Crataegus saligna Greene (willow hawthorn): A Technical Conservation Assessment

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COVER PHOTO CREDIT

Crataegus saligna (willow hawthorn). Photograph by W.A. Weber, used with permission of the University of Colorado Herbarium, Boulder, CO.

Summary of Key Components for Conservation of *Crataegus saligna*

Status

Crataegus saligna (willow hawthorn) is a shrubby tree inhabiting canyons and riparian corridors from 1,630 to 2,620 meters (5,345 to 8,600 feet) in western Colorado (McKee 2002, University of Colorado Herbarium 2003, Colorado Natural Heritage Program 2004, Colorado State University Herbarium 2004, NatureServe 2004). Based on brief descriptions of locations and inferences about land ownership, at least 13 of the 28 known occurrences of this species in Colorado may occur partly or wholly on USDA Forest Service (USFS) lands of the Rocky Mountain Region (Region 2), specifically the Grand Mesa-Gunnison-Uncompahgre, Pike-San Isabel, and White River national forests. Additional occurrences may be on Colorado Bureau of Land Management lands, state and county lands, private lands, or lands of unknown ownership. This species is not listed on the U.S. Fish and Wildlife Service Threatened or Endangered species list, the USFS Rocky Mountain Region sensitive species list, or the Colorado Bureau of Land Management sensitive species list. The global heritage status rank for *C. saligna* is G2 (imperiled globally), and within USFS Region 2, the Colorado Natural Heritage Program state rank is S2 (imperiled in state).

Primary Threats

Crataegus saligna is vulnerable because of its endemic distribution, small number of documented occurrences, and possible human-related and environmental threats. Although up to 13 occurrences may be on USFS Region 2 lands, this species is not protected as a sensitive species. Not enough abundance data or demographic information are available to conclude whether populations of *C. saligna* are increasing, decreasing, or remaining stable.

Threats to the long-term persistence of *Crataegus saligna* in USFS Region 2 are mostly unknown because of a paucity of knowledge of the species, a lack of research on the species, and the considerable uncertainty associated with location information for this species. Direct or indirect negative impacts to *C. saligna* populations or habitat by human-related activities could occur from water management practices (e.g., channelizing, diverting, or impounding), fragmentation of the riparian corridor or surrounding landscape (e.g., from agriculture, bridges, degraded vegetation communities), motorized and non-motorized recreation (e.g., off-highway vehicle use), structure construction and maintenance (e.g., roads, railroads, bridges, diversion structures/canals, houses), domestic livestock activities, logging, pollution (e.g., agricultural runoff, herbicide or pesticide use), gravel mining, and non-native species invasion or control (Grossman et al. 1998, Kittel et al. 1999, Neely et al. 2001, Grahame and Sisk 2002). The extent of these activities near existing populations of *C. saligna* or in suitable *C. saligna* habitat is unknown. Other possible environmental and biological threats to individuals and populations of *C. saligna* include environmental fluctuations (e.g., drought), genetic isolation, succession, herbivory, inadequate pollination, global climate changes, and changes to the natural disturbance regime. It is difficult to assess which threats are most imminent on USFS lands based on our current state of knowledge of this species and the fact that riparian corridors are largely influenced by the surrounding landscape, which may include non-USFS lands.

Primary Conservation Elements, Management Implications and Considerations

The distribution, abundance, ecological range of *Crataegus saligna* and the intensity, frequency, size, and type of disturbance optimal for its persistence are unknown. The lack of information regarding the colonizing ability, adaptability to changing environmental conditions, sexual and asexual reproductive potential, and genetic variability of this species makes it difficult to predict its long-term vulnerability. Assessing current distribution and abundance, surveying high probability habitat for new occurrences, protecting any existing occurrences from direct damage, studying the effects of current management activities and monitoring future management changes, preventing non-native plant invasions, and studying demographic parameters and reproductive ecology are key conservation elements for this species on USFS Region 2 lands. Priorities of future research studies include revisiting and detailed mapping of the extent of any existing occurrences, surveying to locate additional occurrences within USFS Region 2, assessing imminent threats, investigating factors affecting spatial distribution (e.g., microhabitat characteristics), studying taxonomic status, exploring biological and ecological limitations, assessing watershed processes, and producing information related to reproductive mechanisms, demography, and genetic structure.

Table of Contents

ACKNOWLEDGEMENTS 2
AUTHORS' BIOGRAPHIES 2
COVER PHOTO CREDIT 2
SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF *CRATAEGUS SALIGNA* 3
Status 3
Primary Threats 3
Primary Conservation Elements, Management Implications and Considerations 3
LIST OF TABLES AND FIGURES 6
INTRODUCTION 7
Goal 7
Scope and Information Sources 7
Treatment of Uncertainty 7
Publication of Assessment on the World Wide Web 8
Peer Review 8
MANAGEMENT STATUS AND NATURAL HISTORY 8
Management and Conservation Status 8
Federal status 8
Heritage program ranks 8
Existing Regulatory Mechanisms, Management Plans, and Conservation Practices 8
Biology and Ecology 12
Classification and description 12
Systematics and synonymy 12
History of species 13
Morphological characteristics 13
Distribution and abundance 15
Population trends 16
Habitat characteristics 16
Reproductive biology and autecology 17
Reproduction 17
Life history and strategy 18
Pollinators and pollination ecology 18
Dispersal mechanisms 18
Seed viability and germination requirements 20
Phenotypic plasticity 20
Cryptic phases 20
Mycorrhizal relationships 20
Hybridization 20
Demography 20
Life history characteristics 20
Ecological influences on survival and reproduction 23
Spatial characteristics 23
Genetic characteristics and concerns 24
Factors limiting population growth 24
Community ecology 24
Herbivores and relationship to habitat 24
Competitors and relationship to habitat 25
Parasites and disease 26
Symbiotic interactions 26
Habitat influences 26
CONSERVATION 26
Threats 26
Conservation Status of the Species in USFS Region 2 28

Population declines 28
Habitat variation and risk 28
Potential Management of the Species in USFS Region 2 29
Management implications 29
Potential conservation elements 29
Tools and practices 30
Species inventory and habitat surveys 30
Population monitoring and demographic studies 30
Habitat monitoring and management 31
Biological and ecological studies 31
Availability of reliable restoration methods 32
Information Needs and Research Priorities 32
DEFINITIONS 33
REFERENCES USED IN COMPILING DEFINITIONS OF TERMS 36
REFERENCES 37

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LIST OF TABLES AND FIGURES

Table:

Table 1. *Crataegus saligna* occurrences and habitat characteristics in USFS Region 2. 10

Figures:

Figure 1. Distribution of *Crataegus saligna* in USFS Region 2..... 9

Figure 2. Photo and illustration of *Crataegus saligna*..... 14

Figure 3. Life cycle diagram for *Crataegus saligna*..... 19

Figure 4. Envirogram outlining resources for *Crataegus saligna*. 21

Figure 5. Envirogram outlining malentities to *Crataegus saligna*. 22

INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2) of the USDA Forest Service (USFS). *Crataegus saligna* is the focus of an assessment because it is a species with viability concerns due to its regional endemism, small number of documented occurrences, and possible human-related and environmental threats. A species of concern may require special management, so knowledge of its biology and ecology is critical.

This assessment addresses the biology of *Crataegus saligna* throughout its entire range, all of which is in USFS Region 2. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species based on available scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations. Instead, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications).

Scope and Information Sources

This assessment examines the biology, ecology, conservation status, and management of *Crataegus saligna*, with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although some of the literature relevant to the species may originate from field investigations outside the region (e.g., studies of related species), this document places that literature in the ecological and social context of the central Rockies. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of *C. saligna* in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting the synthesis but placed in a current context.

In producing the assessment, we performed an extensive literature search to obtain material focusing on *Crataegus saligna*, as well as related information on the geographical and environmental context of this species. We reviewed refereed literature (e.g., published journal articles), non-refereed publications (e.g., unpublished status reports), dissertations, data accumulated by resources management agencies (e.g., state natural heritage program [NHP] element occurrence records), and regulatory guidelines (e.g., USFS Manual). We did not visit every herbarium with specimens of this species, but we did incorporate specimen label information provided by herbarium staff and available in NHP element occurrence records. While the assessment emphasizes refereed literature because this is the accepted standard in science, non-refereed publications and reports are used extensively in this assessment because they provided information unavailable elsewhere. These unpublished, non-refereed reports were regarded with greater skepticism, and we treated all information with appropriate uncertainty.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, it is difficult to conduct experiments that produce clean results in the ecological sciences. Often, observations, inference, good thinking, and models must be relied on to guide our understanding of ecological relations. Confronting uncertainty then is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

Because of a lack of experimental research efforts concerning *Crataegus saligna*, this assessment relies heavily on the personal observations of botanists and land management specialists from throughout the species' range. When information presented in this assessment is based on our personal communications with a specialist, we cite those sources as "personal communication" Unpublished data (e.g., NHP element occurrence records and herbarium records) were also important in estimating the geographic distribution and in describing the habitat of this species. These data required special attention because of the diversity

of persons and methods used to collect the data, and because of the inability to verify historical information.

Because there is a paucity of knowledge regarding this species, we also incorporated information, where available, from other *Crataegus* species that are endemic to USFS Region 2 or adjacent states. These comparisons are not meant to imply that *C. saligna* is biologically identical to these species, but instead they represent an effort to hypothesize about *potential* characteristics of this species. Although the breeding system and reproductive biology of other *Crataegus* species have been the subjects of preliminary investigative study (e.g., Dickinson et al. 1996), details concerning the reproductive biology of *C. saligna* are largely inferred or unknown. As a result, biology, ecology, and conservation issues presented for *C. saligna* in USFS Region 2 are based on inference from these published and unpublished sources. We clearly noted when we were making inferences based on the available knowledge to inform our understanding of *C. saligna*.

Publication of Assessment on the World Wide Web

To facilitate their use in the Species Conservation Project, species assessments will be published on the USFS Region 2 World Wide Web site. Placing documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More importantly, it facilitates their revision, which will be accomplished based on guidelines established by USFS Region 2.

Peer Review

Species assessments developed for the Species Conservation Project have been peer reviewed prior to release on the Web. This assessment was reviewed through a process administered by the Society for Conservation Biology, employing at least two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Crataegus saligna is a regional endemic species of Colorado and is known from approximately 28 locations in western Colorado (**Figure 1**, **Table 1**; University of Colorado Herbarium 2003, Colorado State University Herbarium 2004, Colorado Natural Heritage Program 2004). This section discusses the special management status, existing regulatory mechanisms, and biological characteristics of this species.

Management and Conservation Status

Federal status

Crataegus saligna is not listed on the U.S. Fish and Wildlife Service (USFWS) Threatened or Endangered species list (U.S. Fish and Wildlife Service 2004), the USFS Rocky Mountain Region sensitive species list (U.S. Forest Service 2003), or the Colorado Bureau of Land Management (BLM) sensitive species list (U.S. Bureau of Land Management 2000).

Heritage program ranks

The global heritage status rank for *Crataegus saligna* is G2 (imperiled globally), and within USFS Region 2, the Colorado NHP state heritage rank is S2 (imperiled in state) (NatureServe 2004). The Colorado NHP apparently proposed changing the heritage rank for this species to G3? (vulnerable globally, with uncertainty) in July 1996 (Spackman 2000), but the rank is still currently listed as G2 on NatureServe (2004) after being updated in 2003 by Spackman and Anderson. NHPs maintain databases with certain species designated as species of special concern due to their rarity or potential downward population trend. However, these designations are not associated with specific legal constraints, such as limiting plant harvesting or restricting damage to critical habitats of sensitive species.

Crataegus saligna is not known to occur in the other four states of USFS Region 2 (i.e., Kansas, Nebraska, South Dakota, or Wyoming) and is thus not currently listed or ranked in those states (Kansas Natural Heritage Inventory 2002, Nebraska 2002, South Dakota 2002, Wyoming Natural Diversity Database 2003).

Existing Regulatory Mechanisms, Management Plans, and Conservation Practices

The majority of information regarding *Crataegus saligna* is contained within brief descriptions associated with herbarium specimens, often with very little specific location information. In many cases, only a town name is provided. In addition, the riparian habitats in Colorado where this species occurs tend to be patchworks of private land parcels, USFS lands, and BLM lands. For example, *C. saligna* is reported to occur

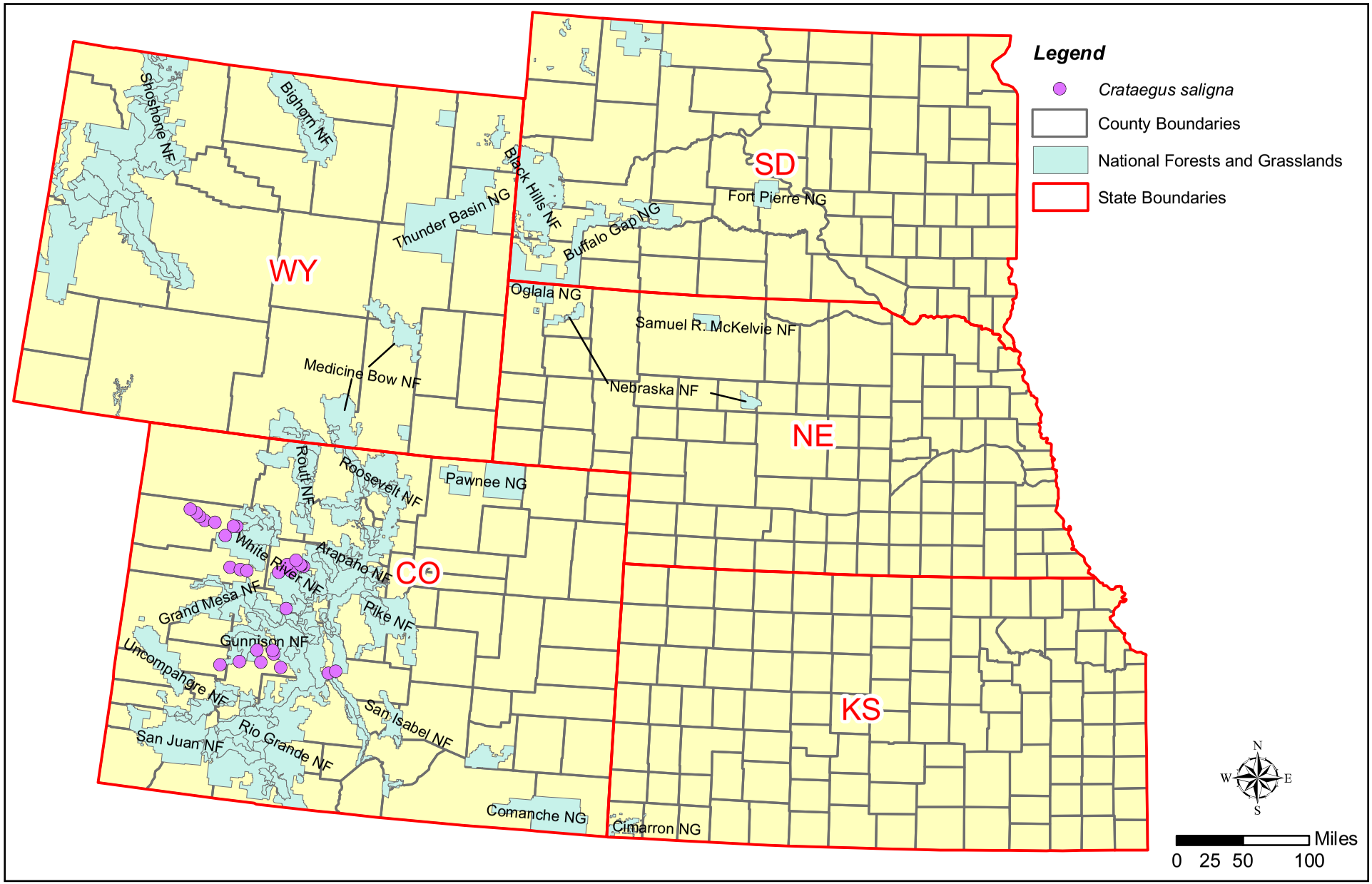

Figure 1. Map of U.S. Forest Service Region 2 illustrating distribution of 28 *Crataegus saligna* occurrences in Chaffee, Eagle, Garfield, Gunnison, Montrose, Pitkin, and Rio Blanco counties, Colorado. Each occurrence may include one to several populations. Refer to document for abundance and distribution information. Sources: University of Colorado Herbarium (2003); Colorado Natural Heritage Program (2004); Colorado State University Herbarium (2004).

Table 1. Information on 28 *Crataegus saligna* occurrences in Colorado (USFS Region 2). Includes county, number of occurrences, date of observations, estimated abundance, land management context, habitat characteristics, and associated plant species. Contact the Colorado Natural Heritage Program for more information regarding specific locations of occurrences. (?) = uncertainty. Sources: University of Colorado Herbarium, Boulder, CO (2003); Colorado Natural Heritage Program, Fort Collins, CO (2004); Colorado State University Herbarium, Fort Collins, CO (2004).

County (number of occurrences)	Date of Observations	Estimated Abundance	Management Area/Ownership	Elevation Range (m)	General Habitat Description	Associated Plant Species
Chaffee (2 sites)	1938	Not Available (NA)	Pike-San Isabel National Forest (?); Private/Other (?)	Not Available (NA)	Beneath *Populus angustifolia* on river bench	*Populus angustifolia*
	1942	NA	Pike-San Isabel National Forest (?); Private/Other (?)	NA	Not Available (NA)	Not Available (NA)
Eagle (7 sites)	1977	NA	White River National Forest (?); Private/Other (?); Colorado BLM (?)	2,134 to 2,207	NA	NA
	1984	Large colony	White River National Forest (?); Private/Other (?); Colorado BLM (?)	2,180	NA	NA
	1986	NA	White River National Forest (?); Private/Other (?); Colorado BLM (?)	2,195 to 2,350	On level surface of bench above river	NA
	1953	NA	Colorado BLM (?); Private/Other (?)	NA	NA	NA
	1894	NA	White River National Forest (?); Private/Other (?)	NA	NA	NA
	1972	NA	Colorado BLM (?); Private/Other (?)	NA	NA	NA
	1972	NA	Colorado BLM (?); Private/Other (?)	NA	NA	NA
Garfield (3 sites)	1909	NA	White River National Forest (?); Private/Other (?)	1,723	NA	NA
	1962	NA	White River National Forest (?); Private/Other (?)	NA	NA	NA
	1900	NA	White River National Forest (?); Colorado BLM (?), Private/Other (?)	NA	NA	NA
Gunnison (6 sites)	1898	NA	Gunnison National Forest; Colorado BLM (?)	NA	NA	NA
	1955	NA	Private/Other (?)	2,286	Gulch along road	NA
	1980	NA	Colorado BLM (?); Private/Other (?)	2,317	Floodplain; intermingled with cottonwoods	*Populus* spp.

Table 1 (concluded).

County (number of occurrences)	Date of Observations	Estimated Abundance	Management Area/Ownership	Elevation Range (m)	General Habitat Description	Associated Plant Species
Gunnison (6 sites) (continued)	2001	NA	Gunnison National Forest (?); Private/ Other (?)	NA	Area with many large granite erratics in spruce-aspen forest along Taylor River; close to the river bank	*Populus* spp., *Picea* spp.
	1985	NA	Private/Other (?)	NA	NA	NA
	1937	Private/Other (?)	Gunnison National Forest (?); State of Colorado (?)	NA	NA	*NA*
Montrose (1 site)	1896, 1899, 1901	NA	Colorado BLM (?); Private/Other (?)	NA	NA	NA
Pitkin (1 site)	2000	NA	Pitkin County Open Space	2,268	On the first terrace above the active channel within a montane riparian forest dominated by *Populus angustifolia* with *Picea pungens* and *Alnus incana*; on the edge of a small wetland dominated by *Carex utriculata*, *Carex nebrascensis*	*Populus angustifolia*, *Picea pungens*, *Alnus incana*, *Carex utriculata*, *Carex nebrascensis*
Rio Blanco (8 sites)	1910	NA	Private/Other (?)	2,195	NA	NA
	1910	NA	Private/Other (?)	1,885	NA	NA
	1992	NA	Private/Other (?)	1,780	River floodplain	*Populus angustifolia*, *Betula fontinalis*, *Cornus sericea*
	1979	NA	Colorado BLM (?); Private/Other (?)	NA	NA	NA
	1962	NA	White River National Forest (?)	NA	NA	NA
	1963	NA	White River National Forest (?); Private/Other (?)	NA	NA	NA
	1959	NA	Colorado BLM (?); Private/Other (?)	NA	NA	NA
	1982	NA	Colorado BLM (?); Private/Other (?)	NA	NA	NA

along Sweetwater Creek in the White River watershed (University of Colorado Herbarium 2003). However, without additional information (e.g., elevation, distance from creek), it is difficult to determine if this species occurs on USFS lands at higher elevations, on private lands along the creek corridor, or in BLM parcels found at lower elevations (K. Giezentanner personal communication 2003). Therefore, there is considerable uncertainty regarding the exact location of many sites and the existence of occurrences on USFS lands; inferences are made from location descriptions and mapping exercises.

Of the 28 occurrences of *Crataegus saligna* in Colorado, up to 13 occurrences may be partly or wholly on USFS lands, specifically the Pike-San Isabel,

White River, and Grand Mesa-Uncompahgre-Gunnison national forests. Additional occurrences may be on Colorado BLM lands, state or county lands (i.e., highway rights-of-way), private lands, or lands with unknown management (**Table 1**). It is possible that occurrences on USFS lands may be within areas with wilderness designations (e.g., Holy Cross Wilderness in the White River National Forest; McKee 2002). Unless a special management designation is made (e.g., research natural area, area of critical environmental concern), USFS and BLM lands are managed for multiple use, with an effort to prevent damage to occurrences of species of special concern. Areas of special management designation usually have restrictions on some uses to conserve identified features of the management area.

Although *Crataegus saligna* has been identified as a species of special concern by the Colorado NHP, this species is not currently listed as a USFWS threatened or endangered species, a USFS sensitive species, or a BLM species of concern, so there are no specific regulatory mechanisms at the federal level to regulate its conservation. This species may obtain some protection from various general conservation strategies designed to protect plants and animals on USFS lands. While managing lands for multiple use, the USFS is directed to develop and to implement management practices to ensure that species do not become threatened and endangered (USDA Forest Service 1995). The National Environmental Policy Act (U.S. Congress 1982) requires an assessment of the impacts of any significant USFS projects to natural environments. However, *C. saligna* has not been specifically targeted in surveys and evaluations because it is not listed as a sensitive species (G. Austin personal communication 2003). USFS travel management plans protect rare species by restricting vehicle use to established roads only (USDA Forest Service/U.S. Bureau of Land Management 2000), and wilderness areas have restrictions on motorized travel (Office of the Secretary of the Interior 1964). In addition, the USFS prohibits the collection of any sensitive plants without a permit (USDA Forest Service 1995).

Given that the abundance and distribution of this species is largely unknown, specific populations may possibly be threatened by human-related and ecological threats, and this species is not considered a sensitive species by the USFS, existing regulations do not appear to be adequate to conserve *Crataegus saligna* over the long term.

Biology and Ecology

Classification and description

Systematics and synonymy

Crataegus saligna Greene is in the genus *Crataegus* of subfamily Maloideae, family Rosaceae (Rose family), order Rosales, and group Dicotyledonae (dicots) of phylum Anthophyta (flowering plants) (NatureServe 2004). The genus *Crataegus* is comprised of trees and shrubs native to northern temperate zones, and it is one of the largest genera in the family Rosaceae, with approximately 200 species in the New World and 50 species in the Old World (Zomlefer 1994, Lasseigne and Blazich 2002). The relationships of species in the genus *Crataegus* are complex and have been the subject of significant taxonomic disagreement. Extensive phenotypic variation in *Crataegus* as a result of a range of breeding systems, hybridization, changes in chromosome number (i.e., polyploidy and aneuploidy), and apomixis, combined with botanical misidentifications and differing taxonomic approaches by specialists, have been implicated in this "*Crataegus* problem" (Little 1979, Dickinson and Campbell 1991). Taxonomic complexity in *Crataegus* has been compounded by the identification of many narrowly-defined species (Dickinson and Campbell 1991). For example, over 1,500 North American *Crataegus* species were described by taxonomists from the 1890s to 1910s, followed by a substantial reduction to 20 to 100 species in the 1980s. Recent revisions currently recognize between 100 and 200 species (Cronquist et al. 1997, Lasseigne and Blazich 2002).

The black-fruited *Crataegus* species of the western U.S., including *C. saligna*, *C. rivularis*, *C. erythropoda*, *C. brachyacantha*, *C. douglasii*, *C. suksdorfii*, and *C. okennonii*, have also been associated with considerable taxonomic confusion, despite the statement from Cronquist et al. (1997) that "With only three native species of *Crataegus* in our [intermountain] range, we are virtually free from the taxonomic difficulties encountered in distinguishing the taxa of the central and eastern part of the continent." For example, *C. saligna* is treated as a species without synonyms in Harrington (1954), Little (1979), Goodrich and Neese (1986), Hartman and Nelson (2001), USDA Natural Resources Conservation Service (2002), and USDA Forest Service (2003). Weber and Wittmann (2000, 2001) included *C. wheeleri* as a synonym with

C. saligna, and Phipps (1999) treated both *C. wheeleri* and *C. douglasii* var. *duchesnensis* within *C. saligna*. Perhaps the account by Phipps (1999) is the most comprehensive taxonomic treatment of these species because it incorporated a range of morphological characteristics in a cladistic analysis. In contrast, Harrington (1954) synonymized *C. wheeleri* under *C. rivularis*, and Welsh (1982) considered *C. saligna* as a variety of *C. douglasii* (*C. douglasii* var. *duchesnensis*). Cronquist et al. (1997) did not treat *C. saligna* as part of the intermountain flora, despite its inclusion in the Uinta Basin flora by Goodrich and Neese (1986). The closely related *C. rivularis* is also treated differently in the various floras, as it is included as a variety within *C. douglasii* by Little (1979), Welsh (1982), Goodrich and Neese (1986), Cronquist et al. (1997), Hartman and Nelson (2001) and as a distinct species from *C. douglasii* in Harrington (1954), Phipps (1999), Weber and Wittmann (2000, 2001), and USDA Natural Resources Conservation Service (2002). In addition, taxonomists have also differed in their placement of *C. saligna* into a *Crataegus* series. Little (1979) placed *C. saligna* into series *Brevispinae* with *C. brachyacantha*, and Welsh (1982) placed *C. saligna* (*C. douglasii* var. *duchesnensis*) into series *Douglasianae*. Phipps (1999) found through cladistic analysis that there is probably a close relationship between *C. saligna* and *C. rivularis*, and these sister species could be placed into their own series called *Rivulares*.

This species assessment treats this species as *Crataegus saligna* Greene, as presented in the PLANTS database (USDA Natural Resources Conservation Service 2002), Integrated Taxonomic Information System (2003), NatureServe database (NatureServe 2004), Colorado Vascular Plant Specimen Database (University of Colorado Herbarium 2003), Checklist of the Vascular Plants of Colorado (Hartman and Nelson 2001), and Colorado NHP records (Colorado Natural Heritage Program 2004). The PLANTS database (USDA Natural Resources Conservation Service 2002) also treats *C. douglasii* (with two varieties: var. *duchesnensis* and var. *douglasii*) and *C. rivularis* as two distinct species. The common name for *C. saligna* is willow hawthorn (Spackman 2000, USDA Natural Resources Conservation Service 2002, Integrated Taxonomic Information System 2002, Colorado Natural Heritage Program 2004, NatureServe 2004). Greene (1896) did not cite a type specimen of *C. saligna*, but Phipps (1999) has lectotypified this species using a Greene specimen housed at the New York Botanical Garden Herbarium (New York, NY). Within USFS Region 2, additional specimens of *C. saligna* are located at the University of Colorado Herbarium (Boulder, CO), Colorado State University Herbarium (Fort Collins, CO), and Rocky Mountain Herbarium (Laramie, WY).

History of species

Crataegus saligna was first described in 1896 by Greene from observations of individuals with ripe fruit along the lower Cimarron River, Colorado (Greene 1896). This species has since been considered in taxonomic treatments of *Crataegus* (Phipps 1999). *Crataegus saligna* was the subject of a preliminary assessment for sensitive species designation by USFS Region 2 in 2002 (McKee 2002). No other status assessments or detailed demographic, ecological, or biological studies of this species have been undertaken.

Morphological characteristics

Members of the family Rosaceae are characterized as perennial herbs, shrubs, or trees often with thorns or prickles, stipulate leaves, actinomorphic, perfect flowers with five sepals and five petals, numerous exserted stamens in several whorls, and a prominent cup-like hypanthium (Zomlefer 1994). The genus *Crataegus* is generally comprised of deciduous trees and shrubs armed with thorns and bearing distinctive fruits (pomes) with a fleshy outer part and inner cartilaginous structures surrounding the seeds (Zomlefer 1994, Cronquist et al. 1997).

Crataegus saligna is a small, shrubby tree from 2 to 6 m tall with a short trunk up to 10 cm in diameter and branches 2 to 5 cm in diameter (**Figure 2**; Greene 1896, Harrington 1954, Sargent 1965, Little 1995, Phipps 1999, Weber and Wittmann 2001, Lasseigne and Blazich 2002). This species grows with a crown of long, slender, spreading, and drooping branches, often forming clumps or small thickets with many stems from one root (Sargent 1965). The name "*saligna*" is derived from "*Salix*", in reference to the drooping, slender twigs and erect stems, similar to willows (Little 1995, Weber and Wittmann 2001). The stems are hardly branched, except for short lateral shoots (Neely et al. 2001). The elliptical, slightly thickened leaves are rounded at the tip and finely saw-toothed with rounded teeth tipped with red glands. The leaves are 4 to 5 cm long and 2 to 2.5 cm wide, and the stipules are lunate in shape. The leaves are appressed hairy on top when young, they become shiny dark green on top and pale beneath, and turn bright orange and red in the autumn. The leaves on sterile branches tend to be rhombic-lanceolate in shape, acuminate at both ends, crenate toothed in the middle, and up to 5.1 cm long, including the short petiole. Leaves at the end of new twigs tend to be larger, oblong-

ovate, long-pointed, evenly coarsely saw-toothed, with few shallow lobes, and veins extending to the notches as well as lobes. The bark is red to reddish-brown, turning gray and scaly. The slender, glabrous, drooping branches are shiny red with blackish, straight or slightly curved spines up to 3 cm long. The flowers develop in the spring on short stalks in corymbose inflorescences. The white flowers are 15 mm wide, with five petals, five sepals, five styles, and 20 yellow stamens. Inflorescences are comprised of five or more flowers. The fruits mature in the fall and occur as drooping clusters. The red to blue-black, glaucous, globose fruits are 5 to 8 millimeters (mm) in diameter with calyx at the tip, and they have a dry, mealy, greenish pulp and five 1-seeded nutlets (Greene 1896, Harrington 1954, Sargent 1965, Little 1995, Phipps 1999, Weber and Wittmann 2001).

(A)

Photographs by W.A. Weber, used with permission of the University of Colorado Herbarium, Boulder, CO.

(B)

Adapted from Sargent, C.S. 1965. Manual of the Trees of North America, Volume I., second edition. Dover Publications, Inc., New York, NY.

Figure 2. *Crataegus saligna* (A) photographs in its natural habitat in Colorado, and (B) illustrations of the vegetative and reproductive structures.

Crataegus saligna can be distinguished from other closely related *Crataegus* species in Colorado by foliage, fruit, and habit characteristics; refer to keys presented in Harrington (1954) and Weber and Wittmann (2001). *Crataegus saligna* can generally be distinguished from *C. chrysocarpa*, *C. erythropoda*, and *C. macracantha* var. *occidentalis* (*C. succulenta*) because *C. saligna* has elliptic to lanceolate leaves at least twice as long as wide, its leaves lack distinct lobes, its few spines are usually less than 3 cm long, and its fruits are generally blue-black. *Crataegus chrysocarpa*, *C. erythropoda*, and *C. macracantha* var. *occidentalis* (*C. succulenta*) generally have ovate to rhombic-ovate leaves, leaves with distinct shallow lobes, many spines that are usually greater than 3 cm long, and fruits that are red (Harrington 1954, Weber and Wittmann 2001). Although *C. saligna* is similar to *C. rivularis* in its intermountain distribution, habit, and narrow leaves, significant morphological differences exist (Phipps 1999). *Crataegus saligna* differs from *C. rivularis* (synonymized with *C. douglasii* var. *rivularis*) in that *C. saligna* has 20 stamens, the leaves are usually under 4 cm long with small crenate-serrate teeth, the leaves have six to nine lateral veins on one side, the stems are erect and hardly branched, the petals are less than 5 mm wide, the dark blue-black fruits are 5 to 8 mm in diameter, and the nutlets are never pitted or deeply concave. In contrast, *C. rivularis* (*C. douglasii* var. *rivularis*) has 10 stamens, the leaves are usually over 4 cm long with sharply serrated teeth, the leaves have four to five veins on one side, the branches are widely spreading, the petals are over 5 mm wide, the red fruits are up to 10 cm in diameter, and the nutlets are pitted or deeply concave ventrally (Harrington 1954, Phipps 1999, Weber and Wittmann 2001).

Technical descriptions of *Crataegus saligna* are presented in Greene (1896) and Harrington (1954). An illustration is available in Sargent (1965) and presented in **Figure 2**. In addition, Cronquist et al. (1997) provided illustrations for *C. douglasii* var. *douglasii*, *C. douglasii* var. *rivularis*, and *C. douglasii* var. *duchesnensis*. Although Cronquist et al. (1997) do not specifically include *C. saligna* in their flora, the illustration of *C. douglasii* var. *duchesnensis* may suffice as a depiction of *C. saligna*. As discussed above, Phipps (1999) concluded that *C. saligna* is synonymous with *C. douglasii* var. *duchesnensis*. In addition, Weber and Wittmann (2000, 2001) synonymized *C. wheeleri* with *C. saligna*, and Cronquist et al. (1997) noted that *C. wheeleri* is similar to *C. douglasii* var. *rivularis*, with the narrower leaves of *C. douglasii* var. *duchesnensis*.

Distribution and abundance

Our knowledge of *Crataegus saligna* is based mainly on historical records (i.e., herbarium specimens) that tend to have sparse location descriptions and generally do not report counts of individuals. Thus, there is a significant lack of knowledge about the current distribution and abundance of *C. saligna* on USFS Region 2 lands throughout its range. We have presented a distribution map (**Figure 1**) and a table summarizing herbarium records for this species (**Table 1**) and hypothesized whether these locations may possibly occur within USFS national forest boundaries. However, there is substantial uncertainty associated with these estimates, especially when herbarium records present only a town, road, or creek name to describe the location of their collections. The plants may have been collected in the town boundaries or anywhere within an undefined radius of the town. Also, collections along roads could occur in highway rights-of-way or National Forest System lands, depending on how far the botanists went to collect the specimen. Similarly, riparian areas in Colorado are often complex patchworks of private lands, USFS lands, and BLM lands, making it difficult to identify land ownership using just a creek name. In addition, the full range-wide distribution of *C. saligna* cannot be adequately determined until the taxonomic status of this species is settled.

Crataegus saligna is a regional endemic species known from riparian areas in the western third of Colorado, including occurrences along creeks and rivers in the Arkansas, Colorado, Gunnison, and White River basins (Harrington 1954, Sargent 1965, Hartman and Nelson 2001, Weber and Wittmann 2001, McKee 2002, USDA Natural Resources Conservation Service 2002, University of Colorado Herbarium 2003, Colorado Natural Heritage Program 2004, NatureServe 2004). Within Colorado, there are approximately 28 occurrences (records) of this species within Chaffee, Eagle, Garfield, Gunnison, Montrose, Pitkin, and Rio Blanco counties in Colorado (**Figure 1**, **Table 1**; McKee 2002, University of Colorado Herbarium 2003, Colorado Natural Heritage Program 2004, Colorado State University Herbarium 2004). Of these 28 occurrences of *C. saligna*, up to 13 occurrences may be partly or wholly on USFS lands, specifically the Pike-San Isabel, White River, and Grand Mesa-Uncompahgre-Gunnison national forests. Additional occurrences may be on Colorado BLM lands, state or county lands (i.e., highway rights-of-way), private lands, or lands with unknown management (**Table 1**).

Phipps (1999) proposed a significant range extension for *Crataegus saligna* based on taxonomic work that synonymized *C. douglasii* var. *duchesnensis* and *C. wheeleri* with *C. saligna*. "These records, and others of my own generated by this discovery, represent quite a significant range extension for *C. saligna*, a species hitherto known only from intermountain Colorado. I therefore offer what I believe to be the first published range map of *C. saligna*." Phipps suggested that the range of *C. saligna* may also include several sites in the western Uinta Basin of Duchesne County in northeastern Utah, near the confluence of the Green and Yampa rivers, previously identified as *C. douglasii* var. *duchesnensis* sites. Refer to Phipps (1999) for a map of *C. saligna* locations in Colorado and Utah. **Figure 1** includes only possible occurrences of this species in Colorado and does not include possible occurrences in Utah.

Abundance estimates for *Crataegus saligna* are lacking (Neely et al. 2001, McKee 2002, Nature Serve 2002, USDA Natural Resources Conservation Service 2002, University of Colorado Herbarium 2003). NatureServe (2004) reports this species as "locally abundant in the Gunnison and upper Colorado River basins". One herbarium specimen label noted that the specimen came from a "large colony," and Greene (1896) reported that this species was "plentiful" along the lower Cimarron River.

Element occurrence rankings by the Colorado NHP (Spackman 2000, NatureServe 2004) estimate that higher quality (A and B ranked) populations would be characterized by multiple age classes, evidence of flowering and fruiting, and be of sufficient size to contain a high degree of genetic variability, have low susceptibility to inbreeding depression, and be relatively resilient. Lower quality (B, C, and D ranked) populations may be characterized by populations small enough (e.g., 10 individuals) to be susceptible to the effects of inbreeding depression, extirpation due to natural stochastic events, and high vulnerability to human impacts. However, no ranks were given to element occurrences because insufficient quantitative information existed to assign ranks (Colorado Natural Heritage Program 2004). Of the four element occurrence records for this species in the Colorado NHP database, three are ranked as "E" (verified as extant; viability not assessed), and one element occurrence is ranked as "H" (historic; not observed for over 20 years).

Population trends

There are no data on population trends for *Crataegus saligna*. Population sizes have not been estimated, and multi-year population or demographic monitoring has not been initiated for any site.

Habitat characteristics

Habitat characteristics have not been adequately described for *Crataegus saligna*; all available notes from herbarium specimen labels and element occurrence records are reproduced in **Table 1** (University of Colorado Herbarium 2003, Colorado Natural Heritage Program 2004, Colorado State University Herbarium 2004). *Crataegus saligna* is a perennial shrub inhabiting canyons and stream corridors from 1,630 to 2,620 m (5,345 to 8,600 feet [ft]) in western Colorado (**Table 1**; Harrington 1954, Weber and Wittmann 2001, McKee 2002, University of Colorado Herbarium 2003, Colorado Natural Heritage Program 2004, Colorado State University Herbarium 2004, NatureServe 2004).

Crataegus saligna has been reported growing on river benches, in a gulch, in a floodplain, on riverbanks, and on the edge of a wetland (**Table 1**; Harrington 1954, Weber and Wittmann 2001, University of Colorado Herbarium 2003, Colorado Natural Heritage Program 2004, Colorado State University Herbarium 2004). Soils in these areas are described as moist (Little 1995). Plant species recorded to be occurring with *C. saligna* include *Alnus incana*, *Betula fontinalis*, *Carex nebrascensis*, *Carex utriculata*, *Populus angustifolia*, *Populus* spp., *Picea pungens*, and *Picea* spp. (University of Colorado Herbarium 2003, Colorado Natural Heritage Program 2004, Colorado State University Herbarium 2004).

Not enough information is available to describe vegetation communities of *Crataegus saligna* with certainty using the vegetation classifications of Grossman et al. (1998) or wetland classifications of Cowardin et al. (1979). Similarly, this species was noted as a species of concern in an assessment of plants and vegetation communities in the southern Rocky Mountains performed by Neely et al. (2001), but the vegetation and plant communities associated with this species were not noted as the result of a lack of information. Based on the available sparse information of general habitat and associated plant species, it is possible that *C. saligna* may occur in the Lower

Montane Riparian Woodland Ecological System (Neely et al. 2001), in vegetation communities such as the *Populus angustifolia* Temporarily Flooded Woodland Alliance (II.B.2.N.b.9) or *Acer negundo* Temporarily Flooded Forest Alliance (I.B.2.N.d.3) (Grossman et al. 1998). One of the occurrences possibly occurs within an *Acer negundo-Populus angustifolia/Cornus sericea* Forest (CEGL000627) (Grossman et al. 1998, Colorado Natural Heritage Program 2004). Under the wetland classification system defined by Cowardin et al. (1979), the riparian habitats with *Crataegus saligna* may be classified as wetlands adjacent to rivers and on floodplains in the Scrub-Shrub Wetland or Forested Wetland class of the non-tidal Palustrine System.

Vegetation in these lower to mid-montane riparian woodlands occurs on terraces or benches along narrow stream channels and along floodplains along broad, meandering rivers within 2 m above the stream channel (Grossman et al. 1998). The riparian zones of rivers on the Colorado Plateau are often narrow, as they occur along steep channels restricted in canyons (Grahame and Sisk 2002). The vegetation in these communities is generally characterized by an open tree canopy dominated by *Populus angustifolia*, 10 to 80 percent cover by shrubs (e.g., *Alnus incana*, *Crataegus rivularis*), a moderately dense to absent forb layer, and insignificant grass cover (Grossman et al. 1998). Neely et al. (2001) described these ecological areas as "a mosaic of multiple communities that are tree dominated with a diverse shrub component." A specific vegetation association is a factor of elevation, stream gradient, floodplain width, and flooding events (Neely et al. 2001). Important abiotic ecological processes in the Lower Montane Riparian Woodland Ecological System include hydrologic processes that affect surface flow, such as annual and episodic flooding (Neely et al. 2001). These riparian woodlands are often temporarily flooded during the growing season, and soils tend to be highly permeable sandy loams, clay loams, silty clay loams, or silty clay soils with large amounts of coarse fragments in subsurface horizons (Grossman et al. 1998).

The *Acer negundo-Populus angustifolia*/*Cornus sericea* Forest is a western Colorado riparian forest community that occurs from 6,000 to 7,000 feet in elevation in broad, alluvial floodplains with strongly meandering stream channels or on narrow streams at higher elevations. The deciduous upper canopy is dominated by *Acer negundo* and *Populus angustifolia* with an average of 60 percent total canopy cover, and the deciduous shrub canopy is dominated by nearly-impenetrable thickets of *Cornus sericea*. A few other shrub species are occasionally present in this community, including *Crataegus rivularis*, *Rosa woodsii*, and *Salix lucida* ssp. *caudata*. Perennial forbs are the most abundant species in the herbaceous layer. This community predominately occurs on terraces about 1 to 1.5 m above the high water level and 1 to 30 m distant from the channel. Soils are unstratified sandy loams or silty clay loams derived from Quaternary alluvium and can be up to 2 m deep. (Grossman et al. 1998). As discussed above, habitat characteristics have not been definitively described for *C. saligna*, and there is significant uncertainty associated with these classifications and descriptions.

No viability ranks were given to *Crataegus saligna* element occurrences because insufficient quantitative information existed to assign ranks (Colorado Natural Heritage Program 2004). Element occurrence habitat conditions estimated by the Colorado NHP projected that high-quality sites (A ranked sites) for *C. saligna* would have less than 1 percent cover by exotic plant species, a natural flood regime, an unfragmented landscape, and no significant anthropogenic disturbance. Lower-quality sites (B, C, and D ranked sites) would have from less than 10 percent to over 50 percent cover by exotic species, alterations to the natural flood regime, landscape fragmentation, and evidence of anthropogenic disturbance (Spackman 2000, NatureServe 2004).

Reproductive biology and autecology

Although the reproductive biology of some black-fruited *Crataegus* species (i.e., *C. douglasii*, *C. suksdorfii*) has been the subject of preliminary investigative study (e.g., Dickinson and Campbell 1991, Dickinson et al. 1996), *C. saligna* is less well known, and details concerning the reproductive biology of this species are largely inferred or unknown. In this and subsequent sections, we summarize available observations of *C. saligna* as well as present information from other closely related *Crataegus* species that occur in USFS Region 2 or adjacent states, such as *C. rivularis* and *C. douglasii*. These comparisons are not meant to imply that *C. saligna* necessarily reproduces in a similar manner, but they may help to elucidate *potential* reproductive mechanisms for this species and suggest avenues for future research.

Reproduction

Crataegus saligna is a shrubby hawthorn that grows up to 6 m tall and produces a corymbose inflorescence with five flowers or more (Greene 1896, Harrington 1954, Little 1995). The reproductive phenology of *C. saligna* is not well known. Lasseigne

and Blazich (2002) reported that flowering occurs in May and fruit ripens in October, Sargent (1976) stated that flowers open in mid-June and fruits ripen towards the end of September, and Greene (1896) noted that fruits ripen at the end of August.

The genus *Crataegus* is characterized by species and populations exhibiting an array of different breeding systems, with evidence of hybridization, polyploidy, and uniparental (i.e., apomixis and selfing) and biparental (i.e., sexual) reproduction (Dickinson and Campbell 1991). The breeding system of *C. saligna* and any inter- and intra-population variation in the breeding system of this species is unknown. The stamen count for *C. saligna* is 20 stamens per flower, which is a condition characteristic of sexual diploid *Crataegus* species, although some 20-stamen *Crataegus* species are polyploid (Dickinson et al. 1996, Evans and Dickinson 1996). The base chromosome count for this species is presumably 17, as recorded for other *Crataegus* species (Lasseigne and Blazich 2002). The extent of sexual or apomictic reproduction and the genetic and environmental factors influencing these processes have not been identified for *C. saligna*. Diploid *Crataegus* species are often self-sterile (Dickinson et al. 1996), thus requiring pollination for successful seed set; polyploid *Crataegus* species are often associated with self-fertility and apomixis (Dickinson et al. 1996). There is no information concerning the extent of vegetative reproduction for *C. saligna*, but it is possible that the formation of thickets is accomplished by root sprouting. Other *Crataegus* species are known to reproduce vegetatively from root sprouts (Dickinson and Campbell 1991). There have also been no studies on other vital aspects of *C. saligna* reproduction, such as identification of effective pollinators, germination requirements and success, demographic parameters, or genetic aspects of reproduction.

Life history and strategy

There have been no studies on the life history, demographic rates, fecundity, or longevity of *Crataegus saligna*. The competitive relationships, ecological limitations, and reproductive biology are really not adequately known to assess the life history and strategy of this species. Stress-tolerant (S-selected) species have a perennial life history, an ability to withstand harsh or unproductive environments, and a capability to access resources with well-developed roots (Grime 1979, Barbour et al. 1987). Ruderal (R-selected) species can exploit low stress, high disturbance environments by minimizing vegetative growth and maximizing reproductive output (Grime 1979, Barbour et al. 1987). Good competitor (C-selected) species tend to be robust, perennial plants that tend to maximize resource capture in relatively undisturbed conditions and allocate resources to growth (Grime 1979, Barbour et al. 1987). Wier (1998) noted that the tree-sized *Crataegus* species in Colorado (*C. rivularis*, *C. macracantha* var. *occidentalis*, and *C. erythropoda*) are quick to reproduce but slow-growing. Dickinson and Campbell (1991) suggested that *Crataegus* species in the northeastern U.S., especially agamospermous species, can disperse widely and rapidly colonize disturbed environments. The perennial growth and long taproot, possible ability to tolerate flooding or fire disturbances, potential capability to exploit disturbed riparian environments, and possibly high reproductive capabilities of *C. saligna* suggest that this species could be a successful competitor and stress-tolerator with capabilities to exploit ruderal environments. The hypothesized life cycle of this perennial plant is depicted in **Figure 3**.

Pollinators and pollination ecology

Pollination biology and specific pollination mechanisms for *Crataegus saligna* have not been studied. Members of the Rosaceae family are generally well equipped to attract pollinators with easily accessible nectar from shallow flowers and abundant pollen (Zomlefer 1994). Pollinators of Rosaceous plants include insects of the orders Diptera, Hymenoptera, Coleoptera, and Lepidoptera, among others (Zomlefer 1994). The use of *C. saligna* by these insect species is not known. In addition, the extent of self-pollination or cross-pollination for *C. saligna* is unknown. In general, Rosaceous plants tend to be protogynous, where the stigma is receptive to pollen before pollen is shed from anthers on the same plant, which would reduce selfing (Zomlefer 1994).

Important issues related to the pollination of rare plants that have yet to be researched for *C. saligna* include the extent of asexual and sexual reproduction, the identity of effective pollinators, the effect of plant density and other spatial factors on pollination, the genetic implications of pollination, and the effect of environmental fluctuations on pollination.

Dispersal mechanisms

Details of seed dispersal mechanisms in *Crataegus saligna* have not been studied. Like other *Crataegus* species, *C. saligna* presumably produces an abundance of small fleshy fruits that are dispersed by endozoochory or water movement (Dickinson and Campbell 1991, McKee 2002). Endozoochory occurs

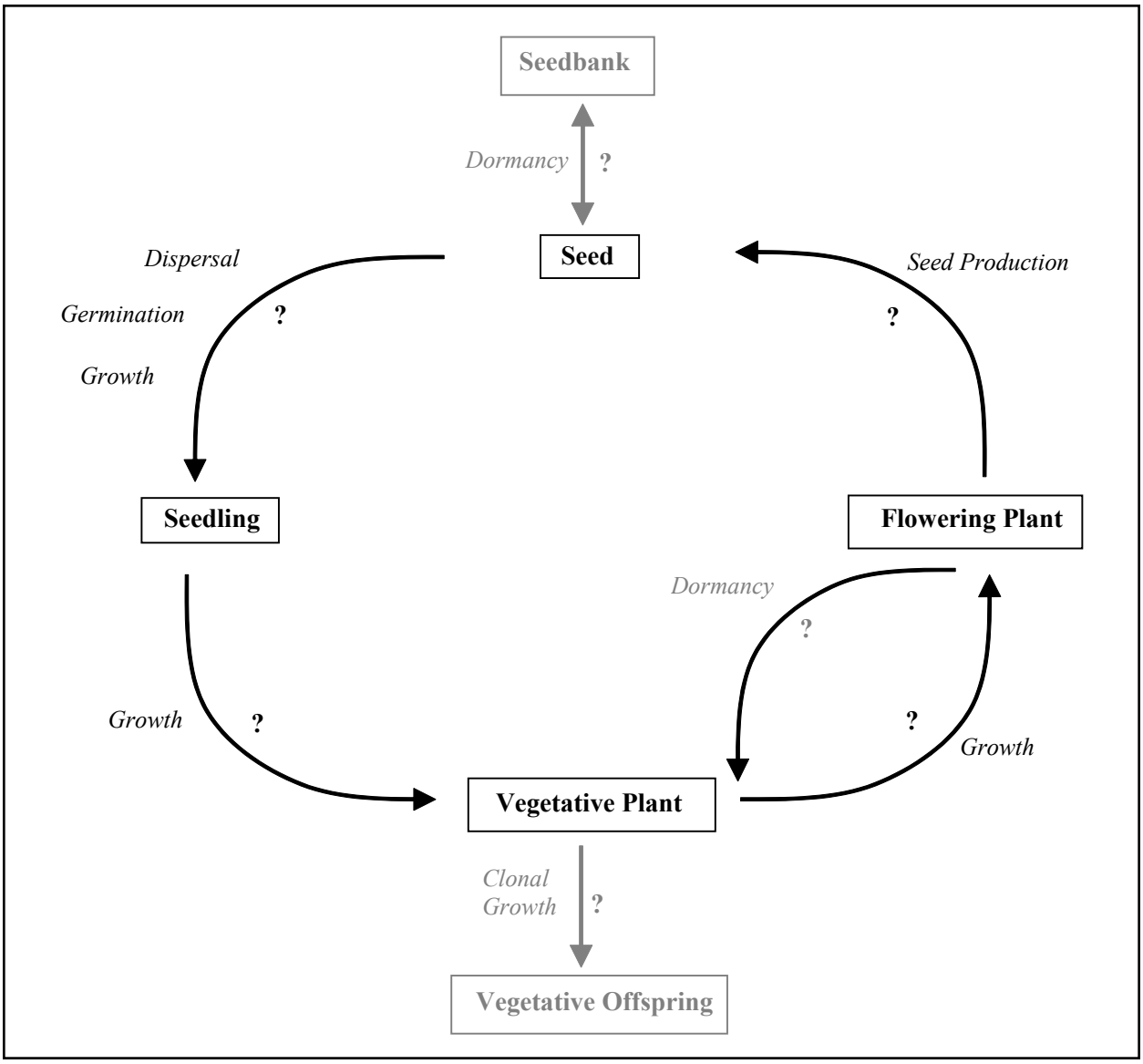

Figure 3. Schematic representation of the hypothesized life cycle of *Crataegus saligna*. Rates of recruitment, growth, dormancy, fecundity, and dispersal are unknown and are indicated by "?". The extent of asexual reproduction and presence of a seedbank are also unknown for this species and are indicated by gray lines. Death at each stage and mortality rates are not indicated on this figure. Figure adapted from Grime (1979).

when fruits on the branches or ground are consumed by birds or mammals and then dispersed through regurgitation or excretion. *Crataegus* fruits in Colorado may be fed upon by birds (e.g., turkeys, grouse, magpies, other songbirds), small mammals (e.g., mice, voles, other rodents), or large mammals (e.g., bear, deer, other ungulates) (McKean 1976, Habeck 1991, Wier 1998, Fitzgerald et al. 1994, Lasseigne and Blazich 2002, USDA Natural Resources Conservation Service 2002). Additionally, seeds that drop to the ground could be dispersed downslope or downstream by water or soil movement. Many riparian plant species rely on over-bank flooding to disperse seeds and deposit them in fresh, fertile alluvial sediments (Grahame and Sisk 2002). Presumably, dispersal success of *C. saligna* may depend on animal activities (e.g., bird or mammal travel patterns), topographic heterogeneity (e.g., barriers of unsuitable habitat between populations [McKee 2002]), precipitation and water movement patterns, substrate characteristics, and soil movement patterns. The dispersal capabilities of this species could also be affected by the availability of suitable "safe" sites,

possibly affected by land use changes, fragmentation, river channelization, or other changes in the natural disturbance regime.

Seed viability and germination requirements

No information is available concerning the fertility, seed viability, and germination requirements of *Crataegus saligna*. Dickinson and Campbell (1991) pointed out that seeds within cartilaginous or otherwise hard seed coats have a mechanical impediment to germination. Seeds of *Crataegus* with this bony endocarp tend to germinate in the second spring after fruiting or may remain dormant and germinate in subsequent years (Brinkman 1974, Dickinson and Campbell 1991). Endozoochory may also play a role in preparing seeds for germination if the persistent seed coats are broken down during passage through the digestive tract of animals. In cultivated settings, treating dried *Crataegus* seeds with acid followed by warm and cold stratification helped to break embryo dormancy and speed germination (Brinkman 1974, Habeck 1991, Lasseigne and Blazich 2002). Seeds of *C. douglasii* apparently exhibit highly variable seed germination, despite being collected from the same stands and processed in the same way (i.e., cleaned and stratified). Brinkman (1974) also noted during seed trials that high percentages of *Crataegus* seeds failed to sprout despite appearing viable. Habeck (1991) also noted that successful seed establishment in the field is difficult and that transplanted nursery stock is recommended for restoration plantings. It is well-known that *Populus* species seeds require scouring events to create suitable bare, moist substrate for germination (Grossman et al. 1998). Although *Populus* species are in a different taxonomic family, they occupy similar habitats to *Crataegus* species. It is unknown whether *Crataegus* species have similar germination requirements.

Phenotypic plasticity

Phenotypic plasticity is demonstrated when members of a species vary in height, leaf size, flowering time, or other attributes, with change in light intensity, latitude, elevation, or other site characteristics. It is possible that characteristics of *Crataegus saligna*, such as flowering time, height, and leaf size, could vary with different microhabitats along a riparian corridor and with hydrologic and environmental fluctuations.

Cryptic phases

No information regarding cryptic phases of *Crataegus saligna* is available. Seed dormancy can be an important adaptation for plant populations to exploit favorable conditions in a harsh environment (Kaye 1997). Details of seed longevity, patterns of seed dormancy, and factors controlling seed germination for *C. saligna* have not been studied.

Mycorrhizal relationships

The existence of mycorrhizal relationships with *Crataegus saligna* or related *Crataegus* species was not reported in the reviewed literature.

Hybridization

Extensive interbreeding and hybridization occur in the genus *Crataegus*, especially because all species possess the base chromosome number of 17 (Lasseigne and Blazich 2002). In addition, the historical use of human-disturbed areas by *Crataegus* species, such as cleared agricultural areas, may have also increased the establishment of *Crataegus* and contact between different populations and species, and thus added to both speciation and hybridization within this genus (Dickinson and Campbell 1991). Other species of *Crataegus* occurring in western Colorado include *C. rivularis*, *C. erythropoda*, and *C. macracantha* var. *occidentalis* (Weber and Wittmann 2001), but the extent of hybridization with these species is not known. The specific role of hybridization in the evolution of *C. saligna* and other issues related to the genetic variability of this species are unknown.

Demography

Little is currently known about the population demographics in *Crataegus saligna*. Research on other *Crataegus* species, where available, may provide insights into some of the ecological, spatial, and genetic considerations for *C. saligna* demography.

Life history characteristics

There is no information regarding population parameters or demographic features of *Crataegus saligna*, such as metapopulation dynamics, life span, age at maturity, recruitment, and survival. Refer to **Figure 4** and **Figure 5** for envirograms outlining resources and malentities potentially important to *C. saligna*. An envirogram is a schematic diagram, first introduced by Andrewartha and Birch (1984) for animal species, that depicts relationships between a target organism and environmental conditions. The centra are the main categories (i.e., resources and malentities) that directly affect the target species, and the web

outlines factors that indirectly influence the centra. The web depicts the most distal to most proximal factors using linear, one-way branches. Because there is a paucity of ecological information about this species, the envirograms outline hypothesized resources and malentities that are *potentially* important for *C. saligna*. Additional information would be needed to create more comprehensive and specific envirograms.

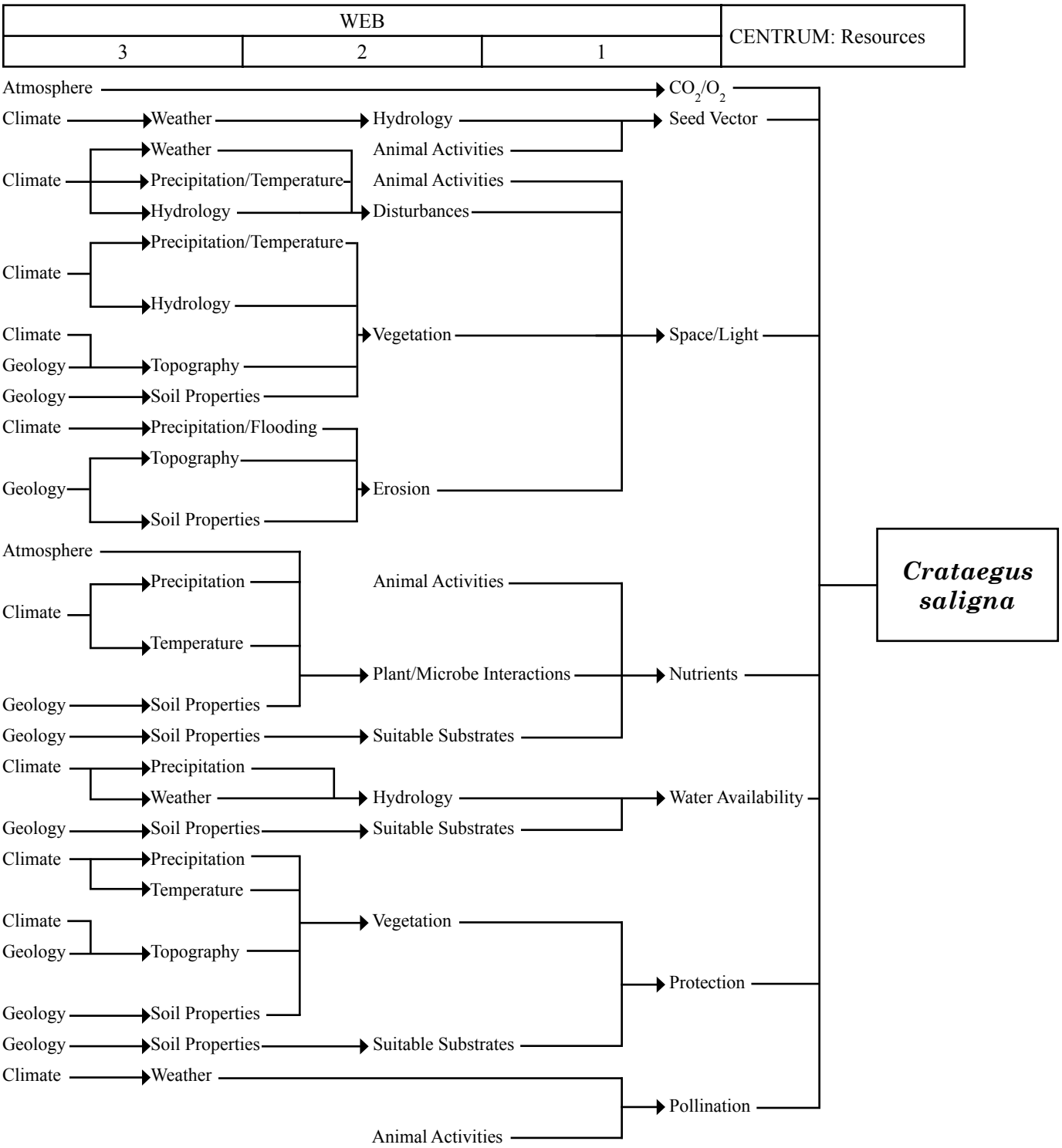

Figure 4. Envirogram outlining resources for *Crataegus saligna*. An envirogram depicts direct and indirect factors that may influence a species. The centrum includes the most proximate factors, and the web includes more distal factors.

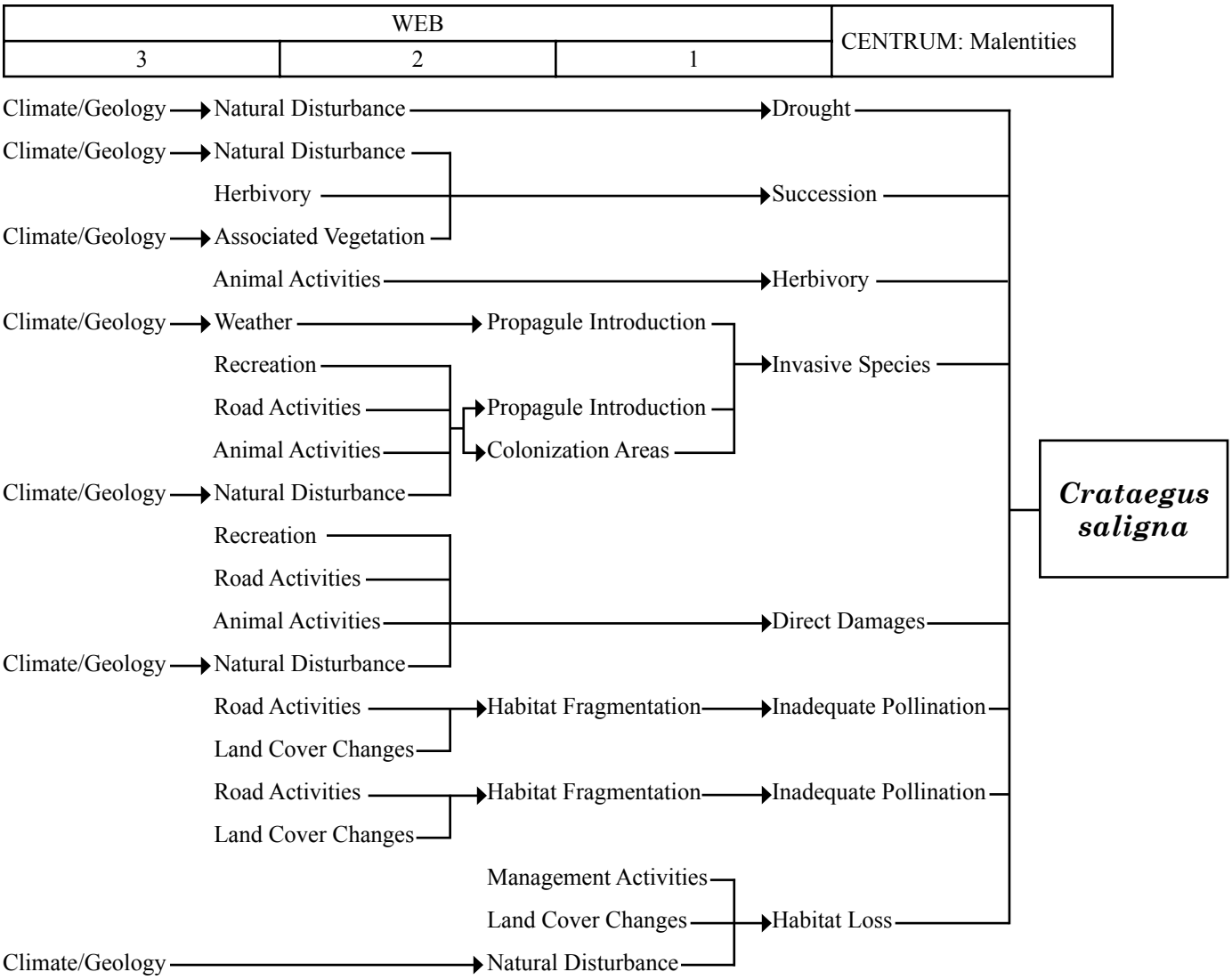

Figure 5. Envirogram outlining malentities to *Crataegus saligna*. An envirogram depicts direct and indirect factors that may influence a species. The centrum includes the most proximate factors, and the web includes more distal factors.

Life cycle diagram and demographic matrix. A life cycle diagram is a graphical model representing the dominant life history stages for a species and the transitions between those stages or vital rates. The diagram consists of a series of nodes that represent the different life stages connected by various arrows for vital rates (i.e., survival rate, fecundity). Demographic parameters, such as recruitment and survival rates, are not currently available for *Crataegus saligna*, and so there are no definitive data regarding the vital rates that contribute to species fitness. Although stage-based models based on population matrices and transition probabilities can be used to assess population viability (Caswell 2001), adequate quantitative demographic data are needed for input into the model. For *C. saligna*, the stages that could be incorporated into a demographic matrix include seed, seedling, vegetative individuals, and reproductive adults (**Figure 3**).

Presumably, seeds of *Crataegus saligna* are dispersed to suitable locations. The probability of germination and subsequent establishment depends on the longevity of these propagules and whether appropriate environmental conditions exist for germination and growth. Seeds that germinate can grow into seedlings, assimilate resources, and mature into reproductive individuals. Growth rates may be influenced by the intensity and frequency of

disturbances and the availability of resources, such as space, light, moisture, and nutrients. Successful seed set will depend on the rate of pollen and ovule formation, pollination, fertilization, and embryo development. Fecundity rates depend on the production of seeds and the percentage of those seeds that survive to germination in subsequent years.

Population viability analysis. In order to initiate a population viability assessment for *Crataegus saligna*, the rates of germination, fecundity, survival, and other important parameters require additional study.

Ecological influences on survival and reproduction

Germination, growth, seed production, and long-term persistence of *Crataegus saligna* most likely depend on a range of ecological influences over many years, including climatic fluctuations, hydrology, microsite conditions, herbivory, disturbance patterns, interspecific competition, seed predation, and pollinator activities. This species appears to occur at a range of elevations and along creeks and rivers of varying size and gradients, but the ecological needs and limitations of this species have not been defined (B. Johnston personal communication 2003). Refer to **Figure 4** for an envirogram outlining resources potentially important to *C. saligna*.

It is unclear what type, size, intensity, or frequency of disturbance regime is important for *Crataegus saligna*. *Crataegus* species in the northeastern U.S. are often known from disturbed areas, such as abandoned agricultural areas, erosion slopes, or stream banks (Dickinson and Campbell 1991, Phipps 1998). In the western U.S., *Crataegus* species generally tend to be concentrated in mesic habitats, such as washes, creeks and riversides; edges of marshes; fencelines along ditches; and floodplains with high water tables (Phipps 1998). *Crataegus douglasii* reportedly avoids disturbed sites in some areas but occupies frequently disturbed sites in other areas (Habeck 1991). Disturbance from fire, agricultural cropping, and flooding appeared to inhibit proliferous thickets of *C. douglasii* in Washington (Habeck 1991).

The riparian environment inhabited by *Crataegus saligna* in USFS Region 2 is likely influenced by ecological processes such as fluctuating water levels and flooding events, scouring and deposition, and succession (Grossman et al. 1998, Neely et al. 2001). "Annual and episodic flooding is extremely important for maintaining a diversity of age classes of *Populus angustifolia* as well as a mosaic of plant associations within any given floodplain." (Neely et al. 2001). Along a riparian corridor, a patchwork of different early, mid, or late seral communities may exist at any time (Grossman et al. 1998). As the river channel is continually changing as a result of hydrologic fluctuations, new areas are scoured and vegetation is established. As the vegetation traps and accumulates sediment, mid to late seral communities can become established. Large flood events can then create new areas for subsequent establishment (Grossman et al. 1998). Stream flow fluctuations presumably could either create suitable habitat for *C. saligna* or directly impact an existing occurrence, depending on the intensity and location of the disturbance. The type, size, frequency, and intensity of disturbance that define the natural disturbance regime and would affect colonization and extirpation events are unknown. In addition, the effects of changes to the natural disturbance regime, as altered by diversion or impoundment structures, channelizing or stabilizing activities, corridor breaks (e.g., bridges), livestock grazing, mining, thinning, or burning, on *C. saligna* are unknown.

The role of other natural disturbances (e.g., fire) in the ecology of *Crataegus saligna* has not been studied. The moist soil conditions in riparian areas may lead to infrequent or patchy fires. The shrubby growth and abundance of dry grasses and twigs in thickets of the related *C. douglasii* create highly flammable conditions, and both low- and high-intensity fires are known to consume the aboveground stems of *C. douglasii* (Habeck 1991). *Crataegus douglasii* is classified as fire tolerant because it is able to resprout and produce suckers from the shallow diffuse root system following removal of aboveground stems (Habeck 1991, USDA Natural Resources Conservation Service 2002). The flexible stems of *C. douglasii* are also capable of withstanding significant snowloading in the winter (Habeck 1991).

It is unclear to what extent *Crataegus saligna* is capable of dispersing, colonizing, and establishing new populations within a river corridor. The establishment of new populations most likely depends on barriers to dispersal and the availability of suitable germination sites and conditions. The rate of population growth could also be influenced by factors that would affect successful reproduction, such as pollinator limitation.

Spatial characteristics

The spatial distribution of *Crataegus saligna* at local and regional scales has not been studied.

Throughout its range in nine counties of western Colorado, *C. saligna* occurs along creeks and rivers in the Arkansas, Colorado, Gunnison, and White River basins (**Figure 1**). This scattered distribution may represent ecological limitations and dispersal patterns, or alternatively, it may reflect "holes" in the distribution due to incomplete inventory efforts. For example, it is possible that this species may occur in additional, adjacent watersheds, such as the Yampa, Green, or San Miguel River basins, but has not been discovered there yet. In addition, the distribution of *C. saligna* along and within each of the river corridors is not known. The size and density of populations and the distribution of individual plants within the population have not been described or studied. The spatial configuration of metapopulations or the extent to which gene flow occurs between local and distant populations is unknown for *C. saligna*. Characteristics that could influence the spatial distribution of this species may include seed dispersal patterns, habitat availability, competition with other vegetation, landscape and microsite heterogeneity, or effects of disturbances (e.g., flooding).

Genetic characteristics and concerns

Genetic concerns, such as the amount of genetic variability between and within populations and genetic implications of the breeding system, have not been studied for *Crataegus saligna*. Issues related to gene flow, inbreeding, and genetic isolation could affect the demography, ecology, management considerations, and long-term persistence for this species. In addition, the genetic distinctiveness of this species and relationships with other closely related species have not been assessed. Although the relationship of *C. saligna* with other black-fruited *Crataegus* species (e.g., *C. rivularis*, *C. douglasii*) in USFS Region 2 has been the subject of preliminary morphological assessment (Phipps 1998), genetic taxonomic work on these species has not occurred.

Factors limiting population growth

There is insufficient knowledge about *Crataegus saligna* to determine factors limiting population growth. Population growth or establishment of *C. saligna* could possibly be limited by competition with other species (e.g., invasive species), inadequate dispersal, ineffective pollination, inadequate genetic variability for long-term persistence, excessive herbivory or grazing, human-related damage, or reduced habitat availability as a result of human-related changes or environmental fluctuations. The rate at which colonization and establishment of new populations occurs is unknown.

Community ecology

Herbivores and relationship to habitat

The extent or effects of herbivory or trampling disturbances on *Crataegus saligna* are unknown. In general, *Crataegus* species provide food and cover for many types of animals during both the growing and winter seasons (Habeck 1991, Wier 1998, Lasseigne and Blazich 2002, USDA Natural Resources Conservation Service 2002). Deer, small mammals, and other wildlife feed on the fruits and leaves and twigs of young seedlings, and frugivorous birds feed on the fruits and stems (Habeck 1991, Wier 1998, USDA Natural Resources Conservation Service 2002). McKean (1976) suggested that *Crataegus* species are generally not palatable to big game ungulates, but the persistent fruits are important yearlong food for turkey and other upland game and songbirds. Fitzgerald et al. (1994) pointed out that bears feed heavily on other Rosaceous fruits, such as serviceberries (*Amelanchier* spp.) and chokecherries (*Prunus* spp.). *Crataegus* species provide abundant cover for birds (e.g., grouse, magpies, thrushes, owls) and small mammals (e.g., deer mice, voles) as a result of its shrubby growth, intricate branching, and retention of dead lower branches (Habeck 1991, Wier 1998). Thorns are more abundant on younger growth than older branches, and thorns may provide some protection to the plant from herbivory as well as protection to nesting birds (Wier 1998, Lasseigne and Blazich 2002).

Because the exact locations of *Crataegus saligna* occurrences are largely unknown, the details of management activities, including livestock allotments, at those areas are difficult to ascertain. Cattle grazing occurs on the White River and Gunnison national forests along riparian areas with possible *C. saligna* populations (G. Austin personal communication 2003, K. Geizentanner personal communication 2003, B. Johnston personal communication 2003), but the potential direct or indirect effects of cattle on this plant are unknown. In some areas, such as Taylor River Canyon, livestock move through the riparian area only for three to 10 days in the summer and fall en route between pastures, and the impact of livestock on riparian areas is thus minimalized (G. Austin personal communication 2003). G. Austin (personal communication 2003) noted that ranchers move the cattle along the road quickly and avoid letting livestock "camp" in riparian areas, which could cause soil erosion or compaction, importation of weed seeds, and heavy grazing impact on native shrubs. Livestock are known to eat the leaves of *C. douglasii* readily when available, but this species has also been reported

as a poor browse source for sheep, cattle, and horses (Habeck 1991, USDA Natural Resources Conservation Service 2002). In addition, livestock tend to keep out of dense *C. douglasii* thickets (Habeck 1991). McKean (1976) also noted that *Crataegus* species in Colorado are not very palatable to livestock and tend not to be heavily browsed under proper range use. Information about the *Acer negundo-Populus angustifolia*/*Cornus sericea* vegetation community along riparian areas in northwestern Colorado notes that heavy livestock grazing at some locations has caused an elimination of the shrubby *Cornus sericea* understory, an increase in exotic plant species, and a reduction in regeneration of the dominant tree species (Grossman et al. 1998). *Crataegus saligna* occurs within this community in some areas (Colorado Natural Heritage Program 2004), but the effects of livestock grazing at those locations have not been studied.

Competitors and relationship to habitat

The interactions of *Crataegus saligna* within the plant community have not been studied. Microhabitat characteristics, the successional or competition dynamics in these habitats, and the full range of tolerances of *C. saligna* have not been studied. In addition, the characteristics of the disturbance regime (e.g., hydrologic) to maintain optimal habitat for this species are also not known. *Crataegus* species are generally known as weedy colonizers of high-light intensity and exposed soil habitats, such as areas along streams, forest margins, or in areas recently disturbed by erosion, fire, or human activity (Dickinson and Campbell 1991). These shrubby trees tend to be understory species and not canopy dominants (Habeck 1991, Lasseigne and Blazich 2002). A population of *C. monogyna* in a woodland in England had lower recruitment than populations on grazed land as a result of more competition with shade-tolerant forest taxa in the woodland (Williams and Buxton 1986). Similarly, *C. douglasii* generally prefers growing in full sun on soils with adequate moisture, but this species can also exist in partial shade on a range of soils (USDA Natural Resources Conservation Service 2002). In Tennessee, the loss of suitable habitats as a result of forest re-establishment and increased agricultural activity has led to the disappearance of *Crataegus* species (Dickinson and Campbell 1991). "Shading has produced deleterious effects on most *Crataegus* taxa, so that without compensating factors (erosion, grazing, human disturbance), topodemes of most North American taxa will only persist while they are not overtopped by woody plants with shade-tolerant juvenile stages." (Dickinson and Campbell 1991). However, the shade-tolerance of *C. saligna* at different life stages is not known, and *Crataegus* species in western riparian areas may have different ecological limitations than those in the eastern U.S. Interestingly, the Global Compendium of Weeds (Randall 2001) and the references therein list *C. saligna* as a weed, it but does not mention where this species is considered a weed.

There are no reports of non-native plant species specifically affecting *Crataegus saligna*. Many exotic perennial species can invade disturbed or undisturbed sites, reproduce vegetatively, form dense, monospecific stands, and outcompete native species by using space, nutrients, and water. *Tamarix ramosissima* (tamarisk), *Elaeagnus angustifolia* (Russian olive), *Lythrum salicaria* (purple loosestrife), *Chrysanthemum leucanthemum* (oxeye daisy), *Poa pratensis* (Kentucky bluegrass), and *Cirsium arvense* (Canada thistle) are invaders of riparian and wetland areas that could potentially negatively impact *Crataegus saligna*. *Tamarix ramosissima* is currently a dominant shrubby riparian tree in many areas of the Colorado River basin below 6,000 ft (Grahame and Sisk 2002). It is known to affect the geomorphology and hydrology of riparian systems profoundly by using excessive water through transpiration, excreting salt into the soil, increasing fire frequency, causing stabilization of sand bars, and generally altering environmental conditions to facilitate its own persistence to the exclusion of native species (Lovich and de Gouvenain 1998). In addition, other invasive species, such as *Poa pratensis*, *Bromus japonicus* (Japanese brome), *Linaria vulgaris* (yellow toadflax), *Acroptilon repens* (Russian knapweed), *Kochia scoparia* (kochia), *Salsola iberica* (Russian thistle), *Ambrosia artemisiifolia* (ragweed), and *Melilotus officianalis* (biennial yellow sweet clover) have been recorded in the Arkansas River corridor, where *C. saligna* is known from the vicinity of Salida (Arkansas Headwaters Recreation Area 2001). Weeds have invaded this area as a result of soil disturbance related to road construction, recreation site development, increased recreation use, and off-highway vehicle (OHV) use (Arkansas Headwaters Recreation Area 2001). The extent of non-native plant invasions near existing populations of *C. saligna* is not known. *Poa pratensis* has increased in some riparian vegetation communities (possibly with *C. saligna*) as a result of heavy livestock grazing (Grossman et al. 1998). *Tamarix ramosissima* and *E. angustifolia* have not yet invaded the Taylor River Canyon of the Gunnison River or creeks in the White River National Forest with possible *C. saligna* populations (G. Austin personal communication 2003, K. Giezentanner personal communication 2003), but there are now small

infestations *of T. ramosissima* at lower elevations of the Gunnison River that were not present 20 years ago (B. Johnston personal communication 2003). G. Austin (personal communication 2003) reported that the USFS has controlled *Chrysanthemum leucanthemum* infestations in the Taylor River Canyon area. The threat of exotic species to *Crataegus saligna* most likely depends on geographic location and elevation, the distance from heavy weed infestations (e.g., along roads and trails), dispersal mechanisms, and other factors related to disturbance factors. Element occurrence habitat conditions ranked by the Colorado NHP (Spackman 2000) estimate that high-quality sites would have less than 1 percent cover by exotic plant species, and lower quality sites (B,C,and D ranked sites) would have from less than 10 to over 50 percent cover by exotic species. However, no occurrences have currently been ranked.

Parasites and disease

Evidence for parasites or diseases on *Crataegus saligna* or related *Crataegus* species was not reported in the reviewed literature.

Symbiotic interactions

Insect pollination of flowering plants is an example of an important symbiotic interaction. Plants lure insects to a pollen or nectar reward, and the insects carry pollen to other flowers, thus helping to cross-fertilize. As discussed previously, specific details concerning the pollination ecology of *Crataegus saligna* are largely unknown. The positive interactions between other associated plant or microbial species and *C. saligna* are also unknown.

Habitat influences

Crataegus saligna appears to be geographically restricted to western Colorado and possibly Utah, but the causes of endemism have not been identified. Within its range, this species has been recorded exclusively from riparian habitats within the Arkansas, Colorado, Gunnison, and White River basins. Riparian areas are defined as the interface between riverine aquatic ecosystem and adjacent upland ecosystem (Kittel et al. 1999). These areas are flooded or at least seasonally saturated by a fluctuating water table and often have plants, soils, and topography unique from upland areas (Kittel et al. 1999). Regeneration of the dominant species in these riparian vegetation communities is probably controlled somewhat by the flooding characteristics of the river (Grossman et al. 1998).

The full range of environmental conditions tolerated by this species has not been studied. The availability and quality of suitable habitat among areas most likely ranges from area to area, depending on heterogeneity in hydrology, substrate, topography, environmental fluctuations, associated species, and disturbance factors.

CONSERVATION

Threats

Threats to the long-term persistence of *Crataegus saligna* in USFS Region 2 are mostly unknown because of the paucity of knowledge about this species and the lack of species research. The information presented in this section is primarily based on a preliminary assessment by McKee (2002), hypotheses by national forest botanists and range specialists (G. Austin personal communication 2003, K. Geizentanner personal communication 2003, B. Johnston personal communication 2003), and analysis of woodland riparian communities in Colorado (Grossman et al. 1998, Kittel et al. 1999, Neely et al. 2001, Grahame and Sisk 2002). *Crataegus saligna* occurrences and habitat throughout its range, including USFS Region 2 lands, could potentially be threatened by human-related actions and environmental changes. These factors are summarized in an envirogram outlining malentities potentially important to *C. saligna* (centrum) and the indirect variables affecting those centrum factors (**Figure 5**). It is important to note that the malentities outlined on the envirogram are possible threats to be researched; they are not definite threats that have been identified as causing population declines.

Of the 28 occurrences of *Crataegus saligna* in Colorado, up to 13 occurrences may be partly or wholly on USFS lands, specifically the Pike-San Isabel, White River, and Grand Mesa-Uncompahgre-Gunnison national forests. Additional occurrences may be on Colorado BLM lands, state or county lands (i.e., highway rights-of-way), private lands, or lands with unknown management (**Table 1**). USFS and BLM lands are generally managed for multiple use, with an effort to prevent damage to populations of species of special concern. It is possible that some occurrences may be on USFS lands within areas with wilderness designations (e.g., Holy Cross Wilderness in the White River National Forest; McKee 2002). As discussed earlier, this species does not receive protection as a sensitive species in USFS Region 2 or Colorado BLM. Management and protection of occurrences of *C. saligna* on county, state, or private lands is not known. It is difficult to identify

possible imminent threats to this species on USFS lands as a result of the considerable uncertainty regarding specific locations.

Because *Crataegus saligna* is a riparian species, threats to its persistence are presumably linked to any factors that may decrease or degrade its riparian habitats. In general, riparian areas in Colorado are "highly used and abused" (Kittel et al. 1999), and destruction, conversion to other uses, or degradation in structure, function, or composition have led to declines of riparian habitats of the Colorado Plateau (Grahame and Sisk 2002). Riparian areas in the western states of the U.S. constitute less than 1 percent of the total acreage of public lands (Neely et al. 2001, Grahame and Sisk 2002), so habitat losses are especially acute. When natural hydrologic regimes are altered through diversions or impoundments, water tables can drop, surface sediments can dry out, fewer floods may occur to shift the channel and create open substrate, and the vegetation communities can decline in diversity and become monocultures (Grahame and Sisk 2002). Some riparian communities unique to western Colorado are considered globally imperiled (G2). For example, the *Populus angustifolia*/*Crataegus rivularis* Woodland (CEGL002644) vegetation community along the lower slopes of the San Miguel and Yampa watersheds in Colorado and the *Acer negundo*-*Populus angustifolia*/*Cornus sericea* Forest (CEGL000627) vegetation community in watersheds of northwestern Colorado (e.g., White River) have both been ranked as G2 (Grossman et al. 1998). Stands of these vegetation communities are declining in some cases as a result of habitat degradation and fragmentation from introduced species invasion, inappropriate livestock grazing, agricultural impacts, and alterations to normal flow regimes (Grossman et al. 1998). An analysis of threats to the *Acer negundo*-*Populus angustifolia*/*Cornus sericea* Forest noted that, "Alteration of the natural flood regime of the undammed White River could seriously affect this plant community." (Grossman et al. 1998).

Crataegus saligna could be directly or indirectly affected by habitat loss, human-related activities, or alterations to natural ecological processes. Because riparian communities depend on watershed processes, these communities are strongly influenced by surrounding land use in the watershed (Grossman et al. 1998). Direct or indirect negative impacts to *C. saligna* populations or habitat by human-related activities could occur from water management practices (e.g., channelizing, diverting, or impounding), fragmentation of the riparian corridor or surrounding landscape (e.g., from agriculture, bridges, degraded vegetation communities), motorized and non-motorized recreation (e.g., OHV use), structure construction and maintenance (e.g., roads, railroads, bridges, diversion structures/canals, buildings), domestic livestock activities, forest clearing or thinning, pollution (e.g., agricultural runoff, herbicide or pesticide use), gravel mining, and non-native species invasion or control (Kittel et al. 1999, Neely et al. 2001, Grahame and Sisk 2002). For example, a *C. saligna* specimen has been collected from along a creek near Gunnison, and B. Johnston (personal communication 2003) noted that significant suburb development is occurring in the lower reaches of this creek. Roads occur in many of Colorado's canyons, and road construction and maintenance are ongoing processes. Due to the considerable uncertainty concerning the location of *C. saligna* occurrences, the extent of these activities near populations of *C. saligna* or in suitable *C. saligna* habitat is unknown. In addition, these activities could either affect the existing individuals or reduce reproductive success, available habitat, development of new individuals, establishment of new occurrences, or other factors important for long-term persistence of the species. Overutilization of *C. saligna* for educational, scientific, or horticultural purposes is also unknown, but it is not thought to be a significant threat. Commercial logging (i.e., road creation, skidding) may be less likely to occur in *Populus*-dominated forests, but clearing or thinning to improve forage for livestock may be a significant activity in these riparian areas. The occurrence of forestry activities upstream or upslope from *C. saligna* and the possible effects (e.g., sedimentation, hydrologic alterations) on riparian communities have not been assessed. In addition, wildfires or prescribed burning activities are probably uncommon or patchy in riparian areas, although the establishment of monotypic stands of tamarisk has introduced episodic fire in heavily invaded areas (Lovich and de Gouvenain 1998, Grahame and Sisk 2002).

Other possible environmental and biological threats to individuals and occurrences of *Crataegus saligna* include environmental fluctuations (e.g., drought), genetic isolation, succession, herbivory, inadequate pollination, global climate changes, or changes to the natural disturbance regime. The successional stages optimal for *C. saligna* establishment and persistence and environmental tolerances (e.g., shading) of *C. saligna* are not known. Disturbances can either create suitable habitat throughout a landscape or directly impact an existing occurrence, depending on their frequency, intensity, size, and location. Environmental stochasticity can affect pollinator

activity and behavior. The effects of native herbivores on *C. saligna* are unknown. *Crataegus saligna* is known from approximately 28 scattered occurrences within its restricted range; the amount of gene flow, genetic variability, and inbreeding is unknown for this species.

Changes to existing climatic and precipitation patterns, perhaps as a result of global climate change, could also impact *Crataegus saligna*. For example, average temperatures are projected to increase and precipitation is generally expected to increase over western North America (U.S. Environmental Protection Agency 1997, Watson et al. 2001). A document about regional climate changes in Colorado by the U.S. Environmental Protection Agency reports that average temperatures have increased by 4.1º F and precipitation has decreased by up to 20 percent in some areas of Colorado over the last century (U.S. Environmental Protection Agency 1997). Over the next century, climate models predict that temperatures in Colorado could increase by 3 to 4º F (with a range of 1 to 8º F) in the spring and fall and by 5 to 6º F (with a range of 2 to 12º F) in the summer and winter. Precipitation is estimated to increase by 10 percent in the spring and fall, increase by 20 to 70 percent in the winter, and create more thunderstorms in the summer (without a significant change in precipitation total) (U.S. Environmental Protection Agency 1997). Climate changes have the potential to affect plant community composition by altering establishment, growth, reproduction, and death of plants (Inouye and McGuire 1991, Inouye et al. 2002, Saavedra et al. 2003). The possible effects of global climate change on *C. saligna* or its associated vegetation communities have not been studied.

It is difficult to prioritize threats to this species on USFS lands as a result of the considerable uncertainty regarding specific locations and the unknown possibility of effects from surrounding land uses on this species. Threats to occurrences of *Crataegus saligna* on USFS Region 2 lands may include any of the threats listed above, such as hydrologic alterations, motorized and non-motorized recreation, livestock overgrazing or trampling, non-native plant invasion, poor water quality (e.g., pollution), landscape fragmentation, and global climate changes. It is possible that occurrences of *C. saligna* on USFS lands would be less likely to suffer direct damage from activities such as structure construction and severe overgrazing than occurrences on private lands. Any occurrences that occur in wilderness areas would also likely be more protected from direct impacts from motorized travel, adjacent landscape fragmentation, water pollution, and construction. Occurrences along rivers heavily used by recreationalists (e.g., Arkansas River) are likely at higher risk for the detrimental effects of trampling and non-native plant invasion.

Conservation Status of the Species in USFS Region 2

Crataegus saligna is a species of special concern because of its endemic distribution, small number of documented occurrences, and possible human-related and environmental threats to its persistence. The viability of this species within USFS Region 2 is difficult to ascertain because its full distribution and abundance are unknown, and demographic parameters have not been studied.

Much information is lacking on the abundance, distribution, and biology of *Crataegus saligna*. Up to 13 *C. saligna* occurrences may be on USFS Region 2 lands, but this species is not specifically protected as a sensitive species. Motorized and non-motorized recreation, water management activities, exotic species invasion, landscape fragmentation, excessive herbivory, structure construction and maintenance, land management activities, and environmental fluctuations potentially threaten this species. It is difficult to predict this species' ability to tolerate environmental stochasticity and any future environmental or management changes.

Population declines

We are unable to conclude whether the distribution or abundance of *Crataegus saligna* is declining, expanding, or remaining stable throughout its range. Although this species has been collected by botanists over the last 100 years, herbarium and occurrence records for this species do not include abundance estimates. There have been no detailed status reports or intensive surveys for occurrences of this species. The rate at which this species disperses and colonizes new locations is unknown because we know little of its dispersal and establishment capabilities.

Habitat variation and risk

The locations of *Crataegus saligna* and the habitat requirements of this species are largely undefined, so the variation and risks within these environments over space and time are thus difficult to assess. Within riparian habitats of the Colorado Plateau, plant communities generally depend on the maintenance of natural hydrologic flow regimes (Grossman et al. 1998, Neely et al. 2001, Grahame and Sisk 2002). Sources of variation within these environments include annual and

episodic hydrologic cycles that affect water levels and sediment movement (Grahame and Sisk 2002). Potential risks within the habitats could include disruption in natural hydrologic flow regimes, competition from surrounding vegetation, lack of suitable germination sites, inadequate pollinator habitat, decrease in dispersal by animals, barriers to gene flow, conditions too harsh for adequate growth and development (e.g., drought, trampling), and other fluctuations in disturbance processes that could affect existing populations or the creation of habitat. Specific occurrences could be at a greater risk than other occurrences, depending on the landscape context, because surrounding land uses strongly influence watershed processes (Grossman et al. 1998). It is difficult to predict the spread of non-native invasive plants and the potential risk of alteration to plant communities. Some examples of the *Acer negundo-Populus angustifolia*/*Cornus sericea* Forest community have poor regeneration of dominant trees, habitat instability, and presence of non-native understory species (Grossman et al. 1998). As a result of human influences on the environment and the unpredictable effects of environmental fluctuations, significant habitat variation and risk may exist for *Crataegus saligna* within USFS Region 2.

Potential Management of the Species in USFS Region 2

Quantitative demographic monitoring and detailed biological and ecological studies of *Crataegus saligna* populations and its habitat on USFS Region 2 lands have not occurred. Based on the available information, we can only hypothesize how changes in the environment may affect the abundance, distribution, and long-term persistence of this species.

Management implications

Crataegus saligna occurrences and habitat may be at risk as a result of management activities within the range. Possible human-related threats to existing occurrences of this species include water management practices (e.g., channelizing, diverting, or impounding), fragmentation of the riparian corridor or surrounding landscape (e.g., from agriculture, bridges, degraded vegetation communities), motorized and non-motorized recreation (e.g., OHV use), structure construction and maintenance (e.g., roads, railroads, bridges, diversion structures/canals, buildings), domestic livestock activities, thinning/clearing, pollution (e.g., agricultural runoff, herbicide or pesticide use), gravel mining, and non-native species invasion or control. It is difficult to assess which threats are most imminent on USFS lands based on our current state of knowledge of this species and the fact that riparian corridors are highly influenced by the surrounding landscape (which may include non-USFS lands). It is possible that the most relevant impacts to this species on USFS lands could be related to motorized and non-motorized recreation, land management (e.g., livestock activities, timbering activities), non-native plant invasion, and global climate changes. This is based on the assumption that some riparian corridors on USFS lands are less likely to experience extensive structure construction, declines in water quality, extensive land clearing, landscape fragmentation, and water channel alterations, which may not necessarily be the case. Currently, there is no protection of this species through travel management plans and regulations requiring surveys before construction on USFS and BLM lands. G. Austin (personal communication 2003) noted that efforts have been taken to reduce negative impacts in riparian areas by encouraging recreationalists to use designated put-in/take-out sites and by minimizing the time spent by livestock in those areas. The effects of livestock exclosures on *C. saligna* and the exposure and response of this species to grazing, prescribed fires, thinning, or timber harvest are unknown. The long-term persistence of this species may rely on studying the effects of current USFS Region 2 land-use practices, reducing any imminent threats to existing occurrences, and monitoring the effects of any future management changes. Studying the effects of different management activities (e.g., varying intensities, frequencies, and types of management) on this species would help to inform future management decisions.

Potential conservation elements

Crataegus saligna is a regional endemic with a small number of recorded occurrences and potentially high vulnerability to human-related activities and environmental changes. The distribution, abundance, ecological range of this species and the intensity, frequency, size, and type of disturbance optimal for its persistence are unknown. The lack of information regarding the colonizing ability, adaptability to changing environmental conditions, sexual and asexual reproductive potential, or genetic variability of this species makes it difficult to predict its long-term vulnerability. Assessing current distribution and abundance, surveying high probability habitat for new occurrences, protecting any existing occurrences from direct damage, studying the effects of current management activities and monitoring future management changes, preventing non-native plant invasions, and studying demographic parameters and

reproductive ecology are key conservation elements for this species on USFS Region 2 lands.

Tools and practices

There are no existing population monitoring protocols for *Crataegus saligna*, and very little is known about its biology, ecology, and spatial distribution. Thus, habitat surveys, quantitative species monitoring, and biological and ecological studies are priorities for constructing a current status assessment and conservation plan.

Species inventory and habitat surveys

The distribution and total abundance of *Crataegus saligna* are not sufficiently known to formulate conservation strategies on USFS Region 2 lands. Understanding the distribution of *C. saligna* through inventories and status assessment is important for developing a conservation plan for this species. Researchers could visit all documented sites to ascertain both current distribution and occurrence status. These sites could be regularly re-visited for update reports. Ascertaining the current abundance of this species would help to estimate its vulnerability to environmental fluctuations and to monitor the effects of human activities.

Additional surveys of habitat are needed to document the full spatial extent of *Crataegus saligna* and to identify its ecological range. The distribution of *C. saligna* is scattered, with occurrences throughout several river basins. The current distribution map for *C. saligna* in USFS Region 2 (**Figure 1**) indicates that the range of this species is discontinuous and that other watersheds could have undocumented occurrences. For example, *C. saligna* is known from the Arkansas, Colorado, Gunnison, and White River basins, and additional occurrences may exist in adjacent basins, such as the Yampa, Green, or San Miguel River basins. There are only a few specimens of *C. saligna* east of the Continental Divide in the Arkansas River, and it is possible that additional occurrences exist upstream from Salida. *Crataegus saligna* apparently occurs at a variety of elevations and along creeks and rivers of varying sizes and gradients, but the environmental tolerances or limitations for this species are unknown.

Once survey areas have been identified, researchers could further identify areas of potential habitat using topographic maps, geologic maps, land status maps, and aerial or satellite images. In addition, surveys could use existing occurrences as a starting point because similar habitats likely extend along the river corridor. Locations downstream from existing occurrences could be surveyed because *Crataegus saligna* seeds can be water dispersed. In addition, smaller streams and tributaries to the main river channel could also be surveyed, because *C. saligna* seeds can also be bird and animal dispersed.

The size and extent of existing occurrences could be mapped and recorded using global positioning system (GPS) and geographic information system (GIS) technology. Mapping each known occurrence of *Crataegus saligna* will maintain consistency for future observations and help in making estimates of density and abundance over time. Mapping occurrences of *C. saligna* will also elucidate the spatial distribution of populations at the regional-level and provide a framework for creating a metapopulation study. Occurrences in areas slated for various management, maintenance, or disturbance activities could be readily identified.

Population monitoring and demographic studies

Additional information is needed to gain an understanding of the life cycle, reproductive biology, demography, and population trends of *Crataegus saligna*. Information is lacking on longevity, germination requirements, seed survival, extent of asexual reproduction, factors affecting flower development, pollination ecology, role of the seed bank, and gene flow between populations. This type of species-specific information would be useful in assessing threats to this species and in estimating species viability. For example, studies of germination needs in the field might elucidate potential limiting factors for the establishment of new individuals. Basic studies on the reproductive biology of *C. saligna* are necessary to begin to understand its demography and genetic considerations important to its conservation. Research on the reproductive biology of other *Crataegus* species could provide useful information and tools for designing future studies of *C. saligna* (see review in Dickinson and Campbell 1991).

No data are available on population trends for this species, and no long-term demographic monitoring has been initiated. Long-term monitoring studies could yield helpful information, such as temporal and spatial patterns of abundance and dormancy; environmental factors that influence abundance (e.g., hydrologic fluctuations); whether occurrences are increasing, decreasing, or remaining stable; and the minimum number of plants necessary to perpetuate the species. In addition, assessing the genetic differences between

and among populations will help to understand metapopulation dynamics and possible taxonomic distinctions between populations and species.

Understanding certain aspects of demography is a priority in order to provide basic population information, as indicated by these questions:

- What is the current abundance?
- What are the rates of survival, longevity, and recruitment?
- What are the population fluctuations from year to year?
- What are the effects of disturbances and environmental fluctuations on demographics?
- What are the role, status, and longevity of the seed bank?
- What is the age structure of the population?
- What is the age at which individuals become reproductive?
- What is the extent of sexual and asexual reproduction?
- What is the gene flow between populations?

Long-term monitoring programs are required to answer these kinds of questions, but it may take decades for a clear pattern to emerge. Several groups have developed protocols for monitoring population and demographic trends of rare plant species. These protocols can be easily accessed and used to develop specific monitoring plans for use in USFS Region 2. For example, Elzinga et al. (1998) and Hutchings (1994) are general references that provide concrete guidance on designing and implementing quantitative monitoring plans for rare plant species. Austin et al. (1999) and Bonham et al. (2001) provide helpful protocols specifically designed for federal agencies monitoring plants on public lands. In addition, population matrix models that measure individual fitness and population growth provide flexible and powerful metrics for evaluating habitat quality and identifying the most critical feature of the species' life history (Hayward and McDonald 1997). Deterministic demographic models of single populations are the simplest analyses and are used as powerful tools in making decisions for managing threatened and endangered species (Beissinger and Westphal 1998).

Habitat monitoring and management

Herbarium and occurrence records for *Crataegus saligna* generally do not identify associated plant species, substrate types, microhabitat characteristics, or the landscape context for each occurrence. The habitat characteristics of this species have not been adequately described to understand what factors and watershed processes are critical in maintaining or restoring habitat for these species. For example, it is currently not known what types, intensities, or frequencies of disturbance create and maintain habitat and are tolerated by existing occurrences of this species. The extent of land management activities and the cumulative beneficial or detrimental effects of these management activities on *C. saligna* and its habitats have not been studied or monitored. Documenting land management and monitoring habitat could occur in conjunction with population monitoring efforts in order to associate population trends with environmental conditions.

Some examples of management practices that would protect *Crataegus saligna* habitat and minimize possible plant destruction include encouraging river recreationalists (including commercial operations that heavily use these rivers) to use established trails, put-in/take-out points, and camping areas; preventing the spread and establishment of non-native invasive species; and regulating cattle activities. Habitat management could also consider issues related to the surrounding landscape, such as barriers to dispersal, landscape fragmentation, and pollinator habitat needs.

Biological and ecological studies

Much of the information regarding habitat requirements, establishment, reproduction, dispersal, relationship with herbivores, competition with other species, and overall persistence has not been studied for *Crataegus saligna*. The ecological needs of *C. saligna* are not known in sufficient detail to evaluate the response of this species to habitat changes. The extent of vegetative and seed reproduction is not known and has ramifications for species persistence. Research studies to evaluate the effects of water management activities, recreation, livestock activities, landscape fragmentation, drought, succession, and fire at several scales (local and regional) would provide valuable input to the development of conservation strategies and management programs. The types of monitoring studies required to understand how this species

responds to environmental fluctuations, changes in the disturbance regime, or natural succession would be complex and could take decades. It will be difficult to determine the characteristics of the optimal natural hydrologic regime to maintain populations of this species and appropriate habitat.

Availability of reliable restoration methods

There has been no published research to date involving the production of *Crataegus saligna* in greenhouse environments or the harvest or storage of seed for use in restoration projects. Sheffield's Seed Co., Inc. in Locke, NY reports that they have *C. saligna* seeds (Sheffield's Seed Co., Inc. 2003). Nursery guidelines suggest that *Crataegus* species can be propagated by vegetative (i.e., softwood cuttings, root-grafting) or sexual (i.e., seed) methods (Dumroese et al. 1997, Lasseigne and Blazich 2002). Habeck (1991) reported that successful seed establishment of *C. douglasii* is difficult in the field, and that transplanted nursery stock is recommended for use as a soil stabilizer at erosion sites. Germination and transplantation studies of *C. saligna* in natural environments would be helpful if populations are at risk of extirpation. In addition, restoration of riparian habitats would also benefit this species.

Information Needs and Research Priorities

Based on our current understanding of *Crataegus saligna*, we can identify research priorities where additional information will help to develop management objectives, initiate monitoring and research programs, and inform a conservation plan. To address these data gaps, information can be obtained through surveys, long-term monitoring plans, and extended research programs. There is so little known about the biology and ecology of this species that there are a large number of research projects that could be implemented.

Revisiting all occurrences, estimating current abundance, assessing imminent threats, studying genetic variability, and determining ecological needs and limitations are of primary importance to further the understanding of *Crataegus saligna* in USFS Region 2. The following types of studies are priorities to supplement basic knowledge regarding this species:

- Revisiting and detailed mapping of existing occurrences
- Surveying for new occurrences
- Addressing imminent threats to known occurrences
- Characterizing microhabitat and watershed processes
- Documenting and monitoring current land and water management practices
- Studying reproductive biology, including germination trials, dispersal capabilities, pollinator surveys, mycorrhizal associations, and seedbank analyses
- Analyzing taxonomic relationships with closely related species
- Performing genetic analyses to assess gene flow and variability throughout range

Additional research and data that may be useful but are not incorporated into this assessment include aspects related to managing data for efficient use. Data acquired during surveys, inventories, monitoring programs, and research projects are most easily accessible if they are entered into an automated relational database. The Colorado NHP and NatureServe have developed databases and GIS components to assist in information storage and habitat modeling (D. Anderson personal communication 2003). Such a database should be integrated with GIS and allow queries and activities such as the following:

- Efficient incorporation of data in the field
- Generation of location and habitat maps
- Identification of occurrence locations
- Characterization of associated habitat types
- Identification of population trends over time
- Identification of data gaps that require further information gathering
- Ease of database modification as additional information becomes available.

Definitions

Achene — small, dry fruit with a close-fitting wall surrounding a single seed.

Actinomorphic — radially symmetrical; divisible into equal halves by two or more planes.

Acuminate — gradually tapering to a sharp tip.

Agamospermous — capable of asexually producing seeds without fertilization.

Aneuploidy — change in the number of chromosomes by a gain or loss of individual chromosomes.

Annual — a plant that completes its entire life cycle in one growing season.

Anther — part of the flower reproductive structure (stamen) that bears pollen.

Apomixis — the ability of some plant species to reproduce asexually with seeds.

Appressed — lying close to (pressed against) an organ, as hairs appressed to a leaf.

Asexual reproduction — any form of reproduction not involving the union of gametes.

Calyx — the collective name for sepals.

Corolla — portion of flower comprised of petals.

Corymb — flat-topped inflorescence.

Crenate-toothed — toothed along the margin with rounded teeth.

Demographics — the study of fecundity and mortality parameters that are used to predict population changes.

Diploid — containing a full set of genetic material comprised of a paired set of chromosomes, usually one set from each parent.

Dormancy — a period of growth inactivity in seeds, buds, bulbs, and other plant organs even when environmental conditions normally required for growth are met.

Endangered — defined in the Endangered Species Act as a species, subspecies, or variety likely to become extinct in the foreseeable future throughout all or a significant portion of its range.

Endemic — a population or species with narrow physiological constraints or other restrictions, which limit it to a special habitat or a very restricted geographic range, or both.

Endocarp — inner part of the matured ovary wall of a fruit.

Endozoochory — dispersal of a seed by an animal.

Entire — having a margin that lacks any toothing or division, as the leaves of some plants.

Exserted — projecting beyond another structure.

Fertility — reproductive capacity of an organism.

Fitness — success in producing viable and fertile offspring.

Fruit — the ripened, seed-containing reproductive structure of a plant.

G1 ranking — critically imperiled globally because of extreme rarity (five or fewer occurrences or very few remaining individuals) or because of some factor making it especially vulnerable to extinction (NatureServe).

G2 ranking — imperiled globally because of rarity (6 to 20 occurrences) or because of factors demonstrably making a species vulnerable to extinction (NatureServe).

G3 ranking — vulnerable throughout its range or found locally in a restricted range (21 to 100 occurrences) or because of other factors making it vulnerable to extinction (NatureServe).

G4 ranking — apparently secure, though it may be quite rare in parts of its range, especially at the periphery (NatureServe).

G5 ranking — demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery (NatureServe).

Glabrous — Smooth, without hairs, trichomes, or glands.

Glaucous — covered with a fine, waxy powder that imparts a whitish cast to the surface.

Habitat fragmentation — the breakup of a continuous landscape containing large patches into smaller, usually more numerous, and less connected patches. Can result in genetic isolation.

Holotype — the single specimen on which the taxon was based or the single specimen designated as the name-bearing (or primary) specimen.

Hybridization — the result of a cross between two interspecific taxa.

Hypanthium — floral cup on which perianth and stamens are borne.

Inflorescence — the flowering part of a plant, usually referring to a cluster of flowers.

Interspecific competition — competition for resources between individuals of different species.

Intraspecific competition — competition for resources among individuals of one species.

Iteroparous — capable of reproducing several or many times over a lifetime.

Lanceolate — lance-shaped; much longer than broad, widening above the base and then tapering to the tip.

Lectotype — a syntype later designated as the one name-bearing type specimen.

Lunate — crescent-shaped.

Mesic — characteristic of an environment that is neither extremely wet, nor extremely dry.

Metapopulation — group of populations that are linked through migration of individuals.

Mycorrhiza — symbiotic association between a fungus and the root of a higher plant.

Nutlet — small, thick-walled achene.

Oblong — shaped more or less like a rectangular, rather than a square.

Ovary — the enlarged portion of the female reproductive structure (pistil) that contains the ovules and develops into the fruit.

Ovate — egg-shaped, with the larger end toward the base (i.e. ovate leaves).

Perennial — a plant that lives for three or more years and can grow, flower, and set seed for many years; underground parts may regrow new stems in the case of herbaceous plants.

Perfect flower — flower with both “male” (stamens) and “female” (pistils) reproductive organs.

Petiole — leaf stalk.

Phenotype — the external visible appearance of an organism.

Phenotypic plasticity — when members of a species vary in height, leaf size or shape, flowering (or spore-producing time), or other attributes, with changes in light intensity, latitude, elevation, or other site characteristics.

Pistil — the seed-producing organ of a flower, consisting of a stigma, style, and ovary.

Pollen — the male spores in an anther.

Polyploidy — having more than two complete sets of chromosomes per cell.

Pome — fleshy fruit with a soft outer part and a core with papery or cartilaginous structures enclosing the seeds.

Population Viability Analysis — an evaluation to determine the minimum number of plants needed to perpetuate a species into the future, the factors that affect that number, and current population trends for the species being evaluated.

Propagule — a reproductive body, usually produced through asexual or vegetative reproduction.

Protogynous — stigma is receptive to pollen before pollen is shed from anthers on the same plant.

Recruitment — the addition of new individuals to a population by reproduction.

Rhombic — diamond-shaped; broadest at the middle, with more or less straight sides of equal length tapering to either end.

Ruderal habitat — temporary or frequently disturbed habitats.

Ruderal species — species that can exploit low stress, high disturbance environments.

S1 ranking — critically imperiled globally because of extreme rarity (five or fewer occurrences or very few remaining individuals) or because of some factor making it especially vulnerable to extinction (NatureServe).

S2 ranking — imperiled globally because of rarity (6 to 20 occurrences) or because of factors demonstrably making a species vulnerable to extinction (NatureServe).

S3 ranking — vulnerable throughout its range or found locally in a restricted range (21 to 100 occurrences) or because of other factors making it vulnerable to extinction (NatureServe).

S4 ranking — apparently secure, though it may be quite rare in parts of its range, especially at the periphery (NatureServe).

S5 ranking — demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery (NatureServe).

Saw-toothed — serrated with teeth that point toward the apex.

Selfing — capable of self-fertilization; fertilization by the union of female and male gametes from the same individual.

Senescence — changes that occur in an organism (or part of an organism) between maturity and death; aging.

Sensitive species — a species whose population viability is a concern due to downward trends in population numbers, density, or habitat capability, as identified by a regional forester (USFS).

Sepals — a segment of the calyx.

Sexual reproduction — reproduction involving the union of gametes.

Stamen — the pollen-producing structures of a flower; the "male" part of a flower.

Stipule — basal appendage found in association with leaves of many species.

Stipulate — with stipules.

Succession — the orderly process of one plant community replacing another.

Symbiosis — an intimate association between two dissimilar organisms that benefits both of them.

Syntype — each specimen of a type series (of equal rank) when no holotype or lectotype has been named.

Taproot — main, central root growing straight down, often stouter than other roots.

Threatened — defined in the Endangered Species Act as a species, subspecies, or variety in danger of becoming endangered throughout all or a significant portion of its range.

Vegetative reproduction — a form of asexual propagation whereby new individuals develop from specialized multicellular structures that often detach from the mother plant.

Viability — the capability of a species to persist over time. A viable species consists of self-sustaining and interacting populations that have sufficient abundance and diversity to persist and adapt over time.

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