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NATIONAL COUNCIL FOR AIR AND STREAM IMPROVEMENT

# MANAGING ELEMENTS OF BIODIVERSITY IN SUSTAINABLE FORESTRY PROGRAMS: STATUS AND UTILITY OF NATURESERVE'S INFORMATION RESOURCES TO FOREST MANAGERS

TECHNICAL BULLETIN NO. 885

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by

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# PRESIDENT'S NOTE

Sustainable management of forests is best accomplished when managers have access to high-quality reliable information about the condition and location of species and ecological communities inhabiting forestlands. Such information especially helps managers learn about and manage for at-risk elements of biodiversity, and its use is increasingly required in forest certification systems. For the past 30 years, NatureServe and its natural heritage member programs have been the leading source in North America for detailed information on rare and endangered species and threatened ecosystems. Both the Sustainable Forestry Initiative® and the Forest Stewardship Council-U.S. have incorporated standards for biodiversity conservation into their forest certification processes that rely on data from NatureServe and its network of natural heritage programs and conservation data centers. This report provides an overview of NatureServe's approach to developing and managing biodiversity information; it identifies priority research and data needs; and it addresses how forest managers can best make use of the NatureServe network's scientific and technological resources.

NatureServe is a non-profit organization that coordinates and supports a network of 75 independent member programs across the Western Hemisphere. The NatureServe network's biodiversity databases include more than 500,000 location-specific records, and are used routinely by government agencies, foresters, consultants, university researchers, and local and regional planners. By using the network's objective and reliable data on the location, condition, and conservation status of species and ecological communities at greatest risk, resource managers can identify areas of high biodiversity value, and make informed decisions regarding their management, protection, and restoration. The NatureServe forest program works with forest certification systems, purchasers and re-sellers of forest products, and forest managers to optimize the accessibility and value of the NatureServe system to users. The program supports on-the-ground conservation by NatureServe network member programs, foresters, and other land managers by improving the quality and availability of scientific data and methods designed to further the goals of sustainable forest management.

Access to NatureServe's biodiversity databases and other information has improved considerably in the past few years. Since 2000, NatureServe has offered public access to comprehensive data on at-risk species and ecological communities of the United States and Canada on its NatureServe Explorer website, http://www.natureserve.org/explorer/, and has made available detailed data on occurrences of at-risk biodiversity across most of North America and Hawaii. Landowners and managers can now determine where their conservation opportunities are located at regional and national levels, by using the multi-jurisdictional element occurrence database (MJD).

This report evaluates the current state of NatureServe's scientific methods and information resources. NatureServe collects and manages biodiversity data and information across the Western Hemisphere, including information on elements of biodiversity—specifically, species, communities, and ecological systems. The NatureServe network of central and regional staff and member programs maintains North America's most comprehensive knowledge base and understanding of identification and management of at-risk elements of biodiversity, by sharing a common set of methodologies, and conducting regular conservation status assessments of those elements. Tracking elements of biodiversity also requires on-the-ground survey methods. NatureServe uses element occurrences (an area of land and/or water in which a species or natural community is, or was, present) as a basis for identifying locations of biodiversity elements. The use of occurrences as a basis for managing forests with high or exceptional conservation value has a sound scientific basis. Each of NatureServe's 75 member programs uses the same scientific criteria to identify and delimit populations and communities of conservation concern.

This technical bulletin also identifies several priorities for additional research and data development. Priorities for NatureServe's Science Division include the continued development of detailed descriptions of species, ecological communities, and ecological system (element abstracts); occurrence viability or integrity standards (element occurrence rank specifications); and development and mapping of ecological systems across the Western Hemisphere. Collectively these methodologies will assist forest managers in their ability to identify high quality occurrences of at-risk elements.

Key findings for additional research and data development include the following needs.

- Improve methods for assessing the conservation status of species and ecological communities to increase transparency and precision of assessments.
- Expand the application of current data management standards to additional types of data, so that forest managers and others can better comply with forest certification standards and target protection towards the highest value occurrences.
- Adopt a standard set of methods for mapping potential conservation areas around occurrences of at-risk biological elements, and develop management guidelines for conserving additional high risk species and communities. Without such a consistent approach and guidelines, managers of certified forests may not be able to manage successfully for all ecological values, and may spend more or less than is justified to protect an occurrence.
- Develop a standard set of methods for prioritizing lands for biological inventories. Many working forests of the United States and Canada have never been inventoried. Such an approach could improve the efficiency of biological inventory efforts and make such inventories more attractive to forest management companies.

Addressing these research and development priorities will help optimize the value of classification systems, data, and information that are developed, collected, and managed by the NatureServe network.

Ronald A. Yeske

August 2004

# MOT DU PRÉSIDENT

Les gestionnaires réalisent les meilleurs aménagements durables lorsqu'ils disposent d'informations crédibles de haute qualité sur les conditions et l'emplacement des espèces et des communautés écologiques habitant les territoires forestiers. De telles informations leur sont particulièrement utiles pour connaître et gérer les éléments vulnérables de la biodiversité et sont de plus en plus exigées par les systèmes de certification forestière. Depuis les 30 dernières années, *NatureServe* et ses programmes de conservation du patrimoine naturel constituent la principale source d'informations complètes en Amérique du Nord sur les espèces rares ou en péril de même que sur les écosystèmes menacés. Les processus de certification forestière du *Sustainable Forestry Initiative*® et du *Forest Stewardship Council*-États-Unis contiennent des normes de conservation de la biodiversité qui reposent sur les données de *NatureServe* et sur son réseau de programmes de conservation du patrimoine naturel et ses centres de données. Le présent rapport donne un aperçu de l'approche qu'emploie *NatureServe* pour élaborer et gérer l'information sur la biodiversité, il établit les besoins en matière de données et les priorités de recherche, et explique aux gestionnaires de forêts la meilleure façon d'utiliser les ressources technologiques et scientifiques du réseau *NatureServe.*

*NatureServe* est un organisme à but non lucratif qui coordonne et soutient un réseau de 75 programmes indépendants implantés par ses membres à travers l'hémisphère occidental. Les bases de données sur la biodiversité du réseau *NatureServe* contiennent plus de 500 000 enregistrements sur des endroits précis et sont régulièrement utilisées par les agences gouvernementales, les forestiers, les consultants, les chercheurs universitaires et les planificateurs locaux et régionaux. En faisant appel aux données crédibles et objectives du réseau concernant les lieux, les conditions et les statuts de conservation des espèces et des communautés écologiques les plus à risque, les gestionnaires de ressources sont en mesure de définir les endroits de biodiversité élevée et de prendre des décisions éclairées sur la gestion, la protection et le réaménagement des sites. *NatureServe* collabore avec les organismes de certification forestière, les acheteurs et les revendeurs de produits forestiers de même que les gestionnaires de forêts afin de rendre son système plus accessible aux usagers et lui donner plus de valeur. Son programme forestier soutient les activités de conservation sur le terrain de ses membres, des forestiers et autres gestionnaires en améliorant la qualité et la disponibilité des données scientifiques et des méthodes conçues pour atteindre les objectifs liés à un aménagement forestier durable.

Depuis quelques années, les informations et les bases de données sur la biodiversité de *NatureServe* sont beaucoup plus accessibles. Depuis l'année 2000, le public peut accéder aux données complètes de *NatureServe* sur les espèces et les communautés écologiques menacées au Canada et aux États-Unis par l'entremise de son site Internet (www.natureserve.org/explorer/) et peut consulter des données détaillées sur des occurrences de biodiversité en péril un peu partout en Amérique du Nord et à Hawaii. Les propriétaires de terrains boisés et les gestionnaires peuvent maintenant repérer les endroits où existent des possibilités de conservation au niveau régional et national en faisant appel à la base de données multi territoriale sur les occurrences des éléments (MJD).

Le présent rapport évalue les méthodes scientifiques et les ressources actuellement utilisées par *NatureServe* qui recueille et gère des données et des informations sur la biodiversité à travers l'hémisphère occidental, y compris des informations sur les éléments de la biodiversité comme les espèces, les communautés et les systèmes écologiques. Le réseau *NatureServe*, soit le personnel de son bureau principal, celui de ses centres régionaux et l'ensemble de ses membres, possède la base de connaissances la plus complète et la compréhension la plus totale en Amérique du Nord de l'identification et la gestion des éléments vulnérables de la biodiversité grâce au partage de méthodes communes et d'évaluations régulières de leur statut de conservation. Le suivi de ces éléments exige aussi l'utilisation de méthodes propices à une évaluation de terrain. NatureServe se sert d'occurrences (une superficie de terre ou une surface d'eau où une espèce est présente ou l'a été) comme base d'identification des endroits où l'on retrouve ces éléments. L'emploi d'occurrences dans la gestion de forêts qui ont une valeur élevée ou exceptionnelle de conservation repose sur des principes scientifiques solides. Chacun des 75 programmes implantés par les membres de *NatureServe* fait appel aux mêmes critères scientifiques pour identifier et définir les limites des populations et des communautés dont le statut de conservation est préoccupant.

Le présent bulletin établit aussi des priorités en matière de recherches et de données additionnelles. Les priorités de la division des sciences de *NatureServe* sont de poursuivre le travail de description détaillée des espèces, des communautés et des systèmes écologiques (résumés des éléments), d'assurer la viabilité des occurrences ou normes d'intégrité (spécifications sur la hiérarchisation des occurrences des éléments) ainsi que l'élargissement et la cartographie des systèmes écologiques à travers tout l'hémisphère occidental. Collectivement, ces méthodes aideront les gestionnaires des forêts à déceler des occurrences de haute qualité dans le cas d'éléments en péril.

Les principales conclusions en matière de recherches et de données additionnelles sont les suivantes :

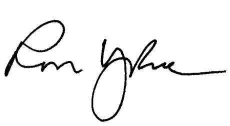
- Améliorer les méthodes d'évaluation du statut de conservation des espèces et des communautés écologiques afin d'accroître la transparence et la précision des évaluations.

- Élargir le cadre d'application des normes actuelles de gestion des données afin d'inclure d'autres types de données que les gestionnaires de forêts et les autres pourraient se servir pour se conformer davantage aux normes de certification forestière et protéger les occurrences qui ont la plus grande valeur.

- Adopter des méthodes standards de cartographie des territoires de conservation éventuels dans les cas d'occurrences liées aux éléments biologiques en péril et élaborer des directives de gestion portant sur la conservation d'autres espèces et communautés à risque élevé. Sans directives et sans approche cohérente, les gestionnaires de forêts certifiées ne seront vraisemblablement pas en mesure de bien gérer toutes les valeurs écologiques et dépenseront peut-être plus (ou moins) que ce qui est nécessaire pour protéger une occurrence.

- Élaborer des méthodes standards d'identification des territoires prioritaires pour les inventaires biologiques. Ce genre d'inventaire n'a jamais été fait dans de nombreuses forêts productives du Canada et des États-Unis. Les inventaires biologiques deviendraient alors plus efficaces et seraient plus intéressants aux yeux des entreprises en aménagement forestier.

En s'attaquant à ces priorités de recherche et de développement, on contribuera à augmenter la valeur des systèmes de classification, des données et des informations qui sont recueillies, élaborées et gérées par le réseau *NatureServe*.



Ronald A. Yeske

Août 2004

# MANAGING ELEMENTS OF BIODIVERSITY IN SUSTAINABLE FORESTRY PROGRAMS: STATUS AND UTILITY OF NATURESERVE'S INFORMATION RESOURCES TO FOREST MANAGERS

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**ABSTRACT**

Criteria and indicators for biodiversity are an important component of sustainable forestry, but identifying those elements of biodiversity that are most critical to sustainability has been a challenge. Over the past few years, a number of innovative approaches have been developed to provide some operational criteria by which progress can be measured. These include the concepts of Forests with Exceptional Conservation Value (FECV), developed by the Sustainable Forestry Initiative® (SFI) and High Conservation Value Forests (HCVF), developed by the Forest Stewardship Council (FSC). These concepts embody the idea that at-risk species and ecological communities, and other ecological values, require special management by forest managers. This technical bulletin evaluates ways in which NatureServe's biodiversity tracking systems and data support the identification and management of critical components of biodiversity, and identifies priorities for improving NatureServe's utility to forest managers. Following the introduction, Section 2 describes NatureServe terminology; its methodologies for classifying, identifying, and managing data for at-risk elements of biodiversity; its analytical conservation services; and its clientele. Section 3 describes NatureServe's system for identifying and classifying at-risk elements of biodiversity, which are species, subspecies, varieties, ecological communities, and ecological systems that are tracked in NatureServe's databases. This section also describes the process of conducting a conservation status assessment (element ranks), particularly at the global level, whereby the elements that are critically imperiled or imperiled are identified. Section 4 describes element occurrences, which are NatureServe's records of elements that are identified on the ground, usually in specific locations. Element occurrences are used by planners, landowners, and land managers to conserve species and communities that are at risk of extinction as well as the best remaining examples of ecological system types. Section 4 also describes occurrence viability or ecological integrity assessments (element occurrence ranks), which are based on specific criteria (element occurrence rank specifications) that determine the thresholds for viability or integrity. Section 5 evaluates the extent to which classification systems and databases that are used by NatureServe require additional efforts, and proposes enhancements to improve usability. Finally, Section 6 discusses an approach by which foresters and other land managers can use the system to obtain biodiversity conservation results in planning and managing their lands; identifies data and information products that are available; and evaluates opportunities and limitations for certification systems and other potential users of the system.



**KEYWORDS**

biodiversity, biological diversity, conservation data centers, conservation planning, conservation priorities, conservation status ranks, critically imperiled, ecological integrity, ecological systems, element occurrences, elements of biodiversity, endangered forests, forests with exceptional conservation value, NatureServe, imperiled, natural heritage programs, sustainable forestry, Sustainable Forestry Initiative®, viability

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# LA GESTION DES ÉLÉMENTS DE BIODIVERSITÉ DANS LES PROGRAMMES DE FORESTERIE DURABLE : ÉTAT DE LA SITUATION ET UTILITÉ DES RESSOURCES DE *NATURESERVE* POUR LES GESTIONNAIRES DE FORÊTS

BULLETIN TECHNIQUE NO. 885
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## RÉSUMÉ

Les critères et les indicateurs de biodiversité sont des composantes importantes de tout aménagement forestier durable, mais ceux qui sont essentiels à la durabilité sont très difficiles à identifier. Au cours des dernières années, on a conçu un certain nombre de nouvelles approches dont le concept de forêts ayant une valeur de conservation exceptionnelle (FECV) élaboré dans le cadre du *Sustainable Forestry Initiative*® (SFI) et le concept de forêts à haute valeur de conservation (HCVF) du *Forest Stewardship Council* (FSC) afin d'avoir quelques critères opérationnels permettant de mesurer les progrès accomplis. Ces concepts reposent sur le principe que les espèces et les communautés écologiques menacées nécessitent une attention particulière de la part des gestionnaires de forêts. Le présent bulletin technique évalue les façons dont les données et systèmes de suivi de *NatureServe* sur la biodiversité viennent soutenir les activités d'identification et de gestion des composantes essentielles de la biodiversité et établit les priorités en matière de travaux subséquents afin de rendre *NatureServe* plus utile aux gestionnaires de forêts. Dans la section 2, on décrit la terminologie de *NatureServe,* ses méthodes de classement, d'identification et de gestion des données sur les éléments de biodiversité en péril, son service d'analyse en matière de conservation et sa clientèle. La section 3 examine le système de *NatureServe* servant à identifier et à classer les éléments de biodiversité en péril, c'est-à-dire les espèces, les sous-espèces, les variétés, les communautés écologiques et les systèmes écologiques, qu'on peut suivre à l'aide de ses bases de données. Cette section décrit aussi le processus d'évaluation du statut de conservation (hiérarchisation des éléments), en particulier au niveau global, par lequel on identifie les éléments menacés ou fortement menacés. La section 4 traite des occurrences des éléments. Ceux-ci constituent les enregistrements de *NatureServe* sur les éléments identifiés sur le terrain dans des endroits généralement précis. Les planificateurs, les propriétaires de terrain boisé et les gestionnaires forestiers se servent des occurrences pour la conservation des espèces et des communautés menacées de disparition et les considèrent comme le meilleur paramètre qui existe pour représenter les différents types de systèmes écologiques. La section 4 décrit aussi la viabilité des occurrences ou évaluations d'intégrité écologique (hiérarchisation des occurrences des éléments) qui s'appuient sur des critères précis (spécifications sur la hiérarchisation des occurrences des éléments) pour déterminer les seuils de viabilité ou d'intégrité. La section 5 évalue dans quelle mesure les systèmes de classification et les bases de données dont se sert *NatureServe* ont besoin d'être perfectionnés et propose des idées pour en améliorer leur utilisation. Finalement, la section 6 décrit aux forestiers et aux autres gestionnaires des forêts comment utiliser le système pour obtenir des résultats sur la conservation de la biodiversité qui leur seront utiles en matière de planification et de gestion de leurs terres. Cette section fait la liste des données et des informations qui sont disponibles et examine les opportunités et les limites relativement aux systèmes de certification et aux autres utilisateurs potentiel du système.

## MOTS CLÉS

biodiversité, centres de conservation des données, classement du statut de conservation, diversité biologique, éléments de la biodiversité, foresterie durable, forêts menacées, forêts ayant un valeur de conservation exceptionnelle, fortement menacé, intégrité écologique, menacé, *NatureServe*, occurrences des éléments, planification de la conservation, priorités de conservation, programmes de conservation du patrimoine naturel, systèmes écologiques, *Sustainable Forestry Initiative*®, viabilité

## AUTRES PUBLICATIONS DE NCASI DANS CE DOMAINE

Aucune

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# MANAGING ELEMENTS OF BIODIVERSITY IN SUSTAINABLE FORESTRY PROGRAMS: STATUS AND UTILITY OF NATURESERVE'S INFORMATION RESOURCES TO FOREST MANAGERS

## 1.0 INTRODUCTION

The forest products industry, government agencies, and consulting foresters use a variety of tools to ensure that criteria and *indicators*[1] for sustainable forestry practices are in place. Criteria and indicators for biodiversity are an important component of sustainable forestry, but identifying those *elements* of biodiversity that are most critical to sustainability has been a challenge. Over the past few years, a number of innovative approaches have been developed to provide some operational criteria by which progress can be measured. These include the concepts of Forests with Exceptional Conservation Value (FECV), developed by the Sustainable Forestry Initiative® (SFI) and High Conservation Value Forests (HCVF), developed by the Forest Stewardship Council (FSC) (Forest Stewardship Council 1999, Sustainable Forestry Initiative 2002). These concepts embody the idea that at-risk species and ecological communities, and other ecological values, require special management by forest managers.

In the United States and Canada, SFI and FSC forest management standards require use of the concepts of *critically imperiled* and *imperiled species* and *ecological communities* (as defined by NatureServe) in FECV and HCVF components of the standards. The Canadian Standards Association (CSA) is also considering adoption of NatureServe data as part of its definition of critical conservation values within its Sustainable Forest Management certification standard. The identification and management of at-risk species, ecological communities, and other ecological values are also increasingly being undertaken outside the scope of forest certification programs, as part of forest products companies' efforts to meet the expectations for long-term forest stewardship of shareholders, customers, and other stakeholders.

This study evaluates the ways in which NatureServe's biodiversity tracking systems and data support the identification and management of critical components of biodiversity, and identifies priorities for improving NatureServe's utility to forest managers. The study was developed primarily through the support of the Forest Products Association of Canada (FPAC), National Council for Air and Stream Improvement, Inc. (NCASI), the American Forest and Paper Association (AF&PA), and member companies of NCASI and AF&PA. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Endangered Species Task Force also supported this study, through Compliance Services International. Because much of the impetus and financial support for the project came from the forest management community, and because there is a critical need to understand the ability of the NatureServe system to support explicit requirements in forest certification standards, the results are intended primarily for use by forest managers. However, this publication describes NatureServe information resources in terms sufficiently broad to be useful to other land managers and decision-makers in the pesticide, transportation, energy, and public land management sectors. NatureServe expects its data and information to be valuable to a wide range of landowners and managers who are responsible for maintaining at-risk species, population, and community elements of biodiversity.

The study conveys important information about the uses and limitations of NatureServe's methods of classifying, describing, and locating at-risk elements of biodiversity. By understanding the system's capacities and limitations, users and managers of the system can make informed, cost-efficient

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[1] Italicized words in the text are defined in the glossary (Appendix A); words are italicized the first time they appear in the text.

judgments about its application and enhancement. Section 2 describes NatureServe terminology; its methodologies for classifying, identifying, and managing data for at-risk elements of biodiversity; its analytical conservation services; and its clientele. Section 3 describes NatureServe's system for identifying and classifying at-risk elements of biodiversity, which are species, subspecies, varieties, ecological communities, and *ecological systems* that are tracked in NatureServe's databases. This section also describes the process of conducting a conservation status assessment (*element ranks*), particularly at the global level, whereby the elements that are critically imperiled or imperiled are identified. Section 4 describes occurrences (*element occurrences)*, NatureServe's records of elements that are identified on the ground, usually in specific locations, which are used by planners, landowners, and land managers to conserve values of biodiversity that are at risk of extinction as well as best remaining examples of ecological system types. This section also describes the occurrence viability or *ecological integrity* assessments (*element occurrence ranks*), based on specific criteria (*element occurrence rank specifications*) that determine the thresholds for viability or integrity. Section 5 evaluates the extent to which classification systems and databases that are used by NatureServe require additional efforts, and proposes enhancements to improve usability. Finally, Section 6 discusses means by which foresters and other land managers can use the system to obtain biodiversity conservation results in planning and managing their lands; identifies data and information products that are available; and evaluates opportunities and limitations for certification systems and other potential users of the system.

## 2.0 OVERVIEW OF NATURESERVE ORGANIZATIONAL AND SCIENTIFIC SYSTEMS

### 2.1 NatureServe Information Resources

In 2000, The Nature Conservancy established NatureServe as an independent, international non-governmental organization. NatureServe encompasses a network of independent *natural heritage programs* and *conservation data centers*, the first of which was established by The Nature Conservancy and the state of South Carolina in 1974, along with regional and central offices. Most central and regional NatureServe staff came from the Science Division of The Nature Conservancy. Until the creation of NatureServe, the network was known as "the *Natural Heritage Network*". It is a network of programs that develop, manage, and distribute authoritative information about biological diversity to landowners and land managers, consultants, and scientists. The *NatureServe network* is the western hemisphere's leading authority on the identification, location, and conservation of at-risk species and ecological communities.

The NatureServe network consists of a central office, four regional offices in the U.S., 54 *member programs* in the U.S., 11 provincial and territorial offices in Canada, and 11 national and territorial offices in the Latin America-Caribbean (LAC) region. Nearly 800 scientists and support staff work in the network, including some of the most knowledgeable and experienced scientists and conservation planners in their regions. The collective annual budget of the network exceeds $US45 million.

In the U.S., member programs are typically called natural heritage programs (NHPs), and in Canada and LAC they are typically called conservation data centers (CDCs). The role of member programs is to collect, analyze, and distribute standardized scientific information about the biological diversity found in their jurisdictions. Member programs are the leading source of standardized information on the precise locations and conditions of at-risk species and ecological communities. Three-quarters of member programs are administered by sub-national government agencies, but about one-fifth are university programs, and a tenth are associated with or are themselves independent non-profit organizations. Other member programs are either multi-organizational partnerships or are in national agencies.

The network's information on species and ecological communities comes from numerous sources, including museum collections, published literature, unpublished reports, outside expert consultants, and field surveys. For new programs, the initial development of information for the databases typically comes from the first four of these sources, and they provide the starting basis for understanding the extent of biodiversity. Most programs now have been gathering and analyzing data for over 20 years. The core business of NatureServe member programs is to conduct field inventories for high-quality ecological communities and at-risk species, to develop and maintain databases to organize and document the field data, and to make information and expertise available to landowners, land managers, land-use planners, scientists, environmental consultants, and regulators. Many programs offer custom analytical and Geographic Information System (GIS) services to help clients prioritize conservation activities. Most provide environmental review services for state, provincial, or national agencies and commercial clients. By providing data, information, and analytical services to these clientele, the NatureServe network connects botanical, zoological, and ecological science to conservation efforts.

Regional and central offices of NatureServe provide coordination and technical support to member programs. For example, much of the work of classification and development of ecological communities is carried out regionally. Regional and central offices of NatureServe establish taxonomic and nomenclatural standards and "cross-walk," or rectify local data to those standards. These offices also engage in data development and application through multi-state/province projects with public and private sector partners. They often work with member programs on the development of new standards, then transfer new knowledge and methods across their region.

NatureServe central and regional offices were created to ensure the quality and uniformity of data managed by the network through the creation and distribution of standardized, universally applicable scientific methods and products and through a formal process of data exchange with the member programs. NatureServe exchanges data once per year with most U.S. and Canadian member programs. In addition, NatureServe has developed a series of conservation science products to support the work of natural heritage programs, land managers, and land-use planners. Among important products of the past few years are:

- the International Vegetation Classification, including, in North America, the U.S. National Vegetation Classification System (1997), which provides a standard, comprehensive framework for vegetation classification across the U.S., and the Canadian National Vegetation Classification, which is in the early stages of developing such a framework for Canada. These classifications provide the definitions for ecological communities tracked by NatureServe.

- *NatureServe (central) databases* (2001–current), which provide standardized data on the taxonomy, status, distribution, ecology, and management needs of more than 64,200 taxa and 5,200 community types of the western hemisphere. The central databases are continuously updated, and were expanded in 2004 to include ecological communities, images, enhanced maps, and enhanced fields of information (e.g., trends and threats to biodiversity).

- NatureServe's main website, http://www.natureserve.org (2001–current), where downloadable data and publications are available;

- *NatureServe Explorer*, http://www.natureserve.org/explorer (2001–current), a website that presents a significant portion of NatureServe's data to the public, ensuring wide access to conservation information on more than 52,000 plants, animals, and ecological communities of the United States and Canada;
- NatureServe (central) *multi-jurisdictional EO database* (MJD) of element occurrences (2001–current) of species across North America, which includes nearly a half-million location-specific records and represents the first compilation and reconciliation of these records continent-wide;
- *Biotics 4* (2002), a spatially explicit data management system that integrates spatial and database management functions into a single software program;
- InfoNatura, http://www.natureserve.org/infonatura (2002–current), a source for conservation information on the birds, mammals, and amphibians of Latin America and the Caribbean;
- A Working Classification of Terrestrial Ecosystems in the Conterminous United States (2003), which provides an "intermediate-scale" ecological classification that applies broadly to a range of resource management and conservation applications, and that facilitates mapping;
- the *Element Occurrence Data Standard* (2003), which establishes standardized methods for identification and mapping of locations where elements of biodiversity occur, and provides a framework for evaluating the viability or integrity of individual occurrences through standardized criteria; and
- the *NatureServe Decision Support System* (2004), a software product that supports flexible analyses of conservation opportunities and costs.

NatureServe also plans to develop A Standard Methodology for Biological Inventory Prioritization (estimated publication in 2005), which will document effective approaches and improve efficiencies and reduce costs to landowners and managers as they seek to identify elements of high biodiversity value on lands they manage.

The NatureServe network was originally established to meet the needs of The Nature Conservancy's land acquisition and conservation programs. As the network seeks to serve the needs of a broader range of landowners and land managers, NatureServe is expanding its suite of tools and analytical services. In addition to the products listed above, the NatureServe central office also offers customized services, such as custom mapping and GIS analyses, environmental reviews of proposed projects, and analyses using NatureServe's decision support system software. Each of these products and services is developed by a team of scientists from NatureServe member programs, NatureServe regional and central offices, and other organizations with relevant expertise.

### 2.2 Key NatureServe Concepts and Terms

NatureServe uses terms to describe its network and system of conservation science in a technical, precise fashion. Understanding the key terms used by NatureServe is essential to comprehension of this report.

Many local users of the NatureServe system know it as the "natural heritage network" or the "*conservation data center network*", which were widely used terms for more than twenty years. When NatureServe was created in 2000, it became the focal point for organizing and managing the science of natural heritage data and classification, and it has taken the role of coordinating the member program network. Accordingly, the NatureServe network is a term synonymous with the former natural heritage network and conservation data center network, and is composed of 76 member programs across the Western hemisphere, four regional offices in the U.S., and the NatureServe central office in Arlington, Virginia. Member programs include natural heritage programs and conservation data centers in the U.S., Canada, and Latin America. Landowners and managers who want data from only one jurisdiction should contact member programs to obtain those data, which are standardized annually to NatureServe data standards. Landowners and managers who are working in more than one jurisdiction, or are interested in cross-regional comparisons, should contact NatureServe (central) or NatureServe Canada to obtain a multi-jurisdictional EO database.

An element is a unit of biodiversity, generally a species (or subspecies, variety, or population[2]), ecological community, or ecological system. The NatureServe system tracks over 70,000 elements (known as *tracked elements*). Elements are assigned a *conservation status rank* that indicates their relative imperilment, risk of extinction, or risk of extirpation. An element occurrence (EO) is an incidence of a population, community, or ecological system in a specific location. It is the mapping unit developed by the NatureServe network that serves as a basis for making conservation assessments and identifying precise locations of at-risk elements. Element occurrences are distinguished from *observations* by meeting minimum standards and being processed into records, known as *element occurrence records* (EORs). Element occurrences are assessed for their *viability* (species) or ecological integrity (ecological communities and systems), also known as EO ranks (see Figure 2.1). *Conservation sites* are the typically larger areas surrounding one or more occurrences that are designed to facilitate conservation and management of the included occurrences. For example, conservation sites may include upslope and upstream buffers. Member programs also maintain records of the locations and conservation status of *managed areas* (e.g., state and national parks, Nature Conservancy reserves) that may be relevant to the conservation of at-risk elements. Table 2.1 compares some of the "new" (more user-friendly) terminology now employed by NatureServe to describe NatureServe concepts with the previous acronym-laden terminology (still used in NatureServe's databases) to describe conservation status assessments for elements, and viability and integrity assessments for occurrences of those elements.

**Table 2.1** Comparison of Some Technical Database Terms with New User-Friendly Terms

| Biotics database term | Concept |
|---|---|
| Element rank | NatureServe conservation status rank |
| Element rank factors | NatureServe conservation status factors |
| Assigning element ranks | Assessing conservation status |
| EO | Occurrence |
| EO specs | Occurrence requirements |
| EO rank | Occurrence viability (when discussing species) or occurrence ecological integrity (when discussing communities and systems) |
| EO ranks | Occurrence viability or ecological integrity assessments |
| EO rank specs | Occurrence viability or ecological integrity criteria (or one or the other as above) |
| Assigning EO ranks | Occurrence viability or ecological integrity assessment |

[2] Tracked populations are primarily anadromous fish stocks, mostly those recognized by the National Marine Fisheries Service or academic researchers.

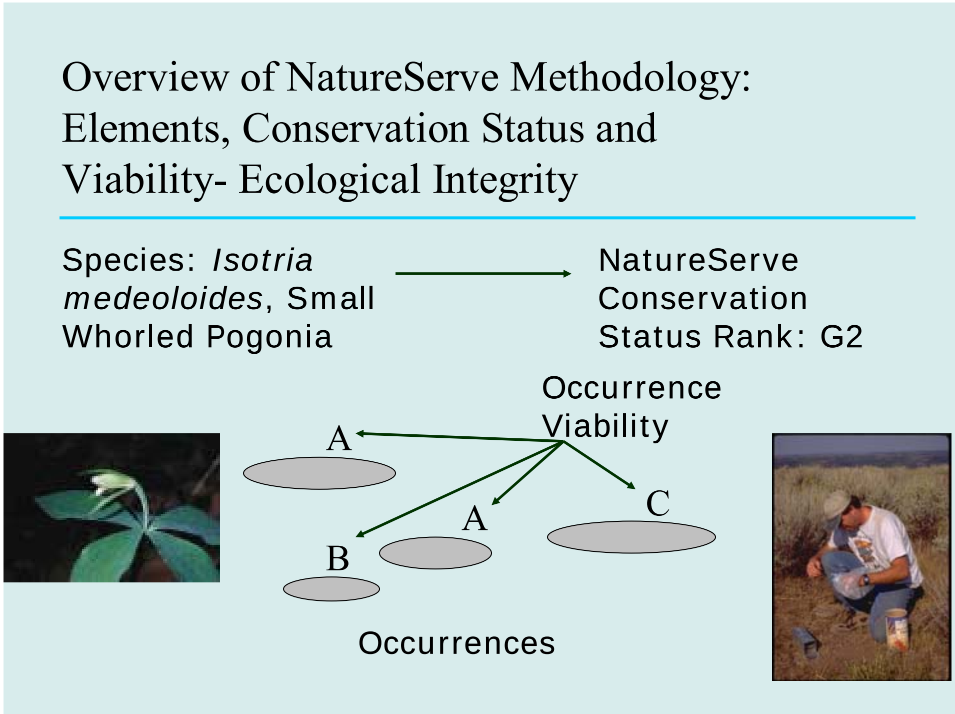


**Figure 2.1** The Relation between Conservation Status Assessments (Global Ranks) and Occurrence Viability or Ecological Integrity Assessments (EO Ranks)

## 2.3 Roles within the NatureServe Network

NatureServe maintains a central multi-jurisdictional EO database (MJD) comprised of data from member programs; it currently contains over 500,000 element occurrence records for species. Member programs in the U.S. and Canada develop the occurrence data, and provide primary data management services for element occurrences. Conservation status ranks are assigned by NatureServe (central) and member program staff and other experts, with central staff assigning the majority of global ranks and member programs assigning subnational ranks. National conservation status ranks for the U.S. and Canada are assigned by central staff, and by national-level staff for other nations. Element occurrence ranks are assigned by member program staff.

NatureServe member programs agree to carry out an annual data exchange with NatureServe central. In the exchange, member programs provide species status and element occurrence data in their database, including those occurrences that have been collected and entered since the previous data exchange. Scientists at NatureServe central rectify botanical, zoological, and ecological data to central standard taxonomic and classification protocols, and review and update global (range-wide) information based on the new local information. Both parties benefit from these data exchanges: the member programs receive updated global information, and NatureServe (central) receives local information and locational (EO) records. To date, no data exchanges have been completed with CDCs in the LAC region. The first exchanges of data for ecological communities were completed in February 2004. Figure 2.2 illustrates the flow of data in the annual data exchange between NatureServe central and member programs.

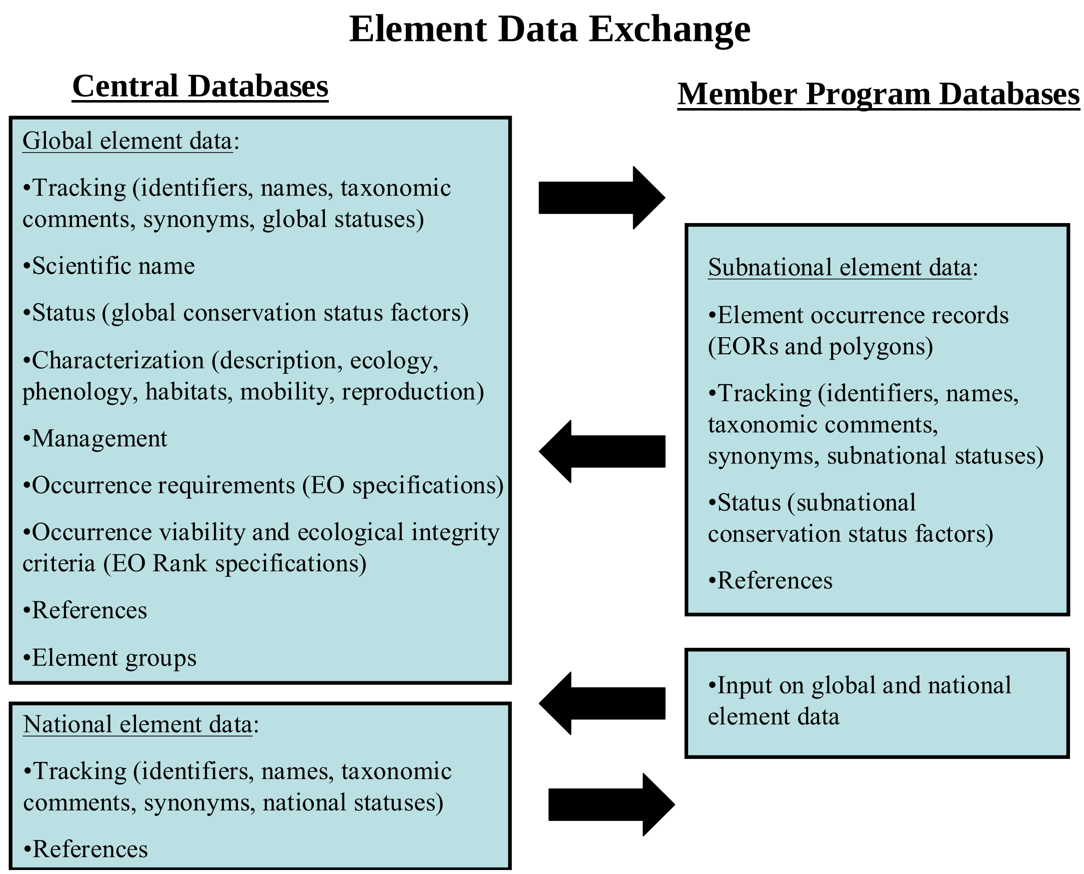


**Figure 2.2** A Schematic Illustration of Annual Data Exchange between NatureServe Central and Member Programs (Arrows indicate the primary direction of information flow.)

## 2.4 Application of NatureServe Network Biodiversity Data to Management Issues

Data, information, and analyses prepared by NatureServe are powerful conservation tools for government and private planners, landowners, land managers, researchers, and others. Conservation groups use NatureServe network data to identify areas of high biodiversity value, and thereby to prioritize conservation activities. Local and regional governments use it to develop land use plans and strategies. Public agencies use it to guide natural resource management activities. Developers, consultants, and corporations use it to guide development and other land-use activities, and thereby address their commitments to conservation and sustainable development. All of these groups use NatureServe network data to monitor and assure compliance with environmental conservation laws, regulations, and policies. A summary of recent NatureServe clients is found in Appendix B.

The U.S. Fish and Wildlife Service (U.S. Department of Interior), the U.S. Forest Service (U.S. Department of Agriculture), and the National Park Service (NPS) are particularly significant public users of NatureServe's species information and tools. The U.S. Fish and Wildlife Service uses NatureServe's conservation status assessments, along with information from other sources, to select species for candidacy for listing under the U.S. Endangered Species Act. Similarly, the U.S. Forest Service uses NatureServe's global conservation status designations to identify sensitive species that receive special management consideration on Forest Service lands.

Among private user groups, forest certification systems have been the first to institutionalize the use of NatureServe data into performance standards. In 2001, the Forest Stewardship Council approved the Rocky Mountain Regional Forest Stewardship Standard, which requires that certificate holders consult databases of the NatureServe network, and protect imperiled and *vulnerable* species and communities. At the time of this writing, seven regional standards have been endorsed by FSC, and each requires consultation and management to protect at-risk elements found in NatureServe network databases. In July 2002, the SFI passed a provision that requires identification and protection of known, viable occurrences of critically imperiled and imperiled species and communities.

The NatureServe network's mapped element occurrence information is designed to show (with specified levels of precision) the approximate physical boundaries of the populations and communities whose occurrences are recorded. However, the occurrence information alone does not recommend the sizes, configurations, or extent of conservation sites or managed areas that need to be established to protect element occurrences. Accordingly, users of the system operate under the caveat that the identification of occurrence boundaries alone is not adequate to develop a suitable management plan for most occurrences.

SFI provisions incorporate the concepts of viability and ecological integrity into a requirement for identifying and protecting occurrences. NatureServe is in the process of establishing viability and integrity criteria (= element occurrence rank specifications) for all species and communities. These criteria provide insights into the area required and specific management actions that are compatible with conserving each occurrence. The application of these criteria results in a viability and integrity rating and date of assessment being recorded in the "element occurrence rank" and date fields of the EO database.

## 3.0 ELEMENTS OF BIODIVERSITY: SPECIES, COMMUNITIES, AND ECOLOGICAL SYSTEMS

### 3.1 Definition and Identification of the Elements of Biodiversity

#### 3.1.1 *Definition of the Elements of Biodiversity*

NatureServe recognizes a suite of elements of biodiversity for potential conservation attention and action. These include species (or infra-species including subspecies, varieties, or populations), communities (the *association* level of the International Vegetation Classification), and ecological systems, and they are assigned a conservation status rank that signifies the extent to which the element is at risk of extinction (see Section 3.5 for more information about NatureServe conservation status rankings). Species and ecological communities are part of taxonomic hierarchies. Organisms may be recognized at any taxonomic level, although typically they are recognized at the species or infra-specific level. Other elements of biodiversity (e.g., animal assemblages, ecological systems) are not classified in a hierarchical system of classification.

### 3.1.2 *Tracking Species, Communities, and Ecological Systems*

Ecological communities, ecological systems, and selected species[3] are known as NatureServe tracked elements. NatureServe tracks over 64,200 species, subspecies, varieties, and populations, all 5,200 ecological communities, and all of the 600 types of ecological systems found in the U.S. (see Table 3.1).

A subset of tracked elements serves as the focus of many biological inventories and conservation actions. A focus both on ecological communities and systems (i.e., the coarse-filter elements of biodiversity) and on species (including sub-specific taxa, i.e., the fine-filter elements of biodiversity) that are at risk of extinction (an irreversible global phenomenon) or extirpation (disappearance from a landscape or region) combine to form a coarse-filter/fine-filter approach to the identification and conservation of biological diversity (Jenkins 1985). The conservation of multiple, high-quality occurrences of all ecological systems and communities (the elements of biodiversity coarsest in scale) may be expected to support the majority of native biodiversity and is an efficient and effective approach to the design and management of a network of reserves (Jenkins 1976; Jenkins 1985; Noss and Cooperider 1994; Groves et al. 2002; Kintsch and Urban 2002). The coarse-filter/fine-filter approach helps minimize complexity and cost associated with strictly species-based approaches, which could require specific attention to hundreds to thousands of individual species in a given area (Scott et al. 1987; Beissinger and Westphal 1998; Willis and Whittaker 2002). The identification and conservation of fine and coarse elements of biodiversity across a landscape or planning area should efficiently conserve the ecological functions, processes, and dynamics that support a majority of biodiversity in an area.

In support of the coarse filter, NatureServe's databases include occurrences of standard *terrestrial ecological systems* and common ecological community types that have been documented in the continental United States. Terrestrial ecological communities are defined at several hierarchical levels. NatureServe has coordinated processes that have resulted in the International Vegetation Classification (IVC), the U.S. National Vegetation Classification System (US-NVC), and the Canadian National Vegetation Classification System (C-NVC, still under development). The US-NVC currently includes 7 *formation* classes, 21 formation subclasses, 60 formation groups, 64 formation subgroups, 218 formations, 1,650 *alliance*s, and 5,156 associations documented for the continental United States. This classification hierarchy is discussed in more detail in Section 3.3.1.2.

NatureServe's terrestrial ecological system units are intermediate in scale between the IVC alliance and formation units. NatureServe's terrestrial ecological system classification system defines groups of plant communities that co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. About 600 terrestrial ecological system units are described in the lower 48 United States (Comer et al. 2003), and all of them are tracked. NatureServe also has developed maps of ecological systems over parts of the western United States.

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[3] Species that are tracked by NatureServe include vertebrates and vascular plants of North America and those nonvascular plants and invertebrates that are well enough known to reasonably assess their status and distribution. See Table 3.1.

**Table 3.1** U.S. Elements of Biodiversity That Are Tracked by NatureServe

| Element Group | Number[a] of tracked elements |
|---|---|
| **VERTEBRATES** | |
| Mammals | 455 |
| Birds | 858 |
| Reptiles, turtles, and crocodilians | 342 |
| Amphibians | 274 |
| Freshwater fishes | 928 |
| **Vertebrates subtotal** | **2,857** |
| | |
| **INVERTEBRATES** | |
| Freshwater mussels | 306 |
| Snails (land & freshwater) | 2,667 |
| Crayfishes | 340 |
| Butterflies & skippers | 634 |
| Tiger beetles | 104 |
| Stoneflies and mayflies | 1,231 |
| Grasshoppers | 749 |
| Dragonflies & damselflies | 463 |
| Other invertebrates | 6,489 |
| **Invertebrates subtotal** | **12,983** |
| | |
| **VASCULAR PLANTS** | |
| Ferns & fern allies | 623 |
| Conifers | 130 |
| Flowering plants | 19,015 |
| **Vascular plants subtotal** | **19,768** |
| | |
| **NONVASCULAR PLANTS** | |
| Mosses, Liverwort and Hornworts | 1,677 |
| Lichens (selected) | 1,797 |
| **Nonvascular plants subtotal** | **3,474** |
| | |
| **ECOLOGICAL COMMUNITIES** | |
| Terrestrial associations | **5,284**[b] |
| | |
| **ECOLOGICAL SYSTEMS** | **600** |
| | |
| **TOTAL** | **44,366** |

[a] Species numbers refer to full species only and do not include tracked subspecies, varieties, and populations.
[b] includes some in Canada that do not occur in the U.S.

In the U.S., ecological systems are described in terms of their component US-NVC alliances and associations. So, where agencies or organizations need to use those classifications, those groups can easily go back and forth between the two classification approaches. Planned revisions to the hierarchy of the US-NVC and IVC are expected to further improve the standardization of ecological systems. A systems classification is also available for Latin America, where nearly 700 ecological systems have been described (Josse et al. 2003).

In support of the fine filter, NatureServe's databases currently encompass approximately 64,200 species, subspecies, and varieties of organisms. These also include all vascular plants, bryophytes, and vertebrate animal species native to the continental United States, Hawaii, and Canada, as well as a large proportion of native North American lichens. This total includes all species in a dozen groups of invertebrate animals (e.g., mollusks, crayfishes, and several insect groups such as butterflies, dragonflies, tiger beetles) in the United States and Canada. However, the 15,840 animal species tracked in the United States are only about 12% of the number of described animal species in the country. Two-thirds of animal species are insects (approximately 100,000 species described in the U.S.), and NatureServe scientists consider the status and distribution of most of these to be too poorly known to meaningfully assess. Other animal groups that are too poorly known to assess include most crustaceans, arachnids, flatworms, annelids, and nematodes, although there are exceptions within some of these groups (e.g., crayfishes, cave-obligate species). Less charismatic groups such as microbes or non-lichenized fungi have not yet been comprehensively assessed. Thus, the conservation of vulnerable species in these groups depends upon the conservation of associated coarse-filter elements and co-occurring vulnerable species in better-known groups.

In addition to tracking animal species, subspecies, and varieties, NatureServe's databases also include information on transient but recurring animal assemblages, particularly for migratory species. Some migratory species occur in large multiple-species aggregations at particular places during periods in their lifecycle or during their annual migrations. Examples of mixed-species animal assemblages include shorebird migratory concentration areas, salmonid marine concentration areas, and bat hibernacula. Such occurrences deserve special conservation attention to efficiently ensure that viable populations of those species persist.

### 3.2 Standards for Species

To ensure that data are always associated with the correct species, each species element included in the NatureServe's databases must have a unique name and *concept reference combination* that differentiates it reliably from all other taxa, regardless of the differing names that may be applied to it by various member programs and other entities. (By contrast, in the scientific literature, the same name has often been applied to two or more entirely different taxonomic concepts and, conversely, the same taxonomic concepts have sometimes been given different names.) In addition, NatureServe (central) maintains internally consistent taxonomic and nomenclatural treatments that reflect currently accepted views for many groups of taxa across North America.

This process of creating a set of standard taxa and their associated names is a complicated and ongoing challenge. New species are constantly being described and others are subsumed (no longer recognized as distinct) in the scientific literature as scientists increase their understanding of the phylogenetic relationships among populations. In addition, the information needed to describe and differentiate species is often incomplete, and relationships among populations may be open to different interpretations, often leading to debate and legitimate differences of opinion among specialists regarding the recognition of species. Despite the difficulties, NatureServe's fundamental goal is to maintain a comprehensive set of "standard" taxa, with associated synonyms and relationships to "non-standard" taxa, in order to receive and integrate data from member programs that may be based on many different taxonomic and nomenclatural treatments. Such standardization prevents taxonomic confusion and dissent from impeding conservation actions.

NatureServe scientists attempt to recognize taxa and names that represent accepted opinion among researchers working in a particular group and that are likely to be adopted in subsequent editions of any widely used standardized lists. The species concepts and associated names recognized by NatureServe are primarily obtained from published standardized lists that are widely accepted among researchers with expertise in a given taxonomic group (e.g., the American Ornithologists' Union *Check-List of North American Birds*, John Kartesz's list of North American vascular plants[4]).

NatureServe's standard references for vascular plants of North America north of Mexico are the synonymized checklists published by Kartesz (1999). These checklists are integrated treatments, internally consistent for all North American flora, and are based on review of the most recent literature on plant systematics. NatureServe's standard references for non-vascular plants and lichens are Anderson (1990); Anderson, Crum, and Buck (1990); Stotler and Crandall-Stotler (1977); and Esslinger and Egan (1995). NatureServe's database contains records for all taxa recognized in these standards, as well as most bryophytes and lichens found in the United States.

For animals, NatureServe's standard taxonomy and nomenclature are obtained from a variety of published references.[5] Although some references represent the view of a research group whose opinions are generally followed by scientists with expertise in a given taxonomic group (e.g., the American Ornithologists' Union Committee on Classification and Nomenclature), globally consistent taxonomy for most animal groups may not be available. For example, available taxonomic lists may be regional rather than global; there may not be a single consensus list; there may be multiple lists; and/or lists may be infrequently updated. For these reasons, and because taxonomy is a dynamic area of investigation, NatureServe zoologists strive to continuously review newly published journals and monographs for taxonomic and nomenclatural changes, and they adopt well-founded taxonomic and nomenclatural changes. Hence NatureServe's taxonomy is often more current than available published lists. NatureServe works diligently to secure funding to maintain current taxonomic treatments in the database, especially for animal elements that are not extremely rare or imperiled.

Currently, NatureServe maintains element records for all U.S. and Canadian vertebrate animals (see Table 3.1). NatureServe also maintains records for all species in the following invertebrate groups: freshwater and terrestrial mollusks, butterflies and skippers, crayfishes, tiger beetles, dragonflies and damselflies, grasshoppers, stoneflies, and mayflies. Records are also maintained for approximately 6,500 invertebrates in other miscellaneous groups and all mammals, birds, and amphibians in the Western Hemisphere.

In addition to widely recognized species, NatureServe databases also include taxa of conservation concern for which a name has not yet been published. Inclusion of these undescribed taxa usually reflects the needs of a member program, or the species is an undescribed species or Evolutionarily Significant Unit on a government conservation list. Such taxa are assigned provisional English and scientific names (e.g., Comal Springs Salamander, *Eurycea* sp. 8 or Steelhead – Central California Coast, *Oncorhynchus mykiss* pop. 8).

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[4] The Integrated Taxonomic Information System (ITIS) also bases its plant taxonomy on an older version of John Kartesz's list via the USDA "Plants" database (although "Plants" and ITIS are currently not maintained in synchrony). NatureServe is a member of the ITIS consortium and continues to work with them to improve both of our databases.

[5] An up-to-date list of major references used by NatureServe Zoology is available at http://www.natureserve.org/explorer.

As with community elements, some level of species taxonomic reconciliation (“cross-walks”) is required between standard taxonomies and others followed by member programs. To ensure consistency, alternative names and taxonomic variations are carefully cross-referenced in the NatureServe database. Additionally, biologists maintaining both central and local databases enter explanatory and historical notes for species whose taxonomic status is controversial, uncertain, or has been modified recently, as well as the author and reference citation of the scientific name source.

Taxonomic practices and the degree to which infra-specific taxa are currently recognized vary tremendously among different groups or organisms. Many of the current major published sources that record a “standard” set of scientific and/or common names for certain zoological taxa (e.g., widely followed standard lists for birds and mammals) do not currently list or evaluate subspecies. In contrast, subspecies and varieties are often recognized for plants; subspecies are often recognized for butterflies and North American amphibians and reptiles; and informally named stocks are often recognized for salmonid fishes.

Most animal subspecies descriptions date from many years ago and were often based on few individuals, on a relatively incomplete understanding of a species’ distribution, and on variable, qualitatively described characters. Furthermore, sub-specific boundaries often were not drawn along ecological or geographic boundaries that might partially isolate subspecies. Thus, sub-specific boundaries are frequently at odds with recently discerned patterns of genetic variation (e.g., Boone, Smith, and Laerm 1999). For these reasons, NatureServe’s central zoologists follow a conservative approach in recognizing animal subspecies and primarily include subspecies that a) are included on an international, federal, country, state, or provincial list of endangered, threatened, or special concern taxa; b) are thought to be taxonomically valid and are globally vulnerable; or c) may warrant recognition as a species.

## 3.3 Standards for Ecological Elements (Communities and Ecological Systems)

### 3.3.1 *Ecological Communities*

#### *3.3.1.1 Development of Standards for Vegetation Classification*

Ecologists and foresters recognize that ecological communities interact with one another through common ecological processes and functions (e.g., Whittaker 1962; Cowardin et al. 1979; Eyre 1980; Brown 1982; Reschke 1990; McPeek and Miller 1996; Kimmins 1997). By describing, classifying, mapping, and managing these ecological communities, researchers and managers are able to track and monitor a complex suite of interactions that are not recognizable through other means.

The development of a standard system of ecological classification is regarded as a major step toward enhancing our ability to understand and manage natural resources (National Research Council 1993; Orians 1993; Noss, LaRoe, and Scott1995). Scientists from a variety of agencies, organizations, and institutions have relatively recently helped to establish an ecological community classification based on vegetation. The International Vegetation Classification system (IVC, initially called the International Classification of Ecological Communities) was first developed in the United States as the U.S. National Vegetation Classification (US-NVC). With support from The Nature Conservancy (TNC) and an array of federal programs, Grossman et al. (1998) and Anderson et al. (1998) produced the first comprehensive draft of the US-NVC, based in part on modifications to a United Nations Educational, Scientific, and Cultural Organization (UNESCO) 1973 international vegetation classification and mapping system. At about the same time, the Federal Geographic Data Committee (1997) adopted a slightly modified version of this classification system as a federal standard for all agencies.

During those deliberations, ecologists from federal agencies, NatureServe, and academia discussed the need to involve the Ecological Society of America (ESA) to provide peer review as well as a forum for discussion and debate among professional ecologists with respect to the evolving NVC (Barbour 1994; Barbour, Glenn-Lewin, and Loucks 2000; Peet 1994; Loucks 1995). The Federal Geographic Data Committee (FGDC) Vegetation Subcommittee invited ESA to participate in the review of the physiognomic standards as well as the development of the standards for the *floristic* levels. The ESA Panel has now published a series of guidelines for the development of vegetation units within the United States, with potential for application in other countries (Jennings et al. 2003).

To meet the need for a credible, broadly accepted vegetation classification, NatureServe, the Ecological Society of America (ESA), the U.S. Geological Survey, and the U.S. Federal Geographic Data Committee joined to form a Vegetation Classification Panel. To formalize this partnership, the four participating organizations signed a formal Memorandum of Understanding (MOU)[6] in August 1998. This MOU defined the working relationship among the signers for the purpose of advancing the US-NVC. NatureServe currently maintains the classification system, in conjunction with partners.

More recently, work in Canada has begun along similar conceptual lines, using the framework of the IVC to guide development of vegetation types (Ponomarenko and Alvo 2000; Alvo and Ponomarenko 2003). IVC partners in Canada are working to ensure that the classification will serve provincial, national, and international needs.

#### *3.3.1.2 The Vegetation Classification Framework*

Five key decisions were made regarding the intent and overall framework for the IVC (Grossman et al. 1998), including the US-NVC and C-NVC; namely, that the classification would:

- be based on the use of natural, existing vegetation;
- use a systematic approach to classifying a natural continuum;
- use a combined physiognomic-floristic hierarchy to organize classifying criteria;
- identify vegetation units based on both qualitative and quantitative data at multiple scales that are practical for conservation and resource management; and
- be appropriate for mapping at multiple scales.

This classification approach is applicable worldwide; however, the focus of much development has been in the United States (US-NVC) and, more recently, in Canada (C-NVC). The classification is intended to cover all terrestrial ecological communities, including wetlands and shallow waters with emergent vegetation, regardless of the size or structure of the vegetation.

Because vegetation classification units are often portrayed as maps, they may appear as fairly discrete units, but this can be more a reflection of the mapping process than the inherent discreteness of the units. The "continuum concept" in vegetation, as developed by Gleason (1926), Curtis (1959), and Whittaker (1956, 1962) argues that because species have individual, independent responses to the environment, their individualistic response produces a continuum of change along gradients. This concept reflects the individualistic nature of the environment—no two segments of the physical terrain are identical. However, there also is ample recognition that species and habitats found in a given area are structured to some degree by interactions with each other, their environment, disturbance regimes, and historical factors, and many combinations of species and habitats do indeed

[6] Forming a partnership to further develop and implement the national vegetation classification standards. Memorandum of Understanding among ESA, TNC (NatureServe), USGS, and FGDC. 1999. Ecological Society of America, Washington, D.C., USA. 6p. (http://www.esa.org/vegweb/ - MOU).

recur (e.g., Austin and Smith 1989). This viewpoint—one that is perhaps intermediate between the "community unit concept" and the "continuum concept"—has been widely used in guiding ecological classification. Although there is continuous variation in species composition and environmental gradients, the level of compositional and environmental change in some places is low (e.g., within a readily recognizable plant community), whereas, in other places, the level of compositional change is high (e.g., across an ecotone).

The overall classification framework has seven hierarchical levels (Figure 3.1). This structure allows the classification to be applied at the spatial level appropriate to a range of conservation and management activities. Five levels (formation class, formation subclass, formation group, formation subgroup, and formation) are based on vegetative structure or *physiognomy*, and two levels (alliance and association) are derived from species composition (floristics).

Only the finest level of classification—the association—receives a conservation status assessment, and that is the most-used level for conservation purposes, including forest certification. NatureServe follows the definition of association provided by Jennings et al. (2003) as "a vegetation classification unit defined on the basis of a characteristic range of species composition, *diagnostic species* occurrence, habitat conditions, and physiognomy."

TERRESTRIAL VEGETATION

FORMATION CLASS
FORMATION SUBCLASS
FORMATION GROUP
FORMATION SUBGROUP
***physiognomic levels*** FORMATION

***floristic levels*** *ALLIANCE*
*ASSOCIATION*

**Figure 3.1** Hierarchical Vegetation Classification System for the Terrestrial Ecological Committees

Several limitations of the UNESCO hierarchy were addressed to meet the objectives for the upper *physiognomic levels* of the US-NVC, including compatibility with other systems. The "subclass level" of UNESCO was modified, and a new formation subgroup was added to support the need to classify managed and cultural vegetation (FGDC 1997). Hydrological modifiers based on Cowardin et al. (1979) were also added at the formation level, because they have been used extensively to map wetlands across the United States. Table 3.2 includes an example set of NVC units at each level of the hierarchy. There are currently 7 formation classes, 21 formation subclasses, 60 formation groups, 64 formation subgroups, and 218 formations documented for the United States.

**Table 3.2** Example of Classification Units at Each Level of the National Vegetation Classification Hierarchy

| **Level** | **Typical Basis for Classification** | **Example** |
|---|---|---|
| Formation Class | Growth form and structure of vegetation | Woodland |
| Formation Subclass | Leaf phenology | Deciduous Woodland |
| Formation Group | Leaf types, corresponding to climate | Cold-Deciduous Woodland |
| Formation Subgroup | Relative human impact (natural/semi-natural, or cultural) | Natural/Semi-Natural |
| Formation | Additional physiognomic and environmental factors, including hydrology | Temporarily Flooded Cold-Deciduous Woodland |
| Alliance | Diagnostic species of uppermost or dominant stratum | *Populus deltoides* Temporarily Flooded Woodland Alliance |
| Association | Additional diagnostic species from any strata | *Populus deltoides —(Salix amygdaloides)/Salix exigua* Woodland |

The upper levels of the classification framework are a modification of the United Nations Educational, Scientific, and Cultural Organization (1973) World Physiognomic Classification of Vegetation that has been applied worldwide for a variety of natural resource and conservation applications. The lowest two levels of the hierarchy—the alliance and the association—are based on floristics, i.e., the plant species that are repeatedly found in examples of a given vegetation type. There are currently 1,650 alliances and 5,156 associations documented for the United States.

*3.3.1.3 Defining Associations through Data Analysis and Interpretation*

The process of classification involves putting similar items into groups. In community ecology, these items are often data from field samples, where field workers have documented the type and abundance of vegetation in a portion of a larger landscape that is predominantly forest, shrubland, or grassland, etc. In subsequent analysis, these samples can be grouped into recognizable communities or associations. Organizing sample data into a community classification requires both scientific method and expert judgment. It can be heavily based on expert knowledge and field experience, or it can be a combination of statistical analysis and expert interpretation. When applying statistical analysis to classification development, it is important to follow consistent methods in collecting field samples. Samples should represent both biotic and abiotic characteristics. Collected data, such as percent cover and/or density of stems by species, and pertinent information about the environment should be recorded (topographic position, soil moisture, hydrology, etc.) representing it in regularly shaped sample "plots" (Mueller-Dombois and Ellenberg 1974; Gauch and Whittaker 1981). While samples are ideally located through random placement, stratification that avoids areas of transition is desirable. Failure to represent the full range of ecological and environmental conditions has been a common shortcoming in efforts to develop or advance ecological classification. However, the full range of the type may be unknown, or resources committed to gathering samples may be severely constrained geographically, so only a limited representation of ecological and environmental variability may be revealed even when this factor is fully considered.

A number of quantitative methods are commonly used to analyze data in creating a classification system. Two of the most common methods are clustering and ordination. Within these categories, there are several statistical tests and methods that are commonly employed. This variety of techniques enables field scientists to choose the most appropriate method to analyze a given data set.

Much of the classification of US-NVC associations is based on hierarchical classification or clustering. In essence, clustering defines groups of items (i.e., samples) based on their similarities. This type of test produces an output called a "dendrogram," with clusters of samples that are similar as distinct branches (Pielou 1984; Jongman, ter Braak, and van Tongeren 1995). Figure 3.2 includes an example of a dendrogram developed during the development of an ecological classification report at Effigy Mounds National Monument, Iowa (Menard pers. comm.). The samples, representing 0.1 ha plots, are arranged along the left-hand side of the graph with alpha-numeric codes. Similar samples are connected by the symbols to the right of the codes. Branches to the right of Figure 3.2 represent divisions into broad groups, while branches on the left divide the sites into increasingly smaller sub-groups.

Expert judgment is usually required to determine which clusters best represent community classification units, e.g., at the scale and concept of a US-NVC association. Further review and expert interpretation of the sample data in Figure 3.2 allowed for identification and description of three major associations, identified as the Maple-Basswood Forest (represented by triangles), White Oak-Red Oak-Hickory Forest (represented by circles), and Chinkapin Oak bluff woodland (represented by asterisks).

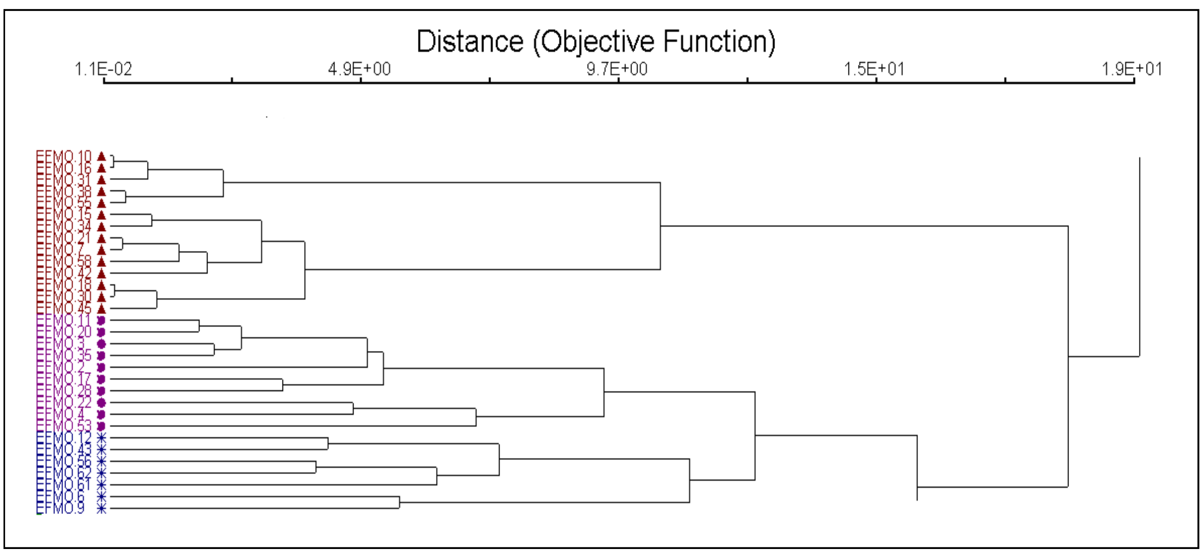


**Figure 3.2** Sample Dendrogram of Upland Forest Samples from Effigy Mounds National Monument, Iowa

In contrast to clustering, ordination groups species and/or samples along environmental gradients, and allows researchers to address the influence of environmental variables on species composition. Most of the common ordination techniques produce a scatter diagram that arranges data such that clusters of points indicate samples of the same or similar communities (Whittaker 1967, McCune and Mefford 1999). Figure 3.3 includes a scatter diagram and a set of interpreted polygons where an expert has grouped samples. Grouping of points on the ordination indicate that those samples and/or combination of species are more similar than others along the axes (i.e., floristic axes that reflect environmental gradients). In this example, each group is an NVC association, except the "Emergent/Submergent Wetlands," and "Other Wetlands" which include multiple associations represented by only a few plots.

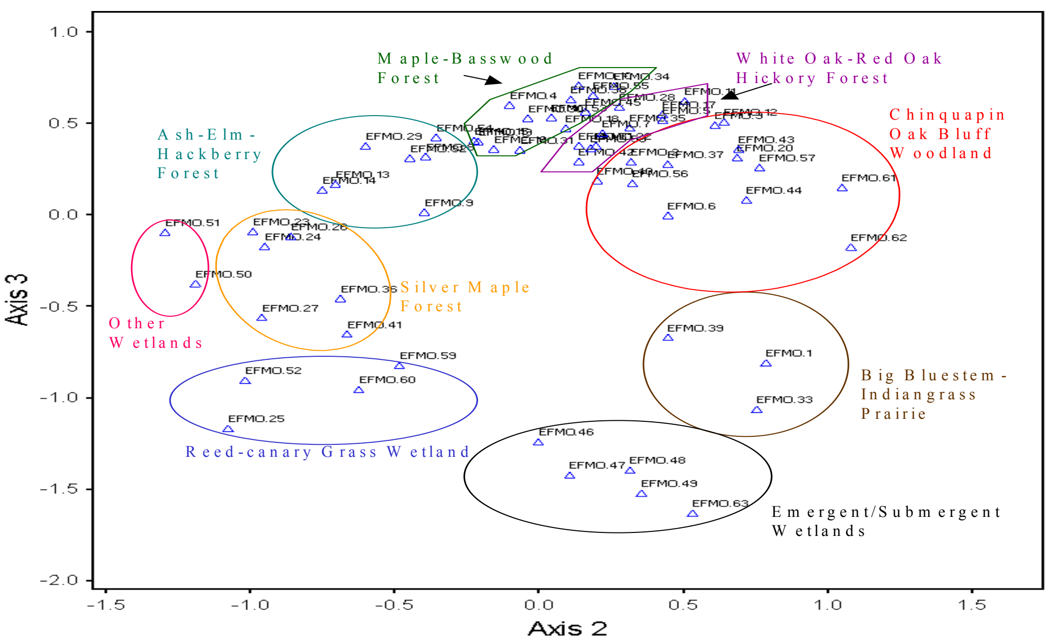


**Figure 3.3** Example Scatter Plot from Ordination of Upland Forest Samples from Effigy Mounds National Monument, Iowa

Clustering and ordination techniques can often be complementary. Clustering depends in part on grouping similar species and/or samples, whereas ordination depends on change over a continuous gradient. Either can provide a way to parse sample data into groups that make large and/or complex datasets easier to understand.

*3.3.1.4 Development of the NVC in the United States*

Ecologists in state natural heritage programs began in the late 1970s and 1980s collecting community information and developing state-level community classification systems. These classification systems organize state-level information on ecological communities, and identify ecological units that are recognized and endorsed by local experts (e.g., White and Madany 1978; Baker 1984; Nelson 1985; Reschke 1990; Schafale and Weakley 1990; Sawyer and Keeler-Wolf 1995). With the spread of natural heritage programs across all states, it became increasingly possible to integrate state and federal classification systems into one national system of classification. Throughout the late 1980s and 1990s, regional and national ecologists reviewed and integrated the state classification systems within each of the four NatureServe regions (Table 3.3). NatureServe and the member programs began using some associations classified in the US-NVC in the mid-1990s. That work is ongoing (see examples in Appendix C).

Portions of the US-NVC are better developed than others. For example, there are current efforts to update and reconcile forest association concepts throughout Montana, Idaho, Washington, and Oregon, along with portions of the C-NVC in British Columbia and Alberta. Other regional efforts to advance the US-NVC include work on sagebrush vegetation in the Intermountain West, mapping of U.S. National Parks, analyses by the USGS Gap Analysis Project, and regional assessments by other federal agencies and TNC.

**Table 3.3** The NatureServe Regions of the U.S.

| East | Southeast | Midwest | West |
|---|---|---|---|
| Connecticut | Alabama | Illinois | Alaska |
| Delaware | Arkansas | Indiana | Arizona |
| Maine | Florida | Iowa | California |
| Maryland | Georgia | Kansas | Colorado |
| Massachusetts | Kentucky | Michigan | Hawaii |
| New Hampshire | Louisiana | Minnesota | Idaho |
| New Jersey | Mississippi | Missouri | Montana |
| New York | North Carolina | Nebraska | Nevada |
| Pennsylvania | Oklahoma | North Dakota | New Mexico |
| Rhode Island | South Carolina | Ohio | Oregon |
| Vermont | Tennessee | South Dakota | Utah |
| Virginia | Texas | Wisconsin | Washington |
| West Virginia | | | Wyoming |

### *3.3.1.5 Development of an NVC in Canada*

Like the US-NVC, the C-NVC is building on the classification work done by provincial or local ecologists. Many provinces have already developed provincial or sub-provincial Forest Ecosystem Classifications (FECs). The general approach to integrating classifications across Canada was described in detail by Ponomarenko and Alvo (2000), who recommended the framework for building the C-NVC and bringing together the provincial classifications. NatureServe, the Canadian Forest Service (CFS), and provincial partners are collaborating to synthesize these classifications into a national and international set of association units. At this time, the CFS is working closely with provincial governments and conservation data centers to link provincial forest and woodland types with any defined associations of the C-NVC. NatureServe (central) staff is currently focused on working at the alliance level, integrating information on association and provincial units to describe alliance units.

*3.3.1.6 Taxonomic Reconciliation*

See Appendix C for examples of ecological community crosswalks used in the United States and Canada. These examples are illustrative of the range of circumstances and methods that have been employed to reconcile existing classifications with US-NVC types. Ongoing development of the C-NVC focuses on integration of existing classification systems from federal and provincial sources. Every association developed by CFS will be reviewed in the process of its integration into the C-NVC. In turn, the CFS process ensures that each association will be linked directly to provincial FEC units.

### 3.3.2 *Ecological Systems*

NatureServe has recently completed classification of terrestrial ecological systems in the conterminous U.S. Six hundred terrestrial ecological system units are described in the lower 48 states (of the United States) (Comer et al. 2003). Nearly 700 ecological system types have been described in Latin America (Josse et al. 2003).

## 3.4 Element-Level Data

NatureServe and its network of member programs maintain information in its databases on many attributes of approximately 70,000 tracked species, ecological communities and systems. Each element has an Element Tracking file (ET file) that serves as a condensed index to the codes, names, classification, distribution, and conservation status rank of all elements. The ET file is used to identify the individual or office that has responsibility for gathering and managing detailed data on each element (especially for assessing global conservation ranks and for writing descriptions). A global, national, and subnational (state or provincial) version of these files allows tracking of elements at these different geographic scales. It also lists the relationship between classification units in NatureServe's databases and related units in other state, regional, or national classification systems. These attributes are briefly described in the sections below. The attributes tracked are those that are thought to be most useful for conservation and management. Significant information on NatureServe's tracked elements can be found at http://www.natureserve.org/explorer/.

NatureServe has recently updated its *Benchmark Data Content Standards* (NatureServe 2004), which are intended to provide guidance, and to help ensure a high level of accuracy, currency, and quality to the species data that are maintained by the NatureServe network in the United States and Canada. Many of NatureServe's customers consider adherence to these standards as a certification that NatureServe's data meet documented quality requirements. The benchmark data standards reflect a NatureServe commitment to register its data collections with global data portals, such as the Global Biodiversity Information Facility (GBIF, http://www.gbif.org/). Through external portals such as GBIF, researchers can determine which components of NatureServe data will be useful to them. The standards allow NatureServe to measure and report on the quality of existing data, and to identify priorities for data development and management.

### 3.4.1 *Taxonomy*

For every taxon tracked in NatureServe's databases, information is maintained on the scientific name, higher level taxonomy (*e.g*., phylum, class, order, family, genus), author, and references for the concept (or circumscription) and the name. For all animals, vascular plants, nonvascular plants, and lichens, English common names are also recorded. For animal species, endemism within a single state or province is recorded. English common names and sequence numbers are recorded for higher taxa. For plants only, the author of the genus is recorded.

For terrestrial ecological communities, taxonomic standards implemented by NatureServe follow those laid out for the International Vegetation Classification, particularly as described for the US-NVC (Grossman et al. 1998; Jennings et al. 2003). These include scientific name and translated names for all associations, plus their placement within the physiognomic/floristic classification hierarchy. Common names for associations are tracked as available. Synonymy with other widely used classification systems is also tracked for most units, particularly those used by member programs.

Before 1998, when a nationally standardized system of vegetative classification did not yet exist, NatureServe member programs recorded information about ecological communities in a variety of state- and provincial-level systems of classification. As a result, the total number of occurrences of a given type of community has been difficult to determine. In the U.S., the US-NVC now provides a common basis for naming ecological communities, and data collected before its completion need to be reconciled or "crosswalked" with the units identified by the US-NVC. Ecologists in NatureServe's regional offices often compare US-NVC designations with those of state and local classifications, and assign an US-NVC identity to ecological communities. The crosswalk relationships might indicate where a type from one classification system is finer or broader in concept, or matching in concept to the NVC classification unit. When the C-NVC is completed, a similar process will be applied to Canadian data.

NatureServe's terrestrial ecological systems classification includes a nomenclatural standard, and all tracked units retain one scientific name (Comer et al. 2003). For all ecological classification units, a concept author, and applicable references are included.

### 3.4.2 *Conservation Status*

Conservation status ranks (see Section 3.5) are maintained for the following taxa (see Section 3.1.2):

- all full vertebrate animal species (native and non-native, excluding marine fishes) that regularly occur in the U.S. or Canada either as a native or an exotic species;
- all vertebrate animal infra-specific taxa that are included, officially proposed, or candidates on the U.S. Endangered Species Act in the U.S. or with a COSEWIC designation or General Status in Canada;
- all full species (native and non-native) of freshwater mussels, butterflies and skippers, crayfishes, tiger beetles, dragonflies and damselflies, grasshoppers, terrestrial and freshwater snails, stoneflies, mayflies, caddis flies, freshwater shrimps, cave obligates (an ecological grouping), and moths in the taxa Sphingidae, Saturniidae, Notodontidae, Arctiinae, Catacola, and Papaipema that regularly occur in the U.S. and Canada either as a native or an exotic species;
- all vascular plants, nonvascular plants, and lichens that regularly occur in the U.S. or Canada as a native species; and
- all natural associations in the IVC.

Units from upper levels of the US-NVC and C-NVC classification systems (e.g., alliances, formations, etc.) have not been assigned conservation status ranks. At the association level, the IVC makes a broad distinction between natural/semi-natural vegetation and planted/cultivated vegetation. Furthermore, in order to help set conservation priorities, it is also helpful to distinguish those communities that have little or no modification by human activity (i.e., natural/near natural communities) from those with some or extensive modification by humans (i.e., semi-natural/altered communities). Such a distinction is based on the correlation that conservationists and others make between naturalness and conservation priority. This is not to say that semi-natural or planted/cultivated communities have no conservation value; e.g., they may serve as important habitat for a particular rare species. But if a community type is assigned to a planted/cultivated or semi-natural status it will not be ranked. Thus, the following set of filters is applied to the application of conservation status assessment for communities.

I. NATURAL/SEMI-NATURAL VEGETATION
- A. Natural/Near-natural Vegetation
  - Apply conservation rank assessment process.
- B. Semi-natural/Altered Vegetation (including ruderal, invasive and modified vegetation)
  - Do not apply conservation rank assessment process.

II. PLANTED/CULTIVATED VEGETATION
  - Do not apply conservation rank assessment process.

Ecological system classification units will be assessed in the future, but this process has not yet begun.

### 3.4.3 *Distribution*

For all taxa listed in Section 3.4.2, as well as for vascular plants that are exotic and naturalized in the U.S. and Canada, the following distributional information is maintained: nation of occurrence (U.S. and Canada only), origin (native, exotic, or undetermined), regularity (regularly occurring, accidental/non-regular, or regularity uncertain), distribution confidence (confident, reported but unconfirmed, reported but doubtful, reported but false, potential, potential but false report exists, or never was there), current presence/absence (present, absent, or unknown/undetermined), and population status (animals only: year-round, breeding, non-breeding, or transient). In addition, full distribution outside of the U.S. and Canada (i.e., all nations of occurrence) is maintained for vascular plants that are globally rare or imperiled, and occur in the U.S. or Canada. For example, the information maintained for a rare plant of the Aleutian Islands will indicate its distribution in Russia if applicable, and information on a rare plant of South Florida will indicate its distribution in any Caribbean nation. Nation of occurrence and digital range maps are maintained for all mammals, birds, and amphibians that occur regularly in the Western Hemisphere. Watershed of occurrence (8-digit HUC) distributions are maintained for all freshwater fishes of the conterminous U.S.

U.S. state of occurrence and Canadian province of occurrence information is maintained for:

- all full vertebrate animal species (native and non-native, excluding marine fishes) that regularly occur in the U.S. or Canada, either as a native or exotic species;
  - all infra-specific taxa that are included, officially proposed, or candidates on the U.S. Endangered Species Act in the U.S. or with a COSEWIC designation or General Status in Canada;

- all full species (native and non-native) of freshwater mussels, butterflies and skippers, crayfishes, tiger beetles, dragonflies and damselflies, freshwater snails, and cave obligates (an ecological grouping) that regularly occur in the U.S. and Canada, either as a native or exotic species;
- all full species of invertebrates ranked GX, GH, G1, G2, or G3 in the following groups: grasshoppers, terrestrial snails, stoneflies, mayflies, caddis flies, freshwater shrimps, and moths in the taxa Sphingidae, Saturniidae, Notodontidae, Arctiinae, Catacola, and Papaipema;
- all vascular plants that regularly occur in the U.S. or Canada either as a native or exotic species; and
- all ecological communities and ecological systems in the U.S., and alliances in the U.S. and Canada.

### 3.4.4 *Habitat and Ecology*

Using a coarse species habitat classification of 56 marine, estuarine, riverine, lacustrine, palustrine, terrestrial, and subterranean habitat types, NatureServe's databases record the habitats for a) all native vertebrate animal species (excluding marine fishes) and all cave obligate species; b) any infra-specific taxa that are included, officially proposed, or candidates on the U.S. Endangered Species Act, COSEWIC, or Canadian national General Status lists; and c) butterflies, skippers, and grasshoppers ranked GH─G3 (see Section 3.5.2 for more information about G ranks and the NatureServe methodology for assessing conservation status). The NVC and ecological systems were not available when this classification was developed in the mid-1980s, and now with the advent of a classification of ecological systems, NatureServe plans to relate all tracked species in the central databases to ecological systems (see Section 5.3). An effort is currently underway to record the habitats for additional invertebrate groups. In addition, habitat, phenology, mobility/migration, ecology, and reproduction comments are recorded for all native U.S. and Canadian vertebrate species, excluding marine fishes.

Habitat descriptions are maintained for about 80% of imperiled (GX─G2) vascular plants in the above categories and for many G3 and more secure species and infra-specific taxa. Ecological and phenological/reproductive data for plants have been developed more sporadically. For both plants and animals, efforts are just beginning to associate imperiled and vulnerable taxa with the specific ecological systems in which they are found. Ecological system units serve as useful descriptors of habitat for most species of conservation concern, thus allowing a standard, more readily analyzable way of characterizing habitat, as well as creating new opportunities for high-resolution habitat modeling, more efficient field inventory, environmental monitoring, and conservation assessment.

Descriptions of units of ecological classification include information about vegetation, physiognomy, composition, geophysical characteristics, and natural disturbances. Data are most comprehensively developed for US-NVC alliance and NatureServe ecological system units. However, most US-NVC associations also have summary descriptions.

### 3.4.5 *Management*

NatureServe's databases record information about the management needs for species and ecological communities and systems. Summary management information is recorded for approximately 1,780 taxa and communities. More detailed assessments of management needs and requirements and existing management programs have been made for approximately 585 plant and animal species. These detailed *element management abstracts* (previously known as *element stewardship abstracts*) summarize the best available information about the management needs for a particular species, group of species, or ecological community, as well as detailed characterization information such as habitat or environmental setting.

## 3.5 Conservation Status Assessment

NatureServe has developed a consistent method for assessing the conservation status of species of plants, animals, and fungi, as well as ecological communities and systems. This assessment leads to the designation of a conservation status rank, which for species elements provides an initial estimate of the risk of extinction or extirpation (Master 1991; Master et al. 2003). For ecological elements, it provides an initial estimate of the relative rarity of an ecological community or ecosystem type, along with trends in the overall abundance and quality of all occurrences. Classification of ecological systems has only recently been completed in the U.S. (and has not yet begun in Canada or LAC), so conservation status assessments have not yet been developed.

### 3.5.1 *Conservation Status Factors*

Many factors can contribute to the decline and ultimate demise of a species or community type, and NatureServe biologists and cooperators assess the condition of each species based on multiple factors (Table 3.4) that have been established in the scientific literature as important to the probability of persistence. While other systems focus entirely on documenting the status of species, the NatureServe system also addresses ecological classification units (e.g., associations). All of the factors listed in Table 3.4, excluding population size, apply to the ecological community types.

The factors considered in assessing the conservation status of elements reflect two theories as to why species go extinct. These theories are encapsulated in the small population paradigm and the declining population paradigm (Caughley and Gunn 1996). The small population paradigm refers to the risk of extinction for species that are rare (Rabinowitz 1981). For example, the rare shrub, *Epacris stuartii,* is known from only one location in southeastern Tasmania, has a restricted range of about 300 $m^2$ and a population size of approximately 1000 individuals (Keith and Ilowski 1999). Such rare species are particularly vulnerable to anthropogenic disturbances, predators, natural disturbances, and natural dynamics of populations. Rarity is addressed by considering factors such as the number of element occurrences (e.g., number of populations) and their condition (likelihood of persistence), the total population size, the geographic range of the species, and the occupied habitat within the range.

Vulnerability to extinction is not isolated to rare species. Abundant species that are declining are also cause for concern. For example, the passenger pigeon (*Ectopistes migratorius*) was once North America's most abundant bird species until it was driven to extinction through hunting and deforestation (Schorger 1995). The NatureServe system addresses the declining population paradigm (Caughley 1994) by considering additional factors such as trends in population size and the scope, severity, and immediacy of any perceived threats.

The adequacy of management initiatives for protecting the element is also considered, as well as the degree to which inherent factors such as intrinsic vulnerabilities (such as life history or behavioral characteristics of species) or environmental specificity (habitat preferences or restrictions) make an element vulnerable to natural or anthropogenic disturbances (Master et al. 2003).

**Table 3.4** Factors Considered by NatureServe in Assessing Conservation Status of Species, Ecological Communities, and Ecological Systems.

| **Factor considered** | **Used to Assess** | |
|---|---|---|
| | **Species** | **Ecological Communities and Systems** |
| Number of occurrences (populations or areas of characteristic vegetation pattern) | √ | √ |
| Number of occurrences with good viability or integrity | √ | √ |
| Population size | √ | |
| Range extent | √ | √ |
| Area of occupancy | √ | √ |
| Long-term trend | √ | √ |
| Short-term trend | √ | √ |
| Threats: scope, severity, and immediacy | √ | √ |
| Number of protected and managed occurrences | √ | √ |
| Intrinsic vulnerability | √ | √ |
| Environmental specificity | √ | √ |
| Other considerations | √ | √ |

Other well-known ranking systems also assess many of the same factors (Table 3.5), and these systems also pay particular attention to population size and trends as major factors. There are good reasons for this. In a study of 16 parameters used in these categorization systems for > 45 taxa, O'Grady et al. (2004) found that the best predictors of extinction risk were current population size and rate of change in population size. Further, simple count-based population viability assessment (PVA) models, based solely on initial population size and variation in population size, have similar predictive abilities to full PVA models (Brook 1999).

### 3.5.2 *NatureServe Methodology for Assessing Conservation Status*

Each conservation status rank factor (Table 3.4), except Other Considerations, has at least two data fields in NatureServe's databases: one or more fields for a short code (with an associated word or short phrase) that indicates the assessment (usually quantitative) for that factor, and a text comment field. Codes are all expressed as either single letters (e.g., A, B) or as letter combinations indicating the estimated range of uncertainty (e.g., AB, BCD, or BD). See Table 3.6 for an example of these values.

**Table 3.5** Biological Attributes of Taxa Assessed by the IUCN -The World Conservation Union Red List (IUCN), Florida Game and Freshwater Fish Commission (FG&FFC), and NatureServe Categorization Systems (adapted from O'Grady et al. in press)

| | **Conservation Status Ranking System** | | |
|---|---|---|---|
| **Attributes assessed** | **IUCN** | **FG&FFC** | **NatureServe** |
| Distribution (area; extent) | √ | √ | √ |
| Distribution trend | √ | √ | √ |
| Population size | √ | √ | √ |
| Population trend | √ | √ | √ |
| Population concentration | √ | √ | √ |
| Ecological specialization | | √ | √ |
| Protection from threats | | √ | √ |
| Taxonomic significance | | √ | √ |
| Recovery potential | | √ | |
| Quality of habitat | √ | | √ |
| Fluctuations in population size or distribution | √ | | |
| Population fragmentation | √ | | |
| Quantitative estimate of probability of extinction | √ | | |
| Susceptibility to threat | √ | | |
| Threat magnitude/immediacy | | | √ |
| Number of occurrences (populations) | | | √ |
| Number of occurrences trend | | | √ |
| General characteristics promoting susceptibility to threat/s (not assessed in the above categories) | | √ | √ |

**Table 3.6** Sample Rank Factor Codes for Area of Occupancy (from Master et al. 2003)

| **Rank Factor Code** | **Area of Occupancy** |
|---|---|
| Z | 0 $km^2$ |
| A | <0.4 $km^2$ (< 100 acres) |
| B | 0.4–4 $km^2$ (~ 100–1,000 acres) |
| C | 4–20 $km^2$ (~ 1,000–5,000 acres) |
| D | 20–100 $km^2$ (~ 5,000–25,000 acres) |
| E | 100–500 $km^2$ (~ 25,000–125,000 acres) |
| F | 500–2,000 $km^2$ (~ 125,000–500,000 acres) |
| G | 2,000–20,000 $km^2$ (~ 500,000–5,000,000 acres) |
| H | >20,000 $km^2$ (> 5,000,000 acres) |
| U | Unknown |

Based on an analysis of the factors in Table 3.4, a trained assessor familiar with the element compiles the available information on the rank factors and assigns a conservation status rank. Typical sources of data for these assessments include published studies as well as unpublished reports and studies (e.g., status surveys done for the U.S. Fish and Wildlife Service, systematic community inventories by NatureServe member programs). New employees are taught to assess status ranks at bi-annual training sessions, and experienced assessors receive ongoing training from NatureServe (central) Science Division staff. Global conservation status ranks are centrally reviewed and then published with their associated documentation.[7]

The process usually treats some factors conditionally such that some factors are emphasized only in the absence of information about more key factors. In particular, the number of occurrences, population size, area of occupancy, short-term trends in these factors, and threats are usually emphasized above other factors. Where knowledge is lacking about number of occurrences and area of occupancy, environmental specificity becomes more important. Lacking information about threats, the number of adequately protected occurrences and the element's intrinsic vulnerability are given increased consideration. For plants, the species overall range, and the amount of appropriate habitat within that range (related to environmental specificity), along with any known threats to that particular habitat can often be used to make a preliminary conservation status assessment when survey data (number of occurrences and population size) are not available.

[7] Global, national, and subnational (state/provincial/territorial) conservation status ranks for individual species and communities can be viewed online at the NatureServe Explorer website (www.natureserve.org/explorer).

Given the relative newness of the IVC and available information on the associations, the procedure for assessing the conservation status of ecological communities has been somewhat different than it has been with species (see Grossman et al. 1998, Appendix B). In principle, the two primary factors used in assessing the conservation status for an association are a) the total number of occurrences, and b) the total area (acreage) of the element. Secondary ranking factors such as the geographic range over which the element occurs, the threats to the occurrences, and the ecological integrity of the occurrences also affect the assessment. However, information on these factors is often incomplete and it has been necessary to use a preliminary assessment procedure. The four main factors useful in arriving at a preliminary assessment of a community's range-wide (global) ranking include:

1. the geographic range over which the type occurs;
2. the long-term decline of the type across this range;
3. the degree of site-specificity exhibited by the type; and,
4. the relative imperilment across the range based on subnational ranks assigned by member programs.

Most of the ranks currently applied to US-NVC types are based on such preliminary assessments of imperilment.

Conservation status ranks are based on a scale of one to five (Table 3.7), ranging from critically imperiled range-wide (G1) to demonstrably secure (G5). In addition, ranks are available for species presumed to be extinct, and those that are missing and that may possibly be extinct.

NatureServe global or range-wide conservation status assessments (designated "G" for global) are augmented by national ("N") and state/provincial/territorial ("S" for subnational) assessments. Combining global and sub-national status ranks (e.g., G3, S1 in Georgia) provides a useful perspective, placing risk levels in a geographic context and helping to set conservation priorities. The bog turtle (*Clemmys muhlenbergii*), for example, is a small turtle that ranges from New York and southwestern New England discontinuously to far northern Georgia. Although not as rare as once thought (100–200 occurrences range-wide), the species is uncommon and is adversely affected by habitat alteration and over-collection for the pet trade. Many occurrences do not represent viable populations. Based on current information, NatureServe biologists regard the turtle as vulnerable at global (G3) and U.S. national (N3) levels. Even though the species is listed as a U.S. threatened species under the Endangered Species Act, its local status differs across its limited range. In the heart of its range, the species is considered imperiled (S2) in New York, New Jersey, Pennsylvania, and Maryland; elsewhere the species is considered critically imperiled and is ranked S1. Thus, the ranks in Maryland are G3S2, and in North Carolina they are G3S1.

National ranks are infrequently used in the United States, due to the presence of subnational data centers and the fact that the combination of global and subnational conservation status assessments provides adequate assistance in inventory and conservation site prioritization, and state-of-the-environment reporting. In Latin America, national ranks are more commonly used due to the presence of country-wide CDCs and the lack of subnational status assessments.

**Table 3.7** NatureServe Global Conservation Status Ranks

| **Rank**[a] | **Description** |
|---|---|
| GX | **Presumed Extinct.** Not located despite intensive searches and virtually no likelihood of rediscovery. |
| GH | **Possibly Extinct.** Missing; known from only historical occurrences but still some hope of rediscovery. |
| G1 | **Critically Imperiled.** At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors. |
| G2 | **Imperiled.** At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors. |
| G3 | **Vulnerable.** At moderate risk of extinction or of significant conservation concern due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors. |
| G4 | **Apparently Secure.** Uncommon but not rare; some cause for long-term concern due to declines or other factors. |
| G5 | **Secure.** Common; widespread and abundant. |

[a]Note: "G" refers to global or range-wide conservation status for a species or ecological community. Infra-specific taxa (subspecies, varieties, and populations) are given an equivalent "T" ranking. For example, the conservation status ranking for an imperiled subspecies of a globally secure species would be G5T2.

### 3.5.3 *How Do NatureServe Status Rankings Compare with Those of Other Ranking Systems?*

There is a close correspondence between NatureServe status ranks and those of other conservation science organizations. Comparisons of ranks for communities with other systems is not possible, since no other ranking systems have been developed that are comparable to that of NatureServe's system. However, species considered endangered, threatened, vulnerable, or near-threatened under other systems such as the Red List system of IUCN—the World Conservation Union or the system of the American Fisheries Society—are generally considered imperiled, vulnerable, or at risk of extinction (i.e., ranked GH, G1, G2, or G3) by NatureServe. Table 3.8 shows roughly equivalent categories in these three systems of conservation status categorization. Differences in emphasis between the systems (e.g., IUCN's method may weigh trends more heavily than NatureServe's system in some cases) and different minimum data requirements for each system lead to different statuses in some cases. Nonetheless, O'Grady et al. (2004) similarly found "the systems employed by the IUCN, NatureServe, and the Florida Game & Freshwater Fish Commission (FG&FFC) provide a positively correlated priority ranking of species and these are related to predicted extinction risk".

In contrast to the status assessments of these organizations, species may also be legally "listed" as endangered or threatened in many U.S. states and Canadian provinces, or by their national governments. Due to legal, financial, political, and other constraints, these official lists are an incomplete reflection of the conservation status of U.S. and Canadian species. For example, many states do not officially list invertebrates or plants, and imperiled species in both these species groups are relatively under-represented in listing under the U.S. Endangered Species Act. See Master, Stein, and Kutner (2000) for a more complete comparative analysis of NatureServe, AFS, IUCN, and Endangered Species Act categorizations of endangerment.

**Table 3.8** Comparative Status Ranks for Species, under Three Different Systems

| IUCN Red List Status | NatureServe Status | American Fisheries Society Status |
|---|---|---|
| Extinct | Presumed Extinct (GX) | Extinct (X) |
| Extinct | Possibly Extinct / Historic (GH) | Extinct (X) |
| Critically Endangered or Endangered | Critically Imperiled (G1) | Endangered (E) |
| Vulnerable | Imperiled (G2) | Threatened (T) |
| Near Threatened | Vulnerable (G3) | Vulnerable (V) |
| Least Concern | Apparently Secure (G4) or Secure (G5) | Currently Stable (CS) |
| Data Deficient | 'Range rank' or GU | Undetermined (U) |

### 3.5.4 *Maintaining Quality and Consistency of Element Rankings*

NatureServe maintains quality and consistency in conservation status assessment through training, data exchanges, listserv discussions, regional meetings, and, for global statuses, a central review process. Global conservation status assessments, whether assigned by NatureServe (central) scientists, member program biologists/ecologists, or outside experts, are centrally reviewed. Any differences of opinion about an assigned status are debated, and if consensus is not reached (a very rare occurrence) NatureServe's chief zoologist/botanist/ecologist is the final arbiter for global status assessments for animals, plants, and ecological communities, respectively.

All persons are encouraged to provide new information or critiques of existing conservation status assessments. For example, a Forest Service biologist reviewing the data behind an assessment of a globally rare plant may perceive that the data posted on NatureServe Explorer does not reflect the number of occurrences, management status, and threats to occurrences occurring on the national forest in which he/she works. The biologist is strongly encouraged (from the NatureServe Explorer website and from training provided to partner organizations and other stakeholders) to provide new information to NatureServe. This input may be provided to NatureServe through on-line submission of the NatureServe Explorer feedback form, through direct email, or through other contacts with central science staff or member program staff. NatureServe staff is responsible for assigning and maintaining the conservation status of species review information submitted. If it is warranted, a review and update of the status is carried out.

Conservation status assessments must be continually reviewed, refined, and updated to reflect advances in knowledge and changes in biological or ecological conditions. NatureServe biologists rely on the best available information in making and documenting conservation status determinations, including such sources as natural history museum collections, scientific literature, ongoing research projects, and documented observations by knowledgeable biologists. To augment this existing knowledge, NatureServe member program biologists conduct extensive field inventories and population censuses, especially targeting those species thought to be at greatest risk, or for which little information exists. Indeed, most changes in status assessments from year to year tend to reflect this improved scientific understanding of the actual condition of the elements. As the process of reviewing conservation status ranks is carried out, scientists, conservationists, landowners, and land managers with knowledge about tracked elements are encouraged to provide member programs and NatureServe (central) with relevant information and data.

The review of a global conservation status rank may be triggered by many different "events," including the following:

- A subnational rank has been changed by a member program for an element with a somewhat limited range (i.e., the new subnational status can mean a significant change in the range-wide status). This usually happens when field research has indicated a change in status is warranted. The new status information can be communicated to NatureServe (central) during a data exchange or outside of a data exchange, or it can be detected through regular quality control checks.
- A member program or other knowledgeable biologist directly recommends a new range-wide conservation status rank based on their research and/or based on their communications with other programs throughout the element's range. Such recommendations are systematically reviewed during each program's data exchange, but new conservation status recommendations may be made at any time.
- NatureServe (central) or a member program receives funding to research and review the range-wide status on a particular subset of elements. The researchers consult literature (published and gray), look at the tabular information associated with element occurrences (e.g., last observation date), and in some cases consult local land managers for a status update on the element. In the case of a member program, additional fieldwork and site visits may be conducted.
- Notification is received that a review of the global conservation status is needed (e.g., a new recommended rank is received during data exchange with a NatureServe member program, or communication is received from a knowledgeable source such as a member program or expert outside the network).
- The subnational or national statuses appear to be in conflict with the global status (e.g., G3S5).
- An existing element undergoes a major taxonomic change.
- Any other information is received (e.g., a status change under the U.S. Endangered Species Act; an updated Red List) that appears to be in conflict with the current NatureServe conservation status.

NatureServe reviews global conservation status ranks at least every 5 years for all animal species in NatureServe's "core groups" (vertebrates and well-studied invertebrate groups [see list at http://www.natureserve.org/getData/vertinvertdata.jsp]) and for any other federally (United States or Canada) listed animal taxa (species or subspecies). For species ranked GX–G3, NatureServe continually updates the documentation of its ranks (e.g., threat and trend information) as new information becomes available (e.g., completion of a status survey in which many new occurrences are documented).

For vascular plant taxa native to the United States or Canada, the rank review emphasis has been on GX–G3- and GU-ranked taxa. NatureServe has reviewed >40% of the GX–G3-ranked species within the last five years, but <10% of the G4–G5-ranked species. For species ranked GX–G3, NatureServe tries to ensure that reasons are documented for the rankings; about 90% of the GX–G3 species have ranking reasons. Newly described species nearly always have a ranking entered for them at the time the species is entered into the databases. In addition to status information, complete state and provincial distributions are maintained for all North American vascular plants, and for GX–G3 plants, and NatureServe tries to maintain complete national distribution outside of the U.S. and Canada. In addition to data for vascular plants, NatureServe maintains selected information on North American nonvascular plants and lichens.

Similar procedures are followed for establishing and updating conservation status rankings for ecological communities. In many instances, review is completed in a systematic fashion for G1–G3 IVC associations where their classification status has been updated and new inventory work has been completed. Conservation status ranks have not been applied to community elements above the association level of the IVC, but will be developed in the future for ecological system units.

### 3.5.5 *Summary of Conservation Status Rankings*

NatureServe conservation status rankings have been assigned to almost all U.S. and Canadian species and communities tracked in NatureServe central databases. Table 3.9 provides a summary of these statuses for U.S. elements.

### 3.5.6. *Application of Conservation Status Assessments to Forest Certification*

One of the first steps in assessing the importance of biodiversity conservation to forest certification programs is the identification of at-risk elements of biodiversity. Much detail about the status and vulnerability of biodiversity is not known; thus, some reasonable standard must be provided for those elements of biodiversity that can be adequately identified and located. NatureServe provides a system in which it is possible to identify those elements, and to manage for their conservation.

For ecological communities, the SFI Standard (4.1.4.1.1) relies on the associations units of the IVC (as documented in both the US-NVC and C-NVC). The listed conservation status of each association defines those types that are considered critically imperiled (G1)[8] and imperiled (G2). As of September 2003, 1,647 associations met these criteria for the United States and 124 associations meeting these criteria were listed for Canada. The relatively low numbers of G1–G2 associations listed for Canada primarily reflects the early stages of development of standard C-NVC association units. Many more units are yet to be fully described and standardized.

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[8] See Section 3.5 for an explanation of global ranks (G1, G2, G3, etc.).

**Table 3.9** Global Conservation Status of U.S. Species and Ecological Communities

| Taxa[b] | Conservation Status Rank[a] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | GX | GH | G1 | G2 | G3 | G4 | G5 | Other | |
| **VERTEBRATES** | | | | | | | | | |
| Mammals | 1 | 1 | 12 | 16 | 47 | 102 | 274 | 2 | 455 |
| Birds | 20 | 10 | 27 | 24 | 42 | 103 | 632 | 0 | 858 |
| Reptiles, turtles, and crocodilians | 0 | 0 | 9 | 19 | 37 | 56 | 217 | 4 | 342 |
| Amphibians | 1 | 1 | 36 | 38 | 44 | 46 | 107 | 1 | 274 |
| Freshwater fishes | 19 | 4 | 120 | 75 | 117 | 204 | 357 | 32 | 928 |
| Vertebrates subtotal | 41 | 16 | 204 | 172 | 287 | 511 | 1,587 | 39 | 2,857 |
| **INVERTEBRATES** | | | | | | | | | |
| Freshwater mussels | 17 | 21 | 84 | 42 | 48 | 45 | 42 | 7 | 306 |
| Snails (land and freshwater) | 36 | 119 | 787 | 341 | 235 | 158 | 327 | 664 | 2,667 |
| Crayfishes | 1 | 2 | 59 | 52 | 59 | 93 | 73 | 1 | 340 |
| Butterflies and skippers | 0 | 0 | 13 | 30 | 83 | 109 | 390 | 9 | 634 |
| Tiger beetles | 0 | 0 | 5 | 4 | 15 | 18 | 61 | 1 | 104 |
| Stoneflies and mayflies | 4 | 27 | 155 | 149 | 201 | 266 | 418 | 11 | 1,231 |
| Grasshoppers | 0 | 22 | 103 | 126 | 43 | 90 | 309 | 56 | 749 |
| Dragonflies & damselflies | 0 | 4 | 8 | 29 | 48 | 104 | 270 | 0 | 463 |
| Other invertebrates | 5 | 164 | 977 | 459 | 362 | 685 | 1,065 | 2,772 | 6,489 |
| Invertebrates subtotal | 63 | 359 | 2,191 | 1,232 | 1,094 | 1,568 | 2,955 | 3,521 | 12,983 |

(Continued on next page. See notes at end of table.)

**Table 3.9** Continued

| Taxa[b] | Conservation Status Rank[a] | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | GX | GH | G1 | G2 | G3 | G4 | G5 | Other | |
| **VASCULAR PLANTS** | | | | | | | | | |
| Ferns & fern allies | 0 | 4 | 41 | 41 | 66 | 172 | 256 | 43 | 623 |
| Conifers | 0 | 0 | 6 | 6 | 9 | 32 | 64 | 13 | 130 |
| Flowering plants | 10 | 133 | 1,105 | 1,498 | 2,546 | 4,539 | 6,008 | 3,176 | 19,015 |
| Vascular plants subtotal | 10 | 137 | 1,152 | 1,545 | 2,621 | 4,743 | 6,328 | 3,232 | 19,768 |
| **NONVASCULAR PLANTS** | | | | | | | | | |
| Mosses, Liverwort and Hornworts | 1 | 6 | 79 | 98 | 228 | 550 | 618 | 97 | 1,677 |
| Lichens | 0 | 2 | 45 | 65 | 190 | 563 | 321 | 611 | 1,797 |
| Nonvascular plants subtotal | 1 | 8 | 124 | 163 | 418 | 1,113 | 939 | 708 | 3,474 |
| **ECOLOGICAL COMMUNITIES** | | | | | | | | | |
| Terrestrial (upland and wetland) associations | 0 | 5 | 603 | 1,082 | 1,321 | 950 | 374 | 949 | 5,284 |
| **TOTAL** | **115** | **525** | **4,274** | **4,194** | **5741** | **8885** | **12,183** | **8,449** | **44,366** |

[a]GX = Presumed Extinct, GH = Possibly Extinct, G1 = Critically Imperiled, G2 = Imperiled, G3 = Vulnerable, G4 = Apparently Secure, G5 = Secure, Other = GU and GNR

[b]Conservation status assessments have not yet been done for ecological systems

Associations listed as vulnerable (G3) fall under the category of "other SFI indicators" in the certification standard. As of September 2003, there were 1,263 associations meeting the vulnerable criteria documented for the United States and 136 associations documented for Canada.

Under the SFI certification standard, *"program participants shall have policies to promote habitat diversity at stand and landscape levels"*. Core indicators include plans to *locate* and *protect* known sites of critically imperiled (G1) and imperiled (G2) associations. This generally requires the involvement of personnel with sufficient background and training to utilize available information and recognize these associations in the field. SFI participants must then be prepared to develop management prescriptions to secure important natural processes that support these communities. Available information could include descriptions of ecological and management information on the NatureServe Explorer website. It could include type-specific and location-specific element occurrence information from NatureServe and/or from member programs. It could also include maps, descriptions, and dichotomous keys developed locally.

SFI certification standards also call for training of appropriate personnel for the identification and protection of critically imperiled (G1) and imperiled (G2) associations. Training materials may be developed from the information sources listed previously. In most cases, expertise for training should include knowledgeable staff from NatureServe and/or member programs.

In addition, NatureServe data are useful for addressing SFI standards requiring policy that sets criteria for retention of stand-level wildlife habitat elements. Field-based observation and experience in the protection and management of critically imperiled (G1) and imperiled (G2) associations may be documented in standard fields of the Biotics 4 database managed by NatureServe. Occurrence Ranking Criteria (detailed in Section 4.1.3) include descriptions of ecological attributes, such as forest composition, structure, and natural disturbance regimes, and where available, may be used for evaluating current conditions and establishing management prescriptions. This information may apply to both stand- and landscape-level management prescriptions.

## 4.0 ELEMENT OCCURRENCES: TRACKING BIODIVERSITY IN THE FIELD

The previous section reviewed how the NatureServe methodology identifies the elements of biodiversity—species, communities, and ecological systems—that have sufficient information to be tracked, and how their conservation status is assessed based on available information. In this section, an explanation is provided regarding the way that the NatureServe network gathers information from the field to document the individual occurrences (populations or stands) of these elements, and assesses their viability or integrity. Over time, as the occurrences are documented, they provide new data that can be used to re-assess the conservation status of elements at risk.

### 4.1 The Element Occurrence (EO) Data Standard

As part of an ongoing effort to upgrade and document the basis for their methodology, NatureServe recently compiled a comprehensive report that sets the standards for documenting occurrences.[9] The main features of that standard are highlighted here.

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[9] Note that Section 4.1 is an abbreviated version of the NatureServe's Element Occurrence Data Standard, which is posted at http://whiteoak.natureserve.org/eodraft/index.htm (NatureServe 2002a).

### 4.1.1 *Definition of Occurrences (EOs)*

The concept of an element occurrence (EO) is one of the fundamental ideas of NatureServe methodology. To be useful for on-the-ground conservation and environmental planning, elements must be mapped at a precise level of detail, and from both evolutionary and conservation perspectives, a population is the most appropriate species-level unit to map. However, the detailed genetic and demographic information needed to define populations is limited to a relatively small number of well-studied populations. In the absence of detailed population information, there are operational considerations, which, while not meeting the demanding standards of population geneticists, can serve as a useful approximation for population units. Primary among these considerations are spatial coherence and geographic separation from other such units, and these considerations are what are used to define element occurrences (Stein and Davis 2000). By comparing the relative viability and ecological integrity of consistently delineated occurrences, one can make informed judgments about their conservation. Similarly, from a community or ecological system, a stand or cluster of stands is the most appropriate scale at which to map occurrences, as these are the most meaningful units for site management or conservation planning, as well as for describing landscape patterns.

An EO is an area of land and/or water in which an element is, or was, present. An occurrence should have practical conservation value for the element as evidenced by potential continued (or historical) presence and/or regular recurrence at a given location. For species[10] , the occurrence often corresponds to the local population, but when appropriate, it may be a portion of a population (e.g., for long-distance dispersers) or a group of nearby populations (i.e., a metapopulation). For ecological communities and systems, the occurrence may represent a recognizable stand or patch of the type, or a cluster of stands or patches of the type. Because they are defined on the basis of biological and ecological information, occurrences may cross political jurisdictional boundaries.

There are two kinds of occurrences: principal occurrences and sub-occurrences. The principal occurrence conceptually represents the entire occupied area (e.g., the known occupied home-range area for one or more nearby pairs of peregrine falcons within the separation distance—see Section 4.1.2). Within this area, there may be smaller geographically distinct areas for which information is usefully assembled for conservation planning, biological monitoring, or biological management at local levels (e.g., individual ponds within a pond complex). These geographically nested components are referred to as sub-occurrences. The individual *source features* that may be part of a principal occurrence may also be used instead of sub-occurrences to record information about sub-areas within a larger principal occurrence. For example, it may be useful to record information about the locations and productivity of pairs of bald eagles or their nests with a larger occurrence comprised of multiple pairs of nesting bald eagles.

The characteristics of principal occurrences are defined for each species or ecological element (see Section 4.1.2 below, "Occurrence Specifications"). Generally, a principal occurrence corresponds to a population or metapopulation.[11] Principal occurrences are typically separated from each other by

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[10] In this document, the term "species" may include all entities at the taxonomic level of species (including interspecific hybrids), as well as all subspecies and plant varieties. Subspecies and varieties are collectively termed "infraspecific taxa". Other subsets of species (e.g., geographically distinct population segments not recognized as infraspecific taxa) are also included. Occurrences are also recorded for recurrent, transient, mixed-species animal assemblages (e.g., shorebird concentration areas).

[11] For animals, metapopulation structure may arise when habitat patches are separated by distances that the species is physically capable of traversing, but that exceed the distances most individuals move in their lifetime (that is, the patches support separate subpopulations). If habitats are so close together that most individuals visit many patches in their lifetime, the system will tend to behave as a single continuous population (Gutierrez

barriers to movement or dispersal, or by specific distances defined for each element across either unsuitable habitat, or suitable habitat that is not known to be occupied by that element. A principal occurrence may be a single contiguous area or may be comprised of discrete patches or subpopulations. For species, a principal occurrence conceptually represents the full *occupied habitat* (or previously occupied habitat) that contributes, or potentially contributes, to the persistence of the species at that location.

For ecological elements, principal occurrences represent a defined area that contains (or contained) a characteristic species composition and structure, and environmental regime. Principal occurrences are separated from each other by barriers to species interactions, or by specific distances defined for each type across adjacent areas occupied by other, distinctly different natural or semi-natural land cover, or by cultural land cover.

Rarely, principal occurrences of the same element can overlap or contain another principal occurrence; however, in such cases, the features must have significantly different levels of associated information. An example of a situation in which this might occur would be when an occurrence based on general historical information is created, and then a second, much smaller, occurrence is developed from new field survey data that locates a specific site for that element within the boundaries of the first. Both principal occurrences are retained until additional survey work establishes that the second occurrence is actually the same as the first and should therefore replace it. Similarly, two or more historical occurrences for the same element may overlap when their precise locations are unknown and they are therefore mapped with spatial uncertainty buffers.

Although a principal occurrence conceptually represents the full occupied habitat (for species) or area (for communities and systems), the evidence for a particular occurrence may not necessarily provide an understanding of the full extent of the occurrence. Whether the full extent of occupied habitat or area is actually known for an occurrence may depend on different factors, including the intensity and extent of survey, the accessibility of all potential habitat to the surveyor, the types of survey techniques employed, characteristics of the element (e.g., plants that seed bank, animals with secretive behaviors), and the level of expertise of the person(s) collecting data. In cases where knowledge of the full extent or area of an occurrence is not known, only the portion of the occupied habitat or area that is known from the evidence available is recorded. The occurrence record indicates whether the full extent of occupied habitat or area of an occurrence is known by distinguishing between situations for which there is a) confidence that the full extent of the occurrence is known; b) confidence that the full extent of the occurrence is *not* known; and c) uncertainty whether the full extent of the occurrence is known.

In some cases, an occurrence may be so extensive that it is impracticably large for information management or site-level conservation action (e.g., many migratory birds, whales, some riparian plants). For example, all of the individuals of a migratory bird species breeding over an area of thousands of square kilometers may function as a single population, making it impractical to treat this population as a single principal occurrence. In these situations, principal occurrences are defined on the basis of separation distances, or natural or cultural geographic features (but not jurisdictional or political boundaries) that subdivide the population (e.g., watershed boundaries). In such cases, the population (or metapopulation) structure should still be considered in management planning.

For migratory species that utilize geographically and seasonally disjunct (i.e., not contiguous) locations, all occurrences are assigned a descriptive *location use class* name that groups occurrences

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and Harrison 1996; McCullough 1996). For plants, demographically significant exchange among subpopulations can occur through dispersal of seeds, spores, pollen, and other propagules. Persistent dormant propagules may result in metapopulation dynamics over time as well as space.

by their season of occurrence or functional category (e.g., breeding, non-breeding, migratory stopover). Because a species may vary in vulnerability during different seasons (e.g., due to more or less aggregation), an occurrence for a species at a particular season may have greater or lesser conservation value than occurrences for the same species at another season. Thus, location use classes allow categorization of these potential differences in conservation value between seasonally and geographically disjunct locations and helps to guide conservation planning and management. Assigning occurrences to location use classes allows identification and conservation of occurrences from each vulnerable class, which is vital to the conservation of such species. Location use classes pertain only to species that occupy geographically disjunct locations at different seasons. Classes are not applicable to non-migratory species and are generally not applicable to terrestrial or freshwater migratory species that move between contiguous areas, as an occurrence for the latter species includes the area occupied during the entire annual cycle.

### 4.1.2 *Occurrence Requirements (= Element Occurrence Specifications)*

Element occurrence information represents one of the principal products of heritage inventory, and it serves as the basis for conservation planning and management. Occurrences and an assessment of their viability or quality are used to guide priorities for conservation and management.

Occurrence requirements (EO specifications) are used to delineate and differentiate occurrences. In other words, occurrence (EO) requirements describe precisely the evidence required to establish a valid occurrence (i.e., the minimum size, quality, or persistence required) and the barriers, distances, and factors that separate one principal occurrence from another. EO specifications may also include mapping guidance for occurrences, and they also provide justification for the separation distances that are listed.

The primary intent of EO specifications is to ensure that EOs are a) consistently defined and mapped within and across jurisdictions, and b) delineated such that they reflect a population, communities of populations, or assemblages of communities, ensuring that the viability or integrity of the occurrence can be meaningfully assessed. Inasmuch as EOs are meant to reflect populations, EO specifications describe the features that constitute barriers that totally or almost completely prevent movement and/or dispersal. EO specifications also provide separation distances. Separation distance is used to establish whether two occupied locations represent the same occurrence or different occurrences. In the absence of a barrier, locations not farther apart than the separation distance are assumed to represent the same occurrence. The separation distance for unsuitable habitat (areas that are highly restrictive to the species' movement or dispersal) may be smaller than for suitable habitat. Species- and community-specific separation distances attempt to delineate population units between which gene flow is significantly reduced (e.g., one successful migrant individual or gamete per year or less [IUCN 1996]).

For most species, data from gene flow studies do not exist; thus, decisions on separation distances are made on the basis of best information available and by consideration of factors related to gene flow. Also, consideration of gene flow in defining EOs may not be practical for species that disperse widely (e.g., birds, wind-dispersed plants or insects), that have very long generation times (e.g., giant tortoises, plants characterized by long-term seed banking or dormancy, persisting clones), or that are dependent on rare but recurrent phenomena for dispersal (e.g., floods, major storms). For these, separation distances are necessarily arbitrary but may be based on practical considerations.

For ecological communities and systems, the concept of dispersal patterns across suitable and unsuitable habitat is most applicable to the characteristic plant species that make up component communities. Consequently, in the absence of barriers, community and system occurrences may be separated by expanses of different natural or semi-natural land cover, or cultural vegetation. Intervening natural and semi-natural areas are thought by scientists to frequently inhibit the expansion or function of community or system occurrences to a lesser degree than intervening cultural vegetation. In a like manner, intervening natural and semi-natural areas with similar kinds of habitat characteristics generally inhibit expansion or function of a community less than those with very different kinds of characteristics. For example, bogs separated by intervening areas of upland jack pine on bedrock are more definitively identified as distinct occurrences than are bogs separated by areas of black spruce swamp.

Several factors are considered when determining standard separation distances applicable across the range of a species, community, or system. These include dispersal distance, home range, spatial and temporal patterns of occurrence, and comparability with similar functional groups

Minimum values for separation distances have been established to ensure that occurrences are not separated by unreasonably small distances, which would lead to the identification of inappropriately fragmented populations as potential targets for conservation planning or action. For both species and ecological types, minimum separation distances are generally at least 1 km for unsuitable habitat and 2 km for apparently suitable habitat that is not known to be occupied. These somewhat arbitrary distances are meant to ensure that the process of delineating EOs does not fragment populations.

Occurrence specifications are sometimes developed as a group (“Specs Group”) for elements that are ecologically and taxonomically similar. For example, map turtles in the genus *Graptemys* are sufficiently similar in their patterns of occurrence and in their movements that barriers to movement and separation distances are the same for all members of the genus. Appendix D provides a sample of occurrence requirements (EO specifications) for a species element.

#### 4.1.3 *Occurrence Viability or Ecological Integrity Assessments (= Element Occurrence [“EO”] Rankings)*

EO rankings provide a succinct assessment of *estimated viability* (species) and ecological integrity (communities and systems), or probability of persistence based on a series of key ecological attributes of occurrences of a given element. In other words, an EO rank provides an initial indication of the likelihood that, if current conditions prevail, an occurrence will persist for a defined period of time, typically 20–100 years depending on the element.

EO rankings serve an important role in conservation status assessments and conservation planning because they specify the relative viability or ecological integrity of specific populations or stands. Information across the range of populations or stands for a species, community or system contributes to the assignment of global, national, and sub-national conservation status rankings for that element.

Thus, EO rankings are used effectively in conjunction with conservation status rankings to help prioritize occurrences for purposes of conservation planning or action, both locally and range wide.[12]

Characterizing and evaluating the viability or integrity of an occurrence provides the basis for assessing ecological stresses—the degradation, or impairment—of element occurrences at a given site (e.g., Cairns 1974; Landres 1983; Angermeier and Karr 1986; Noss 1990; Rapport, Costanza, and McMichael 1998; Johnsson and Jonsell 1999; Landres, Morgan, and Swanson 1999). There are four core components of occurrence evaluation that can be applied in a conservation area of any scale

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[12] Although conservation status and EO ranks (i.e., the probability of persistence) help to set conservation priorities, they are not the sole determining factors. Conservation action, for example, may also be based on other factors, such as explicit numerical conservation goals; the taxonomic distinctness of the species; the genetic distinctness of the occurrence; the co-occurrence of the element with other elements of conservation concern at a site; the likelihood that conservation action will be successful; and economic, political, logistical, and other considerations (NatureServe 2002a; Possingham et al. 2002).

whether these are individual populations or species, assemblages of species, ecological communities, or ecological systems. These core components and their function are as follows:

1) **Key Ecological Attributes** – the structure, composition, interactions, and abiotic and biotic processes that enable the occurrence to persist. For example, evidence of successful reproduction or large area of occupancy are key attributes for species, and low level of previous disturbance and high water quality are key attributes for ecological elements.
2) **Indicator** – the measurable entity that is used to assess the status and trend of a Key Ecological Attribute. For example, occupancy trends and lack of modification of structural attributes are indicators for species and ecological elements, respectively.
3) **Thresholds for Indicator Rating** – the point within a range of variation that describes the current status of an Indicator.
4) **Integration of Indicator Ratings** –an overall assessment of the viability or ecological integrity of the population or stand, including guidance on assessing the relative importance of the various indicators.

*4.1.3.1 Identifying Key Ecological Attributes and Indicators*

To assess the quality of occurrences, one must first identify and document a limited number of key ecological attributes that support them [the terms "key ecological attribute" and "indicators" are comparable to the term "ecological attributes" and "indicator" used by the USEPA publication by Young and Sanzone (2002)]. After these are identified, a set of measurable indicators is established to evaluate each attribute and document their expected ranges of variation. For each indicator, NatureServe establishes a threshold for determining the current status of attributes, and a relative scale of viability or integrity that ranges from "excellent" to "poor".

Documentation of these basic assumptions about key ecological attributes, ranges of variation, thresholds, and indicators for measurement, are called "occurrence viability or ecological integrity criteria" (= "Element Occurrence Rank Specifications"), and these criteria form a central component of NatureServe methodology. These criteria are needed to consistently assess whether the attributes exhibited for a given occurrence are within the viable range, whether they require significant effort to maintain, and whether they are restorable. Each key attribute is reviewed, rated, and then combined with others to rank each occurrence as "A" (excellent), "B" (good), "C" (fair), and "D" (poor). The higher the estimated viability or integrity of the occurrence, the higher its occurrence rank and presumed conservation value. The break between "C" (fair) and "D" (poor) establishes a minimum quality threshold for occurrences. Occurrences with ranks of "D" (poor viability or integrity) are often presumed to be beyond practical consideration for ecological restoration. In subsequent management planning, these ranks and underlying attributes and indicators aid in focusing conservation activities and measure progress toward the local conservation objectives.

Because occurrence ranks are used to represent the relative conservation value of an occurrence as it currently exists, they are based solely on key ecological attributes that reflect the present status, or quality, of that occurrence. NatureServe uses three generalized occurrence rank categories to organize key ecological attributes. These generalized categories are condition, size, and landscape context. Attributes within the three categories are combined to arrive at an overall occurrence rank. Thus,

$$\text{Condition} + \text{Size} + \text{Landscape Context} \Rightarrow \text{Estimated Viability or Integrity} \approx \text{`EO Rank'}$$

For community and system elements, the term "ecological integrity" is preferable to that of viability, because communities and systems are comprised of many separate species, each with their own viability. Ecological integrity is the "maintenance of…structure, species composition, and the rate of ecological processes and functions within the bounds of normal disturbance regimes.[13] More directly, occurrence ranks reflect the degree of negative anthropogenic impact to a community or system (i.e., the degree to which people have directly or indirectly adversely or favorably affected composition, structure, and/or functions including alteration of natural disturbance processes).

Key Ecological Attributes may be difficult or impossible to directly measure (e.g., the degree to which ecological functions are modified by grazing, logging, or other disturbances). Where this is the case, an indicator of the Attribute that may be reasonably and effectively measured should be identified. In a river floodplain system, for example, river flow dynamics may be an ecological process that is a Key Ecological Attribute, but it is not reasonable to expect that every possible parameter would be measured. A few parameters (e.g., flood seasonality and periodicity) can be selected that will give us an overall indication (indicator) of how the status of the Key Attribute (flow dynamics) is changing. So the indicator may be a subset of the variables defining the Key Attribute, or a more measurable substitute for the Attribute.

The Key Ecological Attributes for any element occurrence (and therefore their indicators) varies over time in a relatively undisturbed setting. This variation is not random, but is limited to a particular range that we recognize as either a) natural and consistent with the long-term persistence of each occurrence, or b) outside the natural range because of human influences (e.g., fire suppression in fire-adapted systems) (Landres, Morgan, and Swanson 1999).

#### *4.1.3.2 Establishing Thresholds for Indicator Ratings*

In order to effectively evaluate occurrences relative to each other, overall ecological integrity ranks should establish a scale for distinguishing between "A," "B," "C," and "D" occurrences. This scale should usually spread from a lowermost limit (the "D" rank or minimum EO threshold) up through the threshold for an "A" rank. In addition, the threshold delineating occurrences with "fair" (C) vs. "poor" (D) viability or integrity must be identified. Figure 4.1 illustrates the rank scale for "A," "B," "C," and "D"-ranked occurrences.

Perhaps most critical for development of occurrence viability or integrity criteria is the establishment of the threshold between occurrences with "fair" and those with "poor" viability or integrity (the minimum "C"-rank criteria). As mentioned above, this clarifies whether or not one has a potentially restorable occurrence. Next, the "A"-ranked criteria are established. Typically, these are the best EOs that are reasonably and conceivably achievable (e.g., with restoration or management if needed and feasible). Generally, these will be the minimum "A"-rank criteria unless the best reasonably achievable occurrences have only "fair" or "poor" viability or integrity. Finally, assuming the best occurrences that are reasonably and conceivably achievable are at or above the "A"-rank threshold, one can identify minimum "B"-rank criteria that achieve a spread between "A"- and "C"-ranked occurrences.

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[13]From: Lindenmayer and Recher (cited in Lindenmayer and Franklin 2002). Similarly, Karr and Chu (1995) define ecological (or biological) integrity as "the capacity to support and maintain a balanced, integrated, adaptive biological system having the full range of elements (genes, species, and assemblages) and processes (mutations, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in the natural habitat of a region".

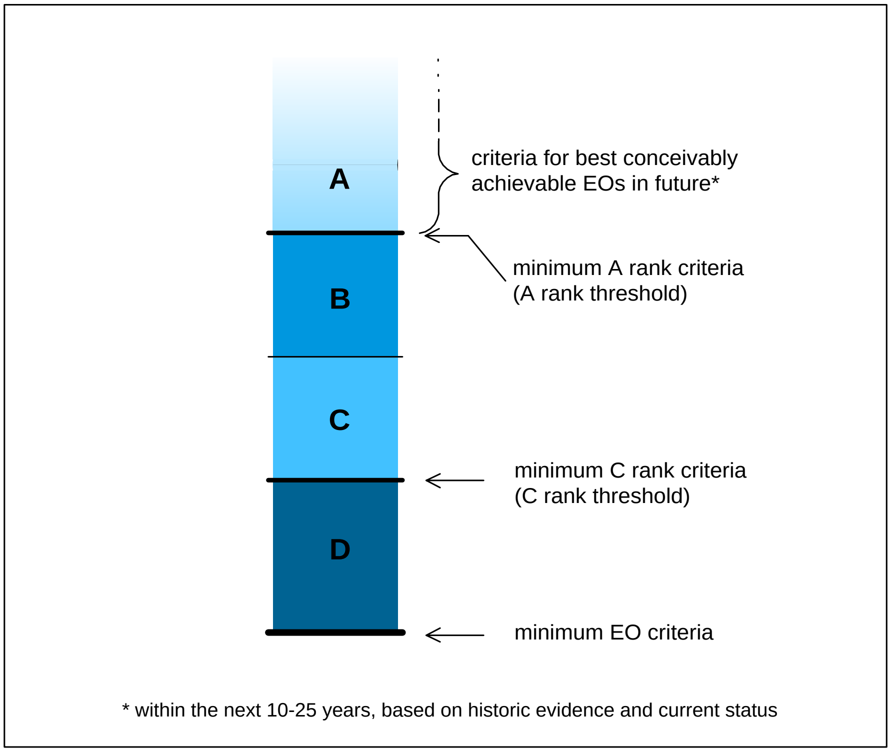


**Figure 4.1** Rank Scale for Occurrences with “A,” “B,” “C,” and “D” Ranks

An EO rank need not always be directly comparable to historical conditions. For example, bison will likely not exist again in their historical condition with herds numbering in the millions; nevertheless a range of viable populations (e.g., herds of differing sizes and conditions) might still be reasonably achievable. In other words, it is still necessary to conceive of a range of viable populations, although the range is truncated when compared to occurrence viability specifications that would have been written 200 years ago. Similarly, some fire-adapted ecological systems historically supported fire on vast landscape scales that could not be feasibly repeated today. But under controlled conditions, many effects of those landscape-scale fires could be reintroduced in smaller areas. These are the types of practical considerations that are documented in occurrence viability or ecological integrity criteria. Further details are provided in NatureServe’s (2003) Element Occurrence Data Standards.

Adult population size of some occurrences may greatly exceed the “A” threshold, but all “A” occurrences should exhibit excellent estimated viability. However, there are situations in which occurrences with excellent estimated viability may be ranked as “B” rather than “A”. For example, single populations of colonial island-nesting birds may be two to three orders of magnitude larger than the usual minimum requirements for an A occurrence as specified above. In these cases, rank criteria may specify that only the largest occurrences qualify for an “A” rank while those with smaller populations that may nevertheless include tens of thousands of breeders may be ranked as “B”. This allows one to distinguish truly exceptional occurrences from others of excellent or good viability. Note that the best existing occurrence of an element is not necessarily an “A”-ranked occurrence (e.g., its estimated viability may not be “excellent”), nor is the worst necessarily ranked “D”. A further conceptual consideration is that population sizes of occurrences ranked higher than “C” are intended to be sufficiently large that they are likely to maintain genetic variability even in bad years.

Table 4.1 provides an example where occurrence ecological integrity criteria were established and applied in the Consumnes River Preserve managed by The Nature Conservancy of California (personal communication, 2003). In this instance, a range of indicators for a particular vernal pool ecological system type was evaluated. Ratings and thresholds were developed for each indicator. They provided the focus for establishing current status and desired future conditions in this area. These criteria could be utilized throughout the range of this ecological system type in other similar examples.

EO rankings are based on *current* measures of key ecological attributes. Because EO rankings are intended to reflect estimated viability, however, they must be based on attributes that are reliable predictors of the future. These attributes are summarized in Table 4.2.[14] For more details about how these attributes are assessed, see the EO Data Standard (NatureServe 2002a; http://whiteoak.natureserve.org/eodraft/index.htm) and the guidance provided in NatureServe’s databases for individual species and ecological systems (http://www.natureserve.org/explorer/). Trends in population size of other factors may be included in the estimation of viability or ecological integrity.

#### *4.1.3.3 Integration of Indicator Ratings into an Overall Measure of Viability or Integrity*

For species, attributes for size, condition, and landscape context are generally considered together. In many cases, where knowledge permits, size attributes are the primary factors influencing EO rank, with attributes for condition and landscape context used secondarily (or not at all for some species). This is because a large size (i.e., number of breeding individuals) would generally not occur without favorable condition and landscape context, especially for relatively short-lived species. For species where little information on size is available (especially many plants and invertebrates), condition and landscape context factors may be relied upon more heavily when developing occurrence viability or ecological integrity criteria.

If available and when appropriate, results from one or more population viability analysis (PVA) may be used to help define minimum criteria for ranks of “A,” “B,” and “C”. However, this is done with great caution and a clear understanding of the underlying assumptions, such as the continuance of the current and/or recent demographic patterns, and the absence of landscape changes for the duration of the projected time period. The increasing use of PVAs seems likely to lead in the future to the development of more robust occurrence viability criteria for species.

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[14] Factors such as defensibility, manageability, and restorability of occurrences are not considered in assessing EO rankings, as these latter considerations, while important for conservation planning, provide highly uncertain predictions of the impacts of future actions and do not represent the relative conservation value of an occurrence as it presently exists, based on known current and recent factors.

**Table 4.1** Partial Occurrence Ecological Integrity (EO Rank) Document for the *Northern California Hardpan Vernal Pool* Modified from the Consumnes River Preserve Plan of The Nature Conservancy of California

| Category | Key Ecological Attribute | Indicators | Indicator Ratings with Thresholds[a] | | | | Viability Objective | Current Status | Basis for Current Status Rating |
|---|---|---|---|---|---|---|---|---|---|
| | | | Poor | Fair | Good | Very Good | | | |
| Landscape Context | Fire Area-Intensity Regime | Buffer around vernal pool complex that can be fire managed | < 0.25 mile buffer | 0.25–0.49 mile buffer | 0.5–0.99 mile buffer | *> 1 mile buffer over >80% of the perimeter of vernal pool properties* | Maintain a buffer of ≥ 1 mile around vernal pool complex on large vernal pool tracts | 1 mi buffer intact around Howard and Schneider Ranches (2001) | Analysis of remote sensing data |
| Landscape Context | Fire Area-Intensity Regime | Fire return interval and area burned | Fire return interval < 1 year or > 10 years for > 10% of the vernal pool grassland. | Fire return interval between 7–10 years for > 10% of the vernal pool grassland. | Fire return interval between 5–7 years for > 50% of the vernal pool grassland. | *Fire return interval between 3–5 years for > 80% of the vernal pool grassland.* | Maintain a prescribed fire return interval of 3–5 years for over 80% of the vernal pool grasslands on the Preserve. | >10 year fire return interval for > 10% of the Preserve's vernal pool grasslands | Historical fire data |
| Landscape Context | Connectivity of vernal pool complexes | Distribution of land permanently protected | < 10% connectivity | 10–49% connectivity | 50–74% connectivity<br>Note: 15–25,000 ac would be protected with this connectivity to be rated Good. | *75% or higher connectivity* | Establish 75% connectivity of protected vernal pool habitat by 2005 | > 50% connectivity (DE. 2001) | Actual land or easement purchases |
| Condition | Native species diversity | Native species cover | Relative native species cover (RNSC) in vernal pools < 80% | RNSC in vernal pools 80–84% | RNSC in vernal pools 85–90% | *RNSC in vernal pools >90%* | Maintain relative native species cover >90% in vernal pools | Howard Ranch mean – 90%, se=1.7%; Valensin Ranch – Mean=84%, se=3% (2001) | Monitoring data |
| Condition | Native species diversity | Native species richness | Richness on pool edge <5 species/quadrat (35 cm x 70 cm) | Richness on pool edge 6–8 species/quadrat | *Richness on pool edge 9–10 species/quadrat* | Richness on pool edge >10 species/quadrat | Maintain average native species richness on the pool edge >10 species/quadrat | Howard Ranch mean – 10.4, se=0.32; Valensin Ranch – Mean=9.4, se=0.34 (2001) | Monitoring data |

[a] Shaded boxes = current state: shaded; *Italics* = desired rating

**Table 4.2** Occurrence Viability or Integrity Factors and Their Component Key Ecological Attributes for Species and Communities

| **Generalized Key Ecological Attributes** | **Examples of Indicators** | **Species** | **Communities and Systems** |
|---|---|---|---|
| **CONDITION** | | | |
| reproduction and health | evidence of regular, successful reproduction; age distribution for long-lived species; persistence of clones; vigor, evidence of disease affecting reproduction/survival | √ | |
| development/maturity | stability, presence of old-growth | | √ |
| species composition and biological structure | richness, evenness of species distribution, presence of exotics | √ | √ |
| ecological processes | degree of disturbance by logging, grazing; changes in hydrology or natural fire regime | √ | √ |
| abiotic physical/chemical attributes | stability of substrate, physical structure, water quality [excluding processes] | √ | √ |
| **SIZE** | | | |
| area of occupancy | | √ | √ |
| population abundance | | √ | |
| population density | | √ | |
| population fluctuation | average population and minimum population in worst foreseeable year | √ | |

(Continued on next page.)

**Table 4.2** Continued

| **Generalized Key Ecological Attributes** | **Examples of Indicators** | **Species** | **Communities and Systems** |
|---|---|---|---|
| **LANDSCAPE CONTEXT** | | | |
| landscape structure and extent | pattern, connectivity, e.g., measure of fragmentation/patchiness, measure of genetic connectivity | √ | √ |
| condition of the surrounding landscape | development/maturity, species composition and biological structure, ecological processes, abiotic physical/chemical attributes | √ | √ |

For species, the suggested criteria for probability of persistence for occurrences are based on a time interval of 50–100 years (Table 4.3). These probability figures are not absolute values but rather guidelines based on expert judgment. Only rarely is there sufficient information that can be used to generate reliably precise persistence probabilities. See Section 5.3.3 of the EO Data Standard (NatureServe 2002a) for a discussion of these probabilities.

**Table 4.3** Suggested Probabilities of Persistence for EO Rankings "A" through "C"

| **EO Rank** | **Probability[a] of Persistence for 50–100 years** |
|---|---|
| A | 95% |
| B | 80% |
| C | 50% |

[a]These probabilities are under review.

Because of the greater complexity of communities and systems, due in part to the interaction of species and successional change, it is difficult to consider the influence of size, condition, and landscape concurrently. Thus, each factor is assigned a separate "A," "B," "C," or "D" rating, sequenced and weighted according to priority, and combined in an algorithm to calculate a suggested EO ranking value, which can be accepted or revised. The process for developing an EO ranking for a community or system is described in detail in the EO Data Standard, Section 5.6 (NatureServe 2002a; http://whiteoak.natureserve.org/eodraft/index.htm).

Occurrence viability or ecological integrity criteria are based on the best available information on the biological and ecological factors that determine the estimated viability of a species or ecological integrity of a community or system type. In some cases, especially for invertebrates and for cryptic species, the best available information will consist of indirect and/or circumstantial evidence (e.g., for many nocturnal moths, evidence of presence coupled with habitat patch size and quality).

#### *4.1.3.4 EO Ranking Values*

Whenever possible, occurrences are assigned specific rankings according to criteria specified for occurrences with “A,” “B,” “C,” and “D” ranks. Range rankings (e.g., “AB,” “AC”) and a “?” qualifier may be used to indicate uncertainty. Range rankings may be assigned when there is insufficient or uncertain information, such that an occurrence has a relatively equal probability of being either, or any, of the rankings included in the range specified. For example, little is known about the population viability of the red hills salamander (*Phaeognathus hubrichti)*, as they are shy hole dwellers. An abundance of holes may suggest good population viability in a given area—but not prove it—and such an occurrence might be ranked “AC”. In other situations (e.g., due to insufficient field information), the uncertainty about an EO rank may be joined with an “A,” “B,” “C,” or “D” ranking. In these cases, a “?” qualifier may be used in conjunction with one of these basic rankings to indicate uncertainty about that ranking. Range rankings and “?” qualifiers are used provisionally, and are replaced with an “A,” “B,” “C,” or “D” ranking when knowledge permits.

When evidence of presence is lacking, or when field information is not sufficient to assign an “A–D” ranking, additional ranks—“E,” “H,” “F,” or “X”—may be used. All of the basic EO ranks are shown in Table 4.4.

An “E” (= extant EO) ranking is used for an occurrence that has been recently verified as still existing, but for which sufficient information on the factors used to estimate viability of the occurrence has not yet been obtained and an “A–D” or range rankings cannot be assigned.

An “H” (= historical EO) ranking is used when there is a lack of recent field information verifying the continued existence of an occurrence, such as when an occurrence is based only on historical data; or when an occurrence was ranked “A–D” at one time and is later, without field survey work, considered to be possibly extirpated due to general habitat loss or degradation of the environment in the area. In general, if there is no known survey of an occurrence within the last 20–40 years, it is assigned an “H” ranking. The actual time frame for historical occurrences varies, particularly in relation to the biology of the species and the degree of anthropogenic alteration of the environment. Thus, an “H” ranking may be assigned to an occurrence before the maximum timeframe has lapsed, but “A–D” rankings are not used for occurrences that have not been surveyed for a period exceeding 40 years.

An “F” (= FAILED TO FIND EO) ranking is assigned to an occurrence that has not been found despite a search by an experienced observer at a time and under conditions appropriate for the species or community at a location where it was previously reported but that still might be confirmed to exist at that location with additional field survey efforts.

An “X” (= EXTIRPATED EO) ranking is assigned to an occurrence for which there is documented destruction of its habitat or environment, or persuasive evidence of its eradication based on adequate survey (i.e., thorough or repeated survey efforts by one or more experienced observers at times and under conditions appropriate for the element at that location).

**Table 4.4** Basic EO Ranks Used by NatureServe

| EO Rank | Description |
|---|---|
| A | excellent estimated viability or ecological integrity |
| B | good estimated viability or ecological integrity |
| C | fair estimated viability or ecological integrity |
| D | poor estimated viability or ecological integrity |
| E | verified extant (viability or ecological integrity not assessed) |
| H | historical |
| F | failed to find |
| U | unknown if extant (date of last observation is unknown and may or may not be recent) |
| X | extirpated |

For purposes of analysis and conservation planning, viable occurrences are those containing “A,” “B,” or “C,” regardless of qualifiers. Potentially viable occurrences are those not assessed or recently assessed, and either unranked or ranked “E,” “F,” “U,” or “H”.

In summary, NatureServe occurrence viability or ecological integrity assessment methodology provides a framework for evaluating the viability (for species) or ecological integrity (for communities and ecosystems) of individual element occurrences. Ranking criteria are organized with several levels, with most detailed key ecological attributes being most relevant for identification of local indicators for ecological assessment and monitoring. These attribute measures may be aggregated into more general categories of size, condition, and landscape context, and/or further aggregated into a composite EO rank. Indicators of more detailed key ecological attributes tend to change more rapidly than their composite EO ranks, but both provide a practical mechanism for ongoing monitoring of the viability or integrity of biodiversity elements on the ground.

##### *4.1.3.5 Application of Occurrence Viability or Integrity Assessments to Forest Certification*

The SFI 2002–2004 Standard and several regional Forest Stewardship Council standards require protection of occurrences of imperiled species and ecological communities. Many of these standards (including the SFI standard) require that viable occurrences (viability or integrity ranks of “A,” “B,” or “C”) be protected, while protection of occurrences that are not proven to be viable is carried out at the discretion of the manager.

### 4.1.4 *Delineating and Mapping Element Occurrences (EOs)*

Where occurrences are found, managers and representatives of NatureServe member programs delineate and map these occurrences. Representing an occurrence (EO) on a map facilitates the finding it, managing the buffer around it, and integrating factors that influence its viability or integrity with that of the larger landscape. Additional information can also be obtained on the associations between the occurrence and other mapped features (e.g., habitat, watershed, counties, observations, other occurrences). Managing occurrence information in a GIS has many advantages, including the capability to perform analyses of relationships among occurrences and other mapped features, and the production of a variety of map products for different purposes.

Four key characteristics of mapping occurrences (EO representation) are that they a) are polygons (instead of points); b) incorporate *locational uncertainty*; c) are developed from source features, each of which corresponds to a discrete observed area based on survey information (i.e., an observation); and d) may be comprised of multiple source features. NatureServe methodology facilitates the development of mapped occurrences that reflect the diverse, often complex ways that elements of biodiversity actually occur on the landscape. For example, mapped occurrences of different elements generally overlap and frequently share boundaries (such as the shoreline of a lake). A mapped occurrence of a single element may contain voids (i.e., holes indicating areas that are not part of the occurrence), be comprised of multiple separate areas/patches, and include different types of contiguous areas (e.g., an occurrence that includes both a stream and pond).

The boundaries of mapped occurrences are delineated to reflect only what has been actually observed during field surveys, confirmed from remotely sensed data, or derived from historical accounts. Despite the possibilities presented by detailed topographic base maps, occurrences are not mapped to include appropriate but un-surveyed nearby areas. Further field survey work would be needed to confirm the presence of the element in a potentially occupied area.

Many factors may affect the quality and reliability of locational data for an occurrence, including survey techniques and any equipment used (e.g., GPS unit, USGS topographic quadrangle map). Therefore, in some cases it may not be possible to pinpoint the actual location at which an observation was seen on a map. In other words, some uncertainty is associated with the mapped representation of that location. (The accuracy of the base map is a separate issue and is not considered in evaluation of locational uncertainty, which deals with accuracy of the data.)

In developing a mapped occurrence, locational uncertainty comes into play when it is time to map the source feature. The type of locational uncertainty (negligible, linear, areal estimated, areal delimited—see Appendix A for definition of each type) assigned to a source feature depends on both the magnitude and the direction of the uncertainty associated with a location. These factors are determined through evaluation of the underlying field data or historical information. A more detailed description of the four types of locational uncertainty can be found in Chapter 7 of the EO Data Standard at http://whiteoak.natureserve.org/eodraft/index.htm.

#### *4.1.4.1 Accuracy of Occurrence Mapping*

In many cases, mapped occurrences appear to be similar on a map despite having incorporated very different amounts of locational uncertainty. *Representation accuracy* (RA), which indicates the relative amount of a mapped occurrence that was observed to be occupied by the element (i.e., not attributable to uncertainty), is provided for some occurrences; for example:

- A report of three Venus flytrap (*Dionaea muscipula*) specimens found in a marsh would likely be categorized as low RA. The occurrence would be created from a polygon Source Feature having areal delimited uncertainty; the boundary of the swamp would be used for the observation, which would add a significant amount of area to the specimens to capture their location.
- A gray wolf (*Canis lupus*) den observed at a particular location with a GPS unit would be categorized as very high RA. The occurrence would be created from a point Source Feature having negligible uncertainty (provided that the corrected GPS data provided accuracy within 6.25 m. [mapping on a 1:24K USGS topo map]). There would be no additional area included in the occurrence boundary to represent locational uncertainty (although the point would have a procedural buffer added to bring the occurrence up to a polygon the size of the minimum mapping unit for the map).

Use of *estimated RA* by member programs provides a common index for the consistent comparison of mapped occurrences, thus helping to ensure that data are correctly analyzed and interpreted. A value for estimated RA (specifically, a percentage range selected from a scale) is assigned for an occurrence by the member program biologist. The estimated RA scale is comprised of five categories: "very high accuracy" (>95%), "high accuracy" (>80% – 95%), "medium accuracy" (>20% – 80%), "low accuracy" (0 – 20%), and "unknown".

Features developed with minimal added locational uncertainty have "very high accuracy," and RA declines as a greater portion of a mapped occurrence is attributable to uncertainty (i.e., the larger the amount of additional area added to the observation to represent uncertainty in its location). Although estimated RA is a subjective assessment by the member program biologist, it is recognized that expertise and familiarity with the data generally enable the biologist to assign an appropriate value indicating the "goodness" of an EO (that is, the percentage not due to added uncertainty). Due to variations in available data and characteristics of different occurrences, no quantitative calculation can replace the subjective estimate of an RA value for occurrences. The calculation of RA is not feasible for most EO point features because, when the observed or inferred area of such an occurrence is typically small, the addition of even a limited amount of area to reflect locational uncertainty usually results in a calculated value that would indicate low RA despite the overall small amount of area added for uncertainty.

#### *4.1.4.2 Observations vs. Occurrences (EOs)*

In order to constitute a valid occurrence, information on a species, community or ecological system must meet minimal criteria provided in the EO specifications for that element. For example, the observation of a lynx or its tracks outside of the area of any known occurrences would not be sufficient evidence to create an occurrence, as the individual may have simply been dispersing through the area but not resident. However, it is often useful to track the location and minimal data for an observation that does not meet the EO specifications, and thus is not a component of an occurrence. Over time, such independent observations may ultimately be combined with data for other observed areas to define an occurrence.

NatureServe's Biotics software permits creating and managing observation data as source features to track observed areas, regardless of whether such observations are to be associated with an EO in the foreseeable future. Minimal information can be associated with the source feature (e.g., observer, date, brief description of the observation), and the feature may be identified as an independent observation rather than a feature that is to be linked immediately to a mapped occurrence. The observation/source feature may later become an occurrence or a component of an occurrence when deemed appropriate based on EO specifications and occurrence tracking considerations.

#### *4.1.4.3 Spatial Requirements for Animals*

Many animal species, especially terrestrial vertebrates, have spatial requirements that define a minimum area for obtaining sufficient food, shelter, and reproductive habitat. These spatial requirements are sometimes referred to as the animal's "home range". Considerable research has been conducted to characterize the movement patterns of some animal species, and results indicate that the spatial requirements (or home range size) for an individual of a particular species may vary temporally and spatially depending on a number of factors, including availability of resources, season, and sex of the individual (Vega Rivera et al. 2003). Despite this variability, it is possible to characterize average home range for many species, and when available these averages are included in NatureServe's characterization abstracts for such species.

Frequently, the spatial requirement of an individual (based on evaluation of the home range) exceeds the size of the EO that is being developed from field survey information. In such cases, an *inferred* *extent* (IE) feature may be generated by buffering the underlying source feature(s) of a mapped occurrence by a distance equal to or slightly greater than the minimum IE distance specified for the species. This distance is an approximate minimum spatial requirement for a particular species, typically based on the average home range (specifically, a distance approximately equal to the diameter of the typical home range size as reported in the literature). However, for some species (e.g., pond-breeding amphibians, rattlesnakes moving from a den) the IE distance represents the distance from an initial location (in any direction) that would encompass the ultimate destination of 75–90% of the dispersing adult individuals.

#### *4.1.4.4 Map-Scale Considerations*

Features digitized in a GIS project may have different levels of map accuracy, depending on the scale of the reference maps used for mapping the observation locations. Generally, the larger the scale of a map, the greater is its accuracy. Different jurisdictions frequently utilize different scale reference maps for mapping spatial data. Currently, in the United States, most member programs map observed area locations from 1:24,000 scale reference maps; however, in Canada, most member programs map observed area locations from 1:50,000 scale reference maps. In addition, some programs use other resolutions, such as satellite imagery or aerial photography, which can be provided at many different scales (e.g., 1:10,000; 1:30,000).

Differences of map scales can also occur within a jurisdiction. For example, a state or province may have large-scale aerial photography available for a portion of the jurisdiction, and utilize 1:24,000 USGS topographic quadrangle maps for the remainder of the jurisdiction. In this case, data mapped using the aerial photography is more accurate than data mapped using the quadrangle maps.

Every mapped occurrence has a reference point located within the boundaries of an underlying *procedural feature*, and this reference point is used to represent an occurrence at any map scale small enough that the boundary of the occurrence is not visible. In cases in which maps distributed to clients and/or the public should not show the precise locations for sensitive elements, a generalized representation that blurs the boundaries and/or offsets the position of occurrences may be used to protect information on the locations of such elements.

For some occurrences, very precise locational information is known, but when the feature is mapped at the scale of a standard map, that detailed information is not discernible (e.g., a circular polygon may result from very precise information for a small area). In such cases, a *detailed feature* may be used to represent the data at a scale larger than that of a standard map, thus retaining the most complete, accurate, and specific spatial information for that occurrence. The process for generating a detailed feature differs from the standard procedure for developing a mapped occurrence only in the use of a larger scale map and smaller minimum mapping unit.

Community and system mapping can present special challenges for mapping because many maps are based on remote sensing imagery such as aerial photography, satellite imagery or other images. These images can vary in their scale, resolution, time of the year, and other factors that may affect the ability of mappers to “see” the community or system types of interest. Where ground surveys are conducted, these issues can usually be resolved. However, in the early stages, the mapped occurrences may have inclusions of other communities that were either too small to observe on the imagery, or contain other similar-looking communities that could not be distinguished on the photos. Only intensive ground surveys can resolve the clarity of the mapped occurrences.

### 4.1.5 *Communities, Ecological Systems, and Forest Stand Management*

The ability to map the NVC provides the opportunity for tracking specific occurrences (stands) on the ground over time. Maps of NVC vegetation units allow analyses of landscape conditions, such as connectivity for selected species or assessments of trends in landscape fragmentation, and facilitate land management. Occurrences depict the location of a given type of association. Most are derived from field-based observation where the boundaries of a given patch or patches are delineated on aerial photographs and/or topographic maps. Others are derived from remotely sensed information. Each method has measures of precision and accuracy. Field-derived occurrences often include information on the date(s) of observation, landscape setting, and a brief description of local conditions, including ecological characterization and assessment of occurrence quality. Other land-use characteristics and potential issues for land management also may be described, depending on the knowledge of the field worker. The element occurrence provides an initial indication of the boundaries that must be considered in land management activities. Additional information, such as buffers, setback distances, adjacent areas of restoration, and other relevant conservation values near the occurrence may also be included. Appendix E provides a sample element occurrence record (EOR).

Field-based observation and experience with many occurrences allow identification of key ecological attributes of ecological communities. These insights may be documented in standard fields of the Biotics 4 database managed by NatureServe. Occurrence Ranking Criteria include descriptions of ecological attributes, such as forest composition, structure, and natural disturbance regimes, and where available, may be utilized for evaluating current conditions and establishing stand- and landscape-level management prescriptions.

NatureServe central staff develops and disseminates methods and tools for field inventory, and they engage in collaborative efforts to map vegetation communities and ecological systems at local and regional scales. As these tools develop, forest managers will play an important role in verifying the validity of models, and of providing feedback about their practicality and utility. Methods for mapping habitat for species of concern continue to evolve (Scott, Heglund, and Morrison 2002).

The US-NVC is increasingly used by public agencies and non-government organizations as a basis for land management. The USGS-Gap Analysis Program utilizes US-NVC alliances for regional mapping and characterization of vertebrate species habitat. The U.S. Forest Service, a long-time supporter of this classification effort, uses it to describe existing vegetation. Both the US National Park Service and US Fish and Wildlife Service utilize the US-NVC for vegetation and habitat mapping and monitoring. Other uses include characterizing stand types in forest inventory or habitats of wildlife species, such as neotropical migratory birds and other vertebrate animals. Because many rare species are linked to associations in the US-NVC, associations can be used to help characterize the habitats and habitat needs of Endangered, Threatened, and Sensitive species. Maps of NVC vegetation units allow analyses of landscape conditions, such as connectivity for selected species or assessments of trends in landscape fragmentation.

## 4.2 NatureServe Occurrence Data

### 4.2.1 *Definition and Scope of the Multi-Jurisdictional EO Database (MJD)*

NatureServe maintains a central database that contains a copy of all species occurrence (EO) data sets from NatureServe member programs. This central EO database is referred to as the multi-jurisdictional EO database (MJD). NatureServe conducts annual data exchanges with each member program in order to maintain the taxonomic integrity and currency of the MJD database. This EO database is a combination of point (e.g., latitude and longitudinal coordinates) and polygon (e.g., areas) occurrence records. Some member programs submit point and polygon occurrence records, while others have thus far used only point data. The MJD also contains element-level information, which describes identifying, biological, and ecological characteristics of tracked elements. Fields from the MJD are shown in Appendix F.

The purpose of the MJD is to provide one regional, national, and/or bi-national data set with range-wide distribution information to industry, conservation, and government partners to aid in their management and conservation efforts. Data-sharing agreements between NatureServe and member programs facilitate the maintenance of the MJD and define the rules that govern the use and dissemination of data to third parties.[15] Procedures for obtaining data from the MJD are found in Section 6.2.

While the majority of occurrence records in the MJD contain exact locational information for imperiled, vulnerable, and federally- and state-listed species, the precise locations of some occurrences in the MJD are generalized or "fuzzed". This means that the coordinates of these occurrences do not reflect the actual location where these species were observed, but instead indicate a location that is close to the exact location (e.g., generally within one mile). Currently, the MJD contains generalized occurrence records for a subset of Utah and Arizona data only. In these cases, member programs are required under state law or under various sharing agreements with their data providers to generalize the location of these specific occurrences. Notwithstanding this limitation, if requested for a conservation project of compelling intentions, NatureServe can provide exact locational information for these occurrences. In the cases where only generalized or "fuzzed" occurrence records are available, NatureServe identifies and provides specific generalization protocols in the metadata of any product delivered to a client.

At this time, the MJD contains only species occurrence records, though there are many community occurrence records in data held by member programs. NatureServe intends to expand the scope of the MJD to include all occurrence records for ecological communities, and has begun acquiring data for wetland community occurrence records from some member programs.

#### 4.2.2 *Status of EO Datasets in the United States and Canada*

The MJD contains over 500,000 occurrence records for species, of which approximately 350,000 contain precise locational information and highly confident identification of species. Included in this sum are records that have latitude and longitude coordinates and those that have completed or empty values for "field identification". In addition, "generalized" occurrence records in Utah and Arizona (mentioned in the previous section) are included, even though their exact location is not revealed in the database. These occurrences occur in every U.S. state (except Massachusetts and Pennsylvania), three additional U.S. member programs (Navajo Nation, Tennessee Valley Authority, and Great Smoky Mountains National Park), and five Canadian provinces (Alberta, British Columbia, Manitoba, Quebec, and Saskatchewan). An additional 50,000 occurrence records are not yet available for MJD analysis because of a lack of data sharing between member programs and NatureServe central databases.

#### 4.2.3 *EO Data Sets and Forest Certification*

A subset of the occurrence records in the MJD meets the standard for Forests with Exceptional Conservation Value under the SFI Standard 2002–2004. These are occurrences with a NatureServe Conservation Status Rank of G1 or G2 and an EO ranking of "A," "B," or "C". To provide information about the occurrences that fall under the SFI provisions as they compare to the total MJD, an analysis was carried out for viable and not viable, imperiled, vulnerable, and stable or

[15] At this time, the MJD contains EO datasets from 56 member programs, including 51 in the United States and 5 in Canada. Because of legal and institutional data-sharing constraints, the MJD does not contain EO data for Massachusetts, Pennsylvania, Ontario, the Yukon Territory, or Atlantic Canada. NatureServe expects to include missing data sets in the MJD within the next year.

apparently stable occurrences. The analysis examines six categories of occurrences (numbers 5 and 6 are not mutually exclusive of each other):

1. **G1/G2 – Viable occurrences**: NatureServe conservation status rank = G1 or G2 and EO rank = A, B, or C (e.g. SFI standard)
2. **G1/G2 – Potentially viable occurrences**: NatureServe conservation status rank =G1 or G2 and EO rank = E, H, H?, NR, U, or null
3. **G3 –Viable occurrences:** NatureServe conservation status rank = G3 and EO rank = A, B, or C
4. **G3** – **Potentially viable occurrences:** NatureServe conservation status rank = G3 and EO rank = E, H, H?, NR, U, or null
5. **G4/G5/GNR S1/S2/S3**: NatureServe conservation status ranks = G4, G5, or GNR (not ranked) and S1, S2, or S3 and EO rank = A, B, C, E, H, H?, NR, U, or null
6. **G4/G5/GNR T1/T2/T3**: NatureServe Conservation Rank = G4, G5, or GNR (not ranked) and T1, T2, or T3 and EO rank = A, B, C, E, H, H?, NR, U, or null

Figures 4.2 and 4.3 show how the G1–G2 and G1–G3 viable or potentially viable occurrences are distributed by political jurisdiction in the United States and Canada.

There are roughly an equal number of G1–G2 viable occurrences (19,009) and G3 viable occurrences (20,120), while there are significantly more G1–G2 potentially viable occurrences (54,061) and G3 potentially viable occurrences (61,208). Approximately 195,000 occurrences are G4–G5 or unranked. Many of these occurrences are globally common, but may be locally rare or significant for conservation in other ways. Of the over 2,000 species represented with analyzable occurrences, close to 50% of them have ≤3 occurrences throughout the United States and Canada (Figure 4.4).

Of the viable occurrences for species ranked G1 or G2, over 40% occur in California (7,114), while about 1,000 viable occurrences occur in North Carolina, Alabama, Florida, and Colorado. No viable EOs for G1- or G2-ranked species occur in the Tennessee Valley Authority, Alberta, or Saskatchewan, while there are ≤10 viable occurrences for G1- and G2-ranked species in each of the following states: Connecticut, Illinois, South Carolina, and Rhode Island.

Under the current SFI standard, the EO ranking attribute is the key consideration in determining whether an occurrence is viable or not. Occurrences that are ranked ”A,” ”B,” or “C” are considered viable, while those occurrences with lower rankings (“D”), historic (“H”), or extirpated are considered not viable. However, most occurrences currently designated as potentially viable are either unranked (“NR” = not ranked) or have not been assigned an EO ranking (null value). In fact, there are more unranked occurrences (28,140) for G1- or G2-ranked species and more unranked EOs (37,462) for G3-ranked species than there are viable occurrences (19,009) for G1- and G2-ranked species and viable occurrences (20,120) for G3-ranked species. Seven member programs (Alberta, South Carolina, Hawaii, Manitoba, New Mexico, Illinois, and Oregon) have ranked <10% of their occurrences, and many more have ranked fewer than half their occurrences (Figure 4.5).

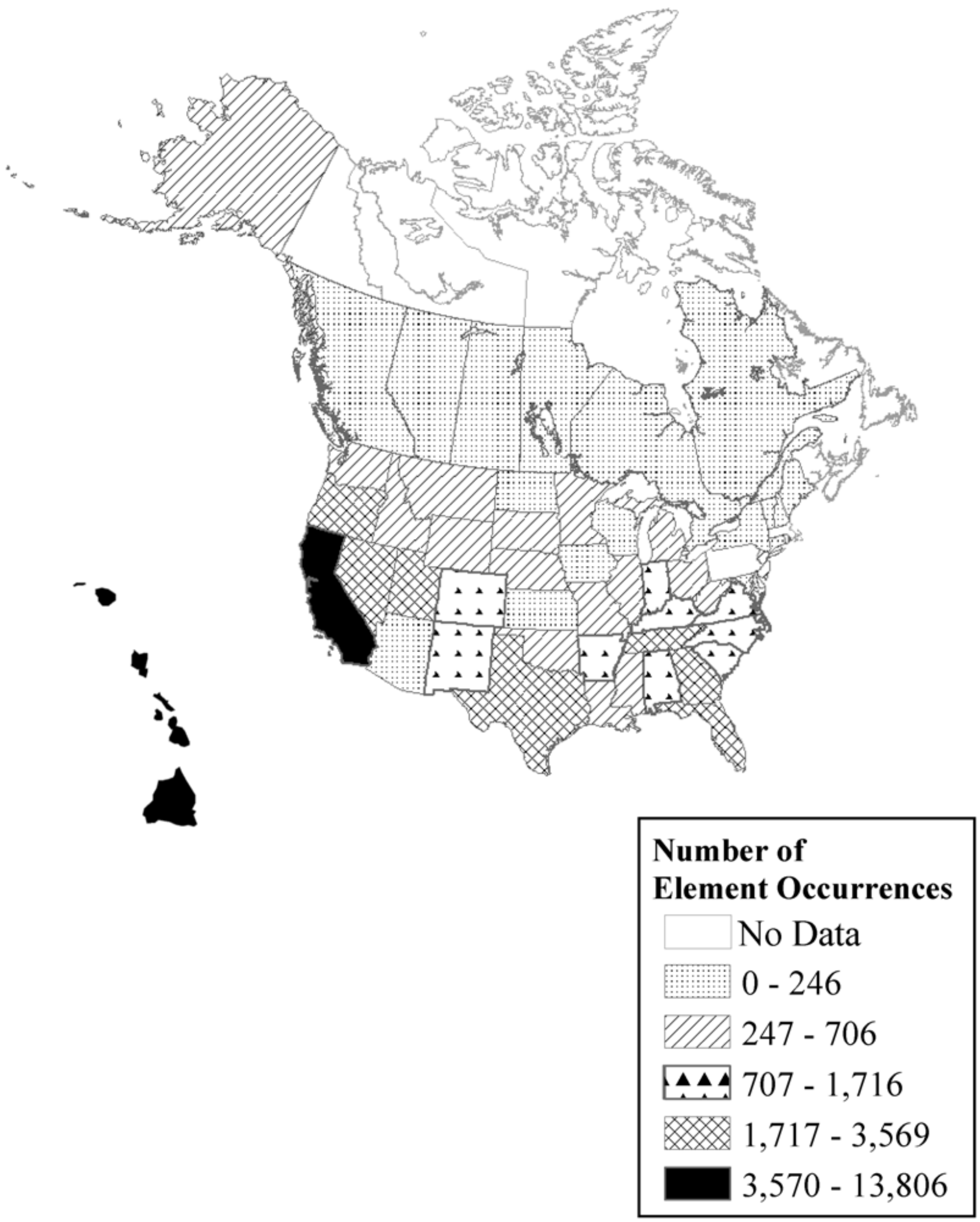


**Figure 4.2** Number of Element Occurrences by State and Province for G1/G2-Ranked Species with Viable Occurrences

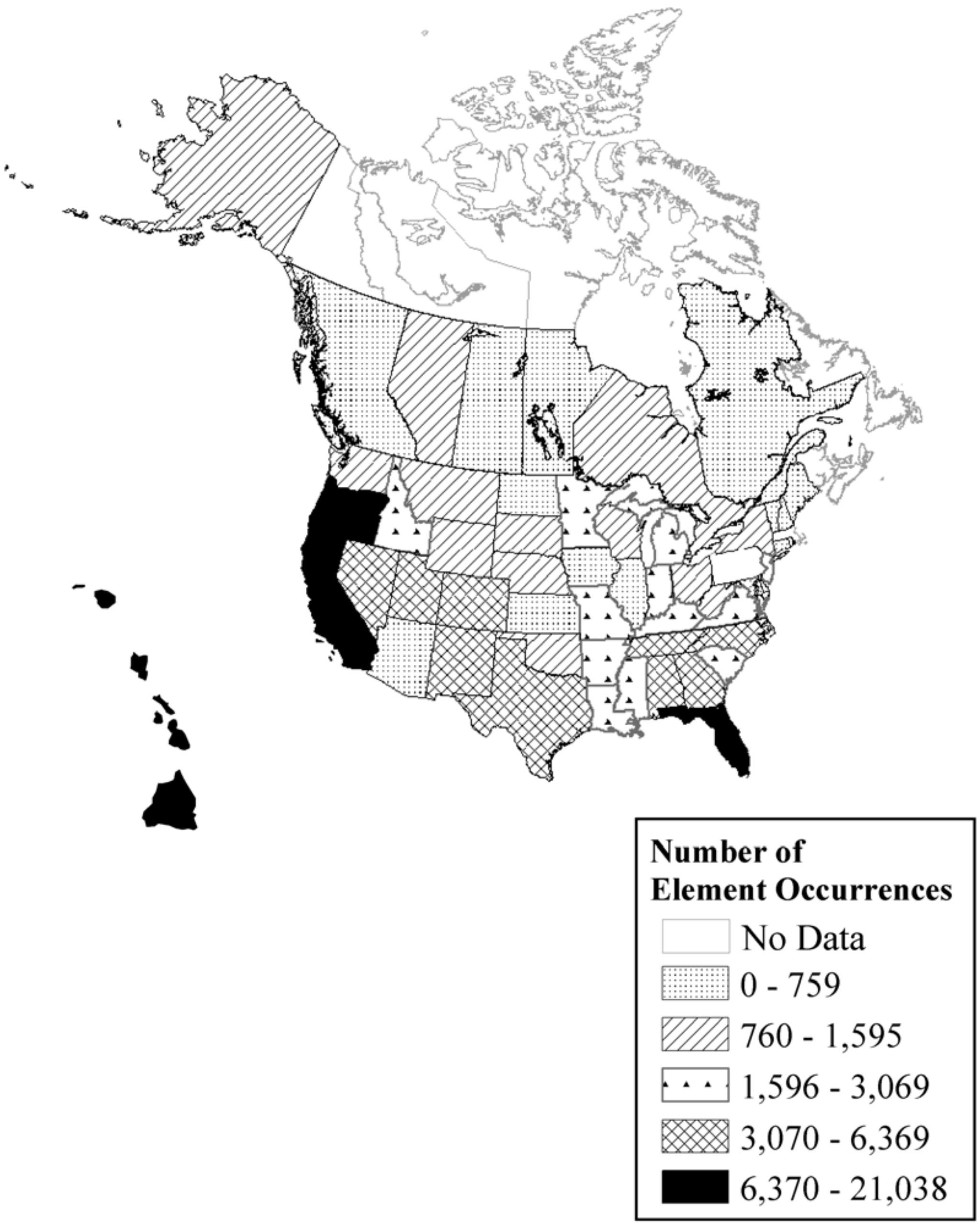


**Figure 4.3** Number of Element Occurrences by State and Province for G1/G3-Ranked Species with Viable or Potentially Viable Occurrences

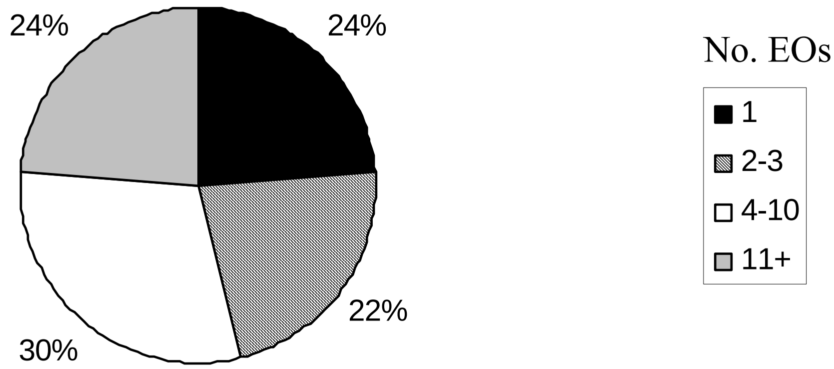


**Figure 4.4** Percent of G1- or G2-Ranked Elements with 1, 2–3, 4–10, or 11 or More Element Occurrences

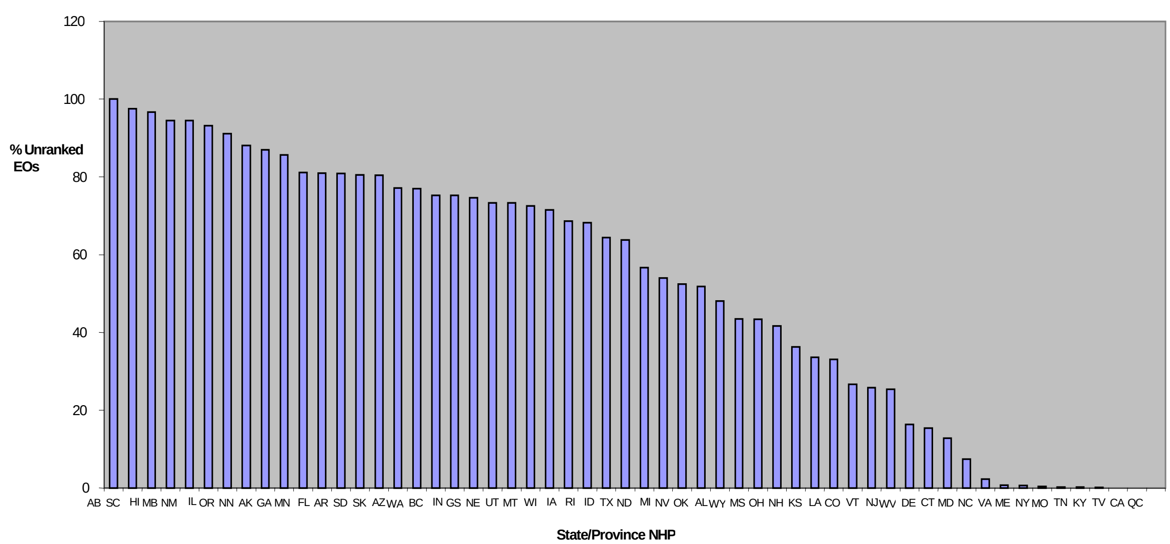


**Figure 4.5** Percentages of EOs That Are Unranked by State and Province

Occurrences remain unranked for several reasons, the primary ones being lack of sufficient information and lack of standardized occurrence viability criteria for most species. Information can be lacking because the biology of species or communities is not well enough known to draw conclusions about viability, because the taxa are exceptionally difficult to observe, or because the data supplier did not include enough information. NatureServe and member programs are developing a complete set of standard occurrence viability and ecological integrity criteria. Examination of unranked occurrences and application of newly developed standards will greatly enhance the value of the EO data sets for conservation decision-making. Unranked occurrences that have a G1 or G2 conservation ranking are of special interest because some portion of these may be assigned an EO ranking of "A," "B," or "C," and thus meet the requirements of forest certification programs.

#### 4.2.4 *Status of Selected Element Occurrence Records (EOR) Fields*

While an element occurrence record (EOR) includes a large number of fields, a subset of EOR fields provides vital information that assists on-the-ground conservation efforts. NatureServe and member programs work diligently to ensure that these fields meet basic internal data content standards such that the information management is consistent across jurisdictional (e.g., state/provincial) boundaries. Table 4.5 shows the percentage of EO records that contain data for these fields for four types of species. Data completion is >80% for all four types of species for the following fields: EO rank, EO data, last observation date, precision, county, quadrangle, and watershed.

For the EORANK field, it is important to note that "data completion" is different from "data that are usable". For example, while data completion is relatively high for EORANK for potentially viable occurrences for species ranked G2 (88%) and potentially viable occurrences (89%) for elements ranked G3, many of these occurrences have an EORANK of "NR (not ranked)," which limits their utility in terms of conservation management. Data completion for the field "IDENTITY," especially for viable and potentially viable occurrences for species ranked G1 and G2, is relatively low because California does not populate this field in their database and California occurrences make up a significant portion of these categories. When California occurrence records are removed from the analysis, data completion percentages for the "IDENTITY" field are 79% and 65% for viable and potentially viable EOs, respectively, for species ranked G1 and G2. Because >97% of all viable occurrences for species ranked G1 or G2 have been verified within the past 25 years (Figure 4.6), currency of records is not a major concern.

**Table 4.5** Percentages of Occurrence Records That Contain Data in Key EOR Fields

| Field Name | Viable Occurrences for G1–G2 Species | Potentially Viable Occurrences for G1–G2 Species | Viable Occurrences for G3 Species | Potentially Viable Occurrences for G3 Species |
|---|---|---|---|---|
| eorank | 100 | 74 | 100 | 69 |
| identity | 55 | 51 | 69 | 60 |
| eo_data | 95 | 75 | 95 | 76 |
| general_description | 90 | 54 | 91 | 58 |
| last_observation_date | 100 | 96 | 99 | 97 |
| survey_date | 78 | 42 | 76 | 40 |
| precision | 98 | 97 | 95 | 95 |
| county | 100 | 97 | 100 | 99 |
| watershed | 97 | 82 | 96 | 94 |
| quadrangle | 99 | 83 | 100 | 97 |

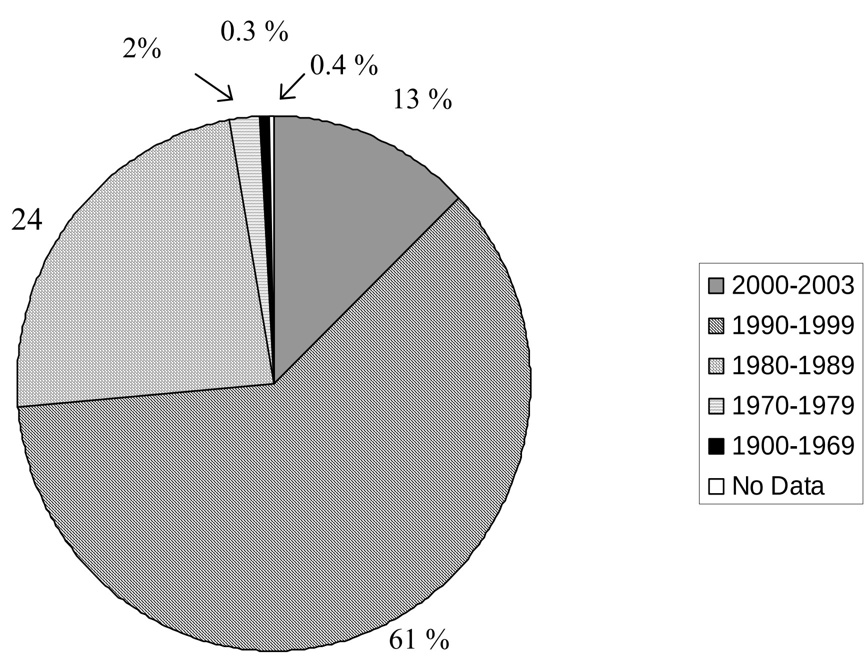


**Figure 4.6** Viable Element-Occurrences-by-Last-Observation-Date Categories for G1- and G2-Ranked Species (Full descriptions of the fields are found in Appendix F)

# 5.0 SCIENTIFIC DATA NEEDS AND GAPS

## 5.1 Maintaining Current Taxonomy and Classification

### 5.1.1 *Species*

One of the basic aspects of NatureServe's data management is maintenance of taxonomic nomenclature and standards. The NatureServe Botany Department currently has a substantial backlog of vascular plant taxonomic changes that must be made to vascular plant data in order to conform to the established taxonomic standard (Kartesz 1999); many genera still follow the previous (1994) checklist. In addition, Kartesz plans to publish new treatments in late 2004 or early 2005. During 2004, NatureServe botanists plan to systematically compare current database records to draft data from that upcoming publication, to ascertain how many plant genera need basic changes (nomenclatural) and how many need more significant (conceptual) updates. This will allow a subsequent analysis of resources that will be needed to process the backlog. With animal data as well, NatureServe often struggles to find funding to maintain current taxonomic treatments in the database, especially for animal elements that are not extremely rare or imperiled.

Taxonomic maintenance for a large number of plant and animal groups is not a trivial task. Taxonomic concepts essentially are NatureServe's fundamental database units—the framework supporting all associated data—so their accuracy, validity, and currency are vital to the credibility of the system. The research and data management required to maintain updated taxonomic treatments for a large network is time-consuming and meticulous work, involving ongoing monitoring of the literature and a thorough understanding of the database design. Taxonomic updates should be made on an entire taxon when work is undertaken (e.g., an entire genus or order) in order to avoid confusing users of the data. Thus, resources must be available for systematic, rather than opportunistic, maintenance of the data.

### 5.1.2 *Ecological Communities and Systems*

The IVC is an international effort to develop a consistent vegetation classification for the western hemisphere, though its design is intended for use anywhere in the world. Individual nations are leading the effort to develop jurisdictional components of the IVC, and are committed to working together to ensure that units are globally standardized. Most of the current activity has been occurring in the United States and Canada, with some activity in the Caribbean and Central American countries.

#### *5.1.2.1 US-NVC Process and Status*

Development and implementation of the NVC as a vital scientific activity depends on the support and participation of scientists and their institutions. Future activities should include updates to current standards, and provision of open access by users to databases (i.e., databases containing the supporting information for classification), and maintenance of a review process for changes in the floristic units of the classification. NatureServe uses its long-term experience with the development and management of the NVC to ensure a practical continuity in the definition of units of classification, and represents the needs of the network of NatureServe member programs in provinces, states, and countries throughout the Americas (NatureServe 2002b). The Federal Geographic Data Committee (FGDC) represents the needs of U.S. federal agencies, and it will coordinate testing and evaluation of updates to the classification system by these agencies (Federal Geographic Data Committee 1997). The Ecological Society of America (ESA) represents the professional scientific community. Its long experience with publication and independent peer review ensures the credibility of the classification. The ESA Vegetation Classification Panel provides an objective, neutral arena for all interested parties in the evaluation of proposed changes to the guidelines as well as the recognized classification units (Jennings et al. 2003).

Table 5.1 provides a summary of the numbers of documented associations, organized by global rank, for each state in the United States. These numbers reflect the variation in size and natural variability across states and sampling effort. Geographic areas where the US-NVC associations have not yet been fully classified include California and Alaska. While much work with vegetation classification has occurred in California, substantial effort is needed to describe association units according to standard. Many of the 649 types listed for that state occur along border regions, or are from specific projects, such as classification and mapping within National Park units. It is likely that over 1,000 new US-NVC associations could be described for California alone. More than one hundred US-NVC associations could be attributed to Alaska. Other states where 30 or more additional US-NVC associations could be described include: Arizona, Hawaii, Illinois, Louisiana, Maine, Michigan, Minnesota, Mississippi, Missouri, New Mexico, Ohio, Pennsylvania, Utah, and Wisconsin.

**Table 5.1** Number of US-NVC Associations by Global Rank Currently Documented for Each State [based on Standard and Provisional Associations in United States with a classification confidence of 1, 2, or 3 (May 2003)]

| State | Conservation Status Rank | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** | **G5** | **GU** | **GX** | |
| AK | 1 | 1 | 14 | 16 | 38 | 13 | 0 | 83 |
| AL | 25 | 87 | 104 | 85 | 8 | 8 | 2 | 319 |
| AR | 24 | 57 | 67 | 49 | 6 | 18 | 1 | 222 |
| AZ | 9 | 37 | 50 | 61 | 53 | 47 | 0 | 257 |
| CA | 29 | 87 | 232 | 148 | 89 | 64 | 0 | 649 |
| CO | 16 | 57 | 130 | 114 | 85 | 88 | 0 | 490 |
| CT | 5 | 15 | 6 | 31 | 12 | 68 | 0 | 137 |
| DE | 6 | 15 | 8 | 12 | 8 | 44 | 0 | 93 |
| FL | 62 | 134 | 93 | 58 | 12 | 7 | 0 | 366 |
| GA | 31 | 108 | 126 | 89 | 12 | 12 | 2 | 380 |
| HI | 35 | 8 | 57 | 6 | | 2 | 0 | 108 |
| IA | 8 | 17 | 22 | 28 | 5 | 4 | 0 | 84 |
| ID | 51 | 82 | 168 | 115 | 77 | 9 | 0 | 502 |
| IL | 13 | 34 | 36 | 42 | 5 | 7 | 0 | 137 |

(Continued on next page.)

**Table 5.1** Continued

| State | Conservation Status Rank | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | G1 | G2 | G3 | G4 | G5 | GU | GX | |
| IN | 7 | 33 | 29 | 44 | 5 | 11 | 0 | 129 |
| KS | 7 | 15 | 23 | 19 | 4 | 7 | 0 | 75 |
| KY | 14 | 46 | 39 | 62 | 7 | 9 | 3 | 180 |
| LA | 38 | 69 | 67 | 57 | 8 | 6 | 0 | 245 |
| MA | 6 | 24 | 13 | 36 | 14 | 83 | 0 | 176 |
| MD | 11 | 22 | 14 | 37 | 12 | 69 | 0 | 165 |
| ME | 2 | 12 | 6 | 42 | 17 | 83 | 0 | 162 |
| MI | 10 | 30 | 41 | 58 | 14 | 32 | 0 | 185 |
| MN | 3 | 23 | 40 | 65 | 19 | 21 | 0 | 171 |
| MO | 15 | 30 | 36 | 32 | 2 | 6 | 0 | 121 |
| MS | 12 | 42 | 55 | 59 | 8 | 7 | 0 | 183 |
| MT | 7 | 48 | 152 | 144 | 73 | 6 | 0 | 430 |
| NC | 79 | 130 | 83 | 69 | 15 | 21 | 3 | 400 |
| ND | 5 | 17 | 33 | 46 | 9 | 14 | 0 | 124 |
| NE | 6 | 14 | 19 | 27 | 7 | 4 | 0 | 77 |
| NH | 3 | 18 | 7 | 37 | 17 | 94 | 0 | 176 |
| NJ | 13 | 23 | 6 | 24 | 12 | 64 | 0 | 142 |
| NM | 16 | 56 | 69 | 75 | 85 | 94 | 0 | 395 |
| NV | 6 | 26 | 80 | 86 | 100 | 16 | 0 | 314 |
| NY | 17 | 36 | 22 | 53 | 21 | 126 | 0 | 275 |
| OH | 6 | 24 | 22 | 29 | 6 | 12 | 0 | 99 |
| OK | 15 | 49 | 55 | 35 | 11 | 29 | 0 | 194 |
| OR | 87 | 147 | 234 | 195 | 67 | 12 | 0 | 742 |
| PA | 8 | 10 | 10 | 33 | 13 | 53 | 0 | 127 |

(Continued on next page.)

**Table 5.1** Continued

| State | Conservation Status Rank | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | G1 | G2 | G3 | G4 | G5 | GU | GX | |
| RI | 1 | 13 | 5 | 24 | 12 | 45 | 0 | 100 |
| SC | 34 | 104 | 91 | 70 | 13 | 12 | 1 | 325 |
| SD | 10 | 23 | 43 | 47 | 7 | 12 | 0 | 142 |
| TN | 58 | 94 | 68 | 85 | 10 | 12 | 2 | 329 |
| TX | 55 | 122 | 104 | 90 | 34 | 58 | 0 | 463 |
| UT | 6 | 26 | 104 | 116 | 87 | 48 | 0 | 387 |
| VA | 54 | 79 | 67 | 77 | 17 | 54 | 2 | 350 |
| VT | 3 | 12 | 8 | 36 | 13 | 71 | 0 | 143 |
| WA | 79 | 106 | 197 | 157 | 63 | 13 | 0 | 615 |
| WI | 6 | 23 | 45 | 46 | 15 | 15 | 0 | 150 |
| WV | 7 | 17 | 14 | 34 | 10 | 35 | 2 | 119 |
| WY | 10 | 50 | 145 | 124 | 70 | 16 | 0 | 415 |
| **Total** | **1,031** | **2,352** | **3,159** | **3,124** | **1,307** | **1,661** | **18** | **12,652** |

### *5.1.2.2 C-NVC Process and Status*

International development and application of ecological classification systems requires collaboration among national programs. Like the US-NVC, the C-NVC uses the same general approach (Ponomarenko and Alvo 2000; Alvo and Ponomarenko 2003). In particular, the Canadian Forest Service is working closely with provincial governments, Conservation Data Centers, and other federal agencies and organizations to define forest and woodland types consistent with the association concept used in the IVC. In addition, provincial governments and CDCs have conducted extensive surveys using standardized plot samples, and they either have well-established vegetation classification systems or are in the process of building them. Some have already developed alliance and association units using the same standards, nomenclature, and codes for types that have been used in the U.S., and are identifying additional types of associations using a methodology that is compatible with that of the IVC (Greenall 1996). This approach ensures that associations developed in the U.S. and in Canada have the potential to be integrated as part of an international vegetation classification that is continentally consistent in scope. Table 5.2 provides a summary of the numbers of associations currently described for Canadian provinces. When comparing this with the above table for the United States, the relatively early stages of development for the classification in each province become apparent.

#### *5.1.2.3 Classification Confidence*

As part of the classification process, each IVC association has been assigned a "confidence level" (i.e., strong, moderate, or weak) based on the relative rigor of description and analysis used to define it. In the mid 1990s, NatureServe developed the following definitions that were used to assess the confidence levels. These are:

1 – STRONG

Classification based on recent field data. Information is based on Element Occurrences or other data based on occurrences that can be relocated. Classification considers information collected across the entire range or potential range of the Element. Classification may be based on quantitative or qualitative data.

2 – MODERATE

Classification is based on data that are of questionable quality, limited numbers of sample points, or data from a limited range.

3 – WEAK

Classification is based on secondary or anecdotal information; or a new type for which data have only been collected at a very small number of sites.

As of 2003, the status for the confidence of classification for associations in the United States is summarized in Table 5.3. Twenty-one percent of United States associations meet confidence level 1, and 72% of all associations described in the United States meet confidence level 1 or 2. Such an evaluation has not yet been undertaken for all Canadian associations, but the current quantitatively based process of developing forest and woodland associations for Canada being led by the Canadian Forest Service should lead to high confidence levels for associations found in Canada. Over 80% of associations in the United States listed G1–G5 have confidence levels of 1 or 2.

**Table 5.2** Number of Associations by Global Rank Currently Documented for Each Province [based on Standard and Provisional IVC Associations in Canada with a classification confidence of 1, 2, or 3 (May 2003)].

| **Subnation** | **Conservation Status Rank** | | | | | | | **Total** |
|---|---|---|---|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** | **G5** | **GU** | **GX** | |
| AB | 0 | 4 | 11 | 6 | 4 | 0 | 0 | 25 |
| BC | 23 | 43 | 83 | 68 | 37 | 3 | 0 | 257 |
| MB | 3 | 12 | 18 | 47 | 15 | 76 | 0 | 171 |
| NB | 0 | 1 | 1 | 18 | 8 | 33 | 0 | 61 |
| NF | 0 | 0 | 0 | 3 | 1 | 2 | 0 | 6 |
| NS | 1 | 3 | 0 | 7 | 6 | 11 | 0 | 28 |
| NT | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| NU | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| ON | 11 | 33 | 43 | 76 | 21 | 114 | 0 | 298 |
| PE | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 5 |
| QC | 1 | 2 | 6 | 20 | 12 | 11 | 0 | 52 |
| SK | 0 | 6 | 21 | 21 | 5 | 11 | 0 | 64 |
| YT | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| **Total** | **39** | **104** | **183** | **267** | **111** | **266** | **0** | **970** |

**Table 5.3** Summary of Confidence Scores for US-NVC Associations Organized by Global Conservation Status Rank as of 2003

| Confidence | Total | % | Conservation Status Rank | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **G1** | **G2** | **G3** | **G4** | **G5** | **G?** | **GH** | **GU** | **Other** |
| 1 | 1156 | 21 | 165 | 272 | 310 | 246 | 103 | 15 | 1 | 3 | 41 |
| 2 | 2808 | 51 | 330 | 618 | 781 | 556 | 227 | 217 | 1 | 3 | 75 |
| 3 | 1246 | 23 | 102 | 159 | 194 | 127 | 43 | 467 | 3 | 99 | 52 |
| null | 258 | 5 | 6 | 33 | 36 | 21 | 1 | 137 | | 8 | 16 |
| total | 5468 | | 603 | 1082 | 1321 | 950 | 374 | 836 | 5 | 113 | 184 |
| % levels 1 or 2 | | | 82% | 82% | 83% | 84% | 88% | 28% | 40% | 5% | 63% |

Recently, the ESA Vegetation Classification Panel published a set of guidelines for the US-NVC that provides more rigorous criteria for defining confidence levels (Jennings et al. 2003). The developing process of peer-review for these classification systems requires review, categorization, and incorporation of existing types and with newly proposed types.

#### *5.1.2.4 NatureServe's Terrestrial Ecological Systems Classification Process and Status*

Ecological systems classification has been established for natural upland and wetland types throughout the coterminous United States (Comer et al. 2003). Current application to regional and local mapping and ecological assessment are most active throughout the western United States. Through these applications, classification concepts and descriptions are tested and updated. NatureServe has also completed a first iteration of this classification for most of Latin America (Josse et al. 2003). New effort is being directed towards classification development in the remainder of North America and Hawaii.

## 5.2 Conservation Status Assessment

NatureServe's databases currently track more than 64,200 species, subspecies, and varieties of animals, plants, and fungi as well as more than 5,200 types of ecological communities and 600 types of ecological systems. Maintenance of conservation status assessments is an increasing challenge, only made possible through the collaborative efforts and resources of many cooperators, including TNC, the U.S. Fish and Wildlife Service, the U.S. Forest Service, the Bureau of Land Management, private foundations, and other NGOs. As forest certification programs make increasing use of the NatureServe system, forest managers will also play an increasingly important role in providing data to NatureServe that will improve the quality of conservation status assessments.

Nearly all (98%) native vascular plant species have been assessed for global conservation status, and about three-quarters of infra-specific taxa have been assessed. Despite these high proportions, many of the ranks are preliminary and are based on limited data. Ultimately, accurate conservation status assessments rely upon data collected in the field, and for most species and ecological communities essential data are lacking, including accurate data on trends and threats to populations and communities. More resources will be required to assess these important factors.

The NatureServe system currently applies 12 quantitative and qualitative factors to rank the conservation status of each element, but it uses guidelines and adjudicated expert judgement rather than a point- or rule-based scoring system to assign relative extinction risk. The degree to which a particular assessor emphasizes factors is a somewhat subjective process. The subjective nature of this aspect of the assessment process has the potential to lead to inconsistencies in the assigning of an element conservation status, and the source of these inconsistencies may not be obvious. Quantitative rule- or rule-and-point-based conservation status assessment systems have been shown to provide more consistent classifications of extinction risk than those that are based on expert judgement alone (Regan, in press). Rule-and-point-based systems also provide transparency to the assignment of conservation status.

NatureServe staff scientists are currently seeking funds to permit a working group to develop a more transparent and repeatable process for assigning conservation status ranks. A pilot of such a system was developed in 2001–2002 at the National Center for Ecological Analysis and Synthesis (NCEAS) in California. This prototype effort developed a hybrid rule-based, point-scoring method, conditioned to reflect the current subjective process. In two test comparisons, 77% of species assessments using this explicit NatureServe method matched the qualitative assessments done by NatureServe staff. Of those assessments that differed, no rank varied by more than one rank-level under the two methods. In general, the prototype NatureServe method produced more conservative assessments (i.e., a given species tended to be ranked as more imperiled) than the qualitative method. The hybrid rule-based, point-scoring method outlined in this study was the first documented attempt to explicitly define a transparent process for weighting and combining factors under the NatureServe system. The method provided a repeatable, transparent, and explicit benchmark for feedback, further development, and improvement (Regan et al., in press). Refinements to this approach will be undertaken as resources become available to do the work.

### 5.3 Developing Habitat, Management, and Other Data for Species

Habitat loss or alteration is the most important factor affecting the imperilment of species in the United States (Wilcove et al. 2000) and detailed, accurate habitat information is needed to enable targeted inventory and monitoring programs. Despite the importance of understanding the specific habitat needs of species, habitat descriptions have only been written for about two-thirds of G1–G3 plants; the remaining one-third (about 1,750 species, mostly ranked G3) constitute a data gap for plant species.

One means of characterizing habitats of species in a standardized, analyzable way is to link species to the ecological systems in which they occur. NatureServe is seeking a continuation of funding from the Environmental Protection Agency to link the rare and vulnerable plant and animal species of the United States to the isolated wetland systems with which they are closely associated. This project builds on a study completed by NatureServe and EPA (Comer et al. in prep.) that evaluates species/ecological systems relationships across 20 states. NatureServe hopes to expand this work to address all wetland and upland systems, and to create a comprehensive dataset that will enable detailed analyses of fine-scale and coarse-scale ecological patterns.

## 5.4 Element Occurrences

### 5.4.1 *Establishing Occurrence Requirements (= EO Specifications) and Occurrence Viability or Ecological Integrity Criteria (= EO Rank Specifications)*

Comparable and methodologically consistent element occurrences are an essential basis for assessing the status and viability or integrity of element occurrences, and for allowing individuals and organizations to focus conservation resources where they will have the greatest impact. Over the past 25 years, NatureServe member programs have collected and managed data with conceptually similar, but methodologically disparate methods. As a result, comparisons among delineated occurrences across jurisdictions have been of limited scientific validity. For example, one jurisdiction may have an extensive population of a species mapped as a single occurrence that adjacent jurisdictions map as multiple occurrences. The result is that one occurrence becomes a half dozen, or vice versa, and the "number of occurrences" factor that influences conservation status rankings is consequently affected differently. Similar ecological contexts are reported differently, and the basis for conservation implications is compromised. Inconsistencies among element occurrence rank specifications create similar conceptual and practical problems.

Publication of the Element Occurrence Data Standard in 2003 addressed the disparity of methods among NatureServe member programs, and all member programs now use the newly issued protocol. However, data collected from 1975 until 2003 were not necessarily comparable in important ways. Those data need to be retrofitted to the new EO Data Standard, and significant resources will be needed to accomplish this task.

Among animal species, EO specifications that conform to the 2003 standard have been prepared that cover almost all EO-tracked species. Only a few hundred element occurrence specifications have been completed among over 20,000 plant elements.

Occurrence requirements (EO specifications) have been developed and applied for approximately 100 ecological communities and ecological systems. Most have been developed in support of projects that were based in specific geographic areas. In other instances, occurrence requirements and ecological integrity criteria (EO rank specifications) have been developed by NatureServe member programs to meet needs of state and provincial projects. Table 5.4 provides a brief summary of the status of occurrence data for ecological communities in a selection of states and provinces. This table provides initial estimates of the numbers of documented occurrences, the degree to which these have been linked to the US-NVC or C-NVC, if they have occurrence rankings, if those rankings were developed from criteria meeting current standards, and estimates of numbers of ranked community occurrences for G1–G3 types. Table 5.4 illustrates a range of circumstances among NatureServe member programs, with some tracking over 5,000 community occurrences while others track none at all. Significant proportions of occurrences have been linked to the US-NVC, and many of those are ranked G1–G3. Among those with EO rankings, most were ranked prior to the development of current ranking standards.

Until occurrence viability and ecological integrity criteria are developed and applied to each element occurrence, it is important for managers to give special consideration to unranked, "null"-ranked, and "E"-ranked (verified extant) occurrences. Their conservation may be more important than suggested by the rankings that have been previously assigned.

It is also worth noting that some state and provincial programs not listed in Table 5.4 have substantial numbers of community occurrences in their databases. These programs include, but are not limited to, British Columbia, California, Florida, Georgia, Kentucky, Maine, New Mexico, North Carolina, Ontario, and Pennsylvania.

**Table 5.4** The Status of Occurrence Data for Ecological Communities in Selected States and Provinces

| Subnation | Status of Element Occurrences[a] | | | | |
|---|---|---|---|---|---|
| | **Total** | **No. linked to US-NVC or C-NVC** | **No. with EO Ranks** | **No. with EO Ranks derived from current standard criteria** | **No. with EO Ranks representing G1–G2, or G3 NVC associations** |
| AL | 265 | 243 | 197 | 143 | 126 |
| AR | 248 | 0 | 190 | 0 | U |
| CO | ~3,000 | ~3,000 | U | U | U |
| CT | 337 | 337 | NA | 0 | 24 |
| DE | 115 | 115 | ~100 | 0 | ~22 |
| IA | 0 | 0 | 0 | 0 | 0 |
| IN | ~1,180 | ~1,180 | U | U | U |
| ID | 3,602 | 2,655 | 1,211 | U | 1,093 |
| IL | 1,026 | NCC | 0 | 0 | 0 |
| KS | 684 | 684 | ~650 | U | U |
| LA | 999 | 988 | 733 | 0 | ~733 |
| MB | 70 | 70 | 28 | 4 | 6 |
| MI | 1,271 | 1,028 | 1,165 | 1,165 | U |
| MN | >5,000 | >5,000 | U | U | U |
| MO | 2,016 | 1,501 | 2,016 | U | U |
| MT | 407 | 407 | 373 | N | 154 |
| NE | 577 | 577 | 577 | U | U |
| NH | 902 | CIP | 749 | 45 | ~40 |
| NJ | 383 | 167 | 169 | 5 | 33 |
| NY | 1,660 | U | 1,660 | ~1,000 | 500 |
| OH | 687 | 0 | U | 0 | 0 |
| OR | 100 | 100 | 0 | 0 | 0 |

(Continued on next page.)

**Table 5.4** Continued

| Subnation | Status of Element Occurrences[a] | | | | |
|---|---|---|---|---|---|
| | **Total** | **No. linked to US-NVC or C-NVC** | **No. with EO Ranks** | **No. with EO Ranks derived from current standard criteria** | **No. with EO Ranks representing G1–G2, or G3 NVC associations** |
| SC | 1,209 | 70 | 474 | 474 | U |
| SK | 0 | 0 | 0 | 0 | 0 |
| TX | 838 | 0 | 655 | 0 | 0 |
| VA | 1,045 | 657 | 1,015 | <200 | 539 |
| VT | 1,105 | 1,105 | 974 | 0 | ~107 |
| WI | 4,528 | 1,592 | 1,398 | 0 | ~340 |
| WA | 2,174 | 1,613 | 1,481 | 466 | 807 |
| WV | 656 | 45 | 79 | 0 | 17 |
| WY | 252 | ~240 | 252 | U | 114 |
| YK | 0 | 0 | 0 | 0 | 0 |

[a]CIP = crosswalk in progress; N = none; NA = not all; NCC= no current crosswalk; U = unknown

The need for standardized occurrence viability and ecological integrity criteria is now receiving increasing support from others, as agencies and organizations recognize the value of ecological integrity assessments to determine how well occurrences of biodiversity elements are doing within or outside of protected areas (Karr and Chu 1995; Noss 2000; Young and Sanzone 2002; Parrish, Braun, and Unnasch 2003). NatureServe's methodology focuses on ecological integrity of occurrences, but the information can also be used as a component of larger efforts to assess ecological integrity at site- or landscape-levels.

### 5.4.2 *Inventory and Mapping Needs*

Field inventory is carried out on a continual basis, mainly by NatureServe member programs, public agency staff, ecological consultants, and others. Some G1–G3 species- and community-types have been inventoried exhaustively. These efforts were likely completed in support of recent status surveys or systematic efforts to document ecosystem conditions. In most instances, however, the need for inventory is ongoing (see examples in Table 5.4 of community occurrence data held by NatureServe member programs). Scientific knowledge continues to grow, and terrestrial and aquatic conditions continue to change. Therefore, there is an ongoing need for systematic inventory to identify new occurrences and to re-evaluate previously documented occurrences.

A standardized, comprehensive, and widely accepted system of classification is required for effective inventory, assessment, and management. Member programs and forest management companies have developed a variety of methods for prioritizing lands for biological inventory, but a standardized methodology has not yet been prepared. A useful methodology should optimize the probability of finding at-risk elements, the ratio of effort to discovery, and the time and money needed to do field work. The need for improving the efficiency of inventories is increasing as individuals in both private and public sectors grapple with the escalating alteration and loss of natural vegetation (e.g., Klopatek et al. 1979; Mack 1986; LaRoe et al. 1995).

To date, there has been no standard methodology for a) documenting priorities for field inventory or b) documenting "negative" data—places an inventoried element was not found. If a standard methodology were developed, NatureServe staff could create an information system to track "negative" data.

NatureServe central staff continues to improve methods and tools for field inventory, and they are engaged in a number of collaborative efforts to map vegetation communities and ecological systems at local and regional scales. Some of these tools may be of interest to forest managers, who may play an important role in verifying the validity of models and in providing feedback about their practicality and utility. Methods for mapping habitat for species of concern continue to evolve (Scott, Heglund, and Morrison 2002).

Extensive areas across the western United States have been mapped to the NatureServe's terrestrial ecological systems classification system, with spatial resolution in the range of 1–20 hectares. At this writing, about 30% of the terrestrial area of North America has been delineated and mapped in this manner. Another 40–60% of United States territory should be mapped in the coming 3–5 years. Because the classification system has significant potential for managers who affect landscape-level patterns, it is critical to advance this work throughout the remainder of North America.

## 6.0 IMPLEMENTING SUSTAINABLE FOREST MANAGEMENT WITH NATURESERVE SCIENCE

### 6.1 Summary of Information Products to Help Managers

Access to NatureServe scientific information is gained through two principal avenues. These include a) a public website, and b) directly from staff in member programs or NatureServe central and regional offices. The NatureServe Explorer website (http://www.natureserve.org/explorer/) provides ready access to lists and descriptive information for associations by conservation status (e.g., all G1–G3 types) and by geographic area (states in the U.S., Canadian provinces, U.S. Forest Service ecoregions in the United States). Descriptive information for each association includes common and scientific names, descriptive summary, distribution maps, conservation status ranking and justification, and scientific literature references.

NatureServe manages Biotics 4, the central database software for standardized information falling under the purview of NatureServe and its network of Natural Heritage Programs. Additional data in Biotics 4 that are not currently available over NatureServe Explorer include site-specific element occurrence records and occurrence viability and ecological integrity criteria. Access to element occurrence data from multiple state/province/tribal jurisdictions may be gained by agreement with NatureServe. Access to complete occurrence data sets within individual state/province/tribal jurisdictions is typically gained through agreements with member programs.

NatureServe and network ecologists, zoologists, and botanists have substantial, relevant expertise and are frequently called upon to:

- assess the likelihood of occurrence for selected species and communities within a given geographic area;
- reconcile local classification and mapping systems with the US-NVC or C-NVC;

- provide the current state of knowledge on the conservation status of biodiversity elements; and
- consult on management prescriptions that could be compatible with protecting occurrences of communities and rare species.

NatureServe's regional ecologists are well suited for consultation on US-NVC and C-NVC classification units. Their expertise pertains to the classification system as a whole, and to the classification units found in the West, Midwest, Southeast, and Northeast regions of the United States. Ecologists from member programs are most familiar with community types and occurrence information within their political jurisdiction.

In most circumstances, there is a continual need to develop new information or maintain the currency of existing information. NatureServe and network ecologists, zoologist, and botanists are frequently called upon to organize a compilation and assessment of existing classification and location information, as well as to conduct new inventory and field assessment. Well-trained experts can structure systematic inventories that are thorough and cost-effective for rare community-types and species. It is often more efficient to have systematic inventories completed by specialists than it is to train non-specialist staff to conduct assessments for rare elements of biodiversity on a piecemeal basis. A web-based directory of network experts, with information on their fields of expertise, is available at http://whiteoak.natureserve.org/HSDS/search/index.cfm.

Training materials may be developed from the information sources listed previously. In most cases, expertise for training may include knowledgeable staff from NatureServe and/or individual Natural Heritage Programs/Conservation Data Centers. There are also opportunities to get training on the use and application of the US-NVC or C-NVC in partnership with public agencies (e.g., U.S. Forest Service, National Park Service, state/provincial agencies), private conservation organizations (e.g., The Nature Conservancy), and private consultants that are frequent users. Training of non-specialist staff may most effectively focus on the integration of biodiversity information into the development of management prescriptions.

NatureServe provides a variety of tools for foresters and land managers. The NatureServe Explorer website (http://www.natureserve.org/explorer/) contains updated information on taxonomic issues, phenology, habitat requirements, distributional range, and the management requirements of some species and communities, which may include conclusions about the susceptibility of the element to structural habitat changes, changes in species composition, and other ecological sensitivities (see Sections 3.4.4 and 3.4.5).

An element occurrence record (EOR) provides information about a specific population, ecological community, or ecological system. EORs contain information about the specific location, viability (for species), integrity (for ecological communities and ecological systems), areal extent, and other occurrence-specific factors about the population or community occurrence that is described. Member programs and NatureServe (central) both provide element occurrence records to users (see Sections 4.2.1 and 6.2).

### 6.1.1 *Site Records*

Many NatureServe member programs have long been engaged in conservation planning activities. Over the past 25 years, methods have evolved to define and document what are sometimes referred to as potential conservation sites that surround element occurrences. In most instances, the area defined as a conservation site a represented by a polygon drawn based on a combination of field observations, 1:24,000 topographic data, and aerial photography. The intent of the polygon is to describe the lands/waters in the immediate vicinity of one or more element occurrences that would be needed to secure ecological processes that support them. In many cases, these polygons and their supporting descriptive text provide a wealth of insights into local landscape conditions, apparent threats to element occurrences, and other information that is useful for conservation.

Although site records may be useful, forest managers should consider several factors when using them. Site records have not been developed across all NatureServe member programs. Member programs that have developed these records have done so using non-standardized information and methods available to them, which vary within and across member program jurisdictions. Notes in site records reflect the perspectives of the scientists who are carrying out a focused inventory in search of certain elements or taxa, and may not reflect an integrated view of all elements that occur on the site. For example, when a member program carries out a rare species inventory, the site records reflect the needs of species elements, but may not consider all ecological processes that support ecological communities and systems at the site.

#### 6.1.2 *Managed Area Records*

Many NatureServe member programs have developed and managed data for a wide range of land management units throughout their state or province. Over the past 25 years, methods evolved to define and document managed area records. Managed areas are natural areas of land under distinct protective or potentially protective management, and are often designated as GAP category 1–3 lands. Examples of managed areas include research natural areas in national forests, TNC preserves, and national wildlife refuges.

In most instances, these areas are defined using readily available mapped information that depicts management units for public land-managing agencies and private cooperators, such as TNC. In many cases, these polygons and their supporting descriptive text provide a wealth of insights into local landscape conditions, current management emphasis, and other information useful for conservation. In some cases, there is a link from specific element occurrences on those areas (such as a population of a rare species) and the managed area record. These are tracked and mapped at the state and provincial levels.

### 6.2 Processes for Obtaining Data and Information

In July 2002, the Sustainable Forestry Board approved four new core indicators in the SFI Standards that are related to Forests with Exceptional Conservation Value (FECV). Two of the indicators (Core Indicator 3 for Performance Measure 4.1.4.1.1 and Core Indicator 1 for Performance Measure 4.1.4.1.3) require specific actions related to locating and protecting FECVs. The other two indicators (Core Indicator 4 for Performance Measure 4.1.4.1.1 and Core Indicator 2 for Performance Measure 4.1.4.1.3) address training or education requirements. SFI Program Participants may opt to use a relationship with NatureServe member programs, or with NatureServe regional or central offices; develop their own plans; or work with other qualified organizations to identify, inventory, map, and protect known viable occurrences of critically imperiled and imperiled species and communities.

The sequence below outlines an approach for using NatureServe information to address SFI performance measures related to FECV. The sequence is illustrative, and may not occur in this order. Many of the actions identified in this process also may be useful within other certification programs.

1) **Communications between land managers and natural heritage programs or conservation data centers.** Every state and province in the United States and Canada and several jurisdictions within them have a NatureServe member program (NHP or CDC) that is responsible for collecting, cataloguing, and managing data related to biodiversity in their jurisdiction. Landowners and managers who seek data, information, or analyses to help them manage successfully for at-risk elements of biodiversity should contact the member program. Initial discussions should be held with the coordinator or director, and follow-up communications may be most appropriate with field scientists, data managers, and other staff. Member programs can

be located by using the online NatureServe Network Staff Directory at http://whiteoak.abi.org/HSDS/search/index.cfm.

2) **Communications between land managers and the NatureServe forest program.** In addition to communications with member programs, land managers may contact the forest program at NatureServe (central) when they are prepared to begin identifying and protecting specific occurrences of biodiversity on their lands. The forest program will work with certificate holders to clarify steps that can be taken jointly to ensure compliance with the forest certification requirements' new SFI core indicators for Forests with Exceptional Conservation Value (FECV) and similar programs of other certification systems. The program will mobilize a team comprised of one or more member programs and NatureServe (central) scientists and technicians to meet the needs that are identified. The point of initial contact at NatureServe is Nick Brown, Forest Program Officer, at (703) 908-1857.

- Certification program participants normally will provide NatureServe with information, such as
  - ✓ the geographic scope of their lands,
  - ✓ the scope of biodiversity that they address through assessments and management, and
  - ✓ on-hand data and information that represent prior inventory work and current data holdings.
- NatureServe normally provides contact information for its personnel to the certification program participant, and
  - ✓ identifies information and services that can be provided by state and provincial member programs, regional offices, and NatureServe (central). Some data products, such as occurrence data from a single jurisdiction, can be provided by member programs or NatureServe central. Technical services may be provided by member programs, regional offices, and/or NatureServe central.
  - ✓ provides classification and ranking services that assure a consistent scientific basis for data acquisition and management. This may include a review and update of taxonomic issues, review and re-ranking of element rankings, and/or a crosswalk of ecological community types from state and provincial standards to national standards.
  - ✓ describes the range of options for assessment and management of biodiversity that can be addressed by a program participant.

3) **NatureServe provides datasets and services to companies**. Member programs or NatureServe (central) will provide a list of tracked elements and element occurrence records for these elements on certification participants' lands, based on the values that have been requested by the company.

- A list of elements (including species and ecological communities) that occur in counties and watersheds that are managed by the certificate holder can be reviewed online using NatureServe Explorer (http://www.natureserve.org/explorer/).

- The element list may need filtering and refinement by member program staff to identify only those species and communities that are likely to occur on company lands.
- Element occurrence (EO) data may be provided by member programs or by NatureServe (central). Member programs often provide data at little or no cost to companies. NatureServe (central) provides data at the cost of processing and shipping it from their Arlington, Virginia offices. As a result, companies often find that if they manage in fewer than four or five jurisdictions, data from member programs is less expensive to obtain than an MJD from NatureServe central.
- When support is available to do so, elements and occurrences are reviewed by member programs and NatureServe central staff to ensure consistency with national classification and ranking standards.

4) **Integration of NatureServe data into management operations.** Companies typically compare locations of acquired occurrence data with operations information (e.g., harvest unit scheduling) to identify near-term priorities for conservation and protection.

5) **Ground verification of existing occurrences (EOs).** Company personnel, usually in partnership with NatureServe member program scientists, often verify the status and viability of occurrences. Where there are discrepancies between information in the database and on the ground, those differences are reported to member programs.

6) **Inventories to find new occurrences (EOs)**. Modeling efforts may also be undertaken to determine elements that occur on lands similar to those managed by the company, but have not yet been located on company lands.

7) **Data re-assessment and management**. NatureServe may re-assess global conservation status and occurrence (EO) rankings, based on the development of additional data from company lands. New rankings are updated in member program databases and NatureServe central databases to reflect the current conservation status of each element.

8) **FECV site identification and strategy development.** Program participants, possibly in partnership with Heritage scientists, would develop strategies in order to conserve viable occurrences (EOs) as Forests with Exceptional Conservation Value.

### 6.3 The Role of NatureServe in Certification Programs

NatureServe supports the use of data and analyses on at-risk biodiversity in all forest management certification programs, and recognizes that different approaches to the issue of biodiversity conservation suit the needs of different programs. Fully comprehensive efforts are the most effective in limiting extirpations and extinctions, but incremental progress and continuous improvements can also produce significant results over a long term.

NatureServe has established working relationships with the three most successful and widespread forest management certification systems in North America: the Canadian Standards Association (CSA), the Forest Stewardship Council (FSC), and the SFI. Each of the systems has a significant footprint on managed forests in North America. Over 103 million acres (41 million ha) have been independently (third-party) certified by the SFI program in the United States and Canada, 21 million acres (8 million ha) by the FSC, and 81.3 million acres (32.9 million ha) by the CSA. Thus, the area of land that can be conserved by effective management of at-risk ecological elements under these programs is quite significant.

NatureServe has engaged with each of these programs in technical assistance and advisory roles. The SFI and FSC systems have incorporated language that requires or recommends the use of NatureServe information in their forest management standards, and the CSA program is exploring approaches for using NatureServe data that will meet the needs of that system. Certificate holders in these programs have worked with natural heritage programs, conservation data centers, NatureServe-Canada, and NatureServe regional and central offices.

### 6.3.1 *Sustainable Forestry Initiative®*

The SFI passed the provision for Forests with Exceptional Conservation Value (FECV) on July 1, 2002. Participants are required to protect known, viable occurrences of G1 and G2 species and communities. One year of grace period was allowed, thus SFI participants have been held to FECV requirements in the SFIS 2002–2004 since July 1, 2003.

Initial funding for NatureServe forest program support to SFI was obtained through the National Fish and Wildlife Foundation (NFWF). The grant was made possible through matching funds (in the form of in-kind efforts) provided by Boise-Cascade Corporation and International Paper Company (IP), which are SFI-participating companies. Both of those companies have provided small contracts of fees-for-services to NatureServe over the past year.

Over the initial year of program operation, significant time and effort of the forest program have gone to communicating with and training of SFI companies. The program has worked with IP, including development of a MOU, field training, site visits, and advice on FECV in the southeastern United States. The program also has worked with Boise-Cascade Corporation, Potlatch Corporation, Temple-Inland Forest Products Company, Weyerhaeuser Company, and other SFI-participant companies. NatureServe representatives have made presentations to regional training sessions across the United States at meetings of company biologists, the SFI Annual Conference, its Auditor Forum, the Customer Forums, and the SFI Standards Committee's FECV Task Force.

### 6.3.2 *Canadian Standards Association*

The Canadian Standards Association (CSA) through the CSA SFM Technical Committee developed Canada's National Standard for Sustainable Forest Management - CAN/CSA Z809 *Sustainable Forest Management: Requirements and Guidance*. The CSA is considering opportunities to revise and upgrade the biodiversity conservation component of the National Standard CAN/CSA Z809 in 2004. NatureServe and CSA are developing a strategy that will result in the delivery of comprehensive information about NatureServe's capacity in Canada to the Z809 Standards Committee, CSA certificate holders, and to other stakeholders.

### 6.3.3 *Forest Stewardship Council*

Each of the nine sets of regional FSC standards in the United States refers to NatureServe or natural heritage programs and requires forest managers to protect some set of imperiled and/or vulnerable species and communities. Standards currently vary in the level of specificity of requirements to inventory, develop plans for, and protect species and communities. For example, the Northeast regional standard requires that S1–S3 and G1–G3 species be maintained and protected, and further requires that S1–S3, G1–G3 and the best examples of G4 and G5 ecological communities be considered for high conservation value forest (HCVF) designation, depending on their local and regional rarity. By contrast, the Mississippi Alluvial Valley standard requires that the manager consult with natural heritage programs, but does not articulate specific categories of habitats or ecological communities that should be considered HCVF. Seven of the nine regional standards in the United States have been accredited to date, and each requires the use of NatureServe data and/or collaboration with natural heritage programs or conservation data centers.

FSC-US seeks to standardize the requirement for protection of at-risk species and communities, and is collaborating with the NatureServe forest program to obtain detailed information sufficient to establish an appropriate provision for their National Indicators. The forest program has provided input to the FSC-US Standards Committee and to senior staff, including analyses of NatureServe databases. NatureServe and FSC-US are in the process of developing a memorandum of understanding for their work together.

The two endorsed regional FSC standards in Canada (British Columbia and Maritimes Provinces) each require protection of NatureServe-ranked elements, by requiring protection of red- and blue-listed (lists currently derived directly from subnational ranks of the British Columbia Conservation Data Centre, a NatureServe member program) and COSEWIC (http://www.cosewic.gc.ca/index.htm) species. FSC-Canada and NatureServe are in the process of developing a memorandum of understanding for their work together.

## 7.0 SUMMARY

Conservation of biological diversity is an important component of sustainable forestry programs, but identifying elements of biodiversity that are most critical to sustainable forestry has been a challenge. Recently, concepts such as the Forests with Exceptional Value (FECV) provisions within the Sustainable Forestry Initiative®, and High Conservation Value Forests (HCVF), used by the Forest Stewardship Council, have been developed to help forest managers address at-risk components of biological diversity. These concepts are making increasing use of information provided by NatureServe, an independent international non-governmental organization.

NatureServe was established by The Nature Conservancy in 2000. The NatureServe network consists of a central office, four regional offices in the U.S., 54 member programs in the U.S., 11 provincial and territorial offices in Canada, and 11 national and territorial offices in the Latin America region. Member programs are typically called natural heritage programs in the U.S. and Conservation Data Centers in Canada and Latin America. The role of member programs is to collect, analyze, and distribute standardized scientific information about the biological diversity found in their jurisdictions. The regional and central offices of NatureServe provide coordination and technical support, such as work on classification and development of ecological communities, to member programs. NatureServe member programs agree to carry out an annual data exchange with NatureServe central.

NatureServe maintains information on elements of biodiversity and occurrences of those elements. An element is a unit of biodiversity, generally a species (or subspecies, variety, or population), ecological community, or ecological system. The NatureServe system tracks over 64,200 species, subspecies, varieties, and populations of invertebrates, vertebrates, vascular plants, and nonvascular plants; 5,210 ecological communities; and 600 types of ecological systems found in the U.S. NatureServe assigns the tracked elements a conservation status rank, based on 12 quantitative and qualitative factors, that indicates their relative imperilment, risk of extinction, or risk of extirpation. Conservation status ranks can be revised as new information is submitted to NatureServe. Significant information on NatureServe's tracked elements can be found at http://www.natureserve.org/explorer/.

As of September 2003, there were 376 critically imperiled (G1) and imperiled (G2) vertebrate elements, 3,423 invertebrates, 2,697 vascular plants, and 287 nonvascular plants. In addition, there were 1,647 G1–G2 associations for the United States and 124 G1–G2 associations for Canada. There were 1,263 G3 associations for the United States and 136 for Canada. The relatively low numbers of associations listed for Canada primarily reflects the early stages of development of standard C-NVC association units. Many more units are yet to be fully described and standardized.

The 2002–2004 SFI Standard and several regional Forest Stewardship Council standards currently require plans to locate and protect viable (viability or integrity ranks of "A," "B", or "C") element occurrences for imperiled species and ecological communities. An element occurrence (EO) is an area of land and/or water in which a species or natural community is, or was, present. An EO rank provides an initial indication of the likelihood that, if current conditions prevail, an occurrence will persist for a defined period of time, typically 20–100 years depending on the element. To assess the quality of occurrences, one must first identify and document a limited number of key ecological attributes that support them, and a set of measurable indicators to evaluate each attribute and document their expected ranges of variation. For each indicator, NatureServe establishes a threshold for determining the current status of attributes, and a relative scale of viability or integrity that ranges from "excellent" (A) to "poor" (D).

NatureServe maintains a central, multi-jurisdictional EO database (the MJD) comprised of data from member programs; the database currently contains over 500,000 element occurrence records for species. The purpose of the MJD is to provide one regional, national, and/or bi-national data set with range-wide distribution information to support management and conservation efforts. At this time, the MJD contains only occurrence records for species (i.e., not for ecological communities or systems), though there are many community occurrence records in data held by member programs. NatureServe intends to expand the scope of the MJD to include all occurrence records for ecological communities, and has begun acquiring data for wetland community occurrence records from some member programs. The MJD currently contains 19,009 G1–G2 viable occurrences, 20,120 G3 viable occurrences, 54,061 G1–G2 potentially viable occurrences, and 61,208 G3 potentially viable occurrences. Approximately 195,000 occurrences are G4–G5 or unranked.

Although NatureServe databases provide the most comprehensive source of information managers can consult regarding at-risk elements of biodiversity, the maintenance and development of NatureServe databases involve several challenges. There is a need to maintain current taxonomic treatments in the database for plant and for animal elements, especially for elements that are not extremely rare or imperiled. The C-NVC must be completed and ecological communities in some regions of the U.S. (particularly in California and Alaska) need to be classified using the US-NVC. There also is a need to update current standards, provide open access by users to databases (i.e., databases containing the supporting information for classification), and maintain a review process for changes in the floristic units of the classification.

There is a need to complete mapping of ecological systems in the conterminous U.S. (it is most advanced in the western U.S.), and to complete classification in the remainder of North America and Hawaii. There also is a need to write habitat descriptions for about 1,750 G1–G3 plant species, and to link rare and vulnerable species to the ecological systems in which they occur.

Many conservation status ranks are preliminary and for most species and ecological communities essential data are lacking, including accurate data on trends and threats to populations and communities. More resources will be required to assess these important factors. NatureServe staff scientists also are currently seeking funds to support the development of a more transparent and repeatable process for assigning conservation status ranks. The new process will be a hybrid rule-based, point-scoring method, conditioned to reflect the current somewhat subjective process.

Publication of the Element Occurrence Data Standard in 2003 addressed the disparity of methods among NatureServe member programs for delineating element occurrences. However, data gathered from 1975 until 2003 are not necessarily comparable and need to be retrofitted using the new EO Data Standard. New EO specifications are needed for most plant elements, ecological communities, and ecological systems.

There is an ongoing need for systematic inventory to identify new occurrences and to re-evaluate previously documented occurrences. There also is a need to develop standardized methods for prioritizing lands for biological inventory and for documenting locations where elements were searched for but not found ("negative" data). A useful methodology should optimize the probability of finding at-risk elements, the ratio of effort to discovery, and the time and money needed to do field work.

Forest managers can acquire NatureServe scientific information through two principal avenues: a) the public NatureServe Explorer website (http://www.natureserve.org/explorer/) and b) directly from staff in NatureServe network member programs or NatureServe central and regional offices. NatureServe Explorer provides significant amounts of descriptive information for tracked elements such as common and scientific names, taxonomy issues, habitat requirements, distribution maps, conservation status rankings, scientific literature, and the management of some species and communities. Element occurrence records, which provide information about a specific population, ecological community, or ecological system, are only available through direct contact with member programs and NatureServe central. A sample process for acquiring NatureServe information and using it to address forest certification standards includes the following steps: a) communications between land managers and natural heritage programs or conservation data centers; b) communications between land managers and the NatureServe forest program; c) the acquisition of NatureServe datasets and integration of those data into management operations; d) ground verification of element occurrences; e) inventories to find new element occurrences; and f) FECV site identification and strategy development.

In conclusion, NatureServe information is highly relevant to sustainable forestry certification programs, particularly for the management of at-risk elements of biological diversity. NatureServe has established working relationships with the three most successful and widespread forest management certification systems in North America (CSA, FSC, and SFI), and is engaged with each of these programs in technical assistance and advisory roles. Thus, the area of land that can be conserved by effective management of at-risk ecological elements under these programs is quite significant.

## REFERENCES

Alvo, R., and S. Ponomarenko. 2003. Vegetation classification standard for Canada workshop: 31 May – 2 June 2000. *Canadian Field Naturalist* 117(1): 125 –139.

Anderson, L.E. 1990. A checklist of sphagnum in North America north of Mexico. *The Bryologist* 93(4):500–501.

Anderson, L.E, H.A. Crum, and W.R. Buck. 1990. List of the mosses of North America north of Mexico. *The Bryologist* 93(4):448–499.

Anderson M., P.S. Bourgeron, M.T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D.H. Grossman, S. Landaal, K. Metzler, K.D. Patterson, M. Pyne, M. Reid, L. Sneddon, and A.S. Weakley. 1998. *International classification of ecological communities* *terrestrial vegetation of the United States. Volume II: The National Vegetation Classification System: list of types*. Arlington, VA: The Nature Conservancy.

Angermeier, P.L., and J.R. Karr. 1986. Applying an index of biotic integrity based on stream fish communities: consideration in sampling and interpretation. *North American Journal of Fisheries Management*. Vol.6, 418–429.

Arno, S.F., D.G. Simmerman, and R.E. Keane. 1985. *Forest succession of four habitat types in western Montana*. U.S. Department of Agriculture, Forest Service General Technical Report INT-177.

Austin, M. P. and T. M. Smith. 1989. A new model for the continuum concept. *Vegetatio* 83:35–47.

Baker, W. L. 1984. A preliminary classification of the natural vegetation of Colorado. *Great Basin Naturalist* 44:647–676.

Baldwin, K. et al. (in preparation). Draft associations for the western Boreal region of Canada. Natural Resources Canada, Canadian Forest Service, Sault Ste. Marie, Ontario. Canada.

Barbour, M. 1994. Special committee on vegetation classification. *Bulletin of the Ecological Society of America* 75:252–253.

Barbour, M., D.Glenn-Lewin and O. Loucks. 2000. Progress towards North American vegetation classification at physiognomic and floristic levels. In *Proceedings, International Association of Vegetation Science Symposium*, pp. 111–114. Uppsala, Sweden: Opulus Press.

Beissinger, S.R., and M.I. Westphal. 1998. On the use of demographic models of population viability in endangered species management. *Journal of Wildlife Management* 62(3):821–841.

Boone, J. L., M. H. Smith, and J. Laerm. 1999. Allozyme variation in the cotton mouse (*Peromyscus gossypinus*). *Journal of Mammalogy* 80(3):833-844.

Bourgeron, P. S. 1988. The Nature Conservancy's classification system: its development and use in the western United States. In *Proceedings of the Montana Natural Areas Conference*, ed. D. Loop. Billings, Montana, USA, October 1986.

Bourgeron, P.S., and L.D. Engelking (editors). 1994. *A preliminary vegetation classification of the western United States*. Unpublished report prepared by the Western Heritage Task Force for the Nature Conservancy, Boulder, Colorado, USA.

Brook, B. W. 1999. Evaluating population viability analysis. Ph.D. dissert., Macquarie University, Sydney, Australia.

Brown, D. E. (editor). 1982. Biotic communities of the American Southwest-United States and Mexico. *Desert Plants* 4(1–4):1–342.

Cairns, J. 1974. Indicator species vs. the concept of community structure as an index of pollution: a framework for an ecosystem integrity report card. *Water Research Bulletin*. 10: 338–347.

Caughley, G. 1994. Directions in conservation biology. *Journal of Animal Ecology* 63:215–244.

Caughley, G. and A. Gunn. 1996. *Conservation biology in theory and practice*. Cambridge, MA: Blackwell Science.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. *Ecological systems in the United States: A working classification of terrestrial systems*. Arlington, VA: NatureServe.

Comer, P., et al. In prep. *Biodiversity values associated with isolated wetlands in the United Status*. Report to the US-EPA, Office of Water. Arlington, VA: NatureServe.

Cooper, S. V., K. E. Neiman, R. Steele, and D. W. Roberts. 1987. *Forest habitats of northern Idaho: A second approximation*. U.S. Forest Service General Technical Report INT-236. Intermountain Research Station, Ogden, Utah, USA.

Cowardin, L. W., V. Carter, F.C. Golet, and E. T. LaRoe. 1979. *Classification of wetlands and deepwater habitats of the United States*. Biological Service Program, U.S. Fish and Wildlife Service, FWS/OBS 79/31. Washington, DC: U.S. Department of Interior, Office of Biological Services, Fish and Wildlife Service.

Curtis, J.T. 1959. *The vegetation of Wisconsin: An ordination of plant communities*. University of Wisconsin Press, Madison, Wisconsin, USA. 657 pp.

Daubenmire, R.F. 1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. *Ecological Monographs* 22:301–330.

Daubenmire, R.F. 1968. *Plant communities: A textbook of plant synecology*. New York: Harper and Row.

Daubenmire, R. F. 1970. *Steppe vegetation of Washington*. Washington State University Agricultural Experiment Station Technical Bulletin No. 62, Pullman, Washington, USA.

Daubenmire, R. F., and J. B. Daubenmire. 1968. *Forest vegetation of eastern Washington and northern Idaho*. Washington State University Agricultural Experiment Station Technical Bulletin No. 60, Pullman, Washington.

DeVelice, R. L., J. A. Ludwig, W. H. Moir, and F. Ronco, Jr. 1986. *A classification of forest habitat types of northern New Mexico and southern Colorado*. U.S. Forest Service General Technical Report RM-131. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado, USA.

Esslinger, T.L., and R.S. Egan. 1995. A sixth checklist of the lichen-forming, lichenicolous, and allied fungi of the continental United States and Canada. *The Bryologist* 98(4):467–549.

Eyre, F. H. (editor). 1980. *Forest cover types of the United States and Canada*. Washington, DC: Society of American Forests.

Federal Geographic Data Committee (FGDC). 1997. *Vegetation classification standard*. FGDC-STD-005. Vegetation Subcommittee, Federal Geographic Data Committee. FGDC Secretariat, U.S.

Fisher, W.C., and B.D. Clayton. 1983. *Fire ecology of Montana forest habitat types east of the continental divide*. U.S. Forest Service General Technical Report INT-141, Intermountain Forest and Range Experiment Station, Ogden UT.

Flahault, C. and C. Schröter. 1910. Phytogeographische Nomenklatur. Berichte und Anträge 3, pp. 14–22. Third International Congress of Botany. Brussels, Belgium.

Forest Stewardship Council (FSC). 1999. Principle 9 of the FSC Principles and Criteria. Oaxaca, Mexico.

Gauch, H. G., Jr., and R. H. Whittaker. 1981. Hierarchical classification of community data. *Journal of Ecology* 69: 135–152.

Gleason, H. A. 1926. The individualistic concept of the plant association. *Bulletin of the Torrey Botanical Club* 53:7–26.

Glenn-Lewin, D. C., and E. van der Maarel. 1992. Patterns and processes of vegetation dynamics. Pages 11–44 in D. C. Glenn-Lewin, R. K. Peet, and T. T. Veblen, editors. Plant succession: theory and prediction. Chapman and Hall, New York, New York, USA.

Greenall, J.A. 1996. Manitoba's Terrestrial Plant Communities. Manitoba Conservation Data Centre MS Report 96-02.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K.D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. *International classification of ecological communities: Terrestrial vegetation of the United States. Volume I: The vegetation classification standard*. Arlington, VA: The Nature Conservancy.

Groves, C.R., D.B. Jensen, L.L. Valutis, K.H. Redford, M.L. Shaffer, J.M. Scott, J.V. Baumgartner, J.V. Higgins, M.W. Beck, and M.G. Anderson. 2002. Planning for biodiversity conservation: putting conservation science into practice. *Bioscience* 52:499–512.

Gutierrez, R. J. and S. Harrison. 1996. Applying metapopulation theory to spotted owl management: a history and critique. Pages 167–185 in McCullough, D.R., editor. Metapopulations and Wildlife Conservation. Island Press, Washington, D.C. 429pp.

Hess, K., and R. R. Alexander. 1986. *Forest vegetation of the Arapaho and Roosevelt National Forests in north central Colorado: A habitat type classification*. Ft. Collins, CO: U.S. Forest Service Research Paper RM-266. Rocky Mountain Forest and Range Experiment Station.

Hironaka, M., M. A. Fosberg, and A. H. Winward. 1983. *Sagebrush-grass habitat types of southern Idaho*. Forestry, Wildlife, and Range Experiment Station Bulletin No. 15. Moscow, ID: University of Idaho.

IUCN. 1996. IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland.

Jenkins, R.E. 1976. Maintenance of natural diversity: approach and recommendations. In *Proceedings of the Forty-first North American Wildlife and Natural Resources Conference*, pp. 441–451. Washington, D.C.

Jenkins, R.E. 1985. The identification, acquisition, and preservation of land as a species conservation strategy. *Animal extinctions*, ed. R.J. Hoage, pp. 129–145. Washington, DC: Smithsonian Institution Press.

Jennings, M., O. Loucks, D. Glenn-Lewin, R. Peet, D. Faber-Langendoen, D. Grossman, A. Damman, M. Barbour, R. Pfister, M. Walker, S. Talbot, J. Walker, G. Hartshorn, G. Waggoner, M. Abrams, A. Hill, D. Roberts, and D. Tart. 2003. *Guidelines for describing associations and alliances of the U.S. National Vegetation Classification.* The Ecological Society of America, Vegetation Classification Panel, Version 3.0 November 2003. 100 pp. (+ Appendices)

Jongman, R. H. G., C. J. F. ter Braak, and O. F. R. van Tongeren, editors. 1995. *Data analysis in community and landscape ecology*. Cambridge, UK: Cambridge University Press.

Johnsson, B.G. and M. Jonsell. 1999. Exploring potential biodiversity indicators in boreal forests. *Biodiversity and conservation*. Vol. 8. pp. 1417–1433.

Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. *Ecological systems of Latin*

*America and the Caribbean: A working classification of terrestrial systems*. Arlington, VA: NatureServe.

Karr, J.R. and E.W. Chu. 1995. Ecological integrity: Reclaiming lost connections. In *Perspectives on Ecological Integrity*, ed. L. Westra and J. Lemons, pp. 34–48. Dordrecht, Netherlands: Kluwer Academic.

Kartesz, J.T. 1999. *A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland*. First edition. In Kartesz, JT and CA Meacham. Synthesis of the North American flora [computer program]. Version 1.0. : Chapel Hill, NC: North Carolina Botanical Garden

Keeton, W. T. and Gould, W. W. 1986. *Biological science*, fourth edition. W. W. Norton and Co., New York, N.Y.

Keith, D. and M. Ilowski. 1999. Epacris stuartii recovery plan 1996-2005. In. Department of Primary Industries, Water, and Environment., Hobart, Tasmania.

Kimmins, J.P. 1997. *Forest ecology: A foundation for sustainable management*. Second edition. Upper Saddle River, NJ: Prentice Hall.

Kintsch, J.A. and D. L. Urban. 2002. Focal species, community representation, and physical proxies as conservation strategies: A case study in the Amphibolite Mountains, North Carolina, U.S.A. *Conservation Biology* Vol. 16 No.4 pp. 936–947.

Klopatek, J.M., R.J. Olson, C.J. Emerson, and J.L. Jones. 1979. Land use conflicts with natural vegetation in the United States. *Environmental Conservation* 6:191–199.

Landres, P. B. 1983. Use of guild concept in environmental impact assessment. *Environmental Management* Vol. 7. pp. 393–398.

Landres, P.B., P. Morgan, and F.J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications* 9:1179–1188.

LaRoe, E.T., G.S. Garris, C.E. Puckett, P.D. Doran, and M.J. Mac (editors). 1995. *Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems*. Washington, DC: U.S. Department of the Interior, National Biological Service.

Lindenmayer, D.B. and J.F. Franklin. 2002. *Conserving forest biodiversity: A comprehensive multi-scaled approach*. Washington, DC: Island Press.

Loucks, O.L. 1995. Special committee on vegetation classification: annual report. *Bulletin of the Ecological Society of America* 76:221–223.

Mack, R.N. 1986. Alien plant invasion into the Intermountain West: a case history. In *Ecology of biological invasions of North America and Hawaii*, ed. H.A. Mooney and J.A. Drake, pp. 191–212. New York: Springer-Verlag.

Master, L. L. 1991. Assessing threats and setting priorities for conservation. *Conservation Biology* 5: 559–563

Master, L. L., B. A. Stein, L. S. Kutner. 2000. Vanishing assets: Conservation status of U.S. species. In *Precious heritage: The status of biodiversity in the United States*, ed. B. A. Stein, L. S. Kutner, and J.S. Adams, pp. 93–118. New York: Oxford University Press.

Master, L. L., L. E. Morse, A. S. Weakley, G. A. Hammerson, and D. Faber-Langendoen. 2003. *NatureServe conservation status criteria*. Arlington, VA: NatureServe.

Mauk, R. L., and J. A. Henderson. 1984. *Coniferous forest habitat types of northern Utah*. U.S. Forest Service General Technical Report INT-170. Intermountain Forest and Range Experiment Station, Ogden, Utah, USA.

McCullough, D.R. 1996. Introduction. Pages 1–10 in McCullough, D.R., editor. Metapopulations and Wildlife Conservation. Island Press, Washington, D.C. 429pp.

McCune, B., and M. J. Mefford. 1999. PC-ORD. Multivariate Analysis of Ecological Data, Version 4. MjM Software Design, Gleneden Beach, Oregon, USA.

McPeek, M. A., and T. E. Miller. 1996. Evolutionary biology and community ecology. *Ecology* 77:1319–1320.

Mueggler, W. F., and W. L. Stewart. 1980. *Grassland and shrubland habitat types of western Montana*. U.S. Forest Service General Technical Report INT-66. Intermountain Forest and Range Experiment Station, Ogden UT.

Mueggler, W. F. 1988. *Aspen community types of the Intermountain Region.* U.S. Forest Service General Technical Report INT-250. Intermountain Forest and Range Experiment Station, Ogden, UT.

Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and methods of vegetation ecology*. New York: John Wiley.

National Research Council. 1993. *A biological survey for the Nation.* National Academy Press, Washington, D.C., USA.

NatureServe. 2002a. Element Occurrence Data Standard. http://whiteoak.natureserve.org/eodraft/index.htm.

NatureServe. 2002b. *International classification of ecological communities: Terrestrial vegetation of the United States*. NatureServe, Arlington, VA.

NatureServe. 2004. Benchmark data standards. Revised draft in review.

Nelson, P. W. 1985. *The terrestrial natural communities of Missouri.* Missouri Department of Natural Resources, Jefferson City, Missouri, USA.

Noss, R.F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. *Conservation Biology* 4:355–364.

Noss, R.F. 2000. Maintaining integrity in landscapes and ecoregions. In *Ecological integrity: Integrating environment, conservation, and health*, ed. D. Pimentel, D. L. Westra, and R.F. Noss, pp. 191–208. Washington, DC: Island Press.

Noss, R. F. and A. Y. Cooperrider. 1994. *Saving nature's legacy*. Washington, DC: Island Press.

Noss, R.F., E.T. LaRoe III, and J.M. Scott. 1995. *Endangered ecosystems of the United States: a preliminary assessment of loss and degradation*. Washington, DC: Biological Report 28, U.S. Department of the Interior, National Biological Service.

O'Grady, J. J., D. H. Reed, B. W. Brook, and R. Frankham. 2004 (in press). What are the best correlates of predicted extinction risk? *Biological Conservation*.

O'Grady, J. J., M. A. Burgman, D. A. Keith, L. L. Master, S. J. Andelman, B. W. Brook, G. A. Hammerson, T. Regan, and R. Frankham. In press. Correlations among extinction risks assessed by different threatened species categorization systems. Submitted to Conservation Biology.

Orians, G. H. 1993. Endangered at what level? *Ecological Applications* 3:206–208.

Padgett, W. G., A. P. Youngblood, and A. H. Winward. 1989. *Riparian community type classification of Utah and southeastern Idaho*. U.S. Forest Service Report R4-ECOL-89-01. Ogden, UT: Intermountain Region.

Parrish, J.D., D. P. Braun, and R.S. Unnasch. 2003. Are we conserving what we say we are? Measuring ecological integrity within protected areas. *BioScience* 53: 851–860.

Peet, R.K. 1994. Vegetation classification in contemporary ecology. *Ecological Society of America Vegetation Section Newsletter* 2-5, Washington D.C.

Pfister, R. D., B. L. Kovalchik, S. F. Arno, and R. C. Presby. 1977. *Forest habitat types of Montana*. U.S. Forest Service General Technical Report INT-34. Intermountain Forest and Range Experiment Station, Ogden, UT.

Pielou, E. C. 1984. *The interpretation of ecological data: A primer on classification and ordination*. New York: Wiley.

Ponomarenko, S. and R. Alvo. 2000. *Perspectives on developing a Canadian classification of ecological communities*. Canadian Forest Service, Science Branch, Information Report ST-X-18E. Ottawa: Natural Resources Canada.

Possingham, H. P., S. J. Andelman, M. A. Burgman, R. A. Medellin, L. L. Master, and D. A. Keith. 2002. Limits to the use of threatened species lists. *Trends in Ecology and Evolution* 17:503–507.

Rabinowitz, D. 1981. Seven forms of rarity. In *The biological aspects of rare plant conservation*, ed. H. Synge, pp. 205–217. Chichester, England: Wiley.

Rapport, D.J., R. Costanza, and A.J. McMichael. 1998. Assessing ecosystem health. *Trends in ecology and evolution*. Vol. 13. pp. 397–402.

Regan, H. In press. Uncertainties in parameter estimation and the structural differences between the classification systems leads to significant and unpredictable differences within and between species' threat classifications that are difficult to control even when the method is objective. *Acta Oecologica*.

Regan, T.J., L.L. Master, and G.A. Hammerson. In press. Making heritage assessments transparent. *Acta Oecologica*

Reschke, C. 1990. *Ecological communities of New York State*. Latham, NY: New York Natural Heritage Program. New York State Department of Environmental Conservation.

Sawyer, J. O. and T. Keeler-Wolf. 1995. *A manual of California vegetation*. Sacramento, CA: California Native Plant Society.

Schafale, M. P., and A. S. Weakley. 1990. *Classification of the natural communities of North Carolina: Third approximation*. Raleigh, NC: North Carolina Department of Environment, Health and Natural Resources, Division of State Parks and Recreation, Natural Heritage Program.

Schorger, A. W. 1995. *The passenger pigeon*. University of Wisconsin Press, Madison, WI.

Scott, J.M., B. Csuti, J.D. Jacobi, and J.E. Estes. 1987. Species richness: a geographic approach to protecting future biological diversity. *Bioscience* 37: 782–788.

Scott, J.M., P.J. Heglund, M.L. Morrison (eds.). 2002. *Predicting species occurrences: issues of accuracy and scale*. Covelo, CA.: Island Press.

Steele, R., R. D. Pfister, R. A. Ryker, and J. A. Kittams. 1981. *Forest habitat types of central Idaho*. U.S. Forest Service General Technical Report INT-114. Intermountain Forest and Range Experiment Station, Ogden, UT.

Stein, B. A. and F. W. Davis. 2000. Discovering life in America: Tools and techniques of biodiversity inventory. In *Precious heritage: The status of biodiversity in the United States*, ed. B. A. Stein, L. S. Kutner, and J.S. Adams, pp. 19–53. New York: Oxford University Press.

Stein, B.A., L. S. Kutner, and J.S. Adams (eds.). 2000. *Precious heritage: The status of biodiversity in the United States.* New York: Oxford University Press.

Stotler, R. and Crandall-Stotler B. 1977. A checklist of the liverworts and hornworts of North America. *The Bryologist* 80(3):405–428.

Sustainable Forestry Initiative (SFI). 2002. Section 4.1.1.4 of the 2002 – 2004 Sustainable Forestry Initiative Standard. Arlington, VA: Sustainable Forestry Board.

Tisdale, E. W. 1986. *Canyon grasslands and associated shrublands of west-central Idaho and adjacent areas*. Forest, Wildlife and Range Experiment Station Bulletin No. 40. Moscow, ID: University of Idaho.

United Nations Educational, Scientific, and Cultural Organization (UNESCO). 1973. *International classification and mapping of vegetation. Series 6. Ecology and conservation*. Paris: United Nations Educational, Scientific and Cultural Organization.

Vega Rivera, J. H., W. J. McShea, and J. H. Rappole. 2003. Comparison of breeding and postbreeding movements and habitat requirements for the scarlet tanager (*Piranga olivacea*) in Virginia. *The Auk* 120: 632–644.

White, J., and M. Madany. 1978. Natural areas inventory technical report. Volume 1. Survey methods and results. Illinois Natural Areas Inventory, Urbana, Illinois, USA.

Whittaker, R.H. 1956. Vegetation of the Great Smoky Mountains. *Ecological Monographs* 26:1–80.

Whittaker, R. H. 1962. Classification of natural communities. *Botanical Review* 28:1–239.

Whittaker, R. H. 1967. Gradient analysis of vegetation. *Biological Reviews* 49: 207–264.

Wilcove, D. S., Rothstein, D., J. Dubow, A. Phllips, and E. Losos. 2000. Leading threats to biodiversity: What's imperiling U.S. species? Chapter 8 in *Precious heritage: The status of biodiversity in the United States*, ed. B.A. Stein, S. Kutner, and J. S. Adams. New York: Oxford University Press.

Willis, K.J., and R.J. Whittaker. 2002. Species diversity – scale matters. *Science* 295:1245–1248.

Young, T.F. and S. Sanzone (editors). 2002. *A framework for assessing and reporting on ecological condition*. Prepared by the Ecological Reporting Panel, Ecological Processes and Effects Committee. Washington, DC: EPA Science Advisory Board.

# APPENDIX A

# GLOSSARY

ALLIANCE

An Alliance is a physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species, which as a rule are found in the uppermost stratum of the vegetation (see Grossman et al. 1998; for more recent proposed definitions see Jennings et al. 2003).

Dominant species are often emphasized in the absence of detailed floristic information (such as quantitative plot data), whereas other diagnostic species (including characteristic species, dominant differential, and constant species groups) are used where detailed floristic data are available.

ASSOCIATION

An Association is the lowest level of the hierarchy, as well as the basic unit for application of the International Vegetation Classification (IVC); that is, the association level is the basic community Element level that NatureServe and the Natural Heritage network track for conservation. It is defined as "a plant community of definite floristic composition, uniform habitat conditions, and uniform physiognomy" (see Flahault and Schröter 1910, in Grossman et al. 1998; for more recent proposed definitions see Jennings et al. 2003).

BENCHMARK DATA CONTENT STANDARDS

The Benchmark Data Content Standards are intended to provide guidance, and to help ensure a high level of accuracy, currency and quality to the species data that are maintained by the NatureServe network in North America north of Mexico. The Benchmark Data Content Standards are essential to demonstrating to our partners and clients that the completeness of our core data is measurable and substantial. Many of our customers consider adherence to these standards as a certification that our data meet documented quality requirements. The Benchmark Data Content Standards additionally reflect a NatureServe commitment to register our data collections with global data portals, such as the Global Biodiversity Information Facility (GBIF, http://www.gbif.org/), so that researchers can see what we have to offer, determine whether we have data that would be useful to them, and understand how to make data requests. These Standards will allow NatureServe to measure and report on the quality of our data, and they will be used to identify priorities for data development and management.

These standards establish priorities and network-wide content goals for:

- types of elements and element occurrences to be tracked,
- priority fundamental database fields that represent the core of our work,
- standards for each of the fields to be completed,
- GIS (spatial) data,
- metadata,
- measuring progress in meeting the Benchmark Data Content Standards.

BIOTICS 4

Biotics is a customized information management system designed to support the Natural Heritage methodology used by NatureServe and the network of Natural Heritage Programs and Conservation Data Centres. Biotics includes four primary applications, briefly described below. Each application provides a Windows interface and manages data stored within a common Oracle database.

Tracker: Provides data management capabilities for tabular data.
Mapper: Provides spatial data management capabilities through a custom GIS interface.
Administrator: Provides an interface for managing security, system options, and extensibility.
Exchanger: Provides utilities for data import/export and bi-directional data exchange.

Biotics Tracker application is a customized information management system designed to support the latest developments in the Natural Heritage methodology used by NatureServe. It allows the entry and management of data related to Elements of biological diversity, Element Groups, Element Occurrences (EOs), Source Features, Managed Areas (MAs), Conservation Sites (Sites), scientific names, references, and contacts. It also provides seamless access to spatial representations of EOs, MAs, and Sites developed in Biotics Mapper and displays the spatial attributes calculated by that application.

CONSERVATION DATA CENTER NETWORK

See “Member Programs”.

CONSERVATION DATA CENTERS

See “Member Programs”.

CONSERVATION STATUS RANK

Value that best characterizes the relative risk of extinction for the Element at the global level (i.e., range-wide), or extirpation at the national or subnational level (i.e., within-nation for national, or within-state or province for subnational) based on a 1–5 scale (see Table 3.7).

CRITICALLY IMPERILED (G1)[16]

At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.

CONCEPT REFERENCE COMBINATION

The combination of a unique name and a reference (i.e., publication that is the source of the taxonomic concept [= circumscription] for a species) for each species element included in the NatureServe’s databases that serves to differentiate the species reliably from all other taxa, regardless of the differing names that may be applied to it by various member programs and other entities.

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[16] See Section 4.2 for explanation of global ranks (G1, G2, G3, etc.)

## DETAILED FEATURE

A feature used to represent an observation at a scale larger than the standard map scale.

## DIAGNOSTIC

Any species or environmental character that unambiguously separates one community or system from others, or any feature (e.g., morphological) that unambiguously separates one species from others.

## ECOLOGICAL COMMUNITIES

Assemblages of species that co-occur in defined areas at certain times and have the potential to interact with one another. Ecological communities are often formally classified into types based on vegetation criteria. See “Association” and “Alliance”.

## ECOLOGICAL INTEGRITY (COMMUNITIES AND SYSTEMS)

Ecological integrity is the maintenance of structure, species composition, and the rate of ecological processes and functions within the bounds of normal disturbance regimes (Lindenmayer and Franklin 2002).

## ECOLOGICAL SYSTEM

Terrestrial Ecological Systems are groups of plant communities and sparsely vegetated habitats unified by similar ecological processes (e.g., fire, riverine flooding), substrates (e.g., shallow soils, serpentine geology), and/or environmental gradients (e.g., local climate, hydrology in coastal zones). They are explicitly defined by spatial and temporal criteria that influence the grouping of communities and habitats. The Ecological System will typically manifest itself in a landscape as a spatial aggregation at an intermediate scale (10 ha–100,000 ha), persisting for at least 50–100 or more years. These and other considerations are intended to ensure that Ecological Systems form relatively robust, cohesive, and distinguishable units on the ground that can serve as practical conservation targets.

Although Ecological Systems do not fit within the framework of the International Vegetation Classification (IVC), in most landscapes the Ecological System will manifest itself on the ground as a spatial aggregation at an intermediate scale (e.g., between the IVC Alliance and Level 5 scales). Recognition of these discrete types, all of which combine Associations from one or more IVC Alliances, are desired as practical conservation targets.

ELEMENT

An element is a biodiversity unit of conservation attention and action for which a Heritage Conservation Status Rank is assigned. Elements may be recognized at any taxonomic level although typically they are only recognized at the species level and below for organisms and the Ecological System, Alliance, and Association levels for communities. Elements may also be recognized for biodiversity units for which there is no systematic hierarchy (e.g., animal assemblages, community complexes).

Elements may be native or exotic at a particular location and collectively represent the full array of biological and ecological diversity for the geographic area covered. Elements of conservation concern serve as the targets of Heritage inventory and mapping. Typically, these targets include native, regularly occurring vulnerable species (including infraspecific taxa and populations) and exemplary ecological communities and ecological systems.

ELEMENT MANAGEMENT ABSTRACT

A set of Biotics database fields that endeavor to summarize the best available information about the management needs for a particular species, group of species, or ecological community, as well as detailed characterization information, such as habitat or environmental setting.

ELEMENT OCCURRENCE

An Element Occurrence (EO) is an area of land and/or water in which a species or natural community is, or was, present. An EO should have practical conservation value for the Element as evidenced by potential continued (or historical) presence and/or regular recurrence at a given location. For species Elements, the EO often corresponds with the local population, but, when appropriate, may be a portion of a population (e.g., long-distance dispersers) or a group of nearby populations (e.g., metapopulation). For community Elements, the EO may represent a stand or patch of a natural community, or a cluster of stands or patches of a natural community.

An Element Occurrence record is a data management tool that has both spatial and tabular components including a mappable feature (i.e., an Element Occurrence Representation [EO Rep]) and its supporting database attributes. See http://whiteoak.natureserve.org/eodraft/index.htm.

Principal EO

For species Elements, a principal Element Occurrence (EO) represents the occupied habitat (or previously occupied habitat) that contributes, or potentially contributes, to the persistence of the species at that location. Generally, a species principal EO corresponds to a population or metapopulation. Principal EOs are typically separated from each other by barriers to movement or dispersal, or by specific distances defined for each Element across either unsuitable habitat, or suitable but apparently unoccupied habitat.

For community Elements, a principal mapped occurrence is a defined area that contains (or contained) a characteristic species composition and structure. Principal EOs are separated from each other by barriers to species interactions, or by specific distances defined for each Element across adjacent areas occupied by other natural or semi-natural community types, or by cultural vegetation.

Sub-EO

A smaller, geographically distinct area contained within a principal Element Occurrence (EO) of the same Element can be a sub-EO. A sub-EO is an EO created to track information that could be useful for conservation planning, monitoring, or management at local levels.

ELEMENT OCCURRENCE RECORD (EOR)

A database record, including its mapped components, for an element occurrence.

ELEMENT STEWARDSHIP ABSTRACT

See "Element Management Abstract".

ESTIMATED REPRESENTATION ACCURACY

Scale that indicates the accuracy of a feature. EOs with negligible uncertainty are the most accurate, with all other features categorized according to the biologist's estimate of the percentage of a mapped occurrence (EO representation) that is attributable to the area of the original field observation (i.e., before added locational uncertainty).

ESTIMATED VIABILITY (SPECIES)

Estimated viability refers to the likelihood that if current conditions prevail, an occurrence will persist for a defined period of time. The estimated viability of a species occurrence is essentially represented by its EO rank.

FLORISTIC

Floristic classifications utilize species composition or species groups, rather than physiognomic patterns of the dominant species, to define vegetation types. Patterns of succession, disturbance, history (including paleoecology), and natural communities are better assessed through floristic composition than physiognomy (Glenn-Lewin and van der Maarel 1992). Floristic methods reveal local and regional patterns of vegetation and are typically more detailed than physiognomic methods. Floristically-based systems rely on intensive field sampling, detailed knowledge of the flora, and careful tabular or quantitative analysis of stand data to determine the diagnostic species groups.

FORMATION

The formation represents vegetation types that share a definite physiognomy or structure within broadly defined environmental factors, relative landscape positions, or hydrologic regimes. Structural factors such as crown shape and life form of the dominant stratum are used in addition to the physiognomic characters already specified at the higher levels. Hydrologic modifiers, adapted from Cowardin et al. (1979), are used for wetlands.

IMPERILED (G2)

At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.

INDICATORS

In the context of classification, a species that is indicative of a particular habitat or set of environmental conditions. See also “diagnostic”.

In the context of sustainable forestry programs, specific metrics that provide information about an organization’s forestry and environmental performance that can be used to assess conformance with objectives and performance measures.

INFERRED EXTENT (IE)

For certain animals, the distance (in kilometers) that the underlying mapped component(s) (i.e., Source Feature[s]) of an EO may be buffered in order to create a separate inferred extent (IE) feature that might better represent the area likely utilized by the Element at that location, which may be useful for conservation planning purposes. See Section 4.1.4.

LOCATION USE CLASS

Value that indicates the class for which a set of EO rank specs attributes have been developed. Location use classes are assigned to migratory animal species that utilize geographically and seasonally disjunct locations, and are used to indicate which season or behavior is associated with a particular area in order to ensure that all of the different locations utilized by such an Element throughout its life cycle are identified and considered for protection.

Domain values for Location Use Class are:

Not applicable, Breeding, Nonbreeding, Migratory Stopover, Migratory Corridor, Staging, Hibernaculum, Maternity Colony, Bachelor Colony, Adult foraging area, Juvenile foraging area, Freshwater, Estuarine, Marine, Nesting area, Calving area, Nursery area, Nonmigratory, Undetermined

For more detailed information, see: EO Data Standard, Appendix A at http://whiteoak.natureserve.org/eodraft/index.htm.

LOCATIONAL UNCERTAINTY

The recorded location of an observation of an Element may vary from its true location due to many factors, including the level of expertise of the data collector, differences in survey techniques and equipment used, and the amount and type of information obtained. This inaccuracy is characterized as locational uncertainty, and is assessed for Source Feature(s) based on the uncertainty associated with the underlying information on the location of the observation.

Four categories of locational uncertainty have been identified, as follows:

**Negligible uncertainty** is less than or equal to half the minimum mapping unit in any dimension. Source Features with negligible uncertainty are based on a comprehensive field survey with high quality mapping and a high degree of certainty. For example, on a 1:24,000 scale map with a mmu of 12.5 meters, a Source Feature will have negligible uncertainty if the uncertainty is less than 6.25 meters in any dimension.

**Linear uncertainty** is greater than half the minimum mapping unit, and varies along an axis (e.g., path, stream, ridgeline). The true location of an observation with linear uncertainty may be visualized as effectively sliding along a line that delineates the uncertainty.

**Areal delimited uncertainty** is greater than half the minimum mapping unit, and varies in more than one dimension. The true location of an observation can be visualized as floating within an area with a boundary that can be specifically delimited. Boundaries can be defined using roads, bodies of water, etc.

**Areal estimated uncertainty** is greater than half the minimum mapping unit, and varies in more than one dimension. However, a boundary cannot be specifically delimited based on the observation information, i.e., the actual extent is unknown. The true location of the observation can be visualized as floating within an area for which boundaries cannot be specifically delimited. Source Features with areal estimated uncertainty require that the user specify an estimated uncertainty distance to be used for buffering the feature to incorporate the locational uncertainty.

For more detailed information, see EO Data Standard, Section 7; at http://whiteoak.natureserve.org/eodraft/index.htm.

## MANAGED AREAS

Natural areas of land under distinct protective or potentially protective management are referred to as Managed Areas. A Managed Area is usually under some formal or legal level of protection and may be managed in accordance with some unified set of management plans. Managed Areas may be established through legislative actions or administrative orders to protect natural areas. They may also be established as the practical outcome of projects to protect formally designated Sites.

A Managed Area is defined by its management (not by its ownership), and has legal boundaries defined by component Tracts; it is distinct from a Site whose boundaries are ecologically determined. A record should not be created for a Managed Area until it has been formally established. Until then, any information concerning the prospect of a future Managed Area should be entered in a Site record.

A Managed Area may be divided into units with special management requirements (e.g., a Ranger District, a Research Natural Area in a National Forest). In such cases, a Managed Area record should be created for each unit, and the unit record should indicate that it occurs within a larger Managed Area (i.e., a major Managed Area).

## MEMBER PROGRAMS

NatureServe represents a network of member programs comprising 76 independent centers that collect and analyze data about the plants, animals, and ecological communities of the Western Hemisphere. Known as Natural Heritage Programs or Conservation Data Centers, these programs operate throughout the United States, in 11 provinces and territories of Canada, and in 10 countries and territories of Latin America and the Caribbean.

Natural Heritage Programs and Conservation Data Centers:

The role of these programs is to collect, analyze, and distribute detailed scientific information about the biological diversity found within their jurisdictions. Natural Heritage Programs are the leading source of information on the precise locations and conditions of at-risk species and ecological communities. Consistent standards for collecting and managing data allow information from different programs to be shared and combined regionally, nationally, and internationally. The nearly 800 staff from across the network are experts in their fields, and include some of the most knowledgeable field biologists and conservation planners in their regions.

The NatureServe network carries on a legacy of conservation work that began when The Nature Conservancy helped to establish the first state Natural Heritage Program in 1974. Over the next two decades The Nature Conservancy and a collection of public and private partners built a network of biological inventories covering most of the Western Hemisphere. Today, most U.S. Natural Heritage Programs are state government agencies; others are housed in universities, and a few remain within Nature Conservancy field offices. As of 2003, the NatureServe network includes 76 independent Natural Heritage Programs and conservation data centers, with some 800 dedicated scientists and a collective annual budget of more than $45 million.

MULTI-JURISDICTIONAL EO DATABASE (MJD)

The multi-jurisdictional EO database, or MJD, is the component of NatureServe's central databases that includes element occurrence records centrally aggregated from member programs. Data aggregated to create the MJD may be either physical (in the NatureServe (central) databases) or virtual (via a distributed Internet system), depending upon the technological capabilities of both NatureServe and the member programs at any given time.

NATURAL HERITAGE NETWORK

See "Member Programs".

NATURAL HERITAGE PROGRAMS

See "Member Programs".

NATURESERVE DECISION SUPPORT SYSTEM

NatureServe's DSS is a collection of desktop and Internet software tools and information resources, supported by a network of experts to apply them to real-world land use and conservation decisions. These tools allow users to harness the power of advanced computer mapping to visualize the environment and project alternative scenarios for the future.

Using sophisticated geographic information systems (GIS) mapping technology, scenario modeling, and the capacity to flexibly incorporate individual and community concerns, the DSS can integrate complex information about:

biological issues (e.g., sensitive habitats, threatened species)
physical issues (e.g., land cover, soils)
socioeconomic issues (e.g., land costs, transportation networks, growth corridors)

## NATURESERVE EXPLORER

The NatureServe Explorer website provides authoritative conservation information in a searchable database for more than 50,000 plants, animals, and ecological communities of the United States and Canada**.** NatureServe Explorer provides the most comprehensive, in-depth information on rare and endangered species currently available, and includes extensive information on common plants and animals as well. It is a valuable resource for conservationists, land managers, researchers, and students and teachers at all levels.

NatureServe Explorer makes data from U.S. Natural Heritage Programs and Canadian Conservation Data Centres easily accessible to the public for the first time—representing a quarter-century of field work, ecological inventory, and scientific database development by a network of hundreds of botanists, zoologists, ecologists, and data managers (http://www.natureserve.org/explorer/).

## NATURESERVE NETWORK

See "Member Programs".

## NATURESERVE (CENTRAL) DATABASES

NatureServe's centrally developed and maintained repository of information on the taxonomy, descriptions, status, distribution, ecology, and management needs of more than 60,000 taxa and 5,400 community types of the Western Hemisphere. The central databases are continuously updated, and were expanded in 2004 to include ecological communities, images, enhanced maps, and enhanced fields of information (e.g., trends and threats to biodiversity). The multi-jurisdictional database component of NatureServe's central databases contains more than 480,000 element occurrence records from member programs.

## OBSERVATION

A record that describes a sighting or historical account of a species, community, or ecological system that is not sufficient to conclude that the area of land and/or water on which it was observed is or was persistently occupied and has or had practical conservation value for the element. An observation record on its own does not meet the minimum criteria established for defining an element occurrence (EO), but with the accumulation of additional data it may eventually form the basis for an EO.

## PHYSIOGNOMIC LEVELS

The upper levels of the classification framework are a modification of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Physiognomic Classification of Vegetation (1973) that has been applied worldwide for a variety of natural resource and conservation applications. Physiognomic levels in the IVC include formation class, formation subclass, formation group, formation subgroup, and formation. See also “Formation”.

## PHYSIOGNOMY

The outward appearance or structure of the vegetation. See “Physiognomic Levels”.

## PROCEDURAL FEATURE

Feature that results from the translation of a basic feature to a shape that represents the occurrence and its locational uncertainty as a polygon on a standard scale map. One or more procedural features comprise an element occurrence (EO).

## RANK

See “Conservation Status Rank”.

## REPRESENTATION ACCURACY (RA)

To facilitate the proper interpretation of data when making comparisons between mapped EOs, a measure reflecting the accuracy of each feature (i.e., the amount not attributable to added locational uncertainty) should be provided for every EO. This measure, referred to as REPRESENTATION ACCURACY (RA), should be displayed using appropriate symbology when EOs are mapped. RA can be either calculated or estimated, depending on the process utilized for determining the value.

## SOURCE FEATURE

A Source Feature is the initial translation of a discrete unit of observation data as a spatial feature on a map.

Creation of a Source Feature requires an interpretive process. The likely location and extent of an observation is determined through consideration of the amount and direction of any variability between the recorded and actual locations of the observation data. In most cases, the Source Feature is delineated to encompass locational uncertainty.

A Source Feature can be a point, line, or polygon. The type of Source Feature developed depends on both the preceding conceptual feature type and the locational uncertainty associated with the feature.

For more detailed information, see EO Data Standard, Section 7 at (http://whiteoak.natureserve.org/eodraft/index.htm).

SPECIES

A genetically distinctive group of natural populations that share a common gene pool and that are reproductively isolated from all other such groups (Keeton and Gould 1986).

The species' name is a binomial, consisting of the genus –(which groups an organism together with others based on shared traits) and the specific epithet –(which denotes the species' uniqueness from others) (Stein et al. 2000).

TERRESTRIAL ECOLOGICAL SYSTEM

See "Ecological System".

TRACKED ELEMENTS

Elements of biological diversity (species and ecological communities and systems) tracked in NatureServe's databases with names, codes, conservation status, distribution, and other information. See Section 3.1.2.

VULNERABLE (G3)

At moderate risk of extinction or of significant conservation concern due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.

# APPENDIX B

## PARTIAL LIST OF RECENT NATURESERVE CLIENTS

U.S. Fish and Wildlife Service
*Data Product/Internet Resources:*
Providing online access to conservation status data for use in setting endangered species listing priorities and for developing species recovery plans.

U.S. National Park Service and U.S. Geological Survey
*Inventory and Mapping / Expert Consultation:*
Providing expert assistance and ecological classification framework for a multi-year project to map vegetation in all U.S. national parks and monuments.

U.S. Department of Transportation
*Custom Data Product:*
Provided nationwide data and scientific expertise on imperiled and endangered species to map ecological resources that would be unusually sensitive to oil pipeline leaks. Includes ongoing provision of data to pipeline industry.

Department of Defense
*Custom Data Product:*
Providing data on the locations of threatened and endangered species for use by U.S. Air Force in minimizing environmental effects of low-altitude military training flights.

Department of Defense
*Internet Resource / Information Technology Service:*
Providing secure GIS-enabled website with detailed information on rare and endangered species for use in natural resource management of DoD lands.

Environmental Protection Agency
*Custom Data Product / Expert Consultation:*
Provided key indicators measuring status of native species for use in EPA's "Draft Report on the Environment," released June 2003.

Environmental Protection Agency and U.S. Fish and Wildlife Service
*Custom Data Product:*
Developed 640 sq km hexagon-of-occurrence distribution maps for all vertebrates, butterflies, mussels, and trees covering nine states and portions of two other states.

National Wildlife Federation
*Custom Data Product / Expert Consultation:*
Provided data and consultation services related to analyses of the impact of urban sprawl on biodiversity.

Conservation International in collaboration with the World Wildlife Fund and others
*Custom Data Product:*
Developed polygon range maps for all birds and mammals of the Western Hemisphere (see http://www.natureserve.org/infonatura/ and http://www.natureserve.org/getData/animalData.jsp).

INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE
*Custom Data Product:*
Assessed the IUCN Red List status for all amphibian species of the Western Hemisphere.

HEINZ CENTER FOR SCIENCE, ECONOMICS AND THE ENVIRONMENT
*Custom Data Product:*
Developed key indicators measuring status of native species for use in Heinz Center report on “State of the Nation’s Ecosystems”.

CORNELL UNIVERSITY
*Custom Data Product:*
Provided GIS data layer of butterfly species locations for use in research on the impact of pesticides on butterflies.

DEFENDERS OF WILDLIFE
*Custom Data Product:*
Provided data on the distribution of sensitive biodiversity to inform an analysis of potential impacts of increased oil and gas exploration.

GEODATA SERVICES, INC.
Provided data layer on imperiled species hotspots to assist in evaluation of broad-scale conservation issues on behalf of the International Association of Fish and Wildlife Agencies.

SUSTAINABLE FORESTRY INITIATIVE
*Custom Data Product / Expert Consultation*
Providing data, mapping, and analyses concerning occurrences of G1–G2 species and communities on timber industry lands in order to facilitate industry compliance with new SFI standards for protecting biodiversity.

# APPENDIX C

## DEVELOPMENT OF CROSSWALKS (SYNONYMIES) BETWEEN IVC ASSOCIATION UNITS AND STATE OR PROVINCIAL CLASSIFICATIONS

Examples of crosswalks in the United States

The examples presented below are illustrative of the range of circumstances and methods that have been employed to reconcile existing classifications with US-NVC types.

1. *Adopting NVC associations identified from studies in habitat typing: United States Inter-Mountain West.* A significant amount of vegetation classification work has been completed in the western United States (e.g., Daubenmire and Daubenmire 1968; Pfister et al. 1977; Mueggler and Stewart 1980; Steele et al. 1981; Mauk and Henderson 1984; DeVelice et al. 1986; Hess and Alexander 1986; Cooper et al. 1987; Daubenmire 1970; Hironaka, Fosberg, and Winward 1983; Tisdale 1986, Mueggler 1988; Padgett et al. 1989). Much of this work followed the approach developed by Daubenmire (1952) and Daubenmire and Daubenmire (1968), in which habitat types are identified as an indication of site potential (i.e., for timber productivity). Plant associations are the basic classification units for both the Daubenmire and Daubenmire system of habitat identification and the US-NVC. They are described as the late successional or presumed "climax" vegetation types for which the habitat types are named. However, there are important distinctions between habitat type classifications and the US-NVC, which is based on existing vegetation. Habitat type units do not describe early seral vegetation, even when it persists on the landscape for decades. Given Daubenmire's emphasis on using indicator species to identify site potential, habitat type classifiers typically label samples for the late successional vegetation type, even if the sample was dominated by early seral vegetation.

As a result of these extensive classification efforts, many associations have been identified for the western United States in both published and unpublished reports, which often provide comprehensive stand and summary data. NatureServe network ecologists reviewed the data provided in these reports and classification systems. In order for an association to be included in the US-NVC, references associated with it had to provide location information, a description of methods used to delineate it, plant species lists, and quantitative measures of plant species abundance. The associations identified by each study were compared and standardized into one classification system (Bourgeron and Engelking 1994). In practice, the names of the associations given by the original author were adopted directly into the US-NVC system unless there was a clear need to differentiate between different associations with the same original name (see Bourgeron 1988).

*2. Identifying plant associations successional to habitat types: Montana.* As noted in example #1, in the habitat typing system, the use of the term plant association is restricted to the "climax" or potential natural vegetation (Daubenmire 1968; Pfister et al. 1977). In order to meet the US-NVC objective of classifying existing vegetation, it was necessary to identify communities that are compositionally and structurally maintained by recurring natural disturbances, such as fire, avalanches, and grazing by large ungulates. In western Montana, successional stages of coniferous *Pseudotsuga menziesii* forests are maintained in the vegetation mosaic by fires of different intensities and frequencies. Fire ecology studies from Pfister et al. (1977), Fisher and Clayton (1983), and Arno, Simmerman, and Keane (1985) were used to identify successional stages within the *Pseudotsuga menziesii/Vaccinium membranaceum* forest habitat type. Following stand-replacing wildfire, stands of old-growth plant associations dominated by *P. menziesii* may be replaced by one of several successional shrubland types (not currently classified in the US-NVC) dominated by a mix of shrubs such as *Xerophyllum tenax, Ceanothus velutinous,* or *Vaccinium membranaceum.* Succession may proceed through sapling, pole, and later mature stages, with *Pinus contorta* often dominating in the sapling and pole stages, and *P. menziesii* gradually becoming co-dominant over time. The *Pseudotsuga menziesii/Vaccinium membranaceum* association is the theoretical end of the successional sequence. The US-NVC system recognizes four types, including the late-seral association, which all can be found in a landscape that is still under natural fire regimes.

*3. Identifying US-NVC alliances and their relation to SAF cover types: upper Midwest.* Many forest alliances are roughly equivalent to the "cover types" developed by the Society of American Foresters to describe North American forests (Mueller-Dombois and Ellenberg 1974; Eyre 1980). In cases where the cover type is based solely on differences in the co-dominance of major species (e.g., Bald Cypress cover type, Water Tupelo cover type, and Bald Cypress-Water Tupelo cover type), the alliance may be broader than the narrowly defined cover types or may recombine them in different ways based on floristic and ecological relationships. In cases where the dominant tree species extend over large geographic areas and varied environmental, floristic or physiognomic conditions, the alliance may represent a finer level of classification than the SAF cover type. In these situations, diagnostic species may include multiple dominant or co-dominant tree and understory species that together help define the physiognomic, floristic, and environmental features of an alliance type. For example, the broad-ranging Jack Pine forest cover type (Eyre 1980) may include at least two alliances, a more closed, mesic jack pine forest type and a more xeric, bedrock woodland type.

*4. A three-way crosswalk among SAF cover types, state community classification, and the NVC in the State of Arkansas.* In some instances, commonly used classifications in a given state could include SAF cover types and an established state community classification from a natural heritage program. The following example helps to demonstrate the three-way linkage among these classifications.

**Table C1** Three-Way Crosswalk in Arkansas

| SAF cover type | Arkansas State Community Type | US-NVC Association | G-rank |
|---|---|---|---|
| White Oak - Black Oak - Northern Red Oak | Mesic Oak-Hickory Forest | *Quercus alba - Quercus rubra / Ostrya virginiana / Arundinaria gigantea / Cynoglossum virginianum* Forest | G2 |
| White Oak - Black Oak - Northern Red Oak | Mesic Oak-Hickory Forest | *Quercus alba - Quercus rubra - Carya (alba, ovata) / Cornus florida* Acid Forest | G3 |
| White Oak | Mesic Oak-Hickory Forest | *Quercus alba - Carya alba / Symplocos tinctoria / Mitchella repens* Forest | G3? |
| White Oak | Mesic Oak-Hickory Forest | *Quercus alba - Quercus falcata - Quercus stellata - Nyssa sylvatica / Carex cherokeensis* Forest | G3G4 |
| White Oak | Mesic Oak-Hickory Forest | *Quercus alba - Carya glabra - Carya alba / Aesculus pavia* Forest | G4? |
| White Oak - Black Oak - Northern Red Oak | Mesic Oak-Hickory Forest | *Quercus alba - Quercus rubra - Quercus muehlenbergii / Cercis canadensis* Forest | G4G5 |

(Continued on next page.)

**Table C1** Continued

| SAF cover type | Arkansas State Community Type | US-NVC Association | G-rank |
|---|---|---|---|
| Sugar Maple | Mixed Mesophytic Forest | *Acer (barbatum, saccharum) - Juglans nigra - Fraxinus americana / Hybanthus concolor* Forest | G2 |
| Beech-Sugar Maple | Mixed Mesophytic Forest | *Fagus grandifolia - Quercus alba / Acer (barbatum, leucoderme) / Solidago auriculata Forest* | G2G3 |
| Beech-Sugar Maple | Mixed Mesophytic Forest | *Fagus grandifolia - Magnolia virginiana - (Pinus palustris) / Chasmanthium sessiliflorum Sandhill* Streamhead Forest | G2G3 |
| Beech-Sugar Maple | Mixed Mesophytic Forest | *Fagus grandifolia - Quercus alba - Liriodendron tulipifera / Hydrangea arborescens / Schisandra glabra* Forest | G3? |
| Beech-Sugar Maple | Mixed Mesophytic Forest | *Fagus grandifolia - Quercus alba - Liquidambar styraciflua - (Liriodendron tulipifera)* Forest | G3G4 |
| Beech-Sugar Maple | Mixed Mesophytic Forest | *Fagus grandifolia - Quercus rubra - Tilia americana var. caroliniana / Magnolia tripetala / Podophyllum peltatum* Forest | G3G4 |
| Beech-Sugar Maple | Mixed Mesophytic Forest | *Fagus grandifolia - Acer saccharum - Liriodendron tulipifera* Unglaciated Forest | G4? |
| Shortleaf Pine - Oak | Xeric Shortleaf Pine-Oak Forest | *Pinus echinata - Quercus (incana, stellata, margarettiae) / Cnidoscolus texanus* Forest | G2 |
| Loblolly Pine - Shortleaf Pine | Xeric Shortleaf Pine-Oak Forest | *Pinus echinata - (Pinus taeda) - Quercus (margarettiae, stellata, falcata) - Carya texana* Forest | G2 |
| Loblolly Pine - Shortleaf Pine | Xeric Shortleaf Pine-Oak Forest | *Pinus echinata - Pinus taeda - Quercus (alba, falcata, stellata)* Forest | G2G3 |
| Loblolly Pine - Shortleaf Pine | Xeric Shortleaf Pine-Oak Forest | *Pinus echinata - (Pinus taeda) - Quercus falcata / Dichanthelium sphaerocarpon* Forest | G2G3 |
| Shortleaf Pine - Oak | Xeric Shortleaf Pine-Oak Forest | *Pinus echinata - Quercus stellata - Quercus marilandica / Schizachyrium scoparium* Woodland | G2G3 |
| Loblolly Pine - Shortleaf Pine | Xeric Shortleaf Pine-Oak Forest | *Pinus echinata - Pinus taeda - Quercus stellata - Carya texana / Vaccinium arboreum* Woodland | G3? |
| Shortleaf Pine - Oak | Xeric Shortleaf Pine-Oak Forest | *Pinus echinata - Quercus alba - Quercus falcata* Forest | G3?Q |
| Shortleaf Pine | Xeric Shortleaf Pine-Oak Forest | *Pinus echinata / Vaccinium (arboreum, pallidum, stamineum)* Forest | G3G4 |
| Shortleaf Pine - Oak | Xeric Shortleaf Pine-Oak Forest | *Pinus echinata - Quercus alba / Schizachyrium scoparium* Woodland | G3G4 |

(Continued on next page.)

**Table C1** Continued

| SAF cover type | Arkansas State Community Type | US-NVC Association | G-rank |
|---|---|---|---|
| Shortleaf Pine | Xeric Shortleaf Pine-Oak Woodland | *Pinus echinata / Schizachyrium scoparium - Solidago ulmifolia - Monarda russeliana - Echinacea pallida* Woodland | G1G2 |
| Shortleaf Pine | Xeric Shortleaf Pine-Oak Woodland | *Pinus echinata /* Rock Outcrop Interior Highland Woodland | G2G3 |
| Shortleaf Pine - Oak | Xeric Shortleaf Pine-Oak Woodland | *Pinus echinata / Quercus incana / Selaginella arenicola ssp. riddellii* Forest | G2Q |

Examples of crosswalks in Canada

*Canadian Forest Service (CFS) Forest Ecosystem Classification (FEC) associations.* Ongoing development of the C-NVC focuses on integration of existing classification systems from federal and provincial sources. Every association developed by CFS will be reviewed in the process of its integration into the C-NVC. In turn, the CFS process ensures that each association will be linked directly to provincial FEC units. The example in Table C2 (Baldwin et al., in preparation) shows how one proposed C-NVC association encompasses ten types listed for Saskatchewan and Alberta. They are organized within two sub-associations.

**Table C2** Crosswalk between Draft Canadian Forest Ecosystem Classification Units and Provincial FEC Units, Using a *Pinus banksiana* (Jack Pine) Association as an Example

| Assoc. Code | Proposed CFEC Association | Province of Origin | Provincial FEC Name |
|---|---|---|---|
| WPj 0136 | *Pinus banksiana / Arctostaphylos uva-ursi – Vaccinium (myrtilloides – vitis idaea) / Cladina* spp Forest | Saskatchewan | a1.1 jP/bearberry/lichen |
| | | Saskatchewan | a1.2 jP/blueberry/lichen |
| | | Alberta | BM-a1.2 Pj/blueberry/lichen |
| | | Alberta | CS-a1.1 Pj/bearberry/lichen |
| | | Alberta | CS-a1.2 Pj/blueberry/lichen |
| | | Alberta | CS-a1.3 Pj/juniper/lichen |
| | | Saskatchewan | CS-a1.3 jP/green alder/lichen |

# APPENDIX D

## SAMPLE OCCURRENCE REQUIREMENTS (EO SPECIFICATIONS) FOR A SPECIES

***Global scientific name*** CLEMMYS MUHLENBERGII

***Global English common name*** BOG TURTLE

***Specs Group*** None

***Location Use Class***

***Minimum EO Criteria*** Occurrences are based on evidence of historical presence, or current and likely recurring presence, at a given location. Such evidence minimally includes collection or reliable observation and documentation of one or more individuals (including eggs) in or near appropriate habitat where the species is presumed to be established and breeding.

***Separation Barriers*** Heavily traveled road or road with barriers such that turtles rarely if ever cross successfully; impoundment; untraversable topography (e.g., cliff); river of third order or higher; urban development lacking suitable wetlands.

***Separation Distance-Unsuitable (km)***

***Separation Distance-Suitable (km)***

***Alternate Separation Procedure*** Separation distance across continuous or mostly continuous suitable wetlands: 3 km.

Separation distance for continuous upland habitat: 1.5 km.

Separation distance for intermediate habitat: 2 km.

***Separation Justification*** Bog turtles rarely leave wetland habitats, although recent radio-telemetry evidence indicates that bog turtles sometimes venture into and across upland habitats (375 m) and cross roads to reach adjacent wetlands. Whitlock (unpublished data) also documented individuals regularly moving back and forth across 1 km of atypical wetland habitat to more suitable habitat patches. Successful movement across developed areas is probably negligible, due to susceptibility to collection, predation, and road mortality.

Home ranges are small. In Virginia, home range size averaged 0.52 ha (median 0.35 ha, range 0.02–2.26 ha, minimum convex polygon). Long-distance movements between wetlands were infrequently observed, though a bog turtle has been documented moving up to 2.7 km from previously documented areas.

Home range size averaged 1.3 ha in Pennsylvania, where the longest distance moved by any individual was 225 m. Home range was 0.04-ha to 0.24 ha in Maryland. In the same area, home range sizes of 0.003 to 3.12 ha (95% Adaptive Kernel method) were recorded; expansion of multiflora rose with cessation of animal grazing probably contributed to the increase in home range size. In North Carolina over somewhat less than 1 year, distances between relocations of radio-tagged turtles were 0–87 m (mean 24 m) for males, 0–62 m (mean 16 m) for females.

***Feature Labels***

***Mapping Guidance*** Occurrences should include known nesting areas and documented upland travel corridors, if any.

***Inferred Extent Distance (km)*** 0.2

***IE Note***

***Specs Author*** Whitlock, A., and G. Hammerson

***Specs Edition Date*** 6/26/2001

# APPENDIX E

## SAMPLE ELEMENT OCCURRENCE RECORD (EOR)

| | |
|---|---|
| **EO_ID** | 204845 |
| **ELCODE_BCD** | IMBIV02030 |
| **ELEMENT_GLOBAL_ID** | 108301 |
| **EO_NUM** | 1 |
| **EO_NUM_BCD** | |
| **SUBNATION_CODE** | NY |
| **GNAME** | Alasmidonta heterodon |
| **GCOMNAME** | Dwarf Wedgemussel |
| **SNAME** | Alasmidonta heterodon |
| **SCOMNAME** | DWARF WEDGEMUSSEL |
| **G_RANK** | G1G2 |
| **ROUNDED_G_RANK** | G1 |
| **G_RANK_CHANGE_DATE** | 6/1/1998 0:00 |
| **USESA_CD** | LE |
| **USESA_DESC** | Listed endangered |
| **USESA_DATE** | 3/14/1990 0:00 |
| **INTERPRETED_USESA** | |
| **STATE_INTERPRETED_USESA** | |
| **EO_INTERPRETED_USESA_STATUS** | |
| **COSEWIC_CD** | XT |
| **COSEWIC_DESC** | Extirpated |
| **COSEWIC_DATE** | 1/1/2000 0:00 |
| **INTERPRETED_COSEWIC** | |
| **S_RANK** | S1 |
| **ROUNDED_S_RANK** | S1 |
| **S_RANK_CHANGE_DATE** | 12/17/1997 0:00 |
| **BCD_STYLE_S_RANK** | S1 |
| **S_PROTECTION_STATUS** | E |
| **S_PRES_AB** | Present |
| **S_EXOTIC** | Native |
| **S_REG** | Regularly occurring |
| **S_POP** | Year-round |
| **LATITUDE** | |
| **LONGITUDE** | |

| | |
|---|---|
| **PRECISION_BCD** | S |
| **DATA_SENSITIVE_EO_IND** | N |
| **EORANK_CD** | A |
| **EORANK_DES** | Excellent estimated viability |
| **LAST_OBS_DATE** | 7/6/1994 |
| **SURVEY_DATE** | 1991-SU |
| **EO_TYPE_BCD** | |
| **EO_DATA** | See OBSEODATA in the optional fields. |
| **GEN_DESC** | The river is approximately 100 feet wide and generally 1–4 feet deep with stony substrate; sand and gravel interspersed, boulders in some stretches, a few slow, sand-bottomed pools may reach >2 meters. Some macrophytes are present. Associated species: A. Varicosa, S. undulatus, Elliptio complanata, A. undulata, A. implicata. |
| **COUNTIES** | Orange |
| **WATERSHEDS** | 2040104 |
| **QUADCODES** | 41074-D5, 41074-D6 |
| **QUADNAMES** | Otisville, Port Jervis North |
| **TRS** | |
| **MA_TYPE** | |
| **G_RANK_REASONS** | Small number of extant EOs whose long-term viability is questionable, given continuing declines and difficult-to-manage threats. Could be ranked either G1 or G2 depending on how many of the existing populations prove to be viable. |
| **SUBNATIONS** | CT(S1), DC(SH), DE(SH), MA(S1), MD(S1), NB(SH), NC(S1), NH(S1), NJ(S1), NY(S1), PA(S1), VA(S1), VT(S1) |
| **G_RANGE_COM** | Discontinuously distributed in Atlantic coast drainages from Maine to North Carolina. The population in the Petitcodiac River in New Brunswick has been searched for since 1994 but not relocated. Historically known from approximately 70 sites in streams. Now known from 25–30 streams and rivers. It is extant in ten states and likely extirpated from Canada and possibly Pennsylvania. |

| | |
|---|---|
| **G_HABITAT_COM** | Typically found in shallow to deep quick running water on cobble, fine gravel, or on firm silt or sandy bottoms. Other habitats included are amongst submerged aquatic plants, and near stream banks underneath overhanging tree limbs. |
| **G_ANIMAL_GENERAL_DESC** | Small freshwater mussel, usually less than 45 mm length and 25 mm high. Shell subtrapezoidal, thick anteriorly and thinning posteriorly; ventral margin mostly straight; posterior margin pointed near base; dorsal margin slightly curved; beaks low and rounded, projecting only slightly above the hinge line; posterior ridge rounded, somewhat inflated and prominent; periostracum brownish or yellowish brown, with variable width reddish brown or greenish rays in young or pale colored specimens. Nacre bluish or silvery white, and iridescent posteriorly. Hinge teeth small but distinct; pseudocardinal teeth compressed, 1 or 2 in the right valve and 2 in the left; lateral teeth gently curved and reversed, that is, in most specimens, 2 in the right valve and 1 in the left. Ventral mantle margin plain; papillae flesh-colored; exhalent aperture without papillae. |
| **G_SHORT_TERM_TREND_COM** | Number of EOs and abundance have declined dramatically as indicated above. Significant declines continued throughout the 1980's. Appears to be declining most in the southern extent of its range. |
| **G_LONG_TERM_TREND_COM** | |
| **G_THREAT_COM** | Chemical and organic pollution, siltation, removal of stream bank vegetation, and impounding and regulating water flow of major rivers apparently continue to impact the species, as well as poor land use practices and urbanization in proximity to extant populations. Collecting may be a threat. |
| **USESA_CD** | LE |

# APPENDIX F

## DATA FIELDS AVAILABLE FOR GIS COVERAGE OF ELEMENT LOCATIONS

In addition to the fields listed below, there are many text fields that can be made available such as life history, threats, trends and management recommendations. For examples of additional data that are available, please visit our public NatureServe Explorer website located at http://www.natureserve.org.

| | |
|---|---|
| ELCODE | Element Code – Unique record identifier for the species that is assigned by the NatureServe (central) database staff. It consists of a ten-character code that can be used to create relationships between all data provided. |
| EO_ID | Element Occurrence ID – Unique identifier for the EO record in the Biotics database system; used as the primary key. |
| EO_NUM | Element Occurrence Number – A number identifying the particular occurrence in a subnation. |
| EOCODE | Element Occurrence Code – Unique record identifier for each Element Occurrence. This code consists of: ELCODE*EONUM*STATE where EONUM is a counter used to identify unique occurrences and STATE is the state in which the occurrence is located. |
| NATION | Nation – Abbreviation for the nation where the Element Occurrence is located (e.g. "US" or "CA"). |
| STATE | State – Abbreviation for the subnational jurisdiction (state or province) where the Element Occurrence is located. |
| GNAME | Global Scientific Name – The standard global (i.e., range-wide) scientific name (genus and species) adopted for use in the Natural Heritage Central Databases based on standard taxonomic references. |
| GCOMNAME | Global [English] Common Name – The global (i.e., range-wide) [English] common name of an element adopted for use in the NatureServe (central) databases. (For example, the common name for Haliaeetus leucocephalus is Bald Eagle.) Many species also have common names in other languages, and many elements have multiple common names in the same language. For many plants and invertebrates, there is no common name. Spellings of plant common names follow no standard conventions and are not systematically edited. |
| SNAME | Subnational Scientific Name – The standard subnational scientific name (genus and species) adopted for use by the program based on selected standard taxonomic reference(s) for the jurisdiction. |
| SCOMNAME | Subnational Common Name – The standard subnational common name of species adopted for use by the program based on selected standard taxonomic reference(s) for the jurisdiction. |

| | |
|---|---|
| CLASS_STAT | Classification Status – Value that indicates the status of the Element in relation to the standard taxonomic classification. Values are: Standard – the Element has been formally recognized, described, and accepted by the standard classification; Nonstandard – the Element has been addressed but not accepted by the standard classification; Provisional – the Element has not yet been formally addressed and accommodated (by acceptance or rejection) in the standard classification. |
| GRANK | Global Conservation Status Rank – The conservation status of a species from a global (i.e., rangewide) perspective, characterizing the relative rarity or imperilment of the species or community. See Section 3.5.2. For more detailed definitions and additional information, see http://www.natureserve.org/explorer/granks.htm. |
| GRANK_RND | Rounded Global Rank – The Global Conservation Status Rank (GRANK) rounded to a single character. This value is calculated from the GRANK field using a rounding algorithm to systematically produce conservation status values that are easier to interpret and summarize. |
| GRANKDATE | Global Rank Date – The date on which the Global Conservation Status Rank (GRANK) of an element was last reviewed and updated by NatureServe scientists. If an Element Rank is reaffirmed but not changed, then the date does not change. |
| GREVDATE | Global Rank Review Date – Date on which the Global Conservation Status Rank (GRANK) was last reviewed (i.e., assigned, reaffirmed, or changed) by NatureServe scientists. Note that the Rank Review Date is updated each time that a global rank is reviewed, regardless of whether the rank is changed. |
| SRANK | Subnational Conservation Rank – The conservation status of a species from the subnational jurisdiction perspective, characterizing the relative rarity or imperilment of the species. Together these values provide national distribution data. The basic subnational conservation rank values are: SX – Presumed Extirpated; SH – Possibly Extirpated (Historical); S1 – Critically Imperiled; S2 – Imperiled; S3 – Vulnerable; S4 – Apparently Secure; S5 – Secure; SU – Unrankable; SNR – Not Ranked; SNA – Not Applicable (Element is not a suitable target for conservation); S#S# – Range Rank indicates uncertainty about the exact status of the element; * – S-ranking has been assigned and is under review; _B – Breeding Population; _N – Nonbreeding Population; _M – Transient (migratory) Population; _? – Denotes inexact or uncertain numeric rank. For more detailed definitions and additional information, please see http://www.natureserve.org/explorer/nsranks.htm. |
| SRANK_RND | Rounded Subnational Rank – The Subnational Conservation Status rank (SRANK) rounded to a single character. This value is calculated from the SRANK field using a rounding algorithm to systematically produce conservation status values that are easier to interpret and summarize. |

| | |
|---|---|
| SRANKDATE | Subnational Rank Date – The date when the Subnational Conservation Status Rank (SRANK) of an element was last reviewed and updated by Natural Heritage Program scientists. If a subnational ranking is reaffirmed but not changed, then the date does not change. |
| S_PRES_ABS | Current Presence/Absence – Indicates the current presence of the Element in the subnation. Values are: Present – Element is known to be currently extant; Absent – Element has been extirpated or was never present; and Unknown/Undetermined – Element is known to have occurred historically, but is not yet confirmed to be extirpated, or Element has been reported to occur but the report has not been confirmed. |
| S_DIST | Distribution Confidence – Indicates the confidence that the Element was ever (either currently or in the past) present in the subnation. Values are: C – Confident, the Element was reported and confirmed in the subnation by a reliable source; R – Reported but unconfirmed, the Element was reported in the subnation, but the report needs confirmation; RD – Reported but doubtful, the Element was reported in the subnation, but the report is in question; RF – Reported but false, the Element was reported in the subnation, but the report has been determined to be erroneous; P – Potential, the Element has not been found or reported in the subnation, but potentially does occur there and has not yet been found, or occurs near enough that it may eventually move into the area through natural means; PRF – Potential, but false report exists, a report of the Element in the subnation has been determined to be false, but there is still reason to suggest that it potentially does occur there; NT – Never was there, the Element was never reported or found to occur in the subnation. |
| S_REG | Regularity – Indicates the regularity of occurrence of the species Element in the subnation. Values are: Regularly occurring - Occurrence of the Element is consistent in the subnation (e.g., it may migrate in and out of the area, but it returns on a regular basis); Accidental/Nonregular – The Element may arrive in the subnation through natural means (e.g., blown in by a hurricane, but does not necessarily persist or return regularly; Unknown/Undetermined –- Regularity of the Element in the subnation has not or cannot be determined. |
| S_POP | Population – Indicates the type of migration that characterizes populations of the animal Element to which the distribution information pertains. Values are: Year-round – Members of the Element are nonmigratory and remain in the subnation throughout the year; Breeding – Members of the Element occur in this subnation only when breeding; Non-breeding – Members of the Element occur in this subnation only when not breeding; Transient – Members of the Element occur in this subnation only as they pass through on a migratory route; Unknown – The migratory status of the members of the Element in the subnation has not or cannot be determined; (Null) – Not assessed. |

| | |
|---|---|
| S_ORIGIN | Species Origin – indicates the origin of the species Element in the subnation (i.e. Native or exotic). Values are: Native – The Element was introduced into the subnation by natural mechanisms; Exotic – The introduction of the Element into the subnation was influenced by human action; Unknown/Undetermined – The origin of the Element in the subnation has not or cannot be determined. |
| EXOTIC_STA | Exotic Status – Indicates that the Element occurs as an exotic in the subnation. If the Element is known to occur as an exotic, the status value assigned the Element within the subnation is SE. A '?' qualifier can be added to that value to indicate uncertainty. Optionally, a numerical rank of 1 – 5 may be added to indicate the abundance of the Element as an exotic in the specified jurisdiction, with 1 indicating the least abundance and 5 indicating the most. |
| SPROT | Subnational Protection Status – Code used by individual subnational jurisdictions for the level of legal protection afforded to the element by that jurisdiction. Values are typically similar to the U.S. ESA status values, but will vary by state or subnation. Full details are provided with the deliverable documentation. |
| USESA_CD | U.S. Endangered Species Act Status – Value that indicates the current status of the taxon as or designated proposed by the U.S. Fish and Wildlife Service (USFWS) or the U.S. National Marine Fisheries Service, and as reported in the U.S. Federal Register in accordance with the U.S. Endangered Species Act of 1973, as amended. Statuses include candidates for listing as reported by either of these agencies in the U.S. Federal Register. The basic values for USESA Status are: LE – Listed endangered; LT – Listed threatened; PE – Proposed endangered; PT – Proposed threatened; C – Candidate; LE(S/A) – Listed endangered because of similar appearance; LT(S/A) – Listed threatened because of similar appearance; PE(S/A) – Proposed endangered because of similar appearance; PT(S/A) – Proposed threatened because of similar appearance; XE – Essential experimental population; XN – Nonessential experimental population; LE, PDL – Listed endangered, proposed for delisting; LT, PDL – Listed threatened, proposed for delisting; (null) – Element has no status under the U.S. Endangered Species Act, as of the most recent update published in the U.S. Federal Register. However, due to taxonomic relationships and/or geographically defined status, the Element may have protection under the Act (see the Interpreted USESA Status field). Note that previous statuses (e.g., when taxa have been delisted) are not recorded in this field. Multiple statuses - A taxon may have more than one federal status. If multiple statuses are reported in the U.S. Federal Register, they are entered in the USESA Status field separated by a comma (,). The USESA Comments field is used to provide a detailed explanation of multiple USESA statuses. Complete definitions of the USESA statuses may be found online at http://endangered.fws.gov. |

| | |
|---|---|
| USESADATE | U.S. Endangered Species Act Status Date – Publication date of the Federal Register notice containing the status of the taxon designated under the U.S. Endangered Species Act (USESA) (entered in the associated USESA Status field). Dates are entered only for taxa and populations that are specifically named in the Federal Register. When a taxon has multiple statuses (see the USESA Status field for details), the date that corresponds to the first status that appears (not necessarily the most recent action) is entered. The USESA Comments field is used to provide a detailed explanation of multiple statuses and to list the dates associated with the other portions of the multiple statuses. |
| USESA_INT | Interpreted USESA Status – The current status of the taxon under the U.S. Endangered Species Act (USESA) as interpreted by NatureServe (central) Sciences. This field does not contain the official status (if there is one) assigned by the regulating agency―that status is recorded in USESA Status. Interpreted status is determined from the taxonomic relationship of the Element to a taxon having USESA status, or its relationship to geopolitical or administratively defined members of a taxon having USESA status. The taxonomic relationships between species and their infraspecific taxa may determine whether a taxon has federal protection. Section 17.11(g) of the Endangered Species Act states: "The listing of a particular taxon includes all lower taxonomic units". Also, if an infraspecific taxon or population has federal status, then by default, some part of the species has federal protection. In cases where all infraspecific taxa of a species have status, the species also has status by default even if this status is not the same everywhere it occurs. Thus, an Element may have an interpreted USESA status value even though it may not be specifically named in the Federal Register. |
| USESA_EO | EO Interpreted USESA Status – The status of the taxon designated under the U.S. Endangered Species Act (USESA) as it applies to the specific Element Occurrence (EO). EO-interpreted USESA status is derived from geopolitically or administratively defined members of a taxon having USESA status different from other members of the taxon in other parts of its range. Due to geographically defined statuses, the taxon may have different protection statuses within a particular state. |
| GHABCOM | Global Habitat Comments – A text summary of the habitats and microhabitats commonly used range-wide describing any daily, seasonal, and geographic variation in habitat use. |
| LAT_DD | Latitude (decimal degrees) – The X coordinate (latitude) of the Element Occurrence centroid expressed in decimal degrees (DD). |
| LATITUDE | Latitude (degrees minutes seconds) – The X coordinate (latitude) of the Element Occurrence centroid expressed in degrees/minutes/seconds (DMS). |
| LONG_DD | Longitude (decimal degrees) – The Y coordinate (longitude) of the Element Occurrence centroid expressed in decimal degrees (DD). |

| | |
|---|---|
| LONGITUDE | Longitude (degrees minutes seconds) – The Y coordinate (longitude) of the Element Occurrence centroid expressed in degrees/minutes/seconds (DMS). |
| PREC_BCD | Precision BCD – A code for the precision used to map the Element Occurrence (EO) on a U.S. Geological Survey (USGS) 7.5' (or 15') topographic quadrangle map, based on the previous Heritage methodology in which EOs were located on paper maps using dots. Values are: S – Seconds: accuracy of locality mappable within a three-second radius; M – Minutes: accuracy within a one-minute radius, approximately 2 km or 1.5 miles from centroid of the EO; G – General: precision within 8 km or 5 miles, or to quad or place name; U – Unmappable. |
| LASTOBS | Last Observation Date – The date that the Element Occurrence was last observed to be extant at the site. Note that the last observation date is not necessarily the date the site was last visited (i.e., the survey date). Dates typically follow a standard YYYY-MM-DD format. It is important to note, however that the LASTOBS field can include text so this field cannot be treated as a true date field. See also: FIRSTOBS, SURVEYDATE |
| FIRSTOBS | First Observation Date –- The date that the Element Occurrence was first reported at the site. If the EO is known from only one field report, then the date entered in this field should be the same as in the Last Observation (LASTOBS) Date field. Dates typically follow a standard YYYY-MM-DD format. It is important to note, however that the FIRSTOBS field can include text so this field cannot be treated as a true date field. See also: LASTOBS, SURVEYDATE. |
| SURVEYDATE | Survey Date –- The date of the last (i.e., the most recent) field survey for the Element Occurrence (EO), regardless of whether it was found during the visit. If the species was found, the LASTOBS field will be the same date. Otherwise the SURVEYDATE serves as a means to identify negative survey results. Dates typically follow a standard YYYY-MM-DD format. It is important to note, however that the SURVEYDATE field can include text so this field cannot be treated as a true date field. See also: FIRSTOBS, LASTOBS. |
| DATASENS | EO Data Sensitivity –- Indicates whether locational information on this Element Occurrence (EO) is sensitive and should be restricted from unsecured use. Values are: Y – Yes, data are sensitive and should not be made available for general use; N – No, data are not sensitive and may be provided for general use; null – Uncertain whether the data are sensitive. |
| COUNTIES | County Name – The name of the county or other sub-provincial/sub-state jurisdiction where the Element Occurrence is located. |
| FIPS_CODE | FIPS Code – A numerical code assigned by the U.S. government as part of the U.S. Federal Information Processing Standard (FIPS) to uniquely identify each county and equivalent subdivisions in the United States. Source: National Institute of Standards and Technology; http://www.itl.nist.gov/fipspubs/fip6-4.htm. |

| | |
|---|---|
| WATERSHEDS | Watersheds – The 8-digit HUC code and name from the U.S. Geological Survey Hydrologic Unit Map for each watershed where the Element Occurrence is located (HUC-8). If the Element Occurrence spans more than one watershed, the code for the centrum watershed is listed first. Information about the USGS HUCs: http://water.usgs.gov/GIS/huc.html. |
| QUADS | Quad Code and Quad Name – The code and name for each USGS 7.5' (or 15') topographic quadrangle map on which the Element Occurrence (EO) is located. If the EO spans more than one map, the code for the map with the centroid of the EO is entered first. |
| TRS | Town Range, Section and Meridian – For those Element Occurrences that lie within the U.S. rectangular land survey (an area including 30 states principally west and south of Ohio) legal township and range, section division, and meridian descriptions that best define the location of the Element Occurrence (EO). If the EO spans more than one township, the township/range description that includes the centrum of the EO should be listed first. For more information about the Public Land Survey System, please see: http://www.nationalatlas.gov/plssm.html. |

As available, the state data sets will also include the following data fields. The data in these fields is provided "as-is". Data in some of these fields have not been standardized between programs and have not been systematically reviewed by NatureServe. Thus, these data should be used in a supplemental manner and not as a core component of analyses.

| | |
|---|---|
| EOTYPE | Element Occurrence Type – A descriptive term used to categorize the specific type of element occurrence. Used primarily for animals (especially migratory species), common EO types include: breeding site, wintering site, roosting area, staging area, bachelor colony, hibernaculum, nursery colony, communal use site. |
| EODATA | Element Occurrence Data – Data collected on the biology of the Element Occurrence, which may include the number of individuals, vigor, habitat, soils, associated species, particular characteristics, etc. |
| GENDESC | General Description – A general (capsule) description or word picture of the area where the Element Occurrence (EO) is located (i.e., the physical setting/context surrounding the EO). |

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| EORANK_CD | Element Occurrence Rank Codes – Value that indicates the relative value of the Element Occurrence (EO) with respect to other occurrences of the Element, based on an assessment of estimated viability (i.e., probability of persistence) for species. Basic values are: A - Excellent estimated viability; B - Good estimated viability; C - Fair estimated viability; D - Poor estimated viability; X – Extirpated; H – Historical; E - Verified extant (viability not assessed); F – Failed to find; U – Unrankable; NR – Not ranked. NOTE: This data is being provided primarily as background information to help identify current extant EOs by potentially excluding those ranked "X" or "H". It is not required that full EORANKs be developed. |
| EORANK_DES | Element Occurrence Rank Descriptions – Definitions for EORANKs (a value that indicates the relative value of the Element Occurrence (EO) with respect to other occurrences of the Element, based on an assessment of estimated viability (i.e., probability of persistence) for species). Please see values for EORANK_CD. |
| ORIGIN_EO | Origin Subrank – Indicates whether the Element Occurrence (EO) is not (or is possibly not) native to that location or natural in origin, if appropriate. This modifier is used in conjunction with the EORANK. Values are: I – introduced; i? – Possibly introduced; r – Reintroduced; r? – Possibly reintroduced. |
| ORIGIN_DES | Origin Subrank Description – Definitions for Origin Subrank. Indicates whether the Element Occurrence (EO) is not (or is possibly not) native to that location or natural in origin, if appropriate. This modifier is used in conjunction with the EORANK. See values for ORIGIN_CD. |
| MA_NAME | Managed Area Name –- The name(s) of a managed area where the Element Occurrence is located. Generally, public lands and private preserves belonging to other organizations have a formal name that will be utilized in naming Managed Areas when available. |
| CITATIONS | Citation – Formal citation(s) for a reference with information on the Element Occurrence. |

Fields available from select programs:

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| THREAT | Threat – A code that indicates the degree to which the Element is threatened globally. The values are: A = Very threatened throughout its range; B = Moderately threatened throughout its range; C = Not very threatened throughout its range; D = Unthreatened throughout its range; U = Unknown. |
| MANAGE_SUM | Management Summary – A general summary of the management concerns for this Element or Element Management Group. |

REPRO_COMM Reproduction Comments – Comments on the reproduction of the Element within the specified geographic level (i.e., range-wide for global, within-nation for national, or within-state or province for subnational).

Fields available from programs using new EO methodology:

EST_REP_AC *Estimated Representation Accuracy* – The approximate percentage of the Element Occurrence representation (mapped occurrence) that was observed to be occupied by the Element (versus area added for locational uncertainty). Use of estimated representation accuracy provides a common index for the consistent comparison of mapped occurrences, thus helping to ensure that aggregated data are correctly analyzed and interpreted. The accuracy values are: Very high, > 95% occupied by the Element; High, >80% - 95%; Medium, >20% - 80%; Low, >0% - 20%; and Unknown.

CONF_EXT Confidence Extent – Indicator whether the full extent of the Element is known (i.e., has been determined through field survey) at that location and, therefore, is represented by the Element Occurrence (EO). The values are: Y - Yes, Confident full extent of EO is known; N - No, Confident full extent of EO is NOT known; and '?' - Uncertain whether full extent of EO is known.

REP_AC_COM Representation Accuracy Comments – Comments related to the value entered in the Estimated Representation Accuracy field for the Element Occurrence representation (mapped occurrence).

SEP_DIST Separation Distance – A separation distance is the amount of intervening area that determines whether Source Features of an Element should be grouped as part of the same (complex) Element Occurrence Representation (EO Rep), or should be considered as discrete Element Occurrences. Separation distances will be provided in the EO specifications for the Element. For species, distances are provided for intervening areas of unsuitable habitat, and suitable habitat that is not known to be occupied. For communities, distances are provided for intervening areas of different natural/semi-natural communities, and cultural vegetation. In the absence of EO specifications providing separation distances, minimum values have been recommended.

SEP_COM Separation Comments – Explanation of methods (including rationale) used to separate this Element Occurrence (EO) from another, particularly when the separation distances provided in the Element Occurrence Specifications record for the Element are not used.

MULTI_JUR Multi-jurisdictional – Indicator whether the Element Occurrence (EO) extends across one or more jurisdictional boundaries. Values are: Yes, No, Unknown.