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THE IMPORTANCE OF OBTAINING VERIFIABLE OCCURRENCE DATA ON FOREST CARNIVORES AND AN INTERACTIVE WEBSITE FOR ARCHIVING RESULTS FROM STANDARDIZED SURVEYS

KEITH B. AUBRY
USDA Forest Service, Pacific Northwest Research Station, Olympia, Washington 98512, USA[1]

LESLIE A. JAGGER
USDA Forest Service, Pacific Northwest Research Station, Olympia, Washington 98512, USA

Abstract: Anecdotal occurrence records (sighting reports, descriptions of tracks etc.) cannot be independently verified and, thus, are inherently unreliable and vulnerable to both scientific and legal challenges. In contrast, verifiable occurrence records (specimens, photos, track-plate impressions etc.) represent conclusive evidence of species presence, and provide a scientifically sound basis for conservation actions and management recommendations. To obtain reliable data on the distribution of forest carnivores in the Pacific states, many federal and state resource management agencies have conducted surveys during the last 15 years to detect the presence of fishers (*Martes pennanti*) and American martens (*M. americana*) using techniques that produce verifiable evidence of species presence (remote cameras and track-plate boxes). Standardized survey protocols were developed that provide reasonable assurance that if a species is not detected, it is not present. By following standard protocols, surveys using these devices have produced reliable information on the distribution of fishers and American martens that can be combined and compared across administrative boundaries. However, existing data on survey efforts and results have not been permanently archived into a centralized database. Thus, not only are survey data unavailable for general use, it is also likely that these extremely valuable data may eventually be misplaced or discarded. To meet this need, we developed an Internet website that consists of a permanent data archive and an interactive mapping application. The user can display data on standardized surveys at any spatial scale based on a minimum mapping unit of 10.4 km^2 (4 mi^2), query the contents of the database, and generate both text and graphical reports. We believe this tool has applications wherever opportunities exist for biologists to apply the results of standardized surveys to the study of forest carnivores.

[1]kaubry@fs.fed.us

Introduction

In the western United States (U.S.), the fisher (*Martes pennanti*) and American marten (*M. americana*) are closely associated with late-successional forest attributes at multiple spatial scales including high levels of canopy closure for security cover, complex physical structure near the forest floor for foraging, and large logs, snags, and decadent live trees for denning and resting (Buskirk and Powell 1994, Buskirk and Ruggiero 1994, Carroll et al. 1999, Powell and Zielinski 1994). In the Pacific states (Washington, Oregon, and California), American martens once occurred from sea level to treeline, whereas fishers were generally restricted to low- and mid-elevation forests where deep snowpacks do not accumulate during winter (Aubry and Lewis 2003, Zielinski et al. 2001). During the late 1800s and early to mid-1900s, unregulated trapping, extensive clearcutting of old-growth forests, human development, and predator-control efforts were concentrated in coastal regions, river valleys, and other low-lying areas that were easily accessed by early settlers and developers (Aubry and Lewis 2003). These activities resulted in the extirpation of the fisher from a large proportion of its former range in the Pacific states (Aubry and Lewis 2003), and of the American marten from most of its coastal distribution in that region (Zielinski et al. 2001).

For these reasons, the fisher and, to a lesser extent, the American marten have long been considered species of conservation concern in the Pacific states. Trapping seasons for fishers were closed in all 3 states by the mid-1940s, and American martens have been protected from trapping in California since the mid-1950s. The fisher is listed as an endangered species in the state of Washington (Lewis and Stinson 1998), and fisher populations in the Pacific states were petitioned for listing under the federal Endangered Species Act 3 times in the last 15 years. The first 2 petitions (Beckwitt 1990, Carlton 1994) were unsuccessful, but the third (Greenwald et al. 2000) resulted in a finding of "warranted but precluded" (U.S. Fish and Wildlife Service 2004). This designation means that the U.S. Fish and Wildlife Service acknowledges that the species needs federal protection in the Pacific states, but listing is currently precluded by higher priority actions.

The first step in the conservation of forest carnivores is to accurately map their current geographic distributions, and evaluate the extent to which current range may differ from historical accounts (Buskirk and Zielinski 2003). Ideally, species distributions should also be monitored over time to evaluate the long-term or cumulative effects of various stressors on their populations (Zielinski and Stauffer 1996). Prior to the closure of trapping seasons and the general decline of trapping as a commercial or recreational activity, trappers were an important source of information on wild populations of fishers and American martens. Their contributions included not only reports of catch in various localities, but also extensive knowledge of the ecological relations, distribution, and population trends of forest carnivores obtained through personal experience in the field (e.g. Bailey 1936, Grinnell et al. 1937, Dalquest 1948, Aubry and Houston 1992, Zielinski et al. 2001). In the Pacific states, the loss of trappers as a source of information on local furbearer populations coincided with growing concern about the conservation status of forest carnivores (Ruggiero et al.

1994). Without information from trappers, biologists had only specimen data (e.g. museum records, road-kills, incidental captures) and anecdotal observations (e.g. sighting reports, descriptions of tracks) to inform them about the current distribution and status of forest carnivores. However, specimen data for rare and secretive forest carnivores, such as the fisher and American marten, are scarce in number and haphazard in space and time, and do not provide an adequate information source for accurately delineating distributional boundaries.

To provide the information needed by public agencies and private institutions to delineate and monitor changes in species distributions, NatureServe (a non-profit conservation organization) maintains a network of biological inventories known as Natural Heritage Programs or Conservation Data Centers that include both anecdotal and verifiable occurrence records for a wide array of species. Although such biological inventories have useful applications for many taxa, especially when information is applied at large spatial scales, there are compelling reasons to question the appropriateness of using anecdotal occurrence records to delineate distributional boundaries for rare and secretive forest carnivores. Anecdotal observations of forest carnivores are often reported by individuals who are unfamiliar with the animal they claim to have seen and, in many instances, species identifications are determined through the process of elimination by examining drawings or photographs in a field guide (K. Aubry, unpubl. data). Moreover, even experienced biologists can misidentify an animal glimpsed briefly at night or in other conditions that are unsuitable for making accurate visual observations (K. Aubry, unpubl. data; Zielinski et al. 1995a). Researchers have used various methods to improve the reliability of such datasets by eliminating suspect observations (e.g. Aubry and Houston 1992), and some anecdotal occurrence records are undoubtedly accurate. However, because such records cannot be independently verified by others, resulting data sets contain an unknown number of inaccurate and misleading records. Consequently, conclusions based on analyses of such data are inherently unreliable and vulnerable to both scientific and legal challenges. This problem is particularly acute for potentially threatened or endangered forest carnivores, because significant social or economic consequences may result from subsequent conservation actions.

Standardized protocols for conducting forest carnivore surveys

By the early 1990s, the Western Forest Carnivore Committee, an ad-hoc group of private, state, and federal carnivore biologists working in the western U.S., recognized the need to develop reliable techniques for obtaining verifiable data on forest carnivore distributions at regional scales. The work they initiated and funded resulted in a "detection manual" that provided specific recommendations for detection devices and survey methods to use, and a set of standardized sampling protocols that could be deployed systematically across broad geographic areas (Zielinski and Kucera 1995).

The sample unit

To facilitate the use of proposed survey methods among a variety of potential partners, sampling protocols were based on the U.S. Public Land Survey System (PLSS), which consists of a grid of 93.2-km^2 (36-mi^2) square townships that was established throughout virtually all ownerships in the U.S. (e.g. National Parks were not surveyed). Each township is further subdivided into 36 square sections, each of which is 2.6 km^2 (1 mi^2) in area. Because the PLSS layer is readily available for use anywhere in the U.S., it provides a common reference base that can be used by anyone to plan and implement standardized surveys for forest carnivores. The sample unit that Zielinski et al. (1995b) recommended for conducting standardized surveys for forest carnivores is the 10.4-km^2 (4-mi^2) area represented by 4 2.6-km^2 (1-mi^2) sections of the PLSS layer arranged in a square configuration (Figure 1); thus, each township contains 9 potential sample units. The sample unit was scaled to encompass the average home range size of the smallest target species, the American marten, as well as for simplicity and ease of application.

Detection methods

Three methods were proposed by Zielinski and Kucera (1995) for detecting forest carnivores during standardized surveys: remotely triggered cameras (line-triggered 110 or sensor-triggered 35-mm cameras; Kucera et al. 1995), sooted track-plates (unenclosed or in open-ended boxes; Zielinski 1995), and snow-tracking (Halfpenny et al. 1995). Although snow-tracking can be a useful technique for surveying forest carnivores (e.g. Bull et al. 1992, Proulx and O'Doherty 2006), its use is limited to boreal habitats that receive adequate and sufficiently frequent snowfalls. In the Pacific states, such habitats represent a relatively small proportion of lands that are actively managed by federal and state resource agencies. Consequently, few biologists in that region have implemented the snow-tracking protocol in the detection manual and, in contrast to remote-camera and track-plate survey protocols (Foresman and Pearson 1998), no published information is available on its efficacy and reliability. Consequently, snow-tracking surveys are not discussed further in this paper.

Recommended protocols for conducting surveys using remotely triggered cameras or track-plates are as follows: for sensor-triggered 35-mm cameras, place 2 cameras in each sample unit at least 1.6 km (1 mi) apart (Figure 1a) in the best habitat for the target species or in areas where anecdotal observations are concentrated for a minimum of 28 days, checking each camera once per week; for line-triggered 110 cameras or track-plate boxes, place 6 devices in each sample unit at least 0.8 km (0.5 mi) apart (Figure 1b) for a minimum of 12 days, checking each device every other day (Kucera et al. 1995, Zielinski 1995, Zielinski et al. 1995b). Recommended survey periods assume that all devices are functioning properly during that time; additional days should be added to the survey period to account for days when 1 or more of the devices was inoperable. These techniques and survey protocols were designed to provide biologists with reasonable assurance that if a species is not detected, it is not present in that sample unit. Although demonstrating the absence of a species is extremely challenging, confidence in such interpretations can be improved if survey

results are consistent among adjacent sample units, and if repeated surveys fail to detect target species.

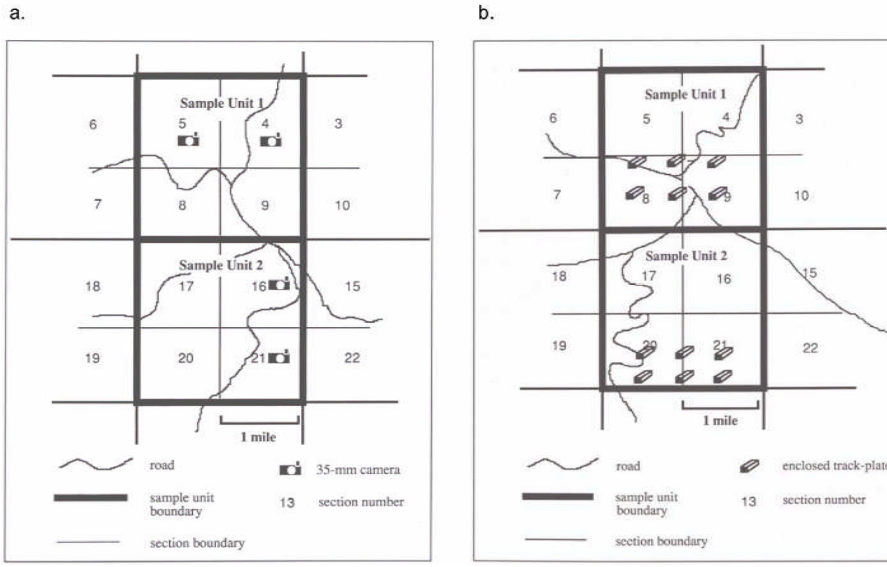

Figure 1. Schematic representation of the 10.4-km² (4-mi²) sample unit showing 2 sensor-triggered 35-mm remote cameras (Figure 1a) and a grid of 6 track-plate boxes or line-triggered remote cameras (Figure 1b) deployed within each sample unit. Detection devices are placed in the most appropriate habitat or near the locations of anecdotal observations. Reproduced from Zielinski et al. (1995b).

Application of results from remote-camera and track-plate surveys in the Pacific states

In response to the publication of Zielinski and Kucera's (1995) detection manual, large numbers of federal, state, and private biologists independently conducted remote-camera and track-plate box surveys for forest carnivores throughout most coniferous forest habitats in the Pacific states (Aubry and Lewis 2003). Many of these detection surveys were conducted in accordance with the protocols recommended by Zielinski and Kucera (1995), but deviations in the size and geographic orientation of sample units, the number of devices used, and the duration of surveys were not uncommon, especially in California where protocols were developed and survey efforts have been underway since the late 1980s (Zielinski et al. 1997, 2001). Nevertheless, these standardized detection surveys have produced significant new information about the distribution of extant populations of fishers and American martens in the Pacific states. More importantly, because standardized surveys have been both numerous and geographically extensive, survey results have also provided an empirical basis for

determining the extent of population losses for fishers and American martens in that region. Consequently, standardized remote-camera and track-plate survey data have played key roles in recent conservation actions for the fisher in the Pacific states.

Researchers compiled and mapped the locations of standardized remote-camera and track-plate box surveys conducted from 1990 to 1997 in Washington (Lewis and Stinson 1998), 1990 to 2000 in Oregon (Aubry and Lewis 2003), and 1989 to 1994 in California (Zielinski et al. 1995a), and the locations of surveys that resulted in verifiable fisher detections (Figure 2b, 2c). The results of these survey efforts played an important role in the recent finding of "warranted but precluded" for the listing of fisher populations in the Pacific states under the federal Endangered Species Act (U.S. Fish and Wildlife Service 2004), and for listing of the fisher as an endangered species in the state of Washington (Lewis and Stinson 1998). In addition, survey results provided an empirical framework for developing new research hypotheses about the origin and genetic affinities of extant fisher populations in Oregon (Drew et al. 2003, Aubry et al. 2004), and levels of genetic diversity and structure among fisher populations in the Pacific states (Wisely et al. 2004).

Standardized survey data have also been used to assess the current distribution and status of the American marten in the Pacific states. Zielinski et al. (2001) used standardized survey data obtained from 1989 to 1998 to demonstrate that American martens have been extirpated from significant portions of their historical range in coastal forests of the Pacific states. Additionally, the survey data they compiled, combined with more recent surveys in the Klamath-Siskiyou region of northwestern California and southwestern Oregon, have provided new information on the status of the Humboldt marten (*M. a. humboldtensis*), a potentially extinct form that once occurred throughout coast redwood (*Sequoia sempervirens*) forests in northwestern California (Zielinski and Golightly 1996, Slauson et al. 2001).

The unreliability of anecdotal occurrence records

To evaluate the scientific value of anecdotal occurrence records, Aubry and Lewis (2003) also mapped the geographic distribution of sightings and other anecdotal observations of fishers in the Pacific states obtained during the last several decades, and compared their geographic extent with that of verifiable occurrence records obtained from standardized detection surveys. Anecdotal occurrence records for the fisher in the Pacific states are numerous and extensive in both space and time (Figure 2a), and indicate a geographic distribution that has changed relatively little from historical accounts (shaded area in Figure 2c). However, the results of recent survey efforts reveal a substantially different assessment of the current distribution of fishers in the Pacific states. Although standardized surveys have been conducted throughout most forested areas in that region, and many were intentionally located in areas where multiple anecdotal observations of fishers had been made, fishers were only detected in restricted portions of southwestern Oregon, and in several disjunct areas in California (Figure 2c). These results demonstrate that anecdotal occurrence records of fishers do not provide a scientifically valid basis for delineating distributional boundaries. In addition, it is clearly inappropriate to assume that because there are numerous

anecdotal observations of fishers in a given area, at least some of those observations must be valid and therefore indicate the presence of a resident population.

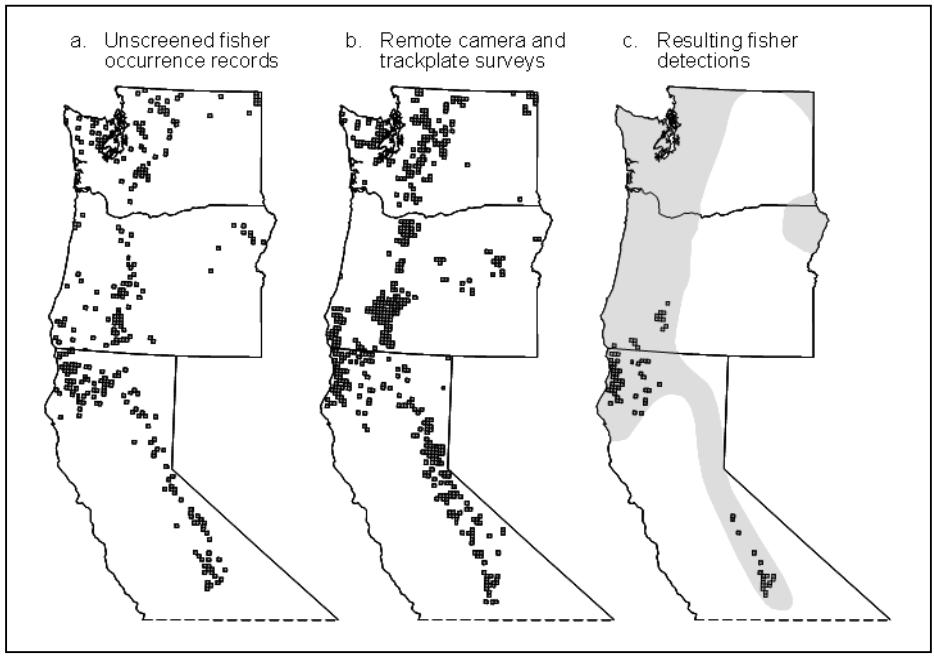

Figure 2. Unscreened (anecdotal and verifiable) occurrence records (Figure 2a), and the location (Figure 2b) and results (Figure 2c) of standardized remote-camera and track-plate box surveys for fishers in the Pacific states. The minimum mapping unit shown in all figures is 1 township (93.2 km² [36 mi²]); townships are shaded whenever an occurrence record, survey effort, or photo/track-plate detection of a fisher was made within that township. The shaded area in Figure 2c represents the presumed historical distribution of the fisher in the Pacific states. Reproduced from Aubry and Lewis (2003).

We believe that many of the inaccurate anecdotal observations depicted in Figure 2a are attributable to the nature and life-history characteristics of forest carnivores. Both lay people and professional biologists have a strong interest in mammalian carnivores, especially little-known, rare, and secretive species. Thus, while questionable observations of other, less charismatic species are likely to go unreported, sightings of forest carnivores, even incomplete descriptions based on fleeting glimpses made by individuals having little familiarity with the species in question, are commonly reported and compiled in agency files. Because of their inherent unreliability, we strongly believe that anecdotal observations of fishers and other forest carnivores should not be used for making conservation decisions or management recommendations. However, anecdotal observations inform biologists of the *potential* presence of forest carnivores in

a given area, and may be useful for guiding future survey efforts using detection devices that produce verifiable evidence of species presence.

The need to permanently archive standardized survey data

Most standardized detection surveys for forest carnivores conducted in the Pacific states were initiated by local agency biologists (e.g. those working for the U.S. Forest Service at Ranger District offices or for the U.S. Bureau of Land Management at Resource Area offices) prior to a management action, or to determine the presence or absence of forest carnivores within an administrative area. Details on the nature and results of such detection surveys are typically included in administrative reports, and paper records of those surveys are placed in local agency files. Consequently, such data are generally not available for use by biologists working for other agencies in that area, nor are they readily available for use by those interested in conducting larger scale assessments or regional analyses. Additionally, federal and state agency biologists often spend only a few years at a given location before moving to another job. If surveys were conducted by personnel who no longer work at that location, it can be very difficult to obtain detailed data on the nature or results of those surveys. It is also likely that essential details of past survey efforts may not have been recorded in agency files, or that data associated with survey efforts may eventually be misplaced or discarded. There is currently no process in place anywhere in the Pacific states to compile and permanently archive data from standardized surveys for forest carnivores across administrative boundaries.

To obtain the data that Aubry and Lewis (2003) used in their distributional assessment for the fisher in Oregon (Figure 2), the authors sent letters to all local agency biologists in Oregon on 2 separate occasions, followed by e-mails or phone calls, as needed. They also spent a considerable amount of time and effort searching museum records and available published and unpublished literature for verifiable occurrence records of the fisher in Oregon. During this process, it became clear that much of the data resulting from standardized surveys would be unavailable for general use or lost altogether, unless a concerted effort was made to compile and archive those data in a centralized storage and retrieval system. For similar reasons, Ballard et al. (2002) recently advocated the development of a permanent archive and retrieval system for radiotelemetry data collected by researchers at different institutions.

Because Zielinski and Kucera's (1995) survey protocols have been used extensively by state and federal resource management agencies throughout the Pacific states (Aubry and Lewis 2003), we concluded that the most useful and efficient way to create such a data management system was to develop an interactive Internet mapping application based on a minimum mapping unit equivalent to the size and shape of Zielinski et al.'s (1995b) 10.4-km^2 (4-mi^2) sample unit (Figure 1). By using a minimum mapping unit of 10.4-km^2 (4-mi^2), we would also avoid potential problems associated with making point-location data on sensitive, threatened, or endangered species available to anyone via the Internet. We also reasoned that the relatively small size and regular shape of the sample unit would enable future developers to expand the scope of the application to include survey protocols designed to detect other species of

conservation concern with larger spatial requirements, such as the Canada lynx (*Lynx canadensis*) or wolverine (*Gulo gulo*). In addition, new techniques are currently being developed for surveying fishers and American martens using various types of hair-snagging devices, whereby species identification is determined through DNA analysis (K. Aubry, unpubl. data; W. Zielinski, pers. comm.). This approach to conducting presence-absence surveys would have the added advantage of providing DNA samples for use in other research applications. If standardized and reliable protocols for conducting presence-absence surveys with hair-snagging devices can be developed, it should be possible to expand the scope of the website to include them.

An interactive Internet application would enable users to display survey data at various spatial scales, query the contents of the database, and generate both text and graphical reports. Using this tool, local and regional biologists, researchers, or anyone interested in the conservation of forest carnivores would be able to determine where and when previous standardized surveys had been conducted, exactly how each survey was conducted, and what the results were. Previous survey results could be summarized at any spatial scale and used to design and prioritize future survey efforts, avoid duplication of effort among agencies, and evaluate changes in species distributions over time.

An interactive website for archiving and retrieving results from standardized surveys

We compiled data on standardized surveys for fishers and American martens in the Pacific states that were based on the sampling designs and survey protocols recommended by Zielinski and Kucera (1995) for remote cameras and track-plate boxes. The archival database we created includes detailed information on survey effort and survey results, as well as contact information for the reporting individual (Table 1). Records of all mammalian carnivores detected during standardized surveys are included in the database. However, one of the primary reasons for conducting standardized surveys is that they produce occurrence records that can be independently verified by others. Consequently, we believe that users should be able to examine the physical evidence associated with occurrence records for species of significant conservation concern. Accordingly, we requested that each reporting individual submit a paper or electronic copy of either the photo or track-plate impression for the 4 forest carnivores of greatest conservation concern in the Pacific states: American marten [coastal records only], fisher, wolverine, and Canada lynx (Ruggiero et al. 1994). We limited this aspect of the website to coastal American marten populations (i.e. those occurring west of Interstate Highway 5) because this species remains relatively common in the interior mountains of the Pacific states, and is readily attracted to baits at detection devices; thus, surveys conducted in appropriate habitats in those regions typically result in large numbers of American marten detections. To reduce the time, effort, and storage space required to obtain and archive digital images of photos or tracks, we

Table 1. Data fields used in the Forest Carnivore Surveys database.

Unique Identifier		
	Sample Unit	The 10.4-km² (4-mi²) sample unit where the survey was conducted (identified by Meridian, Township, Range, and the 4 sections comprising the sample unit).
Reporting Individual		
	Name	The name of the person who provided the survey data.
	Employer	The employer of the person who provided the survey data.
	City, State	The city and state of the person who provided the survey data.
	Phone	The phone number of the person who provided the survey data.
	E-mail	The e-mail address of the person who provided the survey data.
Survey Details		
	State	The state where the survey was conducted.
	County	The county where the survey was conducted.
	Ownership	The jurisdiction where the survey was conducted.
	Locale	The primary administrative unit within the jurisdiction where the survey was conducted.
	Sub-locale	The secondary administrative unit within the jurisdiction where the survey was conducted.
	Source	The data source (remote-camera survey, track-plate box survey, or other verifiable record).
	Device Type	The type of detection device used during the survey.
	Number of Cameras	The total number of remote cameras deployed within the sample unit during the survey.
	Number of Track-plates	The total number of track-plate boxes deployed within the sample unit during the survey.
	Start Date	The day, month, and year the survey was initiated.
	End Date	The day, month, and year the survey was completed.
	Number of Camera Nights	The total number of nights that remote cameras were operational.
	Number of Track-plate Nights	The total number of nights that track-plate boxes were operational.
	Carnivores Detected	List of all carnivore species detected during the survey.
	Survey Notes	Any other relevant information about the survey (protocols used, problems etc.).
Other Verifiable Record Details		
	Other Verifiable Record - Species	Species of other verifiable record (coastal American marten, fisher, wolverine, or Canada lynx).
	Other Verifiable Record - Type	Type of other verifiable record (museum specimen, DNA identification etc.).
	Other Verifiable Record - Notes	Any relevant information about the other verifiable record.

limited the inclusion of physical evidence for American martens to the geographic area that is currently of greatest conservation concern (Zielinski et al. 2001). If needed at a later date, the geographic scope of this aspect of the website could easily be expanded. Lastly, to prevent future researchers from repeatedly having to search museum records, agency files, and historical literature for other verifiable occurrence records (e.g. museum specimens, opportunistic photos or DNA identifications etc.), and to ensure that such records are preserved in a permanent archive, we also included other verifiable records of coastal American martens, fishers, wolverines, and Canada lynx in the database.

To create an interactive Internet website and mapping application requires highly specialized software and technical expertise, as well as the ability to create and maintain a website outside U.S. Forest Service firewalls. Because none of these capabilities were available to us locally, we established a cooperative relationship with the U.S. Forest Service's Geographic Information Systems Group at the Geospatial Service and Technology Center in Salt Lake City, Utah.

The Internet website we developed uses ESRI ArcIMS® technology to create interactive maps and dynamic web pages that display the results of user-defined queries of the database. Popup-blocking software may need to be disabled to take full advantage of the website's functionality. Most of the website does not require plug-ins or installations, but Adobe Acrobat Reader® v. 4.0 or later is required to view user-created pdf files, Microsoft Excel® is required to save query results in a spreadsheet, and recent updates of common web browsers (e.g. Microsoft Internet Explorer® v. 5 or later and Netscape® v. 7 or later) are required to use the pull-down menus.

Using the Map Toolbar

The buttons in the Map Toolbar (Figure 3) enable the user to navigate in the map frame and perform other functions, including: Zoom In and Zoom Out—zooms in or out to a map extent chosen by the user; Pan—moves the map display in any direction; Zoom Out to all 3 Pacific States—zooms to the maximum extent of the geographic area encompassed by the application; Clear Selection—clears all sample units that have been selected by the user; Identify Sample Unit—displays data associated with any sample unit that has been surveyed or that contains an "Other Verifiable Record" in a table below the map frame; Print Map—creates a printable map of the image in the map frame as a pdf file, including a title, legend, North arrow, and scale bar; Help—launches the help menu, which provides the user with detailed information about the website and various functions. To the right of the map buttons are the Dynamic Map Slider, a tool for quickly zooming in or out, and the Map Size Icons, which increase or decrease the size of the map by approximately 30%.

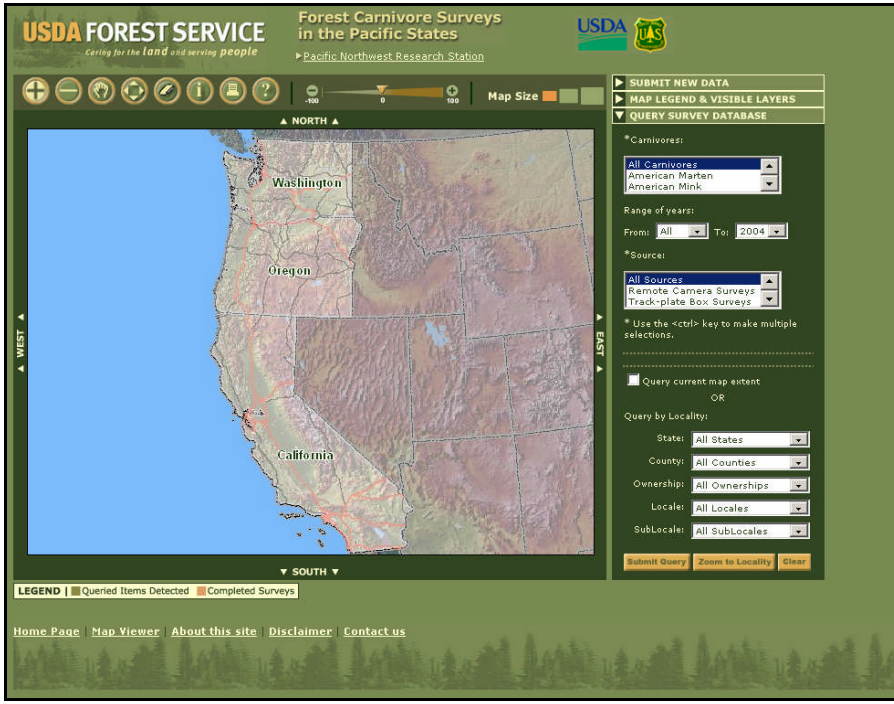

Figure 3. Initial query page for the Forest Carnivore Surveys website showing the full extent of the geographic area encompassed by the database. The Map Toolbar is located directly above the map frame.

Querying the database

The **Query Survey Database** window to the right of the map frame (Figure 3) enables the user to select and view survey efforts and carnivore records of interest. We will use the following example to illustrate how queries are made: a Forest Service biologist wants to know where standardized surveys have been conducted and where fishers were detected on the Prospect Ranger District of the Rogue River National Forest in Jackson Co., Oregon. In the survey database, State = Oregon, County = Jackson, Ownership = Forest Service, Locale = Rogue River National Forest, and SubLocale = Prospect Ranger District. The biologist selects "Fisher" in the **Carnivores:** pull-down menu, leaves the **Range of years:** pull-down on the default values of "**From**: All" and "**To**: 2004" (the default values include all data currently in the database; the end year will change as new data are entered), and leaves the **Sources:** pull-down on the default value of "All Sources" (i.e. all fisher detections resulting from both "Remote Camera Surveys" and "Track-plate Box Surveys", as well as any "Other Verifiable Records") (Figure 4). The **Carnivores:** and **Sources:** pull-down menus are

multi-select boxes, whereby the user can make multiple selections by holding down the control key.

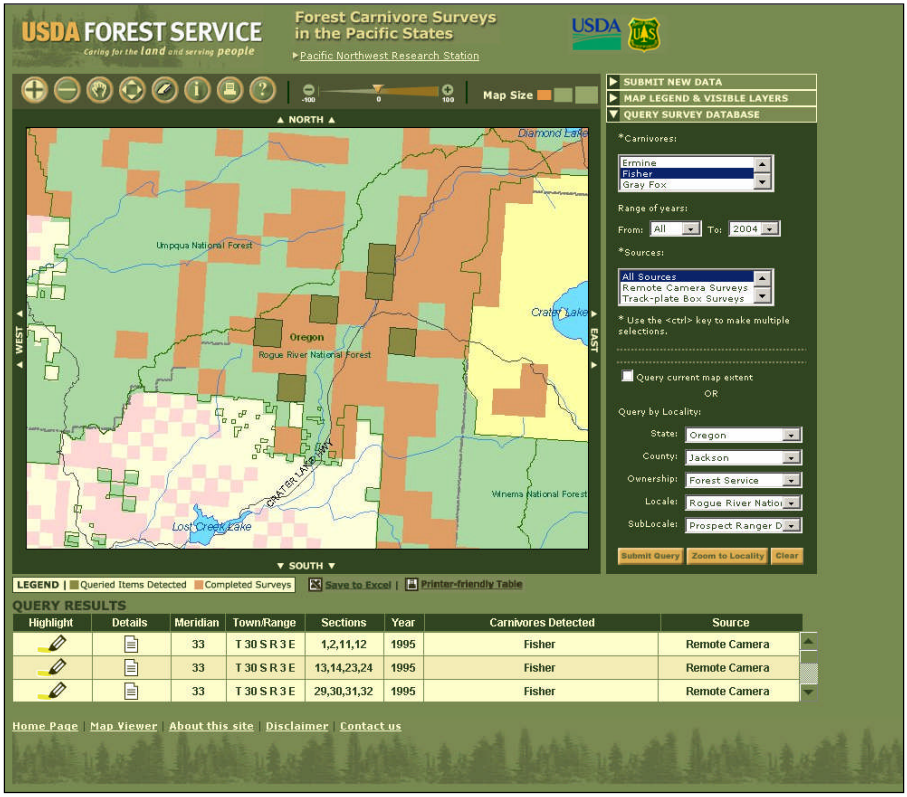

Figure 4. Results of a database query for fisher detections from all sources during all years on the Prospect Ranger District of the Rogue River National Forest in Jackson Co., Oregon. Surveyed sample units that detected fishers are coloured dark olive; those that did not detect fishers are beige. Detections are also listed in tabular form below the map frame.

In the bottom half of the Query window, the biologist selects the geographic extent of the query in either of 2 ways: (1) with the **Query current map extent** box checked, the biologist uses the map navigation tools to locate the Prospect Ranger District in the map frame, or (2) with the **Query current map extent** box unchecked, the biologist goes directly to the **SubLocale:** pull-down menu and selects "Prospect Ranger District" (Figure 4). Pull-down menus are context-sensitive, whereby making a selection in one pull-down menu affects the selection or content of other pull-down menus. Thus, when the biologist selects "Prospect Ranger District", **Ownership:** automatically changes to "Forest Service", and **Locale:** automatically changes to "Rogue River National Forest". Conversely, if the biologist selects "Rogue River

National Forest" from the **Locale:** menu, then available choices in the **SubLocale:** menu are automatically limited to the Ranger Districts on that Forest.

When the biologist clicks on the **Submit Query** button at the bottom of the window, the query results appear graphically in the map frame and in tabular form below the map frame (Figure 4). All surveyed sample units are shown in the map frame; sample units with fisher detections (either from surveys or "Other Verifiable Records") are coloured dark olive, those without detections are beige. A subset of the data for all sample units that meet the query criteria are listed in tabular form under **Query Results**. By clicking the appropriate link directly below the map frame, the user can save the results to an Excel file or view a printer-friendly version of the results table. If desired, the user can identify the sample unit associated with each record in the table by clicking on the **Highlight** button, which turns the sample unit from dark olive to yellow. More detailed information on each record can be viewed by clicking on the **Details** button; for coastal American marten, fisher, wolverine, or Canada lynx records, a digital image of the photo, track-plate impression, or other verifiable record can be viewed by clicking on 1 or more file names listed under **Available Images:** at the bottom of the **Details** screen (not shown). The biologist can use the **Identify** button in the Map Toolbar to view details for a sample unit that was surveyed but did not detect fisher. If desired, these pull-down menus can also be used to navigate within the website by clicking on the **Zoom to Locality** button.

Recommendations for future surveys

Standardized protocols for forest carnivore surveys (Zielinski and Kucera 1995) included 2 recommendations that are not compatible with designing and implementing a regional archive and retrieval system for resulting survey data: (1) that the 10.4-km^2 (4-mi^2) sample unit could be located in any 4 sections of the Public Land Survey System (PLSS), and (2) that surveys should be terminated once the target species (typically fisher or American marten) is detected. Standard protocols were designed to be as flexible as possible to meet individual needs, and to enable field biologists to expend the least amount of effort to document the presence of target species in their area of interest. It was not expected that survey data would be archived in a centralized database or combined across geographic and administrative boundaries to generate information on forest carnivore distributions at regional scales.

To create a spatially referenced archive for these data, it was necessary to establish a fixed grid of sample units throughout the Pacific states. The grid we chose to use for the website is the one delineated by the 9 sample units contained within each Township of the PLSS. Secondly, both positive and negative survey results have biological significance if the survey is conducted in accordance with standardized protocols. However, if a survey was terminated early because a fisher was detected, it would not be a valid survey for American martens; i.e. the survey would not provide strong empirical evidence that American martens are absent from that sample unit. To maximize the long-term value of future survey efforts, we recommend that surveys be conducted in accordance with the grid of sample units that is defined by Township

boundaries, and that they be run for the recommended survey period, regardless of the species detected.

Conclusions

Conducting surveys for forest carnivores requires a substantial investment of time and money. The recent development of standardized protocols for conducting detection surveys have enabled biologists working for any resource agency or research institution to collect scientifically valid data on the presence or absence of fishers and American martens. Although the results of standardized surveys have useful applications at local scales, they are most valuable when data from different sources are compiled for use in larger scale analyses. The potential for using standardized survey data in regional assessments of species distributions, or for monitoring changes in distribution, has only begun to be realized. Accomplishments thus far have only been possible through the concerted efforts of a few individuals who have invested substantial time and effort to compile available data by hand. The development of this website will provide an institutional framework for permanently archiving these extremely important and scientifically valuable data, and will provide future generations with verifiable data on historical distributions of forest carnivores in the Pacific states. In addition, it will provide contemporary biologists with access to existing survey data for use in planning and prioritizing new survey efforts, and make that information available to anyone interested in applying standardized survey data to monitoring and research on forest carnivores. We believe this tool has applications wherever opportunities exist for biologists to apply the results of standardized surveys to the study of forest carnivores. A link to the Forest Carnivore Surveys website is available at the following URL: http://www.fs.fed.us/pnw/olympia/wet/index.html.

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