definition, with provisions for local or regional modifications. The "common denominator definition" proposed by Barnes (1989) is a "forest ecosystem dominated by old trees". This can be expanded using details of species age, size, and composition, canopy structure and other attributes for specific landscape ecosystem types. He emphasized the need to consider (1) the age for old growth to be species-specific and (2) the amount of human disturbance which is acceptable for a stand to be considered old growth. Hunter (1989) established his "broad conceptual definition" by stating "old growth forests are relatively old and relatively undisturbed by humans". He listed several age criteria and several disturbance criteria that are likely to be ecologically important. The definition can be tailored for a given forest type, by choosing an age criterion and a disturbance criterion appropriate for the region or locale. Another more elaborate "generic definition" has been formulated by the USDA Forest Service (1990): "Old-growth forests are ecosystems distinguished by old trees and related structural features. Old growth encompasses the later stages of stand development that typically differ from earlier stages in several ways including tree size; accumulations of large, dead, woody material; number of canopy layers; species composition; and ecosystem function". Definitions for each forest type can be made based on specifics of these later successional stage attributes.

Whether certain forest types should be referred to as old growth has been addressed by several definitional papers. Barnes (1989) pointed out that ecosystems dominated by paper birch or bigtooth aspen are old growth on the basis of his general definition, but he urged managers to decide on a suitable disturbance criterion before determining whether this type of stand (initiated after human disturbance) is old growth. In contrast, the USDA Forest Service (1990) specifically stated that "old growth can develop following human disturbance, such as logging or wildfire". One other aspect to old growth is that of tree size. The Pacific Northwest definition of Douglas-fir old growth included specific sizes of trees as old-growth criteria (Old-growth Definition Task Group 1986). However, Barnes (1989) was careful to comment that since size is influenced by stand density and site quality, these aspects should be considered as well. The USDA Forest Service (1990) qualified its tree size description of old growth as "large trees for species and site". This type of definition would support considering such ecosystems as the taiga in Alaska as old growth (e.g., Thomas et al. 1988).

Functional aspects of old growth are still being explored, although the importance of ecological processes and the interrelationships occurring in old-growth ecosystems have received earlier recognition (e.g., Juday 1978). Research related to the relationships of wildlife to successional stages (e.g., Carey 1989) and the importance of the dead wood component of old-growth forests (e.g., Harmon et al. 1986, Spies et al. 1988) have added a greater dimension to the concept of old growth. The emerging ecological understanding of old-growth forests continues to modify perceptions of what old growth is and is not.

North Atlantic Region. Blackwoods, a stand of 150+ year old spruce and white pine, south of Bar Harbor, Acadia National Park. Photo credit: Judith Hazen / Acadia National Park.

Methods

To canvass information about old-growth forests on lands of the NPS, phone contacts were initially made to the Regional Chief Scientists of the 10 NPS regions. These contacts, as well as other NPS staff and Cooperative Park Studies Unit (CPSU) personnel, provided lists of NPS units that possibly contain old-growth forests and names of those to whom the questionnaire should be sent.

In September 1988, the questionnaire (Appendix A) was distributed. Most respondents completed the survey form by the end of 1988. By April 1990, information had been obtained by survey form or follow-up phone call from each of the 58 NPS units identified as possibly having old-growth forests (100% response).

The questions were arranged in three sections: (1) definition and inventory, (2) landscape context and (3) management/conservation/research (Appendix A). As many responses to several landscape context questions (#1 and #2, Appendix A) were incomplete, summaries of these questions are not included. Not all 58 units gave responses to the questions summarized in this report. Therefore, the summary figures are presented as the number of units that gave a certain answer as a percentage of those units that responded to that question.

Southwest Region. A 120-year old old-growth aspen stand is being replaced by Engelmann spruce, limber pine and Douglas-fir, Bandelier National Monument.
Photo credit: Craig Allen / Bandelier National Monument.

Western Region. Old-growth *Metrosideros polymorpha*-dominated forest at 1200 meters in the Kipahulu Valley, Maui, Haleakala National Park. Photo credit: Research Division, Haleakala National Park.

Results and Discussion

Respondents and response

The personnel who completed the questionnaires hold a variety of positions in their respective NPS units, but are primarily Resource Management Specialists, Research Biologists (Ecologists, Zoologists) and Park Rangers (Appendix B).

The responses have the limits of detail and accuracy available to these NPS personnel. The information provided by the respondents about old-growth forests in their respective NPS units is a function of many things, including how they interpreted the wording of the questions; their familiarity with old-growth forests, based on personal interest, background and training, or longevity of employment in that unit; other demands at the time of the survey request; and the priority given old-growth forests in that NPS unit or NPS region. Scientists, researchers and various other people who have also been involved with the old growth of these NPS units might be able to add to the information presented here; however, the logistics of this informal survey precluded an extensive search beyond personnel in the NPS.

As community processes occurring in old-growth forests are dynamic, and as management outlooks, research projects and personnel turnover may be equally dynamic, the questionnaire responses completed in 1988 or 1989 may already be in need of updating. For example, recent events such as the Yellowstone fires and Hurricane Hugo might influence various survey responses on the issue of disturbance in old-growth forests. In the response from Congaree Swamp National Monument, completed in 1988, there is no mention of windthrow as a disturbance, but given the influence of Hurricane Hugo, an updated response would surely include this (Sharitz and Putz 1990).

Mid-Atlantic Region. A windthrow in Sophia's Woods, a 10-acre, old-growth stand of red maple, black cherry, yellow poplar and white ash at Friendship Hill National Historic Site. Photo credit: Friendship Hill National Historic Site.

What is old growth?

As there is no official NPS definition of old growth, the working definitions of old growth differed widely among respondents (Table 1, Fig. 1). Six NPS units from several NPS regions (11% of those which responded to the working definition question of the survey form) indicated that they do not use the term (Table 1, Fig. 1). This variability should be kept in mind as other aspects of the questionnaire are considered.

The two characteristics of old-growth forests that were included in the working definitions most frequently were (1) a description of some aspect of an undisturbed quality of the forest and (2) a minimum age of trees (mentioned by

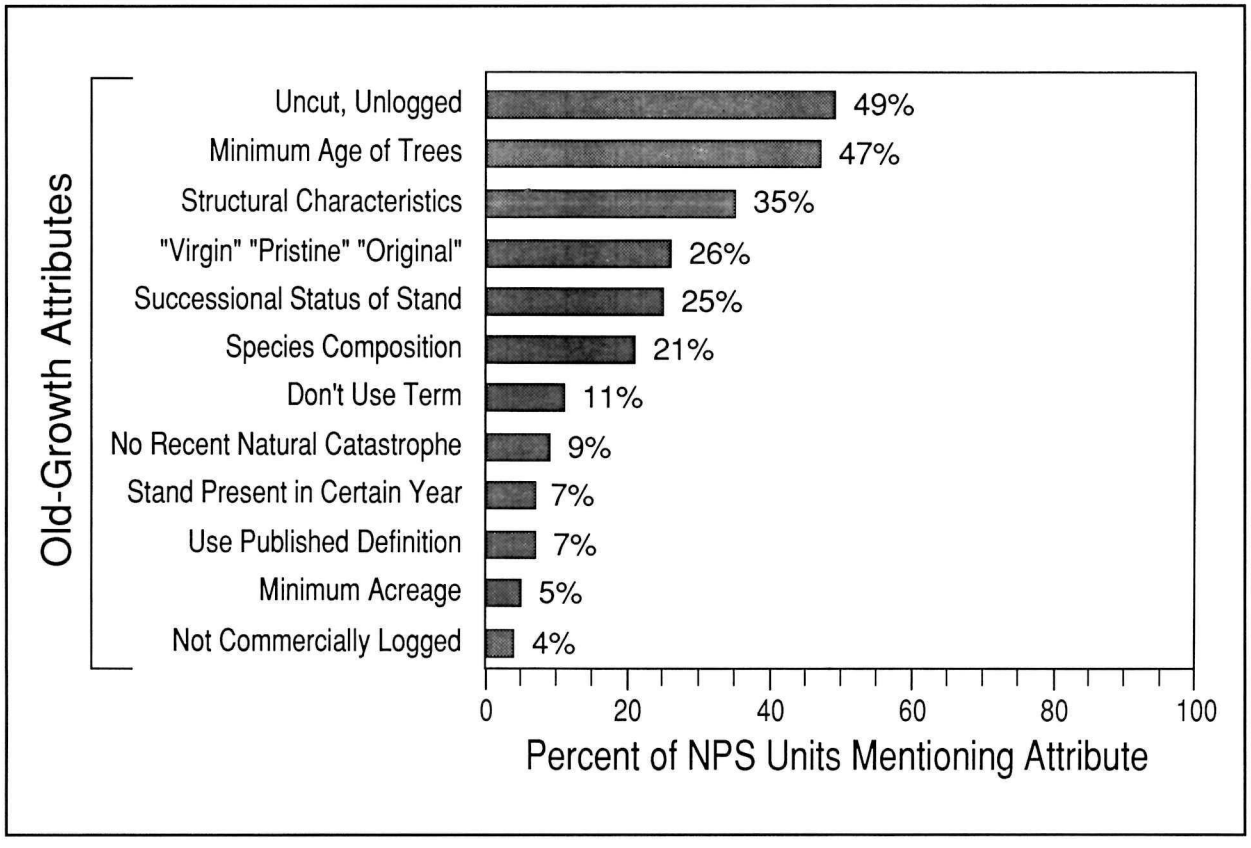


Fig. 1. Summary of attributes of old-growth forests mentioned by respondents in their working definitions. The number of definitions in which the attribute was mentioned is expressed as a percentage of the 57 NPS units providing a definition. Each working definition mentioned one or more attributes.

47% of NPS units, Fig. 1) (c.f. age and disturbance criteria, Hunter 1989). The undisturbed nature of old growth was variously expressed as no logging (49%) or, specifically, lack of commercial logging (4%), or in such terms as virgin, pristine, relict, original, undisturbed (26%) and having no recent natural catastrophe (9%) (Fig. 1).

With respect to the mention of a minimum age, the youngest age listed was 30 years, given by Great Sand Dunes National Monument for aspen (Table 1). The most frequently cited age was 200 years, given for many western units (Pacific Northwest and Western Regions, Table 1). All four Pacific Northwest Region units used 200 years. Three units listed this number on the informal survey form, and the fourth, North Cascades National Park, referred to the published Franklin and Spies (1984) definition, which cites 200 years as the minimum tree age (Table 1). There was a consistent response in terms of age (200 years), as well as other attributes mentioned, from the California units (Western Region, Table 1), as the 8 California unit responses were coordinated by the CPSU at the University of California-Davis. Some variation in the California responses was recorded, however, because some units also replied separately. For these units, the attributes which were recorded were those mentioned in the individual responses, as

well as those given by Stephen Veirs, in his broad definition provided for the California units (Table 1). Likewise, responses for all National Capital Region units were made by one individual, so the responses for this region are also consistent (Table 1).

Units in both the Midwest and North-Atlantic Regions listed the age of 100 years most frequently (Table 1). This may reflect differences in maximum tree longevity between eastern and western species, but also may indicate a willingness in the east to accept younger stand ages as old growth, given that the eastern regions have been logged more extensively in the past. The inclusion of age as an old-growth criterion was listed in several cases as species-specific (see especially the Southwest Region, Table 1), recognizing the differences in lifespan among species.

In terms of structural characteristics, included in some definitions were mention of a closed canopy (e.g., Haleakala National Park), the presence of all age classes (e.g., Mammoth Cave National Park), a minimum tree height (Hawaii Volcanoes National Park), large woody debris (Bandelier National Monument) and an understory that is similar in composition to the canopy (National Capital Region units).

Sixteen (33%) of the respondents indicated that they did not have a problem with the informal working definition of old growth that they presented. The problems mentioned by the 32 respondents (67%), who indicated one or more drawbacks or deficiencies in their definitions, fell into several categories. These are: (1) vagueness of the definition and inability to define such things as "natural" or "long period of time", (2) usefulness or specificity only for a given NPS unit, (3) no standardized definition, (4) lack of data records, or time constraints in getting stand age information, (5) arbitrariness of the minimum age figure used as a criterion, (6) finding stands that meet the criteria, (7) whether to consider stands as old growth if they are (a) stands of species with relatively short lifespans (e.g. aspen, alder), (b) stands with frequent natural disturbances (e.g., lodgepole pine forests) (c) stands in subalpine areas and (d) open forest types and (8) inability to take into account such things as understory vegetation, structural and successional variability, and effects of fire suppression and of use of forests by Native Americans.

Midwest Region. An old-growth forest on Outer Island, Apostle Islands National Lakeshore, with eastern hemlock and yellow birch in the canopy, and Canada yew in the understory. Photo credit: Lucy Tyrrell

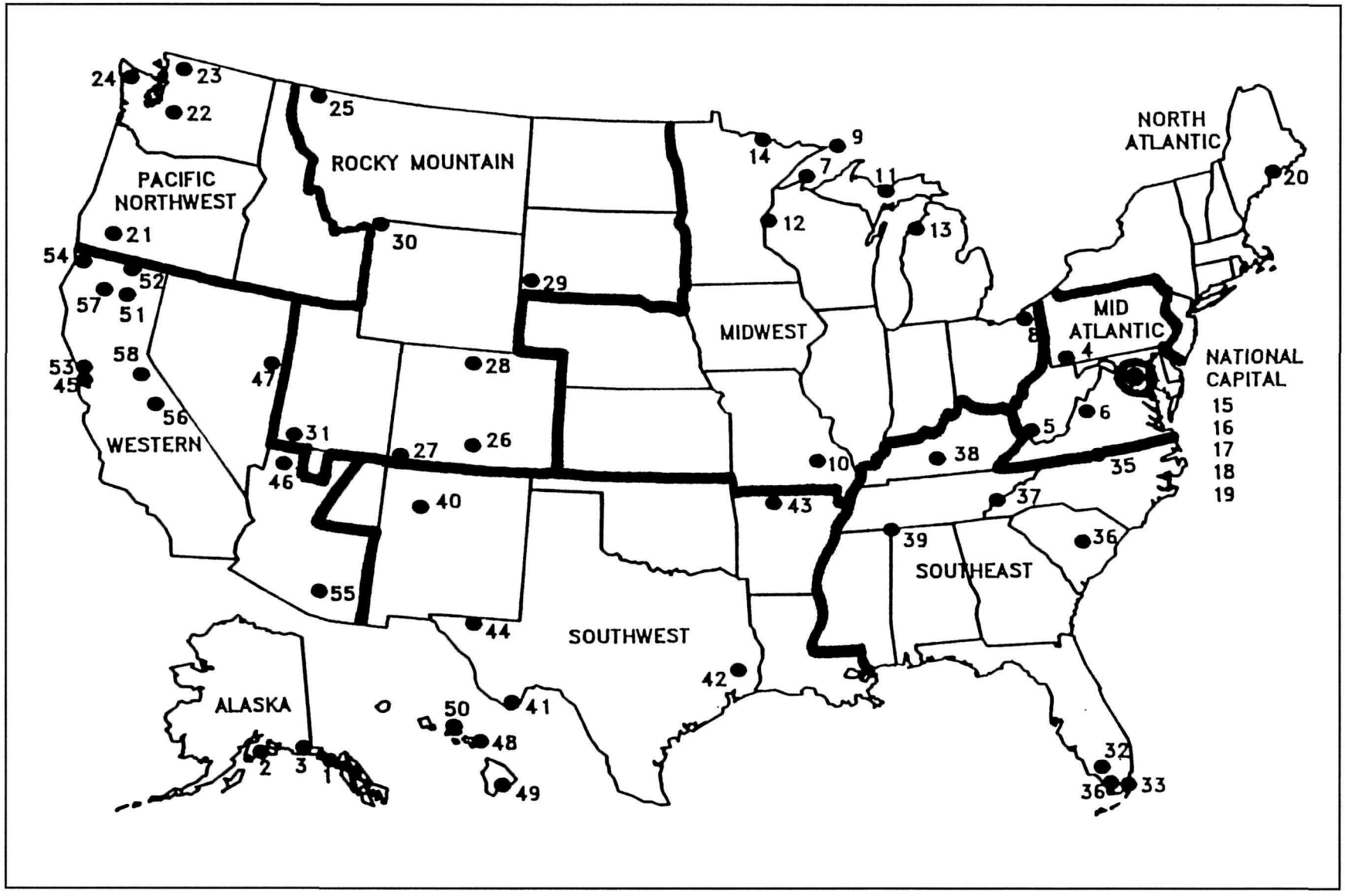


Fig. 2. Location of National Park Service (NPS) units with old-growth forests, as identified by this informal survey. The numbers are keyed to the names of the NPS units, listed alphabetically by NPS region, in Table 2. NPS regions are outlined, and identified by name.

There seems to be no clear consensus on what constitutes old growth, and on whether definitions should be established which are region- or NPS unit-specific. It seems unlikely that one definition would be very useful for all NPS units, given the variability among different regions, forest types and species' life histories (c.f., Hunter 1989).

Where is the NPS old growth?

Based on this informal survey, a total of 58 of the 357 NPS units (as of June 1991) have old-growth forests. This total includes those units that report some uncertainty as to whether old-growth forests exist in the unit and those that do not use the term old growth. The 58 units occur in all 10 NPS regions and in 32 states and the District of Columbia (Table 2, Fig. 2). Of the 58 NPS units with old growth, 30 of these are National Parks, represented by 29 survey responses, as Sequoia National Park and Kings Canyon National Park are managed as one unit. Old growth also occurs in other types of NPS units, as follows: National Historic Site (1), National Historical Park (2), National Lakeshore (3), National Monument (6), National Parkway (3), National Preserve (2), National Park and Preserve (2), National Recreation Area (3), National River (2), National Scenic Riverway (2) and Park or other (3) (Appendix C). The Rock Creek Park unit includes two park areas with old growth, Rock Creek Park and Glover Archbold Park.

How much old growth is there?

The total estimated minimum area of NPS-protected old growth reported is 1,970,770 hectares (4,867,800 acres). This figure does not include 14 NPS units that did not indicate the areal extent of their old growth (Table 2). Those units that did not provide an estimate fall into several categories. In several units, old growth is present, but the amount is unknown or unreported (C & O Canal National Historical Park, George Washington Memorial Parkway, Big Cypress National Preserve, Everglades National Park, Blue Ridge Parkway, Natchez Trace Parkway and Buffalo National River), or reported in a different form (old growth as a percent of all forests, Rocky Mountain National Park).

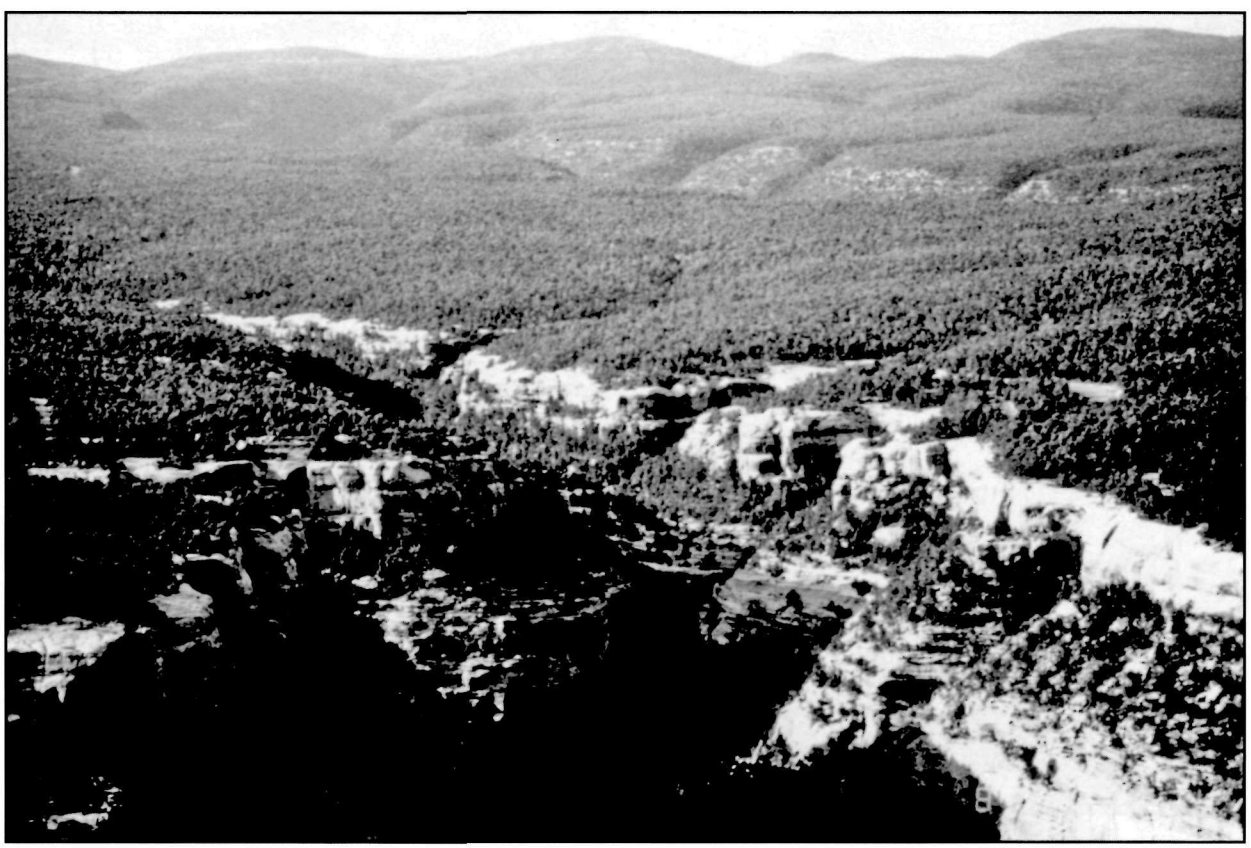
Pacific Northwest Region. Old-growth mountain hemlock/Shasta red fir forest on the rim of Crater Lake caldera, Crater Lake National Park. Photo credit: R.G. Warfield / Crater Lake National Park.

In three units the term is not used, even though by some definitions old growth might be said to be present (Glacier National Park, Isle Royale National Park and Cuyahoga Valley National Recreation Area). For New River Gorge National River, no old growth is known, but some might exist. In the remaining three units, the status is unknown (Zion National Park), or practically no old growth is present (Biscayne National Park, Big Thicket National Preserve). Biscayne, with only one small island of hardwoods, has negligible acreage, and only scattered old trees remain after past logging in Big Thicket (Table 2). If the area of old growth were recorded for Rocky Mountain, Glacier, Isle Royale and Big Cypress, this would increase the total hectares by a substantial amount.

The totals of minimum estimated area of old growth have been tallied by NPS region and are listed here in descending order. The numbers have been converted from the acreage reported on the survey form (1 hectare = 2.47 acres), and rounded to the nearest 10 hectares (except for the two smallest areas). The regional totals are: Western (573,420 hectares), Alaska (538,060), Rocky Mountain (396,830), Pacific Northwest (362,400) (c.f. 310,122 ha reported by Greene 1988), Southeast (62,070), Southwest (30,300), Midwest (6,770), National Capital (850), Mid-Atlantic (45) and North Atlantic (12). Western Region has the most NPS units with old growth (14 units), while the North Atlantic has but one (Table 2).

Four NPS units, all in the western portion of the United States, report old-growth forests covering more than 200,000 hectares (one-half million acres): Wrangell-St. Elias National Park and Preserve, 404,860 hectares; Yellowstone National Park, 387,710 (post-fire estimate); Yosemite National Park, 225,510; and Sequoia/Kings Canyon National Park, 202,430 (Table 2).

Of those reporting estimates, the two NPS units with the greatest percentage of the unit in old-growth forest are Muir Woods National Monument (100%) and Congaree Swamp National Monument (80%). At the other end of the spectrum, several units reported less than one-tenth of the unit acreage as old growth. Of interest, but not reported here, is what percentage of the forested habitat present in each unit is old growth.



Rocky Mountain Region. Pinyon/juniper on the mesa top of Cliff Canyon, Mesa Verde National Park.
Photo credit: Marilyn Colyer / Mesa Verde National Park.

What are the old-growth forests like?

The species composition of the old-growth forests in NPS units is diverse. Without doing a careful cross-check of species' common names in different regions, at least 65 different tree species have been listed as components of the old growth (Table 3). Old-growth forests represented in the NPS units are monospecific stands (e.g., slash pine in Everglades National Park) as well as multispecies stands (e.g., mixed conifer in Grand Canyon National Park) (Table 3).

There was some confusion in the interpretation of the term "mixed forests" on the questionnaire (Appendix A). The inquiry "Are there forests that include both conifers and hardwoods (mixed forests)?" may have been interpreted by respondents as "Are there forests which include several species (mixed forests)?" (Table 3). When the summaries were prepared, if there could have been a misinterpretation, an "x" was placed in the columns of conifer, hardwood and conifer/hardwood, based on what species were mentioned for the forest type(s) (Table 3).

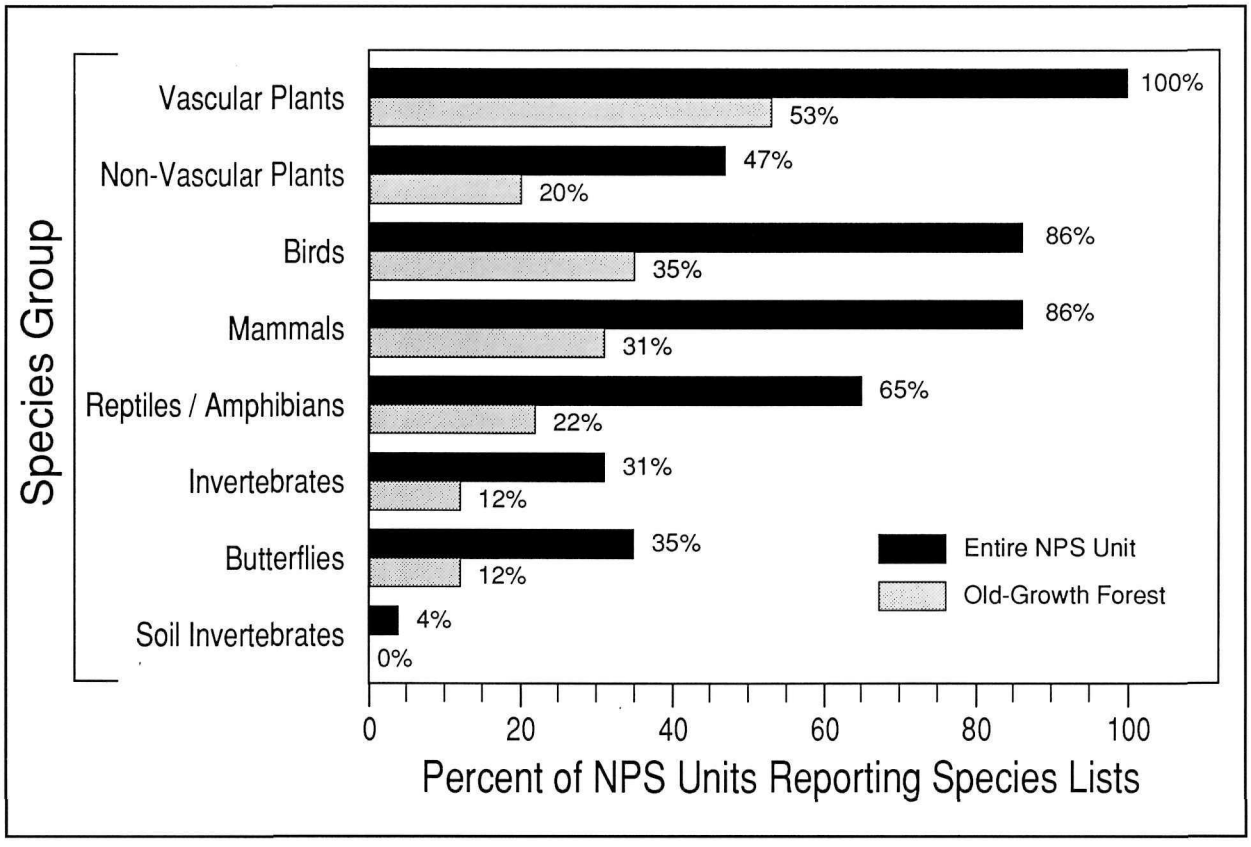


Fig. 3. Percentage of NPS units with species lists (1) for the entire NPS unit (solid bars) out of the 51 units responding, and (2) specifically for the old-growth forests (stippled bars) out of the subset of 49 units recognizing the term old growth in the informal survey.

Both conifer and hardwood old-growth stands are present in seven of the NPS Regions. The North Atlantic and the Pacific Northwest Regions report only conifer old-growth forests, and the forests in the National Capital Region are primarily hardwoods (Table 3).

Tree ages (maximum) in the old-growth forests range from 30 years, for aspen in Great Sand Dunes National Monument, upwards to more than 1,000, for Pacific Northwest Region forests and more than 4,000, for bristlecone in Great Basin National Park (Table 3). Twenty-four NPS units (56% of those giving tree ages) reported that the tree ages are based on increment cores (Table 3). Hawaiian NPS units commented on the absence of annual rings in a tropical climate. Some other methods of establishing tree ages, which were reported by respondents, involve ages of stumps, tree size and form (including bark color), knowledge of past logging and ages of lava flows.

What kind of species inventories exist for the old-growth forests?

All 51 NPS units responding about species lists (100%) have a vascular plant species list, but only 53% have one specific for plants in the old-growth forests of the unit (Table 4, Fig. 3). Likewise, for every other species group, more units reported lists for the unit as a whole, than specifically for the old-growth forest (Table 4, Fig. 3). Only in one NPS unit, Kalaupapa National Historic Park, are there lists for the old-growth forest where none for the entire unit exists (Table 4). Only for vascular plants and birds does 35% or more of the units have old-growth species lists (Fig. 3). Some units report having an invertebrate list for either the unit (31%) or the old growth (12%) (Fig. 3). However, several of these units specifically mentioned that their lists are partial, and probably most, if not all, of the other units have lists that are also partial. Thus, although some of the NPS old-growth forests have been studied rather extensively, in general, species inventories for the old-growth forests of NPS units are, as yet, incomplete, particularly for the phylogenetically lower species groups.

This portion of the questionnaire was worded: "Do species lists exist for ... vascular plants, non-vascular plants, etc.?" (Appendix A). How the question was interpreted influenced responses. Thus, a NPS unit with a complete species list and one with an incomplete list both might have checked yes, given that some kind of list has been made. Many respondents did clarify that the lists were incomplete, partial, or in the process of being made (Table 4). In addition, if a list is present for a unit, the unit may have responded that a list exists for the old growth as well. Some respondents did state that there was not a list specific to the old growth, which was recorded as no list for old growth when the responses were summarized (Fig. 3).

Species associated with old-growth forests

Few data were provided by the NPS units in the species associations section of the questionnaire, where it was asked whether any species were (1) probably obligately dependent on old growth, (2) quite restricted, though not obligately, or (3) associated with old growth (higher numbers there) (Appendix A, Definition and Inventory, Question 8). Nineteen NPS units (35%) specifically indicated that no information was available on old-growth dependent species (Table 5). Assessing what level of dependency and association exists between old-growth forests and certain organisms would require that species inventories, and some measure of density of species in old-growth forests as well as in non-old-growth areas, be available (c.f., Table 4).

Of the units listing species under at least one of the association categories, the largest number of species was presented by two units in Hawaii, Haleakala National Park and Hawaii Volcanoes National Park (Table 5). Haleakala mentioned that the species obligately dependent on the ohi'a-lehua/koa forests number several hundred birds, plants and arthropods. Hawaii Volcanoes provided a list of 34 plants and one bird as examples of species that are obligately dependent on the old-growth forests. This high degree of association reflects the specialization characteristic of island habitats.

For all NPS units, aside from these two Hawaiian units, a total of 16 species were listed as probably obligately dependent on old-growth forests, 13 species as being "quite restricted" and 24 species as having "much higher numbers in old-growth forests than other habitats" (Table 6). Of the 16 obligate candidate species, there were eight birds (including four woodpeckers and two owls), five mammals, two plants and one invertebrate (Table 6). Olympic National Park suggested that some of the species of salamanders may be obligately dependent on old growth, but no information is available at present.

Southeast Region. The largest mahogany tree in the United States, along a boardwalk trail through Mahogany Hammock, Everglades National Park. Photo credit: Lucy Tyrrell.

In addition to the 13 quite restricted species, several species groups were mentioned for this category. Apostle Islands National Lakeshore suggested the possibility of some lichen and bryophyte species, Mesa Verde National Park reported 30-40 species of cavity-nesting birds and dense forest birds and Sequoia/Kings Canyon mentioned several herbaceous plant species that would be quite restricted to old growth. For species that have much higher numbers in old-growth forests than other habitats, species groups rather than specific taxa were also mentioned by several units (herbaceous plants, orchids, birds; Table 6).

Several species were listed by more than one NPS unit. These species were: spotted owl (listed by eight NPS units under some category), pileated woodpecker (3), black bear (3), pine marten (3), marbled murrelet (3), northern goshawk (2), red-cockaded woodpecker (2) and flying squirrel (2) (Table 6). Some species were placed in several categories of association by the same NPS unit. For example, Crater Lake National Park listed the pine marten as an obligate, restricted and associated species (Table 6). Some species were placed in different categories by different units. For example, Olympic National Park listed the spotted owl as an obligate old-growth species and Crater Lake National Park, as an old-growth associate. Mesa Verde National Park named the spotted owl as a species of special concern that does not occur in old growth, as in that unit it uses cliff cavities. There does not seem to be a definitive answer on what the nature of the dependency on old growth is, for even the best known species of birds and mammals. There may also be variation in the nature and extent of the dependency on old growth by a species, based on regional differences in habitat use, as seen by the spotted owl example (cliff versus tree cavity nesting).

Most of the species listed as having some species relationship with old-growth are birds, mammals, or vascular plants, the best studied and most conspicuous species groups. The exceptions were lichens and bryophytes mentioned by Apostle Islands National Lakeshore, arthropods by Haleakala National Park, the Chisos snail by Big Bend National Park, the Jemez Mountain salamander by Bandelier National Monument and the general mention of salamanders by Olympic National Park. It is likely that more species, particularly soil organisms and invertebrates associated with the coarse woody debris or soil of the old-growth forests, are specialized sufficiently to be obligately dependent on, or have some other kind of restricted association with, old-growth forests. No such organisms are listed by survey respondents.

It might be predicted that the looser the old-growth association, the more species would be involved. Thus one would expect the lists to be longer for associated than for restricted species, and more for restricted than for obligate. However, as the numbers listed among the categories do not differ very much (16, 13, 24), probably the respondents have listed only a small percent of the total number of species with some sort of dependency. There is likely to be a greater disparity between the responses and reality for the associated species than for species obligately dependent on old growth. Spies and Franklin (1988) cite Brown's (1985) edited work listing 76 wildlife species, in addition to the

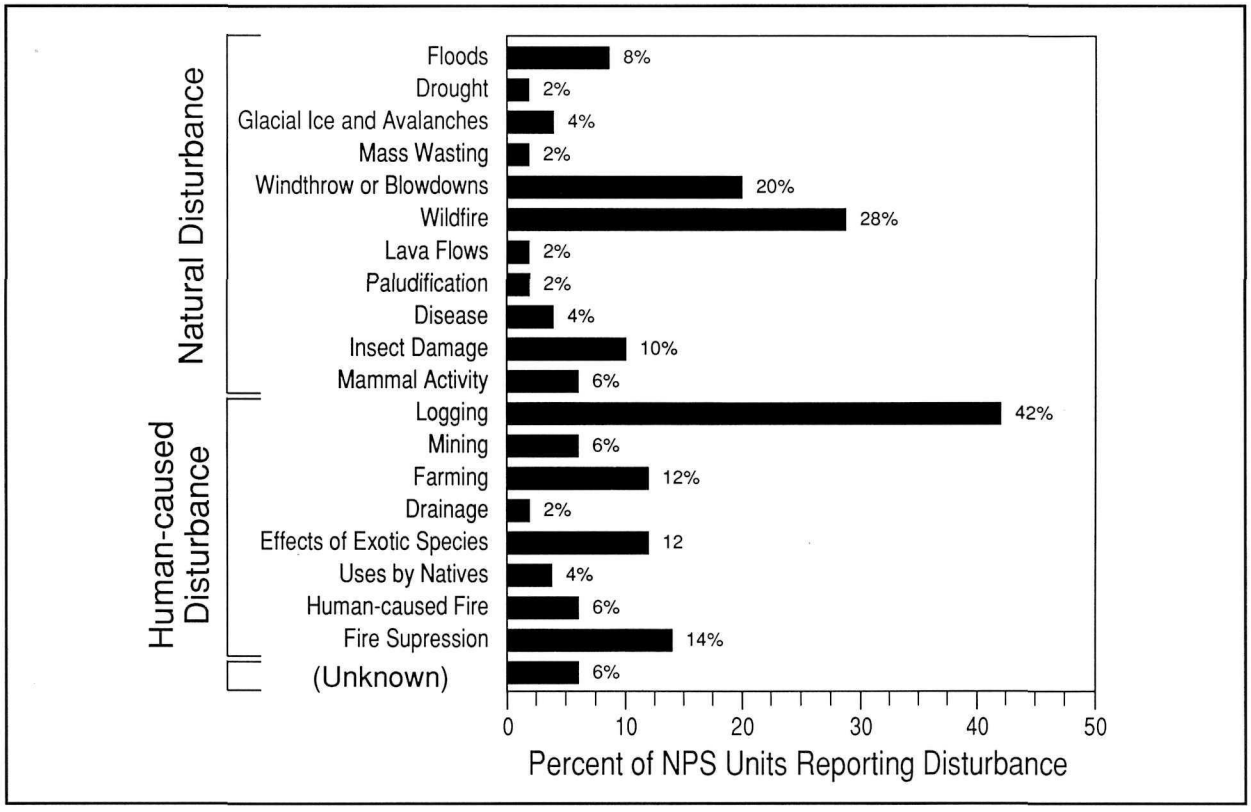


Fig. 4. Summary of natural and human-caused disturbances affecting old-growth forests. The number of NPS units listing a given disturbance is expressed as a percentage of 50 NPS units reporting disturbance information on the questionnaire.

spotted owl, that use old growth as their primary breeding habitat and 65 other species that use old growth as their primary feeding habitat.

Responses to the fourth category, "of special concern, but do not occur in old growth" should include mention of endangered, threatened and other species of special concern in non-forest habitats and younger forest habitats. This is likely to be a sizeable number of species in most units that have a variety of aquatic and terrestrial habitats represented. Only eight NPS units responded with such words as "several", "many", "100+", "compiled", indicating some recognition of this as a category which includes a large number of species (Table 5). Most of these same respondents indicated that the necessary information to list species in the other categories, is not available at present.

The number of species listed in the three categories (Table 6) is relatively few (16, 13, and 24, respectively). There may be fewer species present in old growth than in earlier forest stages, yet some of those that are present in old growth may be species not found in other stages and thus are important in maintaining broadscale biodiversity. Also, respondents in this survey most likely only listed the species that are more documented at present. Knowledge of species occurrence and the level of understanding of the community organization in old-growth forests, in NPS units as well as elsewhere, need to be expanded before final judgments can be made about the number of species associated to any extent with old growth.

Disturbance and old-growth forests

Many types of disturbance, both human-caused and natural, have had a major impact on the old-growth forests on the lands of the NPS (Table 7, Fig. 4). The three most widespread types of disturbance found in most or all NPS regions are logging (42%), wildfire (28%) and wind damage (20%) (Fig. 4). Other types of disturbance are quite restricted to certain NPS units or NPS regions. For example, paludification (process of mire formation over previously forested land or grassland) was only reported from the Alaska Region (Table 7). Not a single unit mentioned acid rain,

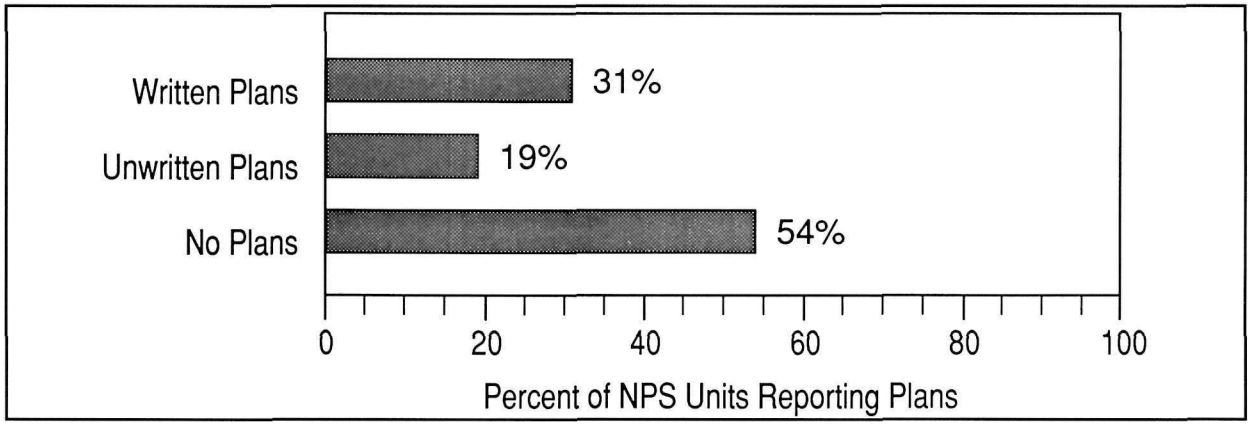


Fig. 5. Summary of management plans for old-growth forests in NPS units. The number of NPS units reporting written plans, unwritten plan or no plans is expressed as a percentage of the 52 NPS units providing this information on the questionnaire.

global warming and greenhouse effects, or forest fragmentation as disturbances to the old-growth forests; these may become of increasing concern in the future.

Most of the human-caused disturbance, including logging, occurred prior to acquisition of the forests by the NPS. For example, livestock grazing (exotic species) affected the old growth in Big Bend National Park until the 1940's, and in Buffalo National River until the 1970's (Table 7). However, there is still some human-caused disturbance occurring at present. Harvesting (including logging), of a subsistence nature, by rural Alaska residents granted permits, occurs in Wrangell-St. Elias National Park and Preserve. Exotic species were listed as major disturbances in all three Hawaiian NPS units (Table 7). Both fire suppression and human-caused fires continue to occur. It is likely, as the role of fire is more completely understood, that management will continue to use both prescribed fire and fire suppression, balanced as most appropriate for a given NPS unit.

In contrast to human-caused disturbances, most natural disturbances, both abiotic and biotic (Table 7), have continued to occur, even after NPS acquisition. Wildfire, however, has been altered by fire suppression policies. Mammal species that were mentioned as causing disturbance to old growth are white-tailed deer and beaver. Although these mammals are native ones, and their effects have been listed under natural disturbance (Table 7, Fig. 4), it is possible that the extent of their impact is due to a increase in their population size, either as result of human settlement, activity and extirpation of natural predators, or of human management for the species, and thus this disturbance might be considered a human-caused disturbance.

Natural disturbances can be viewed as an integral part of the old-growth forests, yet disturbances of too large a magnitude (size or intensity) can destroy the protected old growth, if the stand is not large enough to incorporate patches of disturbance. As previously mentioned, several units cite the lack of a recent, natural catastrophic event as an old-growth criterion (Table 1). There was also commentary as to whether forests subject to disturbance of short return intervals could be considered old growth. Thus in old-growth forests, there is an ecological tension between the dynamics of natural forest processes including windthrow and wildfire, and a certain stability needed to maintain old trees and a pristine, undisturbed character. The term old growth may not be as appropriate for forests with short return intervals of natural disturbance (thus making them fairly young forests), yet these forests, if undisturbed by humans, do meet the low disturbance criterion for old growth.

Management of old-growth forests

More than half (54%) of the NPS units reported no management plan specific to their old-growth forests (Fig. 5), while the remaining units reported either a written plan, an unwritten plan or both (Table 8). The Western Region is most consistent in reporting an old-growth plan of some kind (Table 8). Some of the NPS units mention their General Management Plan (GMP), Resource Management Plan (RMP) or Fire Management Plan (FMP) in response to this question on the survey (Table 8). These plans, though not specific to old-growth forests, are applied to the old-growth

forests along with other areas of the units (see comments, Table 8). Units with GMP, RMP or FMP's that are not specific to old growth, apparently responded to the survey in one of two ways, saying either yes, a management plan exists, or, no, a (specific) management plan for old growth does not exist (Table 8). Therefore, it is difficult to interpret or compare among units the extent of the management of old growth, without further examination of the GMP, RMP or FMP's for each NPS unit. It is clear, however, that special management of old growth has not been considered appropriate, necessary, or high enough of a priority in many units to warrant a separate management plan (Table 8).

Despite the difficulty in interpreting the extent or nature of the plans, each of the following management strategies for old-growth forests was described by at least one respondent: (1) general protection and preservation, in some cases as wilderness or as part of a natural area, (2) restoration of forests affected by past lumbering, (3) regeneration of forests, (4) restoration of the natural role of fire, with prescriptions for let-burn and no-burn zones, and for natural and prescribed fires, (5) control of exotic or problem native species and (6) establishment of trails and/or interpretive programs.

Management/scientific research priorities

The questionnaire asked each respondent to list the top four management/scientific research priorities of the NPS unit (Appendix A). The intention in this was to see whether old-growth forests were among the first four priorities of management/scientific research. It is unknown whether the four priorities listed by each unit are an official list for the unit (i.e., funded projects to which the unit is committed according to their RMP or GMP), or whether this is a unofficial listing by the respondent.

Only three NPS units specifically mentioned some aspect of forest or old-growth forest management or research activity as one of the four items. Big Cypress National Preserve listed exotic plant management, adding a note that *Melaleuca* invasion is occurring in old-growth forests, to a minor degree. The first two priorities reported for Kalaupapa National Historical Park were fencing the (old-growth) forest, and removing the feral pigs and goats from the forest. Watershed/forest rehabilitation following pre-park logging was listed as the first priority for Redwood National Park.

The remainder of the research priorities are either not old growth related or possibly related only in a very general way. Some priorities that were listed by respondents are definitely not oriented toward old growth. The most frequent categories of this type were: water quality and resources (15 responses), specific non-forest habitats (cave, river, bay, estuary, peatlands, coral reef, mangrove, marine; total for all habitats 14), visitor impact studies (13), air pollution (9), fisheries management (7) and visitor-related park improvements (fix roads, vistas, visitor center, etc.) (6).

Another set of general responses, which are likely to include old-growth forests, if only as part of a broader NPS unit-based project, are: fire-related studies (fire history, control, management and ecology) (13), gathering baseline information and inventory of natural resources and ecosystem function (10), vegetation surveys, monitoring and

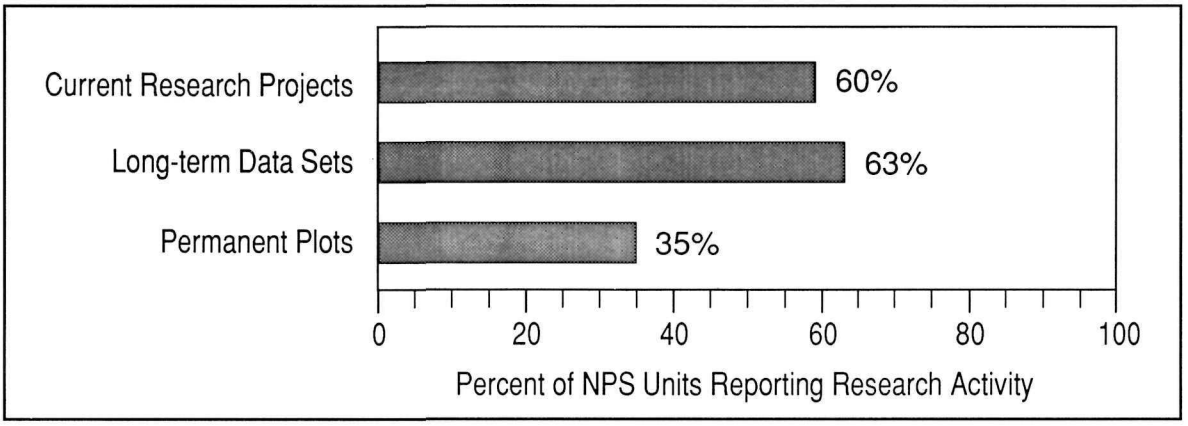


Fig. 6. Summary of research activities in old-growth forests in NPS units. The number of units reporting projects, long-term data sets and permanent plots is expressed as a percentage of the 52 NPS units providing this information on the questionnaire.

management (8), endangered species and habitats (not specific) (8) and broad planning (GIS, landscape ecology, Resource Management Plan, General Management Plan) (7).

Two frequently mentioned priorities may or may not involve old-growth forests, although it was hard to interpret this from the survey replies. These priorities are: alien plant and animal control (13) and wildlife management or species reintroductions (9 listed in general terms, 12 for specific species).

Research activities in old-growth forests

More than 319 research projects occurring in or associated with old-growth forests were reported (Table 9). Sixty percent of the NPS units responding have at least one project being conducted in old-growth forests (Fig. 6). Most projects are being conducted in Yellowstone National Park (200), Yosemite National Park (30), Great Smoky Mountains National Park (>15) and Sequoia/Kings Canyon National Parks (10-13) (Table 9). The Yellowstone projects include projects being conducted on the old-growth vegetation and on animals that occupy this vegetation, even though the focus of the projects is not old growth per se. In addition to the Yellowstone projects, at least 72 projects in 24 NPS units are funded or initiated by the NPS, and more than 47 projects in 15 NPS units have sponsorship outside the NPS (Table 9).

Long-term data sets exist for the old growth in 33 NPS units (63%) (Fig. 6). These are primarily data taken in the 1970's and 1980's, but also include some aerial photos, weather data and vegetation information from much earlier. Permanent plots have been established in the old-growth forests in 18 NPS units (35%) (Table 9, Fig. 6).

Summary comments

Based on this informal survey, there is no clear agreement among NPS respondents as to what constitutes old growth (Fig. 1), paralleling the general scientific community's controversy about definitions of old-growth forests. There is still much to be learned about old-growth forests, including what species live in association with old growth and to what degree of dependency (Fig. 3), and how disturbance (Fig. 4) and other ecological processes function in old-growth forests. The extent of active management (Fig. 5) and research (Fig. 6) going on at present in old growth on NPS lands can be considered in conjunction with these questions: Have these forests been considered a natural resource to be incorporated in NPS management plans and research priorities? What more can be done to ensure the preservation of these unique natural resources? What can be learned from these old-growth forests to ensure biological diversity and sustainable forest ecosystems?

At present in the United States, many hectares of old-growth forests are protected on lands of the NPS, possibly more hectares of protected old growth than on lands of any other public or private institution. These old-growth forests have inherent value as important national, ecological resources. With the custody of these old-growth forests, the NPS has a unique opportunity to manage what may be a rapidly disappearing forest type.

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Table 1. What is old growth? Attributes of old-growth forests mentioned by respondents in their working definitions. Postal abbreviations are given for the state in which the NPS unit is located.

	OLD-GROWTH ATTRIBUTE	Minimum age of trees	Reference to a stand in a certain pre-settlement year	Successional status	Structural characteristics of stand	Species composition	Minimum acreage	Virgin, pristine, relict, original, undisturbed	Lack of recent, natural catastrophic disturbance	Unlogged, uncut	Not commercially logged	Don't use term	Reference to another published definition
NPS REGION	NPS UNIT (STATE)	1	2	3	4	5	6	7	8	9	10	11	12
Alaska	Glacier Bay (AK)	250						X	X				
	Kenai Fjords (AK)		X	X		X				X			
	Wrangell-St. Elias (AK)												X
Mid-Atlantic	Friendship Hill (PA)		X	X									
	New River Gorge (WV)									X			
	Shenandoah (VA)										X		
Midwest	Apostle Islands (WI)						X				X		
	Cuyahoga Valley (OH)											X	
	Isle Royale (MI)	X								X		X	
	Ozark (MO)	120		X	X								
	Pictured Rocks (MI)	100											
	St. Croix (MN, WI)	300						X					
	Sleeping Bear Dunes (MI)	100											
	Voyageurs (MN)		X					X		X			
National Capital	C & O Canal (DC, MD)			X	X					X			
	George Washington (MD, VA)			X	X					X			
	Prince William Forest (VA)			X	X					X			
	Rock Creek (DC)			X	X					X			
	T. Roosevelt Island (MD)			X	X					X			
North Atlantic	Acadia	100		X		X		X	X				
Pacific Northwest	Crater Lake (OR)	200				X							
	Mt. Rainier (WA)	200											
	North Cascades (WA)												X
	Olympic (WA)	200											
Rocky Mountain	Glacier (MT)											X	
	Great Sand Dunes (CO)	X[1]				X							
	Mesa Verde (CO)	X[2]		X		X							
	Rocky Mountain (CO)			X				X					
	Wind Cave (SD)		X										
	Yellowstone (ID, MT, WY)	X[3]		X	X	X							
	Zion (UT) none given												
Southeast	Big Cypress (FL)					X				X			
	Biscayne (FL)											X	
	Blue Ridge (NC, VA)												X
	Congaree Swamp (SC)							X					
	Everglades (FL)							X		X			
	Great Smoky Mountains (NC, TN)							X					X

NPS REGION	NPS UNIT (STATE)	1	2	3	4	5	6	7	8	9	10	11	12
	Mammoth Cave (KY)				X	X		X		X			
Southeast (cont.)	Natchez Trace (AL, MS, TN)	X								X			
Southwest	Bandelier (NM)	200			X			X		X			
	Big Bend (TX)					X	X	X					
	Big Thicket (TX)	X					X[4]			X			
	Buffalo (AR)	100								X			
	Guadalupe Mountains (TX)									X			
Western	Golden Gate (CA)	200			X					X			
	Grand Canyon (AZ)									X			
	Great Basin (NV)			X					X				
	Haleakala (HI)				X	X[5]		X	X	X			
	Hawaii Volcanoes (HI)	200		X	X								
	Kalaupapa (HI)					X[5]		X					
	Lassen Volcanic (CA)	200			X	X		X		X			
	Lava Beds (CA)	200			X					X			
	Muir Woods (CA)	200			X					X			
	Redwood (CA)	200			X			X		X			
	Saguaro (AZ)											X	
	Sequoia/Kings Canyon (CA)	200			X				X	X			
	Whiskeytown (CA)	200			X					X			
	Yosemite (CA)	200			X					X		X	

[1] The age differs among species: conifers (pinyon/juniper and ponderosa pine) 100-800 years, aspen 30+ years, and cottonwood 75+ years.
[2] The age differs among species: pinyon 100-200 years, juniper 100-500 years, Douglas-fir 150-500 years.
[3] The age for lodgepole pine is 250+ years.
[4] The older trees must be present in continuous stands (thus a minimum acreage is implied), rather than scattered individuals. This is the criterion which was used to determine that Big Thicket does not have any old-growth forests.
[5] Native species were specified.

Table 2. How much old growth is there? Estimated areal extent of old-growth forests in NPS units, by region, in hectares, and expressed as a percentage of the NPS unit area. These numbers were compiled from an informal survey of NPS units with old growth (see Methods for details). Acreage of old growth was converted using 1 hectare = 2.47 acres. Figures were rounded to the nearest 10 hectares, except for areas of less than 100 hectares, where the number is given to the nearest hectare. The number beside the unit name (map key) corresponds to the location on the map (Fig. 1). States are listed by postal abbreviation following the NPS unit name.

NPS REGION	MAP KEY	NPS UNIT (STATE)	ESTIMATED OLD GROWTH (HECTARES)	TOTAL AREA OF UNIT (HECTARES)	PERCENT (%) OLD GROWTH
Alaska	1	Glacier Bay (AK)	121,460	1,336,030	9
	2	Kenai Fjords (AK)	11,740	234,820	5
	3	Wrangell-St. Elias (AK)	404,860 +	5,303,640	8
Mid-Atlantic	4	Friendship Hill (PA)	2-4	270	1-2
	5	New River Gorge (WV)	0 ?[a]	25,370	?
	6	Shenandoah (VA)	40	79,090	< 0.1
Midwest	7	Apostle Islands (WI)	530	17,130	3
	8	Cuyahoga Valley (OH)	unknown [b]	13,360	?
	9	Isle Royale (MI)	unknown [c]	231,500 [d]	?
	10	Ozark (MO)	97	32,790	0.3
	11	Pictured Rocks (MI)	405	14,170	3
	12	St. Croix (MN, WI)	<810 ?	28,340	3 ?
	13	Sleeping Bear Dunes (MI)	4,860	20,240	24
	14	Voyageurs (MN)	77 +	89,070 [e]	< 0.1
National Capital	15	C & O Canal (DC, MD) [f]	unknown	8,410	?
	16	George Washington (MD, VA) [g]	unknown	2,890	?
	17	Prince William Forest (VA)	810	6,880	12
	18	Rock Creek (DC) h	40	1130	4
	19	T. Roosevelt Island (DC)	3-4	36	8-11
North Atlantic	20	Acadia (ME)	10-12	15,790	< 0.1
Pacific Northwest	21	Crater Lake (OR)	20,240	76,520	26
	22	Mt. Rainier (WA)	36,900	95,390	38
	23	North Cascades (WA)	143,320	277,020	52
	24	Olympic (WA)	161,940	374,930	43
Rocky Mountain	25	Glacier (MT)	— [i]	410,360	?
	26	Great Sand Dunes (CO)	2,020	15,390	13
	27	Mesa Verde (CO)	5,950	21,050	28
	28	Rocky Mountain (CO)	— [j]	108,100	?
	29	Wind Cave (SD)	1,150	11,450	10
	30	Yellowstone (ID, MT, WY)	387,710	890,690	44
	31	Zion (UT)	unknown	59,350	?
Southeast	32	Big Cypress (FL)	— [k]	230,770	?
	33	Biscayne (FL)	0 + [l]	75,300 [m]	0
	34	Blue Ridge (NC, VA)	unknown	32,390 +	?
	35	Congaree Swamp (SC)	4,860	6,070	80
	36	Everglades (FL)	unknown	10,120	?
	37	Great Smoky Mountains (NC, TN)	57,090 [n]	209,000	27
	38	Mammoth Cave	120	21,230	0.6
	39	Natchez Trace (AL, MS, TN)	unknown	20,650 +	?
Southwest	40	Bandelier (NM)	2,020-3,240 [o]	13,360	15-24
	41	Big Bend (TX)	8,100 +	286,640	3
	42	Big Thicket (TX)	unknown [p]	34,210	?
	43	Buffalo (AR)	unknown [q]	38,150	?
	44	Guadalupe Mountains (TX)	18,970	30,890	61

NPS REGION	MAP KEY	NPS UNIT (STATE)	ESTIMATED OLD GROWTH (HECTARES)	TOTAL AREA OF UNIT (HECTARES)	PERCENT (%) OLD GROWTH
Western	45	Golden Gate (CA)	8,100	29,600	27
	46	Grand Canyon (AZ)	70,450	490,330	14
	47	Great Basin (NV)	4,450 [r]	31,220	14
	48	Haleakala (HI)	4,050	11,340	36
	49	Hawaii Volcanoes (HI)	10,120	92,710	11
	50	Kalaupapa (HI)	140	4,050	4
	51	Lassen Volcanic (CA)	27,130	42,920	63
	52	Lava Beds (CA)	570	18,850	3
	53	Muir Woods (CA)	240	240	100
	54	Redwood (CA)	15,790	42,920	37
	55	Saguaro (AZ)	3,240	33,840	10
	56	Sequoia/Kings Canyon (CA)	102,430-202,430 [s]	364,370	28-56
	57	Whiskeytown (CA)	1,220	17,210	7
	58	Yosemite (CA)	225,510	308,230	73

[a] As reported, no old growth is known, although it is possible some exists.
[b] As reported, the acreage of old growth is unknown/N.A., because the term old growth is not used.
[c] There are portions of the park (less than 10-20%) that have trees of 150 years and might be considered old growth. However, as the park is managed as wilderness, old growth has not been distinguished as such; the term is not used on Isle Royale.
[d] The land area is 54,450 hectares.
[e] The land area is 54,540 hectares.
[f] This entry represents the park area of the Palisades Parkway administered by the C & O Canal.
[g] This entry represents the park area of the Great Falls of the Potomac administered primarily by the C & O Canal, but also by the George Washington Parkway.
[h] This entry represents stands in two areas administered by Rock Creek: Rock Creek Park and Glover Archbold Park.
[i] A figure was not reported for the acreage of old growth, because the term is not used. (Reported as N/A.)
[j] A figure was not reported for the acreage of old growth; instead, ninety-nine percent of all forests were reported as being old growth.
[k] A figure was not reported for the acreage of old growth.
[l] There is only one very small stand of hardwoods on one island; the remainder of vegetation is mangroves.
[m] The land area (above mean low water) is 3,780 hectares.
[n] Areas which are "high in virgin forest attributes based on little or no record of pre-Park disturbance" constitute approximately 41,000 hectares. Areas of "big trees with diffuse disturbance" constitute approximately 16,380 hectares. If stands over 80-90 years old are taken to be old growth, then most of Great Smoky Mountains, would be considered old growth.
[o] This excludes all pinyon/juniper woodland types.
[p] There is no old-growth forest per se, as all lands were cut over. However, some older trees were left scattered throughout the preserve.
[q] There are some forest stands which may qualify (depending on one's definition of old growth), but such stands have not been mapped or identified.
[r] This is an estimate of the hectares of bristlecone pine. Other old stands of pinyon pine, and of other species, are present in the park, but no information on these stands is available at present.
[s] The higher figure includes subalpine forest types.

Table 3. What are the old-growth forests like? Tree age (maximum), forest type, and dominant tree species for old-growth forests in NPS units, by region, according to an informal survey of NPS units with possible old growth (see Methods for details). Trees are aged by cores **(C)**, by estimate **(E)**, or some other **(O)** means indicated in the footnotes. Forests are typed as conifer **(CON)**, hardwood **(HAR)**, or mixed conifer and hardwood **(C/H)**. Species occurring together in mixed stands are separated by (/). States are listed by postal abbreviation following the NPS unit name.

NPS REGION	NPS UNIT (STATE)	TREE AGE (YEARS)	HOW WAS TREE AGE DETERMINED?	OLD-GROWTH FOREST TYPE CON	HAR	C/H	FOREST DESCRIPTION(S) BASED ON DOMINANT SPECIES
Alaska	Glacier Bay (AK)	<500	E	x			Western hemlock/Sitka spruce with some Alaska cedar and mountain hemlock
	Kenai Fjords (AK)	<400	C	x			Sitka spruce/western hemlock
	Wrangell-St. Elias (AK)	180-400+	C	x			White spruce
		100	C		x		Birch
Mid-Atlantic	Friendship Hill (PA)	200-300	E		x		Red maple/black cherry/yellow poplar/white ash
	New River Gorge (WV)	unknown	—	x			Eastern hemlock
					x		Oak/hickory
	Shenandoah (VA)	200-400	—	x			Hemlock
Midwest	Apostle Islands (WI)	200-300	C	x			White cedar
						x	Northern hardwood/hemlock/white pine/yew
	Cuyahoga Valley (OH)	70+	E		x		Oak/beech/maple; oak/hickory
						x	Hemlock/beech
	Isle Royale (MI)	150	E	x			Spruce/fir
					x		Northern hardwoods
	Ozark (MO)	120+	E		x		Sycamore/oak/elm
						x	Shortleaf pine/oak/hickory
	Pictured Rocks (MI)	150-250	C			x	Yellow birch/hemlock
	St. Croix (MN, WI)	unknown	—	x			White pine; black spruce
					x		Oak savanna
	Sleeping Bear Dunes (MI)	80-500	C, E		x	x	Beech/maple with some hemlock and white pine
	Voyageurs (MN)	450	E	x		x?	Red pine/white pine
National Capital	C & O Canal (DC, MD)	100+	E		x		Green ash/sycamore
	George Washington (MD, VA)	unknown	—			x	Post oak/red oak/black haw/pawpaw/Virginia pine
	Prince William Forest (VA)	unknown	—		x		White oak/red oak
	Rock Creek (DC)	130+	E		x		Chestnut oak; mixed mesophytic (tulip tree/beech/northern red oak/white oak)
		unknown	—		x		Beech/tulip tree
	T. Roosevelt Island (DC)	160-198	E		x		Silver maple/green ash
North Atlantic	Acadia (ME)	150-200	C	x			Red spruce; red spruce/white pine
Pacific Northwest	Crater Lake (OR)	200-600	C, O[1]	x			Mixed conifer forest (hemlock/Douglas-fir/red Shasta fir)
	Mt. Rainier (WA)	200-1000+	C	x			—
	North Cascades (WA)	unknown	—	x			Douglas-fir/western redcedar/western hemlock/Pacific silver fir
	Olympic (WA)	200-1000+	C	x			Douglas-fir; western hemlock; western redcedar; silver fir; subalpine fir; mountain hemlock; Sitka spruce

NPS REGION	NPS UNIT (STATE)	TREE AGE (YEARS)	HOW WAS TREE AGE DETERMINED?	OLD-GROWTH FOREST TYPE CON	HAR	C/H	FOREST DESCRIPTION(S) BASED ON DOMINANT SPECIES
Rocky Mountain	Glacier (MT)	—	—	—			—[2]
	Great Sand Dunes (CO)	30-800	C, E[3]	x			Pinyon/juniper; ponderosa pine; spruce-fir
					x		Aspen; cottonwood
	Mesa Verde (CO)	100-500[4]	C, E	x			Pinyon/juniper; Douglas-fir
					x		Gambel oak
	Rocky Mountain (CO)	<450	C[5] E	x			Lodgepole pine; ponderosa pine/Douglas-fir; Engelmann spruce/subalpine fir
					x		Aspen
	Wind Cave (SD)	120-300+	C, O[6]	x			Ponderosa pine
					x		Riparian hardwoods
	Yellowstone (ID, MT, WY)	250-400	C	x			Lodgepole pine; Engelmann spruce/subalpine fir;
		600		x			Douglas-fir
				x			Whitebark pine
					x		Aspen; cottonwood
						x?	
	Zion (UT)	unknown	—		—		—
Southeast	Big Cypress (FL)	90-150	C, E	x			South Florida slash pine
	Biscayne (FL)	unknown	—		x		Lignum vitae
	Blue Ridge (NC, VA)	unknown	—	unknown			—
	Congaree Swamp (SC)	100-300+	E, O[7]	x	x	x?	Cherrybark oak/sweetgum/shumard oak/bald cypress/water tupelo
	Everglades (FL)	100-200	E	x			Slash pine
					x		"Hammock" (mahogany, *Lysiloma*)
	Great Smoky Mountains (NC, TN)	200+	C[8]	x			Spruce/fir
					x		Cove hardwoods; oaks
						x	Hemlock/hardwoods
	Mammoth Cave (KY)	400+	E		x		Beech/tulip poplar; white oak/black oak
	Natchez Trace (AL, MS, TN)	—	—	—			—
Southwest	Bandelier (NM)	200-450	C	x			Mixed conifer (ponderosa pine/Douglas-fir/white fir/limber pine/aspen); spruce-fir (Engelmann spruce/subalpine fir)
					x		Riparian zones of narrow-leaved cottonwood
						x	Riparian areas with cottonwood/mixed conifers including Colorado blue spruce
	Big Bend (TX)	300-400	C	x			Pinyon/juniper; moist woodland (ponderosa pine/Arizona cypress/Douglas-fir)
						x	Pine/oak
	Big Thicket (TX)	120	E	x		x?	Scattered large bald cypress and loblolly pine
	Buffalo (AR)	unknown	—	x			Cedar glades
					x		Oak/hickory; beech
						x	Pine/oak
	Guadalupe Mountains (TX)	484	C[9]	x			Douglas-fir/limber pine/ponderosa pine

NPS REGION	NPS UNIT (STATE)	TREE AGE (YEARS)	HOW WAS TREE AGE DETERMINED?	OLD-GROWTH FOREST TYPE CON	HAR	C/H	FOREST DESCRIPTION(S) BASED ON DOMINANT SPECIES
Western	Golden Gate (CA)	—	—	x			Douglas-fir/redwood
	Grand Canyon (AZ)	<300	C	x			Pinyon/juniper; ponderosa pine
						x	Mixed conifer (pine/aspen/spruce/fir)
	Great Basin (NV)	1000-4000+	C	x			Bristlecone pine
	Haleakala (HI)	< several 100's	E[10]		x		Ohi'a-lehua/koa
	Hawaii Volcanoes (HI)	200-1000	E, O[11]		x		Several forest types [12]
	Kalaupapa (HI)	150	E[10]		x		Ohi'a-lehua
	Lassen Volcanic (CA)	unknown, 200+	O[13]	x			Red fir/Jeffrey pine/white fir
	Lava Beds (CA)	—	—	x			Ponderosa pine
	Muir Woods (CA)	—	—	x			Redwood/Douglas-fir
	Redwood (CA)	< 2000[14]	O[15]	x	x	x	Redwood/Douglas-fir/tan oak/hemlock
	Saguaro (AZ)	100-350	C	x			Ponderosa pine; mixed conifer
	Sequoia/Kings Canyon (CA)	100-2500	C, E	x	x?	x?	Mixed conifer; giant sequoia/mixed conifer; lodgepole pine; red fir; subalpine fir
	Whiskeytown (CA)	—	—	x			Mixed conifer
	Yosemite (CA)	<3000	C	x			Mixed conifer
					x		Oak woodland
						x	Mixed forests

[1] Stumps were also aged.
[2] Not using the term old growth, the responses here were N/A.
[3] This was based on cores for ponderosa pine and estimates for aspen, cottonwood, and pinyon/juniper.
[4] A few trees of 700 years exist.
[5] Tree cores were taken from spruce and fir trees.
[6] Also used were bark color, and tree size and form.
[7] Knowledge of past logging was also used.
[8] One area of shortleaf pine was reported to date by core to the year 1620.
[9] This figure was based on 49 SW white pines.
[10] Trees in the tropics have no annual rings.
[11] The age of lava flows was also used.
[12] The forest types are these:
Metrosideros polymorpha/Cibotium spp. rainforest
closed *Metrosideros polymorpha/Acacia koa/Sapindus saponaria* mesic forest
closed *Acacia koa* dry forest
open/closed *Metrosideros polymorpha/Acacia koa* mesic forest
closed *Metrosideros polymorpha* rainforest
open *Metrosideros polymorpha* mesic forest
open *Metrosideros polymorpha* dry forest
open *Metrosideros polymorpha/Diospyros ferrea* dry forest
[13] Information was obtained from blister rust control projects in the 1930's.
[14] The average age for old-growth overstory redwoods is 600 years.
[15] Stand/age analysis was used.

Table 4. What kinds of species inventories exist for NPS old-growth forests? A tabulation of responses from an informal survey of whether species lists exist in NPS units for vascular plants **(VP)**, non-vascular plants **(NVP)**, birds **(B)**, mammals **(M)**, reptiles and amphibians **(R/A)**, invertebrates **(INV)**, butterflies **(BUT)**, and soil organisms **(SOIL)**. The first column for each organism group is for the NPS unit as a whole; the second column is for the old-growth forests of that unit. Some respondents specifically indicated if the lists are "in progress" or "partial", or "incomplete". These are noted here **(P)**. Several respondents checked that a list existed, but commented that is was not specifically **(NS)** for the old-growth forests. A species list for reptiles and amphibians in Hawaiian units is indicated **(NA)** as there are no native species of herps.

NPS REGION	NPS UNIT (STATE)	SPECIES GROUP															
		VP		NVP		B		M		R/A		INV		BUT		SOIL	
Alaska	Glacier Bay (AK)	X	P	P		X	P	X	P	X							
	Kenai Fjords (AK)	X	NS			X	NS	X	NS								
	Wrangell-St. Elias (AK)	P	P	P	P	P	P	P	P								
Mid-Atlantic	Friendship Hill (PA)	X	X														
	New River Gorge (WV)	X				X		X		P							
	Shenandoah (VA)	X	X	X		X	X	X	X	X							
Midwest	Apostle Islands (WI)	X	X	P	P	X	X	X	X	P	P						
	Cuyahoga Valley (OH)	X	—[1]	X	—	X	—	X	—	X	—			X	—		
	Isle Royale (MI)	X		P		X		X		X				X			
	Ozark (MO)	X		X		X		X		X							
	Pictured Rocks (MI)	X	X			X		X		X							
	St. Croix (MN, WI)	P		P		P		P				P[2]					
	Sleeping Bear Dunes (MI)	X	X			X		X									
	Voyageurs (MN)	X	X	X		X		X		X							
National Capital	C & O Canal (DC, MD)	X[3]															
	George Washington (MD, VA)	X	NS														
	Prince William Forest (VA)	not reported															
	Rock Creek (DC)	not reported															
	T. Roosevelt Island (DC)	X[3]															
North Atlantic	Acadia (ME)	X	P	X		X		X		X		X		X			
Pacific Northwest	Crater Lake (OR)	X	X	X	X	X	X	X	X	X	X	X	X	P	P		
	Mt. Rainier (WA)	X	X			X	X	X		X							
	North Cascades (WA)	X		P		X		X		P							
	Olympic (WA)	X	NS			X		X									
Rocky Mountain	Glacier (MT)	X	—[1]		—	X	—	X	—		—		—		—		—
	Great Sand Dunes (CO)	X				X		X		X		X		P[4]			
	Mesa Verde (CO)	X	X			X	X	X	X								
	Rocky Mountain (CO)	X		X		X		X		X		X		X		X	
	Wind Cave (SD)	X				X		X									
	Yellowstone (ID, MT, WY)	X	NS	P	NS	X	NS	X	NS	X	NS	P	NS	P	NS		
	Zion (UT)	not reported															
Southeast	Big Cypress (FL)	X	X														
	Biscayne (FL)	X	—[5]	X	—	X	—	X	—		—	X	—	X	—		—
	Blue Ridge (NC, VA)	X	X														
	Congaree Swamp (SC)	X	X			X	X	X	X								
	Everglades (FL)	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
	Great Smoky Mountains (NC, TN)	X	P	P	P	X	NS	X	NS	X	NS	P	P	X	NS	P	
	Mammoth Cave (KY)	X				X		X		X		X					
	Natchez Trace (AL, MS, TN)	X				X		X		X							

NPS REGION	NPS UNIT (STATE)	SPECIES GROUP VP		NVP		B		M		R/A		INV		BUT		SOIL
Southwest	Bandelier (NM)	X	NS	X		X	NS	X	NS	X	NS	X	NS	X	NS	
	Big Bend (TX)	X	X	X	X	X	X	X	X	X	X	P	P	X	X	
	Big Thicket (TX)	X				X		X		X						
	Buffalo (AR)	X				X		X								
	Guadalupe Mountains (TX)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Western	Golden Gate (CA)	not reported														
	Grand Canyon (AZ)	X	NS			X	NS	X	NS	X	NS					
	Great Basin (NV)	X	X	X	?	X	?	X		X						
	Haleakala (HI)	X	NS	X	NS	X	NS	X	NS	NA	NA	X	NS	X	NS	
	Hawaii Volcanoes (HI)	X	P			X		X		NA	NA			X		
	Kalaupapa (HI)	X	P				X		X	NA	NA					
	Lassen Volcanic (CA)	X				X		X		P?		P?		X		
	Lava Beds (CA)	not reported														
	Muir Woods (CA)	not reported														
	Redwood (CA)	X	X			X	X	X	X							
	Saguaro (AZ)	X	X	X	X	X	X	X	X	X	X					
	Sequoia/Kings Canyon (CA)	X	X	P	P	X	X	X	X	X	X	P	P	P	P	
	Whiskeytown (CA)	not reported														
	Yosemite (CA)	X	X			X	X	X	X	X	X			X	X	

[1] Cuyahoga Valley and Glacier both reported not using the term old growth. Cuyahoga Valley reported species lists for forested areas and not old-growth forests; Glacier responded that the species lists for old growth are N/A.
[2] Unionid mussels only.
[3] Vascular plant list could be compiled from existing records.
[4] Insect collection, no list.
[5] Biscayne has essentially no old growth, hence old-growth lists are N/A.

Table 5. Species associated with NPS old-growth forests. The number of species that are (**1**) probably obligately dependent on the old-growth forests (**OBLIGATE**), (**2**) quite restricted to this system, though not obligately (**RESTRICT**), (**3**) have much higher numbers in the old growth than other habitats (**ASSOCIATE**), and (**4**) are of special concern but do not occur in old growth (**NOT OG**). (—) indicates that the respondent left this section blank on the informal survey form.

NPS REGION	NPS UNIT (STATE)	(1) OBLIGATE	(2) RESTRICT	(3) ASSOCIATE	(4) NOT OG
Alaska	Glacier Bay (AK)	too complicated to answer briefly			
	Kenai Fjords (AK)	3	2	1	—
	Wrangell-St. Elias (AK)	not determined to date			none known
Mid-Atlantic	Friendship Hill (PA)	no data to answer this question			none known
	New River Gorge (WV)	—	—	—	2
	Shenandoah (VA)	1	—	—	1
Midwest	Apostle Islands (WI)	none yet identified	perhaps some lichens and bryophytes	1	—
	Cuyahoga Valley (OH)	data to answer this unavailable			unknown
	Isle Royale (MI)	no species known at this time			several
	Ozark (MO)	—	—	—	—
	Pictured Rocks (MI)	1	—	—	2
	St. Croix (MN, WI)	no information			100+
	Sleeping Bear Dunes (MI)	—	—	—	—
	Voyageurs (MN)	—	—	—	3
National Capital	C & O Canal (DC, MD)	unknown			
	George Washington (MD, VA)	unknown			
	Prince William Forest (VA)	unknown			
	Rock Creek (DC)	unknown			
	T. Roosevelt Island (DC)	unknown			
North Atlantic	Acadia (ME)	no survey of associated species			many
Pacific Northwest	Crater Lake (OR)	3	2	3	2
	Mt. Rainier (WA)	1	—	3	—
	North Cascades (WA)	no direct data			3
	Olympic (WA)	1	—	2	—
Rocky Mountain	Glacier (MT)	N/A			
	Great Sand Dunes (CO)	5	1	several	1
	Mesa Verde (CO)	—	30-40	2	3
	Rocky Mountain (CO)	unknown			1
	Wind Cave (SD)	—	—	6	—
	Yellowstone (ID, MT, WY)	—	—	4+	—
	Zion (UT)	unknown			
Southeast	Big Cypress (FL)	—	—	1	—
	Biscayne (FL)	—	—	—	—
	Blue Ridge (NC, VA)	unknown			
	Congaree Swamp (SC)	—	—	—	—
	Everglades (FL)	unknown at this time			
	Great Smoky Mountains (NC, TN)	these data are not readily available			many
	Mammoth Cave (KY)	—	—	1	none
	Natchez Trace (AL, MS, TN)	—	—	—	—
Southwest	Bandelier (NM)	—	3	several	many
	Big Bend (TX)	3	2	2	1?
	Big Thicket (TX)	2	—	—	—
	Buffalo (AR)	—	—	several	3
	Guadalupe Mountains (TX)	1	2	—	none

NPS REGION	NPS UNIT (STATE)	(1) OBLIGATE	(2) RESTRICT	(3) ASSOCIATE	(4) NOT OG
Western	Golden Gate (CA)				
	Grand Canyon (AZ)	1	—	—	compiled
	Great Basin (NV)	unknown			—
	Haleakala (HI)	100's	some	some	many
	Hawaii Volcanoes (HI)	many-(35 examples given)	many—(5 examples given)	many—(11 examples given)	—
	Kalaupapa (HI)	—	—	—	—
	Lassen Volcanic (CA)	1	—	—	1
	Lava Beds (CA)				
	Muir Woods (CA)				
	Redwood (CA)	1	2	—	—
	Saguaro (AZ)	—	—	—	—
	Sequoia/Kings Canyon (CA)	—	several	several	several
	Whiskeytown (CA)				
	Yosemite (CA)	2	1	—	1

Table 6. What species are associated with old-growth forests in NPS units? Based on an informal survey of NPS units with old growth, these are the species (listed by respondents) which are (**1**) probably oligately dependent on the old-growth forests (**OBLIGATE**), quite (**2**) restricted to this system, though not obligately (**RESTRICTED**), and (**3**) have much higher numbers in the old growth than other habitats (**ASSOCIATED**), listed by species group. If more than one NPS unit listed a given species, the NPS units are listed alphabetically in the appropriate column.

SPECIES GROUP	OBLIGATE	RESTRICTED	ASSOCIATED
BIRDS			
Marbled murrelet		Redwood	Kenai Fjords
			Olympic
Bald eagle (nesting)	Kenai Fjords		
Northern goshawk		Bandelier	Mt. Rainier
Band-tailed pigeon			Big Bend
Spotted owl	Crater Lake	Bandelier	Crater Lake
	Grand Canyon	Redwood	
	Lassen Volcanic		
	Mt. Rainier		
	Olympic		
	Yosemite		
Great gray owl	Yosemite		
Vaux's swift			Olympic
Acorn woodpecker	Big Bend		
Red-cockaded woodpecker	Big Thicket		Big Cypress
Pileated woodpecker	Crater Lake	Crater Lake	Buffalo
			Crater Lake
			Mt. Rainier
Ivory-billed woodpecker	Big Thicket		
Red-bellied woodpecker			Buffalo
Flicker			Buffalo
Williamson's sapsucker			Yellowstone
Clark's nutcracker			Wind Cave
Pinyon jay			Wind Cave
Gray jay			Wind Cave
Gray-breasted jay			Big Bend
Hermit thrush			Yellowstone
Colima warbler	Big Bend		
Pine grosbeak			Yellowstone
Western tanager			Wind Cave
Woodpecker	Great Sand Dunes		
Owl	Great Sand Dunes		
Birds			Great Sand Dunes
Passerine forest nesting birds			Buffalo
MAMMALS			
Long-nosed bat		Big Bend	
Black bear	Kenai Fjords	Kenai Fjords	
	Great Sand Dunes	Yosemite	
Fisher	Pictured Rocks		
Pine marten	Crater Lake	Crater Lake	Crater Lake
			Mt. Rainier
			Yellowstone
Coyote	Great Sand Dunes		
Least chipmunk			Wind Cave
Red squirrel			Mesa Verde
Northern flying squirrel	Shenandoah		
Flying squirrel			Buffalo
Abert's squirrel			Mesa Verde
			Wind Cave
Beaver		Great Sand Dunes	
White-tailed deer		Big Bend	
Mountain goat (wintering)		Kenai Fjords	

SPECIES GROUP	OBLIGATE	RESTRICTED	ASSOCIATED
AMPHIBIANS			
Jemez Mountain salamander		Bandelier	
Salamanders(?)	Olympic		
INVERTEBRATES			
Chisos snail	Big Bend		
VASCULAR PLANTS			
Canada yew			Apostle Islands
Giant sequoia		Sequoia/Kings Canyon	
Redwood (old-growth)	Redwood		
Gray oak	Guadalupe Mountains		
American chestnut (sprouts)			Mammoth Cave
Aspen		Guadalupe Mountains	
Unspecified herbaceous spp		Sequoia/Kings Canyon	Sequoia/Kings Canyon
Several orchid species			Bandelier
NON-VASCULAR PLANTS			
Lichen and moss species		Apostle Islands	

Table 7. What are the disturbances that have had a major impact on NPS old-growth forests? Results compiled from an informal questionnaire filled out by NPS resource managers, indicating the kinds of disturbance (natural and human) affecting old-growth forests in NPS units. Natural disturbances include floods (**FLO**), drought (**DRO**), glacial ice and avalanches (**ICE**), mass wasting (**MAS**), windthrow or blowdowns (**WIN**), wildfire (**FIR**), lava flows (**LAV**), paludification (**PAL**), diseases (**DIS**), insect damage (**INS**), and mammal activity (**MAM**). Human-caused disturbances include logging and timber harvests (**LOG**), mining (**MIN**), agriculture (**AGR**), drainage (**DRA**), effects of exotic species including grazing (**EXO**), uses by indigenous populations (**IND**), human-caused fires (**+FI**), and fire suppression (**-FI**). If the disturbances were considered unknown, this is indicated (**UNK**). State names are given by postal abbreviation.

NPS REGION	NPS UNIT (STATE)	NATURAL DISTURBANCES											HUMAN-RELATED DISTURBANCES								UNK
		FLO	DRO	ICE	MAS	WIN	FIR	LAV	PAL	DIS	INS	MAM	LOG	MIN	AGR	DRA	EXO	IND	+FI	-FI	
Alaska	Glacier Bay (AK)			X	X	X			X												
	Kenai Fjords (AK)	X																			
	Wrangell-St. Elias (AK)													X				X		X	
Mid-Atlantic	Friendship Hill (PA)					X						X	X	X							
	New River Gorge (WV)												X								
	Shenandoah (VA)																				
Midwest	Apostle Islands (WI)											X	X							X	
	Cuyahoga Valley (OH)														X						
	Isle Royale (MI)					X	X						X	X					X		
	Ozark (MO)												X								
	Pictured Rocks (MI)												X								
	St. Croix (MN, WI)						X						X								
	Sleeping Bear Dunes (MI)												X		X						
	Voyageurs (MN)												X								
National Capital	C & O Canal (DC, MD)	X																			
	George Washington (MD, VA)	X	X																		
	Prince William Forest (VA)										X		X		X						
	Rock Creek (DC)																X[1]				X
	T. Roosevelt Island (DC)	X																			
North Atlantic	Acadia (ME)					X															
Pacific Northwest	Crater Lake (OR)						X														
	Mt. Rainier (WA)					X[2]															
	North Cascades (WA)						X						X								
	Olympic (WA)					X	X														

NPS REGION	NPS UNIT (STATE)	NATURAL DISTURBANCES											HUMAN-RELATED DISTURBANCES								UNK
		FLO	DRO	ICE	MAS	WIN	FIR	LAV	PAL	DIS	INS	MAM	LOG	MIN	AGR	DRA	EXO	IND	+FI	-FI	
Rocky Mountain	Glacier (MT)																				
	Great Sand Dunes (CO)										X		X								
	Mesa Verde (CO)						X			X		X									
	Rocky Mountain (CO)			X		X	X														
	Wind Cave (SD)												X							X	
	Yellowstone (ID, MT, WY)																				
	Zion (UT)												X								
South-east	Big Cypress (FL)						X												X		
	Biscayne (FL)																				
	Blue Ridge (NC, VA)																				X
	Congaree Swamp (SC)												X								
	Everglades (FL)												X			X					
	Great Smoky Mountains (NC, TN)									X	X										
	Mammoth Cave (KY)					X															
	Natchez Trace (AL, MS, TN)																				
South-west	Bandelier (NM)					X	X				X		X								
	Big Bend (TX)		X				X										X				
	Big Thicket (TX)						X						X								
	Buffalo (AR)												X		X		X				
	Guadalupe Mountains (TX)																			X	
Western	Golden Gate (CA)																				
	Grand Canyon (AZ)						X												(X)	X	
	Great Basin (NV)																				X
	Haleakala (HI)														X		X	X			
	Hawaii Volcanoes (HI)						X	X									X				
	Kalaupapa (HI)																X				
	Lassen Volcanic (CA)																			X	
	Lava Beds (CA)																				
	Muir Woods (CA)																				
	Redwood (CA)												X								
	Saguaro (AZ)																			X	
	Sequoia/Kings Canyon (CA)												X								
	Whiskeytown (CA)																				
	Yosemite (CA)														X[3]						

[1] Chestnut blight and gypsy moth.
[2] This windthrow relates to improperly designed clearcuts adjacent to the park, and although windthrow is in the natural disturbances category, this disturbance is human-related.
[3] Farming was not specified; rather "human development" was listed.

Table 8. Management of old-growth forests in NPS units. The questionnaire asked: "Are there written/unwritten management plans for these old-growth forests?" Reference to a general management plan (GMP), a resource management plan (RMP), or a fire management plan (FMP) has been made by some respondents. States are listed by postal abbreviation.

NPS REGION	NPS UNIT (STATE)	DO PLANS EXIST? WRITTEN YES	WRITTEN NO	UNWRITTEN YES	UNWRITTEN NO	COMMENTS
Alaska	Glacier Bay (AK)		X		X	Not specific to old growth
	Kenai Fjords (AK)		X		X	GMP; RMP
	Wrangell-St. Elias (AK)		X	X		Management with subsistence use (ANILCA mandate)[1] including harvesting permits and limits
Mid-Atlantic	Friendship Hill (PA)		X		X	Old-growth area falls within historic zone (GMP)
	New River Gorge (WV)		X		X	
	Shenandoah (VA)		X			No specific plan, but managed as natural zone; GMP lists as outstanding natural area
Midwest	Apostle Islands (WI)	X (draft)				Suppression of deer and beaver; crown openings; soil scarification; direct seeding; plantation
	Cuyahoga Valley (OH)		X		X	Protection of old forests as for all vegetation
	Isle Royale (MI)		X		X	No plan specific to old growth; FMP allows natural fires and no prescribed fires; management of entire wilderness (including any old growth) is a "leave alone" policy
	Ozark (MO)		X		X	RMP
	Pictured Rocks (MI)	X				Preservation of natural systems; no logging; possible trails
	St. Croix (MN, WI)		X		X	NPS traditional management
	Sleeping Bear Dunes (MI)		X	X		Manage to retain natural quality
	Voyageurs (MN)	X				Restoring natural role of fire; protecting old growth and young growth from logging
National Capital	C & O Canal (DC, MD)		X		X	
	George Washington (MD, VA)		X		X	
	Prince William Forest (VA)		X		X	
	Rock Creek (DC)		X		X	RMP not specific for this forest type; hope to develop plans
	T. Roosevelt Island (DC)		X		X	
North Atlantic	Acadia (ME)		X	X		Written being developed in GMP; areas left undisturbed except foot trails; increase public knowledge of old growth through interpretation
Pacific Northwest	Crater Lake (OR)		X		X	RMP, FMP not specific to old growth; FMP includes prescribed burns
	Mt. Rainier (WA)		X		X	General NPS policy; preservation of natural ecological processes
	North Cascades (WA)	X				FMP includes let-burn zones for natural fires and maximum control zones for suppression of all fires
	Olympic (WA)			X		NPS natural area management includes old growth
Rocky Mountain	Glacier (MT)					N/A
	Great Sand Dunes (CO)		X			Discussing prescribed burn plans; formulating plans to protect and interpret trees scarred by Native American cultural use; consulting U.S.D.A. Forest Service forester
	Mesa Verde (CO)		X	X		Wildland fire control; no backcountry development or or harvest; park fencing to stop trespass grazing
	Rocky Mountain (CO)		X		X	Natural resources of park considered as a whole
	Wind Cave (SD)	X				FMP uses prescribed fire to restore forest boundaries and minimize mortality in old growth
	Yellowstone (ID, MT, WY)		X	X		Old-growth management best reflected in FMP; allowing fire, insects, windthrow to play natural role in shaping forest communities
	Zion (UT)		X		X	RMP does not address old-growth forests

NPS REGION	NPS UNIT (STATE)	DO PLANS EXIST? WRITTEN YES	WRITTEN NO	UNWRITTEN YES	UNWRITTEN NO	COMMENTS
Southeast	Big Cypress (FL)		X		X	Old-growth forests not treated differently than pinelands in prescribed burns, but given greater protection from oil development; habitat management for red-cockaded woodpeckers affects old growth
	Biscayne (FL)					N/A
	Blue Ridge (NC, VA)		X		X	Old growth in parkway not identified; not considered a priority
	Congaree Swamp (SC)	X				Do not disturb; manage outside influences to lessen their impact
	Everglades (FL)		X		X	GMP; RMP does not deal with old growth as separate issue
	Great Smoky Mountains (NC, TN)		X			RMP; old growth managed as part of the natural zone
	Mammoth Cave (KY)		X	X		Continued preservation; development of minimum trail for public education
	Natchez Trace (AL, MS, TN)		X		X	
Southwest	Bandelier (NM)			X		FMP indirectly provides written plans; unwritten "hands-off" approach; goal to return natural role of fire through prescribed burns
	Big Bend (TX)		X		X	Suppress fires until FMP approved; few active management activities occur
	Big Thicket (TX)		X		X	None exist
	Buffalo (AR)		X		X	
	Guadalupe Mountains (TX)	X			X	FMP (1985) for natural and prescribed fires
Western	Golden Gate (CA)					
	Grand Canyon (AZ)	X			X	FMP and backcountry management plan provide general guidelines
	Great Basin (NV)		X		X	
	Haleakala (HI)	X				Control of feral goats, pigs, alien plants
	Hawaii Volcanoes (HI)	X				Control of feral animals and alien plants; fencing; monitoring of rare plants, aliens, and vegetation recovery
	Kalaupapa (HI)	X				Fence off forest, then exclude pigs and goats
	Lassen Volcanic (CA)	X				RMP; FMP; neither specific to old growth
	Lava Beds (CA)					
	Muir Woods (CA)					
	Redwood (CA)	X				FMP; GMP; no specific management of old growth except fire control and prescribed fire
	Saguaro (AZ)	X		X		FMP
	Sequoia/Kings Canyon (CA)	X				Vegetation management plan; FMP; RMP
	Whiskeytown (CA)					
	Yosemite (CA)	X		X		RMP; FMP; Yosemite Master Plan

[1] Alaska National Interest Lands Conservation Act

Table 9. Research activities in old-growth forests in NPS units. Listed are the number of research projects, as reported by survey respondents as currently being conducted in the old-growth areas of each NPS unit, initiated and/or funded either (**a**) by the National Park Service (**column headed NPS**), or (**b**) outside the NPS (**column headed non-NPS**). Whether long-term data sets exist is indicated by **Y** (yes, followed by the year (19__) the data set(s) were established) or **N** (no). Presence of permanent plots as a part of any study is indicated **Y** (**yes**) or **N** (**no**).

REGION	NATIONAL PARK (STATE)	CURRENT RESEARCH NPS	CURRENT RESEARCH non-NPS	LONG-TERM DATA? DATE(S)	PERMANENT PLOTS? Y	PERMANENT PLOTS? N
Alaska	Glacier Bay (AK)	0	3	Y- (40 yrs?)		?
	Kenai Fjords (AK)	0	1	N		X
	Wrangell-St. Elias (AK)	1	0	N		X
Mid-Atlantic	Friendship Hill (PA)	1	0	Y-83	X	
	New River Gorge (WV)	0	0	N		X
	Shenandoah (VA)	0	1	Y-88	X	
Midwest	Apostle Islands (WI)	2	1	N		X
	Cuyahoga Valley (OH)	0	0	N		X
	Isle Royale (MI)	+[1]	+	Y-	X	
	Ozark (MO)	0	0	N		X
	Pictured Rocks (MI)	1	0	Y-84,85	X	
	St. Croix (MN, WI)	0	0	N		X
	Sleeping Bear Dunes (MI)	0	0	N		X
	Voyageurs (MN)	0	0	Y-26,76-78	X	
National Capital	C & O Canal (DC, MD)	0	0	Y-69		X
	George Washington (MD, VA)	0	0	Y-70		X
	Prince William Forest (VA)	0	0	Y-81		X
	Rock Creek (DC)	0	0	Y-67		X
	T. Roosevelt Island (DC)	0	0	Y-64		X
North Atlantic	Acadia (ME)	0	0	Y-59,80		X
Pacific Northwest	Crater Lake (OR)	1	0	?	– ? –	
	Mt. Rainier (WA)	0	2	Y-78-79,79-82, 83	X	
	North Cascades (WA)	0	1	Y-83-86		X
	Olympic (WA)	6	0	Y-78?	X	
Rocky Mountain	Glacier (MT)	N/A				
	Great Sand Dunes (CO)	1	3	N		X
	Mesa Verde (CO)	5	0	Y-75,75,82,83	X	
	Rocky Mountain (CO)	2	0	Y-73-76		X
	Wind Cave (SD)	0?	0	Y-80?		X
	Yellowstone (ID, MT, WY)	– 200 –		Y-30's,30's,78	X	
	Zion (UT)	0	0	N		X
Southeast	Big Cypress (FL)	4	1	Y-79-80	X	
	Biscayne (FL)	0	0	N/A	N/A	
	Blue Ridge (NC, VA)	0	0	N		X
	Congaree Swamp (SC)	1	0	N		X
	Everglades (FL)	0	0	Y-83-87		X
	Great Smoky Mountains (NC, TN)	10-15	several	Y-many	X	
	Mammoth Cave (KY)	0	0	Y-32-50,75,85	X	
	Natchez Trace (AL, MS, TN)	0	0	N		X
Southwest	Bandelier (NM)	3	3	Y-35,84,87-88, 88		X
	Big Bend (TX)	3	0	Y-64,78	X	
	Big Thicket (TX)	0	0	N		X
	Buffalo (AR)	0	0	N		X
	Guadalupe Mountains (TX)	1	0	Y-73,80,83	X	

REGION	NATIONAL PARK (STATE)	CURRENT RESEARCH NPS	CURRENT RESEARCH non-NPS	LONG-TERM DATA? DATE(S)	PERMANENT PLOTS? Y	PERMANENT PLOTS? N
Western	Golden Gate (CA)					
	Grand Canyon (AZ)	0	0	N		X
	Great Basin (NV)	0	0	Y-?68,69,73,83	– ? –	
	Haleakala (HI)	1	1	Y-83	X	
	Hawaii Volcanoes (HI)	4?	2?	Y-70,75,80,83, 84,85,86	X	
	Kalaupapa (HI)	1	0	N		X
	Lassen Volcanic (CA)	1	misc.	Y-?	– ? –	
	Lava Beds (CA)					
	Muir Woods (CA)					
	Redwood (CA)	1	0	N		X
	Saguaro (AZ)	1	0	Y-85,87,87	X	
	Sequoia/Kings Canyon (CA)	7-10	3	Y-?	– ? –	
	Whiskeytown (CA)					
	Yosemite (CA)	5	25	Y-30's	X	

[1] There are several NPS and non-NPS projects which are taking place in areas of old trees. However, because Isle Royale does not refer to these areas as old growth, it is hard to categorize the research as being on old growth or not. Permanent plots and long-term data sets are present, but are not specific to old growth.

Appendix A. Original survey form

Old-Growth Forests in the National Parks

Thank you for participating in a survey being conducted as part of a project for a seminar entitled "Ecology of the National Parks" held by the Botany Department, University of Wisconsin-Madison. If you wish to receive a copy of the results of this survey, indicate this on the last page of the form. Please direct any questions and return completed form BEFORE NOVEMBER 15, 1988 to:

Lucy Tyrrell
Department of Botany, University of Wisconsin-Madison
Madison, Wisconsin 53706

National Park: _____ **State:** _____

Definition and Inventory

1. What working definition of "old-growth forest" are you using in order to decide what forest area(s) to include in this survey?

2. What kind of problems, if any, do you see with this definition of old-growth?

3. What is the estimated acreage of the old-growth forest in the Park? _____ total acreage of Park? _____

4. Check off the type or types of old-growth forest present in the Park:
☐ conifers ☐ hardwoods ☐ both types in separate areas ☐ mixed forests

5. Name the forest type or types. (Give dominant species of trees.) _____

6. The approximate age or range of ages of trees found in the old-growth forest of this Park is: _____.

This is based on: ☐ an estimate ☐ tree cores ☐ other (specify): _____

7. Have species lists been made (check if yes)

	in the Park?	in the old-growth forests?
for vascular plants	_____	_____
for non-vascular plants	_____	_____
for birds	_____	_____
for mammals	_____	_____
for herps	_____	_____
for invertebrates	_____	_____
for butterflies	_____	_____
for soil organisms	_____	_____

8. List any species that occur within the old-growth forests of this Park which are:

- probably obligately dependent on this system:
- quite restricted to this system, though not obligately:
- have much higher numbers in the old-growth than other habitats:

9. List any species of special concern that do not occur in old-growth:

Landscape Context

1. Describe the old-growth forest in terms of fragmentation patterns:
   e.g. The old-growth forest consists of approximately _____ stands which range in size from _____ to _____ (perhaps the average stand size is _____). The stands are separated from each other by a distance of anywhere from _____ to _____. Stand shape can best be described as being _____ (e.g., block, linear, irregular)

If the above format is not suited to this Park, please provide your own summary of the size, shape, etc. of the old growth present. Other comments are welcome:

2. The old-growth forest is surrounded by:
☐ young forest (what type or age?) _____

☐ non-park land (specify type): _____

☐ water (specify type): _____

☐ non-forest natural habitats (specify type(s)): _____

☐ other (specify): _____

(If the old growth is surrounded by more than one type, please estimate percentages for each, and/or make additional comments here):

3. Please add any notes of interest about the topography, elevation or land features on which the old growth is located:

4. What are the disturbances (both human-caused and natural) that have had a major impact on the old growth in the Park?

date or interval	type of disturbance	acreage of old growth affected

5. PLEASE ENCLOSE A NATIONAL PARK MAP (visitor brochure type) with a rough outline of the approximate LOCATION(s) of old-growth forest.

Management/Conservation/Research

1. Are there written management plans for these old-growth forests? _____yes ____no
2. Are there unwritten management plans for these old-growth forests? _____yes ____no

3. If there are plans of some kind, briefly describe, or list management techniques employed in executing these plans:

4. Are there any local (non-Park? public? private?) views toward the old-growth forests which are providing support for, or pressure against, National Park policies? Please describe.

5. What are the top four management/scientific research priorities of this Park?

   1.

   2.

   3.

   4.

6. How many research projects initiated and/or funded by the National Park Service are currently being conducted in the old-growth areas? _____

   If a list is available of project titles or general objectives of these research projects, please provide.

7. How many research projects initiated and/or funded outside the National Park Service are currently being conducted in the old growth of this Park? _____
   If any information on titles or objectives is available, please provide:

8. Please describe any long-term data sets which are known for the old-growth in this Park, giving date of collection and type of data. Have any permanent plots been set up? If so, when, and what kind of data is being collected, and how often?

Year(s)	Type of data collected	Permanent plots?	Other comments?

Please feel free to provide additional comments, or list additional information. Please send any other reports, publications or other information pertinent to old growth in this National Park.

This survey completed by: _____

Title: _____

Address/Phone: _____

☐ I would like a copy of compiled results.

THANK YOU!

Appendix B. NPS respondents to the informal survey and their positions in the National Park Service.

NPS REGION	NPS UNIT (STATE)	SURVEY RESPONDENT	POSITION*
Alaska	Glacier Bay (AK)	G. P. Streveler	RM staff member
	Kenai Fjords (AK)	Bud Rice	RM Specialist
	Wrangell-St. Elias (AK)	Bruce Connery	NR Specialist
Mid-Atlantic	Friendship Hill (PA)	Steve Linderer	Site Manager
	New River Gorge (WV)	Meg Weesner	NR Specialist
	Shenandoah (VA)	David Haskell	Chief NRM
Midwest	Apostle Islands (WI)	Robert Brander	Park Ecologist
	Cuyahoga Valley (OH)	Garree Williamson	RM Specialist
	Isle Royale (MI)	Robert Krumenaker	RM Specialist
	Ozark (MO)	David Foster	Research Biologist
	Pictured Rocks (MI)	Walter Loope	Park Ecologist
	St. Croix (MN, WI)	A. R. Weisbrod	Research Zoologist
	Sleeping Bear Dunes (MI)	Max Holden	RM Ranger
	Voyageurs (MN)	Jim Benedict	RM Specialist
		Peter Gogan	Wildlife Research Biologist
National Capital	C & O Canal (DC, MD)	L. K. Thomas	Research Biologist
	George Washington (MD, VA)	L. K. Thomas	Research Biologist
	Prince William Forest (VA)	L. K. Thomas	Research Biologist
	Rock Creek (DC)	L. K. Thomas	Research Biologist
	T. Roosevelt Island (DC)	L. K. Thomas	Research Biologist
North Atlantic	Acadia (ME)	Judith Hazen	Acting Chief RM
Pacific Northwest	Crater Lake (OR)	Jim Milestone	Park Biologist
	Mt. Rainier (WA)	Stanley Schlegel	RM Specialist
	North Cascades (WA)	Jonathon Bjorklund	North Cascades biological staff
		Robert Kuntz	
		Robert Wasem	
	Olympic (WA)	Edward Schreiner	Research Biologist
Rocky Mountain	Glacier (MT)	Gary Gregory	RM Specialist
	Great Sand Dunes (CO)	Dan Kirschner	Park Ranger
	Mesa Verde (CO)	Marilyn Colyer	Park Ranger
	Rocky Mountain (CO)	Mary Kwart	Forestry Technician
		Dave Stevens	Research Biologist
	Wind Cave (SD)	Richard Klukas	Research Biologist
	Yellowstone (ID, MT, WY)	Roy Renkin	Biological Technician
	Zion (UT)	Harold Grafe	Superintendent
Southeast	Big Cypress (FL)	James Snyder	Research Biologist
	Biscayne (FL)	Richard Cuddy	RM Coordinator
	Blue Ridge (NC, VA)	Bambi Teague	NRM Specialist
	Congaree Swamp (SC)	Michael Rikard	Hydrologist
	Everglades (FL)	R. F. Doren	Supervisory Botanist
	Great Smoky Mountains (NC, TN)	Keith Langdon	NR Specialist
		Charlotte Pyle	former NPS employee
	Mammoth Cave (KY)	Ken Kern	Park Ranger
		Henry Holman	Park Ranger
	Natchez Trace (AL, MS, TN)	Patrick Toops	RM Specialist
Southwest	Bandelier (NM)	Craig Allen	Research Ecologist
	Big Bend (TX)	Carl Fleming	RM Specialist
	Big Thicket (TX)	Craig Hauke	Biologist
	Buffalo (AR)	John Apel	RM Specialist
	Guadalupe Mountains (TX)	Vidal Davila	RM Specialist

*N=Natural, R=Resource(s), M=Management

NPS REGION	NPS UNIT (STATE)	SURVEY RESPONDENT	POSITION
Western	Golden Gate (CA)	Stephen Veirs	Unit Leader, CPSU/UC
	Grand Canyon (AZ)	John Ray	RM Specialist
		Peter Rowlands	Chief RM and Planning
	Great Basin (NV)	William Brock	RM Specialist
	Haleakala (HI)	Lloyd Loope	Research Biologist
	Hawaii Volcanoes (HI)	Linda Cuddihy	Research Associate
	Kalaupapa (HI)	C. W. Smith	Director, CPSU/UH
	Lassen Volcanic (CA)	Al Denniston	Resource Management
		Stephen Veirs	Unit Leader, CPSU/UC
	Lava Beds (CA)	Stephen Veirs	Unit Leader, CPSU/UC
	Muir Woods (CA)	Stephen Veirs	Unit Leader, CPSU/UC
	Redwood (CA)	Stephen Veirs	Unit Leader, CPSU/UC
	Saguaro (AZ)	Robert Hall	Chief RM
	Sequoia/Kings Canyon (CA)	Tom Stohlgren	Ecologist
	Whiskeytown (CA)	Stephen Veirs	Unit Leader, CPSU/UC
	Yosemite (CA)	Jan van Wagtendonk	Research Scientist
		Stephen Veirs	Unit Leader, CPSU/UC

Appendix C. National Park Service units with old-growth forests.

NATIONAL PARK SERVICE UNIT	NPS REGION
Acadia National Park	North Atlantic
Apostle Islands National Lakeshore	Midwest
Bandelier National Monument	Southwest
Big Bend National Park	Southwest
Big Cypress National Preserve	Southeast
Big Thicket National Preserve	Southwest
Biscayne National Park	Southeast
Blue Ridge Parkway	Southeast
Buffalo National River	Southwest
Chesapeake and Ohio Canal National Historical Park	National Capital
Congaree Swamp National Monument	Southeast
Crater Lake National Park	Pacific Northwest
Cuyahoga Valley National Recreation Area	Midwest
Everglades National Park	Southeast
Friendship Hill National Historic Site	Mid-Atlantic
George Washington Memorial Parkway	National Capital
Glacier Bay National Park and Preserve	Alaska
Glacier National Park	Rocky Mountain
Golden Gate National Recreation Area	Western
Grand Canyon National Park	Western
Great Basin National Park	Western
Great Sand Dunes National Monument	Rocky Mountain
Great Smoky Mountains National Park	Southeast
Guadalupe Mountains National Park	Southwest
Haleakala National Park	Western
Hawaii Volcanoes National Park	Western
Isle Royale National Park	Midwest
Kalaupapa National Historical Park	Western
Kenai Fjords National Park	Alaska
Lassen Volcanic National Park	Western
Lava Beds National Monument	Western
Mammoth Cave National Park	Southeast
Mesa Verde National Park	Rocky Mountain
Mt. Rainier National Park	Pacific Northwest
Muir Woods National Monument	Western
Natchez Trace Parkway	Southeast
New River Gorge National River	Mid-Atlantic
North Cascades National Park	Pacific Northwest
Olympic National Park	Pacific Northwest
Ozark National Scenic Riverways	Midwest
Pictured Rocks National Lakeshore	Midwest
Prince William Forest Park	National Capital
Redwood National Park	Western
Rock Creek Park	National Capital
Rocky Mountain National Park	Rocky Mountain
Saguaro National Monument	Western
Sequoia National Park/Kings Canyon National Park	Western
Shenandoah National Park	Mid-Atlantic
Sleeping Bear Dunes National Lakeshore	Midwest
St. Croix National Scenic Riverway	Midwest
Theodore Roosevelt Island	National Capital
Voyageurs National Park	Midwest
Whiskeytown Unit—Whiskeytown-Shasta-Trinity National Recreation Area	Western
Wind Cave National Park	Rocky Mountain
Wrangell-St. Elias National Park and Preserve	Alaska
Yellowstone National Park	Rocky Mountain
Yosemite National Park	Western
Zion National Park	Rocky Mountain

Appendix D. Regional perspectives and summary comments of old-growth forests from six NPS regions.

Alaska Region

Little information pertaining to the vegetation, not to mention the extent, characteristics or species composition of old-growth forests is readily available for the national parks in Alaska. Species lists based upon herbaria collections do exist for all national parks in the Alaska Region, a major effort is underway to classify community types for all parks in the region using Landsat thematic imagery, and fire-related studies are on-going in many of the areas.

Old-growth forests are not a specific focus of research in the Alaska Region; however, limited information is available from studies that deal with species related in one way or another to old-growth forests. Consequently, few faunal species were reported in association with old-growth forests in national parks of Alaska. Other less obvious, undocumented faunal occurrences undoubtedly exist, such as use of trees by greater and lesser yellowlegs for roosting and for lookouts in some old-growth forests that border muskegs or open marshes near coastal areas of national parks in Central and Southeast Alaska. Colonies of great blue herons may nest in the upper parts of tall trees in these same forests. Similar old-growth forests serve as denning areas for river otter and mink.

It is apparent from reading the report that ideas and concepts concerning old-growth forests are diverse and that, at least within the National Park Service, there is no clear consensus on what constitutes an old-growth forest. The term "old-growth" is used exclusively in reference to temperate and a few tropical forests. May I suggest that a broad definition of old growth might also include the taiga or boreal forest? Although much of the area covered by the taiga in Alaska is subject to a relatively short fire cycle, *Picea glauca* in excess of 250 years old have been dated from forests at Gates of the Arctic, Denali, Lake Clark, Wrangell-St. Elias national parks and preserves; Kobuk Valley and Kenai Fjords national parks; and Yukon-Charley Rivers National Preserve. Most likely there are *P. mariana* growing in muskegs or spruce bogs of equal or greater age in many of these areas.

An even broader, if not ridiculous, interpretation of the term might take into consideration arctic and alpine tundra "forests" of dwarf willow (e.g., *Salix reticulata* and *S. phlebophylla*). These are present in most national park areas in Alaska and share many of the attributes mentioned in the report that were used to characterize old-growth forests.

Clearly, we have much to learn concerning these forests in Alaska. When a consensus is reached on a definition, we believe that geographic information system aided analyses will be instrumental in making initial determinations of the extent of old-growth forests in this region's national parks.

Gary Ahlstrand, Research Ecologist

Midwest Region

It is safe to say that over 95% of the forests in the Midwest U.S. was lumbered by 1900. The landscape is now dominated by agricultural fields and second growth forests, most less that 100 years old. Forest areas that have not been lumbered are extremely rare, small, fragmented and on steep slopes or other hard to get to places. Based upon the above, I feel a good working definition of old-growth forest for the Midwest Region is an area of forest that has not been lumbered and has not experienced any recent major natural or anthropogenic disturbance. This definition may have to be modified as stand ages approach the average age of senescence of the dominant trees. If all park respondents in the region would have used this definition, fewer parks would have claimed to have old-growth forests.

The use of the term old growth or recognition of old growth as a special management entity is rare in the Midwest. Non-lumbered/virgin/big tree stands are, however, considered special in Midwest Region parks and are often highlighted in park brochures, interpretive talks and guided hikes. Management policy is usually one of protection from disturbance. Only one park (Apostle Islands) has specific plans for old growth which involve active management to encourage perpetuation of the composition and character of old-growth forests.

Due to the rarity of old-growth forests in the Midwest, their value as models for restoration, and the

genetic memory they provide, I encourage augmented efforts to preserve and understand these vignettes of our past.

Ron Hiebert, Regional Chief Scientist

National Capital Region

This survey of old-growth forests in the NPS will prove quite useful even as a preliminary report to provoke thinking on the subject. With some dialogue a consensus may be reached and a refinement made of this listing of old growth. Some stands now listed may be removed and other stands included after some critical evaluation. It appears evident that an absolute chronological age cannot be universally applied, but different associations would have different chronological ages and still be old growth.

There are a number of terms that seem to be closely related, and at times identical, which need to be sorted out: virgin, pristine, primary forest (as opposed to secondary forest), climax, old growth. Virgin and pristine appear to imply no disturbance caused by post Columbian technology; they may or may not be old growth or climax. Primary forest is generally considered the original forest observed by European explorers and generally considered as climax and as old growth (but there would have to be exceptions to this also). The secondary forest is considered a) as not the original even if it is now identical with the original, or b) is still successional. A climax forest is one that is undergoing changes as a part of the dynamic equilibrium, but it is no longer undergoing the successional changes. Since the later stages of succession occur more slowly than some of the earlier ones, climax status could be considered as old growth. However, there may be some value to distinguish, if possible, forests that have just come into climax from those that have been in such a status for a long time.

In the natural scheme of things, however, forests are regenerated by natural disturbance. The nature of that disturbance, whether catastrophic or in patches, and its relative importance in maintaining a given forest type, will influence definitions of old growth. Catastrophic events set up a successional process and the canopy trees tend to be even-aged.

After even age is achieved, gap dynamics take over to produce an all-aged canopy. But, if another natural catastrophic event comes along, succession begins again. Such forests are dependent primarily on successional processes for their regeneration and maintenance. Other forests, however, depend primarily on gap dynamics for regeneration and maintenance, with natural catastrophic agencies being absent. Such a forest, having recovered to climax after an artificial disturbance, might well be chronologically younger than a forest that is naturally regenerated primarily through succession. Add to this the natural capacities for trees to age in given environments.

Silver maple only gets to be about 125 years old before it dies, so any age minimum for old growth, such as 200 years, would eliminate all climaxes containing this maple as a dominant. On the other hand oaks often die back to their roots several times as seedlings before they finally begin developing into a sapling and then a tree, so oaks may be quite a bit older than any ring count would indicate.

L. K. Thomas, Research Biologist

North Atlantic Region

In the North Atlantic Region, only Acadia National Park was included in the survey. However, there may be other parks with remnant stands of relatively old-growth forests, depending on the definition used. A comprehensive survey to identify old-growth stands, much less associated species, has yet to be completed at Acadia or any other National Park Service area in the region. At Acadia, historical records indicate that the entire Park was either burned or cleared by European man by 1870. Therefore a clear definition of what constitutes an old-growth forest is the first step in performing such an inventory.

The nature of the questions, the wide background and perspectives of respondents, and most importantly, the variety of definitions of what constitute old-growth forests make a survey like this one very difficult. Despite these hardships, what clearly emerges is the need for the National Park Service to begin to define, inventory and develop management strategies for old-growth forests if a comprehensive resource protection program is to be achieved.

Judith Hazen, Biologist, Acadia National Park

Pacific Northwest Region

Old-growth forests mean many things to many people. This simple fact has been brought sharply into focus in the past decade in the Pacific Northwest, which contains the largest remnant stands of virgin forest in the contiguous United States. Big trees in the Northwest are synonymous with wildlife, jobs, recreation, economic stability or ecosystem preservation, depending on your point of view.

The northern spotted owl has become a metaphor for old-growth forests in the Northwest in recent years, but issues relevant to the management of these forests go much deeper than the preservation of a single species. The owl is but one component of a complex ecosystem, and its decline is a symptom of the disruption of the natural landscape. Habitat loss is the greatest threat for the spotted owl and other organisms that depend on the forest. Indeed only 10-15% of the original Douglas-fir/Western hemlock old-growth forests that stretch from British Columbia to northern California have been spared from timber harvest or development. Nearly all of the remaining old growth is located on federal lands. The remnant stands are highly fragmented, and many of the largest stands are managed in National Parks.

Old-growth forests, no matter how defined, are believed to be relatively intact in national parks in the Pacific Northwest. The principal concerns associated with management of these forest ecosystems relate to human activities near and adjacent to the parks. These are the lands that a number of wildlife populations occupy when not in the parks. They also form habitat linkages which allow populations to remain viable breeding and reproducing populations. Population imbalances occur by either increasing or decreasing suitable habitats for different species. When people think of old growth in the Pacific Northwest, they usually think of the lush, low elevation forests that contain Douglas-fir, Western hemlock, Western redcedar, Sitka spruce and a wide range of ferns and herbaceous plants. These forests typically have many large trees, a multistoried canopy, large amounts of woody debris, and a thick mat of organic material on the forest floor. However, there are many other less "charismatic" forest ecosystems throughout the Northwest. These forests may have less grandeur to the human eye, but they have important values for recreation, water production, wildlife, fish—and timber—and they are also threatened by logging and other uses.

A new set of values is needed that recognizes the intrinsic value of all old-growth forests, independent of human judgement and political viewpoints. A gnarled old subalpine fir growing on a mountain top may not be very tall and it may not produce high quality wood products, but it is part of an ecosystem that has been around since the last glaciers covered the landscape. Its growth rings may hold clues to past climates and to future changes that humans may inflict on the earth due to greenhouse warming. To save the last stands of virgin Douglas-fir without protecting other old-growth forest ecosystems would be an unbalanced and biased approach to the protection of biodiversity.

Various organizations are attempting to determine how much old growth is left and where it is located, especially on federal lands. This undoubtedly will set off another round of controversy about definitions and management strategies. Starting in FY 1992 the National Park Service is scheduled to begin inventorying all forests in the major national parks in the Pacific Northwest. A guiding principle of this effort will be to focus on data collection exclusive of old-growth forest definitions. The important idea is that high quality data on critical ecosystem attributes (e.g., species, canopy layering, type and amount of woody debris, snags, tree age, landforms, soils, and other landscape characteristics) be collected. Various definitions can then be applied to the dataset as necessary to calculate the quantity and distribution of old growth or other designated habitat.

Dave Peterson, CPSU, University of Washington; and Jim Larson, Regional Chief Scientist

Southeast Region

This report contains an impressive amount of information relating to the status of forest resources on National Park Service (NPS) lands. The many tables and figures generally provide clear presentations of the data derived from the survey of NPS areas. As indicated in the Results section, the reliability of the information is dependent upon a large number of variables, not the least of which is definition of the term "old-growth". The report certainly illustrates the confusion that exists inside and outside the NPS in attempting to discuss management and ecological characteristics of old-growth forests without first

determining a working definition.

Another significant variable is the background and interest of the individuals providing survey information. The list of respondents reveals a group with diverse educational backgrounds in varied disciplines. Absent a definition of old-growth forests, this diversity casts further doubt on the reliability of area estimates and species associations.

F. Dominic Dottavio, Regional Chief Scientist

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Produced by University Publications, University of Wisconsin–Madison

United States Department of the Interior
National Park Service
Great Lakes Cooperative Park Studies Unit