U.S. Fish & Wildlife Service

Draft Recovery Plan for *Lilaeopsis schaffneriana* ssp. *recurva* (Huachuca water umbel)

Lilaeopsis schaffneriana ssp. *recurva* (Huachuca water umbel). Photograph by Brandi Eide, Desert Botanical Garden, Phoenix, Arizona.

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2016

Region 2
U.S. Fish and Wildlife Service
Arizona Ecological Services Office
Tucson, Arizona

Approved: **Draft**

Regional Director, Southwest Region, Region 2,
U.S. Fish and Wildlife Service

Date:

Disclaimer

Recovery plans delineate reasonable actions that are believed to be required to recover and protect listed species. We, the U.S. Fish and Wildlife Service (Service), publish recovery plans, sometimes preparing them with the assistance of recovery teams, contractors, state agencies, Tribal agencies, and other affected and interested parties. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Costs indicated for action implementation and time of recovery are estimates and subject to change. Recovery plans do not obligate other parties to undertake specific actions, and may not represent the views or the official positions of any individuals or agencies involved in recovery plan formulation, other than the Service. Recovery plans represent the Service's official position *only* after they have been signed by the Director or Regional Director as *approved*. Recovery plans are released for public comment and submitted to peer review before we adopt them as approved final documents. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

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An electronic copy of this draft recovery plan will be made available at:
http://www.fws.gov/endangered/species/recovery-plans.html and at
http://www.fws.gov/southwest/es/arizona/HuachucaUmbel.htm.

Executive Summary

Current Species Status

Lilaeopsis schaffneriana ssp. *recurva* was listed as endangered under the Endangered Species Act (Act) on January 6, 1997 (62 FR 665) and 83.2 kilometers (km)(51.7 miles (mi)) of streams or rivers in Cochise and Santa Cruz Counties, Arizona, were designated as critical habitat on July 12, 1999 (64 FR37441). The majority of critical habitat is under Federal administration through the Coronado National Forest (National Forest Service), the San Pedro Riparian National Conservation Area (Bureau of Land Management), and Fort Huachuca Military Reservation (United States Army); a small portion is in private ownership. The taxon occurs in aquatic habitats such as cienegas, rivers, streams, and springs of five watersheds in southeastern Arizona and adjacent portions of Sonora, Mexico. In the United States, we are aware of 17 locations supporting extant occurrences of *L. schaffneriana* ssp. *recurva*, 8 locations where all *L. schaffneriana* ssp. *recurva* occurrences are considered extirpated, and 6 locations where no occurrences have been relocated in recent years. In Sonora, Mexico, we are aware of 21 locations supporting *L. schaffneriana* ssp. *recurva* occurrences, though most of these locations have not been revisited in recent years. It is difficult to estimate the number of individuals due to the clonal nature of the taxon, though estimates of density indicate most occurrences are stable or in decline. As recently as 2014, flooding associated with monsoon storms has scoured drainages with occurrences of *L. schaffneriana* ssp. *recurva* affecting the status of this species in some locations.

Habitat Requirements and Limiting Factors

Lilaeopsis schaffneriana ssp. *recurva* occurs in shallow and slow-flowing waters that are relatively stable, or in active stream channels containing refugial sites where the plants can escape the effect of scouring floods (62 FR 665, p. 667; 64 FR 37441, p. 37442). Groundwater pumping, regional drought, and climate change are among the largest threats to this taxon, which depends on the availability of permanently wet (or nearly so), muddy, or silty substrates with some organic content. At this time, the most significant long-term threats to the continued existence of the species are: 1) aquatic habitat degradation; 2) the effects of drought and climate change; 3) wildfire and resulting sedimentation and scouring; 4) invasive non-native plant competition; and 5) livestock grazing.

Recovery Priority

The recovery priority number for *Lilaeopsis schaffneriana* ssp. *recurva* is 3C, meaning that the listed entity is a subspecies, the level of threat is high, the potential for recovery is high, and there is a conflict with some form of economic activity (groundwater withdrawal for mining, agriculture, Fort Huachuca, municipal use, and private wells).

Recovery Strategy

The principal recovery strategy is to conserve the habitat of *L. schaffneriana* ssp. *recurva* by implementing a variety of protection strategies, including decreasing groundwater pumping,

increasing water conservation and recharge, and protecting *L. schaffneriana* ssp. *recurva* occurrences and their seedbanks. Providing conservation and restoration of the taxon and its habitat will allow stable, self-sustaining occurrences to persist with some level of connectivity and opportunities for expansion and dispersal. Additional efforts will focus on improving the baseline understanding of *L. schaffneriana* ssp. *recurva* ecology and threats.

Recovery Goal

The principal recovery goal is to remove the taxon from the Federal List of Endangered and Threatened Plants (50 CFR 17.12).

Recovery Objectives

1) Protect and restore functional aquatic habitat and reduce dewatering threats to known and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and habitat.
2) Conserve existing and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and their seedbanks, establish new occurrences in appropriate habitat, establish plants at botanical gardens for research, recovery, and educational purposes, and maintain seeds for conservation and recovery at seed storage facilities.
3) Remove stressors related to invasive plants, unmanaged livestock grazing, and small population size to *L. schaffneriana* ssp. *recurva* occurrences and their habitats.
4) Develop a standardized monitoring technique based on existing protocols; monitor *L. schaffneriana* ssp. *recurva* occurrences, threats, and outcomes from management actions allowing for adaptive management.
5) Encourage scientific study to improve our understanding of *L. schaffneriana* ssp. *recurva* geography, ecology, viability, genetics, propagation, restoration, and threats in the United States and Mexico.
6) Develop public outreach, collaborative partnerships, agency management plans, and agreements with private land owners in the United States and Mexico that encourage *L. schaffneriana* ssp. *recurva* conservation.

Recovery Criteria

To downlist

1) A minimum cumulative extent of 2,000 m^2 (0.5 acre / 0.2 hectare) of naturally occupied habitat exists in the San Pedro Watershed, 20% of which occurs in tributary streams, springs, or cienegas; **and** a minimum of 2,000 m^2 (0.5 acre / 0.2 hectare) in the Santa Cruz Watershed, 90% of which occurs in tributary streams, springs, or cienegas, distributed among the areas of Cienega Creek (35%), Sonoita Creek (10%), the San Rafael Valley uplands and mainstem (10%), and the western Huachuca Mountains (35%); **and** a minimum of 125 m^2 (0.03 acre / 0.01 hectare) exists in the Rio Yaqui Watershed; this level of occupancy is sustained or improved for a minimum of 10 years over a 15 year period.

2) At least three separate introduced occurrences with a minimum cumulative extent of 150 m^2 (0.037 acre / 0.015 hectare) of occupied habitat are placed in each of the three United States watersheds and are stable or increasing over a 10 year period;
3) Threats to the taxon and its habitat have been managed and reduced, and management is in place for a minimum of 20 years to ensure the persistence of occurrences with minimum cumulative extent (as reflected by the achievement and maintenance of downlisting criteria 1 and 2) in each of the three United States watersheds;
4) A living collection of as many plugs as resources allows, collected from genetically distinct regions (e.g. Fort Huachuca/SPRNCA north; San Rafael / Las Cienegas/Sonoita; SPRNCA south/SanBernardino), from both the San Pedro and the Santa Cruz watersheds is maintained in at least one botanical garden in southern Arizona for recovery and educational purposes; and
5) Seeds of *L. schaffneriana* ssp. *recurva* are collected following Center For Plant Conservation guidelines, which include collecting from no more than 10 percent of the standing seed crop from 50 individual seed bearing plants per population (if the population size permits), and collecting from a variety of microsites and physical characteristics within the stand of plants. These seeds are stored at both the Agricultural Research Service National Center for Genetic Resources Preservation in Fort Collins, Colorado and stored according to protocols at a local facility such as the Desert Botanical Gardens in Phoenix, Arizona, for long-term conservation and recovery purposes.

To delist *L. schaffneriana* ssp. *recurva*, the criteria for down-listing must be met and the level of occupancy in the downlisting criteria is sustained or increasing for a minimum of 20 years over a 30 year period.

Actions Needed

1) Maintain or enhance groundwater hydrography, as measured by stream gages, by reducing water withdrawal and increasing water conservation and recharge;
2) Preserve existing *L. schaffneriana* ssp. *recurva* occurrences and their seedbanks through the protection of occupied habitat, unoccupied corridors, and habitat quality;
3) Remove stressors such as trampling and invasive non-native plant competition to *L. schaffneriana* ssp. *recurva* occurrences;
4) Conduct research and monitoring that will facilitate better understanding of: a) the distribution and genetics of the taxon in both the United States and Mexico, b) population and metapopulation dynamics and trends, c) life history, d) response to threats, and e) other relationships key to recovery of the species;
5) Establish introduced *L. schaffneriana* ssp. *recurva* occurrences to help ensure the long-term survival of the taxon in southern Arizona;
6) Develop collaborative partnerships with Federal and State land managers, private landowners, museums and botanical gardens, seed storage facilities, and others; and provide outreach to the public as needed to accomplish recovery;
7) Promote the achievement of conservation and recovery in Mexico, resulting in long-term protection of *L. schaffneriana* ssp. *recurva* and its habitat;
8) In coordination with stakeholders, revise this plan as needed as new information comes to light so that the recovery strategy and actions implement recovery in as efficient a manner as possible.

Estimated Date and Cost of Recovery

Date: 2035
Cost: $52,006,000*

* The importance of preventing excessive water drawdown and increasing water recharge into the San Pedro, Santa Cruz, and Rio Yaqui watersheds in the United States cannot be understated in the recovery of this and co-occurring listed species. Arizona is an arid state with finite water supplies, a population expected to double by 2050, and ongoing drought (ADWR 2014, entire; Marshall et al. 2010, p. 1). There is a potential for a long-term imbalance between available water supplies and projected water demands over the next 100 years if no action is taken (ADWR 2014, entire). A clean and sustainable water supply is essential for humans and the environment; water resources planning must embrace the need for water for urban growth, as well as environmental water needs (Marshall et al. 2010, p. 1). Using water more efficiently, reusing water, capturing water, and purchasing surface water rights are all methods whereby water availability can be increased for the benefit of *L. schaffneriana* ssp. *recurva*. These activities would have added benefit to many other co-occurring listed and unlisted plant and animal species, ecosystem services provided by healthy watersheds, and economic benefits such as from increased tourism.

Of the three United States watersheds which support *L. schaffneriana* ssp. *recurva*, the San Pedro supports the greatest amount. Studies estimate the depletion of the Sierra Vista Subwatershed, which contains the upper San Pedro River, to be 4,600 acre feet per year (Upper San Pedro Partnership 2011). We have developed an estimate of water resources needed for recovery, based on the best available information, and have included a target of 1,000 acre feet per year for recovery of this taxon across the entire range. Although this may ultimately be inadequate to meet the water needs of the taxon across the range, it is unlikely that more acre feet of water could be attained annually through any combination of methods; there may simply not be sufficient water rights, conservation savings, or other available water resources (lack of water or precipitation, lack of water rights, lack of willing sellers, lack of conservation opportunities in the appropriate areas, etc.). Therefore, we utilize the 1,000 acre feet per year as a realistic estimate. It is unknown if all of the below-listed methods will need to be or even can be employed to down-list or de-least this taxon. Issues surrounding water are complex and the political, social, economic, and environmental aspects of water are constantly changing, and may affect the scope and scale of the implementation of these recovery actions. In addition, actions taken to improve aquatic habitats for *Spiranthes delitescens* (Canelo Hills ladies' tresses), Chiricahua leopard frog (*Lithobates chiricahuensis*), Northern Mexican gartersnake (*Thamnophis eques megalops*), beautiful shiner (*Cyprinella formosa*), desert pupfish (*Cyprinodon macularius*), Gila chub (*Gila intermedia*), Gila topminnow (*Poeciliopsis occidentalis occidentalis*), Yaqui catfish (*Ictalurus pricei*), Yaqui chub (*Gila purpurea*), Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis*), southwestern willow flycatcher (*Empidonax traillii extimus*), and yellow-billed cuckoo (*Coccyzus americanus*) would benefit *L. schaffneriana* ssp. *recurva*; therefore costs listed above may not reflect the actual cost of recovery, as such costs may be distributed across a variety of efforts targeting riparian and aquatic restoration, reducing the recovery cost per species.

Resumen Ejecutivo

Estado Actual de la Especie

Lilaeopsis schaffneriana subsp. *recurva* fue listada como en peligro de extinción bajo el Acta de Especies en Peligro de Extinción (Acta) el 6 de enero de 1997 (62 FR 665) y 83.2 kilómetros (km)(51.7 millas (mi)) de riachuelos o ríos en los condados de Cochise y Santa Cruz, Arizona, fueron designados como hábitat crítico el 12 de julio de 1999 (64 FR37441). La mayoría del hábitat crítico está bajo administración federal por medio del Bosque Nacional Coronado (Servicio Forestal de los Estados Unidos), el Área Ribereña de Conservación Nacional de San Pedro (Oficina de Administración de Tierras), y la Reservación Militar del Fuerte Huachuca (Ejercito de los Estados Unidos); una pequeña porción esta en propiedad privada. El taxón ocurre en hábitats acuáticas como ciénagas, ríos, riachuelos, y manantiales de cinco cuencas en el sureste de Arizona y porciones adyacentes de Sonora, México. En los Estados Unidos, conocemos 17 sitios apoyando ocurrencias existentes de *L. schaffneriana* subsp. *recurva*, 8 sitios donde todas las ocurrencias de *L. schaffneriana* subsp. *recurva* se consideran extirpadas, y 6 sitios donde ninguna ocurrencia se han reubicado en años recientes. En Sonora, México, conocemos 21 sitios apoyando ocurrencias de *L. schaffneriana* subsp. *recurva*, aunque la mayoría de estos sitios no se han visitado de nuevo en años recientes. Es difícil estimar el número de individuos debido a la naturaleza clonal del taxón, pero los estimados de densidad indican que la mayoría de las ocurrencias están estables o en declive. Tan reciente como 2014, las inundaciones asociadas con tormentas monzónicas ha erosionado los desagües con ocurrencias de *L. schaffneriana* subsp. *recurva* afectando el estatus de esta especie en algunos sitios.

Requisitos de Habitat y Factores Limitantes

Lilaeopsis schaffneriana subsp. *recurva* ocurre en aguas poco profundas y de flujo lento que son relativamente estable, o en cauces activos que contienen sitios de refugio donde las plantas pueden escapar el efecto de las inundaciones que causan erosión (62 FR 665, p. 667; 64 FR 37441, p. 37442). La extracción de las aguas subterráneas, la sequía regional, y el cambio climático están entre las amenazas más grandes a este taxón, el cual depende de la disponibilidad de sustratos permanentemente mojados (o casi así), lodosos, o sustratos limosos con algún contenido orgánico. En este momento, las amenazas más significantes a largo plazo a la continua existencia de esta especie son: 1) degradación de hábitat acuática; 2) los efectos de sequía y cambio climático; 3) incendios y la sedimentación y erosión resultantes; 4) competencia de plantas invasoras no nativas; y 5) pastoreo de ganado.

Prioridad de Recuperación

El número de prioridad de recuperación para *Lilaeopsis schaffneriana* subsp. *recurva* es 3C, indicando que la entidad listada es un subespecie, el nivel de amenaza es alta, el potencial de recuperación es alta, y hay conflicto de alguna forma con la actividad económica (extracción de aguas subterráneas para minería, agricultura, Fuerte Huachuca, uso municipal, y pozos privados).

Estrategia de Recuperación

La estrategia principal de recuperación es conservar el hábitat de *L. schaffneriana* subsp. *recurva* por medio de la implementación de varias estrategias de protección, incluyendo la disminución de la extracción de aguas subterráneas, aumentando la conservación y recarga del agua, y protegiendo las ocurrencias de *L. schaffneriana* subsp. *recurva* y sus bancos de semillas. Proveer conservación y restauración del taxón y su hábitat permitirá ocurrencias estables y autosostenibles persista con algún nivel de conectividad y oportunidades para expansión y dispersión. Esfuerzos adicionales se centrará en mejorar la comprensión básica de la ecología y amenazas de la *L. schaffneriana* subsp. *recurva*.

Meta de Recuperación

La meta principal de la recuperación es retirar el taxón de la Lista Federal de Plantas Amenazadas y En Peligro de Extinción (50 CFR 17.12).

Objetivos de Recuperación

1) Proteger y restaurar el hábitat acuático funcional y reducir las amenazas de la extracción del agua por las ocurrencias conocidas y recién descubiertas de *L. schaffneriana* subsp. *recurva* y su hábitat.
2) Conservar las ocurrencias existentes y recién descubiertas de *L. schaffneriana* subsp. *recurva* y sus bancos de semillas, establecer nuevas ocurrencias en hábitat adecuado, establecer plantas en jardines botánicos para propósitos de investigación científica, recuperación y educación, y mantener las semillas para conservación y recuperación en instalaciones de almacenamiento de semillas.
3) Quitar los estresores relacionados a plantas invasoras, pastoreo de ganadería no administrado, y tamaño de población pequeña de las ocurrencias de *L. schaffneriana* subsp. *recurva* y su hábitat.
4) Desarrollar una técnica estandarizada de monitoreo basada en los protocolos existentes; monitorear la ocurrencias, amenazas, y resultados de acciones de manejo de *L. schaffneriana* subsp. *recurva*, permitiendo el manejo adaptativo.
5) Fomentar estudios científicos para mejorar nuestro entendimiento de la geografía, ecología, viabilidad, genética, propagación, restauración, y amenazas de *L. schaffneriana* subsp. *recurva* en los Estados Unidos y México.
6) Desarrollar participación publica, socios colaborativos, planes de manejo de las agencias, y acuerdos con dueños de tierras privadas en los Estados Unidos y México que fomentan la conservación de *L. schaffneriana* subsp. *recurva*.

Criterios de Recuperación

Para la reclasificación a amenazada

1) Una extensión mínima acumulada de 2,000 m^2 (0.5 acre / 0.2 hectáreas) de hábitat naturalmente ocupada existe en la Cuenca San Pedro, de la cual 20% ocurre en riachuelos tributarios, manantiales, o ciénagas; **y** un mínimo de 2,000 m^2 (0.5 acre / 0.2 hectáreas) en la Cuenca Santa Cruz, de la cual 90% ocurre en riachuelos tributarios, manantiales, o

ciénagas, distribuidas entre las áreas del riachuelo Ciénega (35%), el riachuelo Sonoita (10%), las tierras altas y rio principal del Valle de San Rafael (10%), y el oeste de las montañas Huachuca (35%); **y** un mínimo de 125 m^2 (0.03 acre / 0.01 hectáreas) existe en la Cuenca del Rio Yaqui; este nivel de ocupación esta sostenido o mejorado por un mínimo de 10 años de un periodo de 15 años.

2) Por lo menos tres ocurrencias distintas con una extensión acumulada mínima de 150 m^2 (0.037 acre / 0.015 hectáreas) de hábitat ocupado están ubicadas en cada una de las tres cuencas de los Estados Unidos son estables o aumentando durante un periodo de 10 años;
3) Se han manejado y las amenazas al taxón y su hábitat reducido, y el manejo está asegurada por un mínimo de 20 años para asegurar la persistencia de las ocurrencias con una extensión acumulada mínima (reflejada por el logro y manutención de los criterios 1 y 2 para la reclasificación a amenazada) en cada una de las tres cuencas en los Estados Unidos;
4) Una colección viva de tantos plantones como lo permitan los recursos, recolectados de regiones genéticamente distintas (p.ej. Fuerte Huachuca/SPRNCA norte; San Rafael/Las Cienegas/Sonoita; SPRNCA sur/San Bernardino), de ambas cuencas San Pedro y Santa Cruz están mantenidas en por lo menos un jardín botánico en el sur de Arizona para propósitos de recuperación y educación; y
5) Las semillas de *L. schaffneriana* subsp. *recurva* se recolectan siguiendo las guías del Centro para la Conservacion de Plantas, las cuales incluyen la recolecta no más que 10 por ciento de la cosecha de semillas de 50 individuos de planta con semillas por población (si el tamaño de población lo permite), y recolectar de una variedad de micro sitios y características físicas dentro del grupo de plantas. Estas semillas están almacenadas en el Centro Nacional del Servicio de Investigaciones Agrícolas para Recursos Genéticos en Fort Collins, Colorado y están almacenadas según protocolos en una instalación local tal como los Jardines Botánicos del Desierto en Phoenix, Arizona, para propósitos de conservación y recuperación a largo plazo.

Para retirar *L. schaffneriana* subsp. *recurva* de la lista, tienen que cumplirse los criterios para la reclasificación a amenazada y el nivel de ocupación en los criterios para reclasificación sea sostenible o incremente por un mínimo de 20 años en un periodo de 30 años.

Acciones Necesarias

1) Mantener o mejorar la hidrografía de agua subterránea, tanto medido por medidores de flujo, reduciendo la extracción de agua y aumentando la conservación y recarga de agua;
2) Preservar las ocurrencias existentes de *L. schaffneriana* subsp. *recurva* y sus bancos de semillas por medio de la proteccion de habitat ocupado, corredores desocupados, y calidad de habitat;
3) Eliminar estresores, como pisoteo y la competencia de plantas invasoras y no nativas, de las ocurrencias de *L. schaffneriana* subsp. *recurva*;
4) Realizar investigaciones y monitoreo que facilite un mejor entendimiento de: a) la distribución y genética del taxón en los Estados Unidos y México, b) las dinámicas y tendencias de poblaciones y meta poblaciones, c) ciclo biológico de vida, d) respuesta a amenazas, y e) otros relaciones claves para la recuperación de la especie;
5) Establecer ocurrencias introducidas de *L. schaffneriana* subsp. *recurva* para ayudar a asegurar la sobrevivencia del taxón en el sur de Arizona a largo plazo;

6) Desarrollar asociaciones colaborativas con administradores de tierras federales y estatales, propietarios privados, museos y jardines botánicos, instalaciones de almacenamiento de semillas, y otros; y proveer educación al público como sea necesario para lograr la recuperación;
7) Promover el logro de conservación y recuperación en México, resultando en la protección de *L. schaffneriana* subsp. *recurva* y su hábitat a largo plazo;
8) En coordinación con los interesados, revisar este plan como fuese necesario cuando nueva información salga a la luz para que la estrategia de recuperación y las acciones conducen a la recuperación de manera tan eficiente como sea posible.

Fecha y Costos Estimados para la Recuperación

Fecha: 2035
Costo: $52,006,000*

* La importancia de prevenir el exceso de extracción de agua y aumentar la recarga del agua en las Cuencas San Pedro, Santa Cruz, y Rio Yaqui en los Estados Unidos no se puede subestimar para la recuperación de este y otros especies que ocurren en el mismo lugar. Arizona es un estado árido con suministro de agua limitado, una población humana proyectada a duplicarse a partir del 2050, y una sequía que continúa (ADWR 2014, todo; Marshall et al. 2010, p. 1). Hay un desequilibrio potencial a largo plazo entre los suministros disponibles de agua y las demandas de agua proyectadas durante los siguientes 100 años si no se tomen las acciones (ADWR 2014, todo). Un suministro limpio y sustentable de agua es esencial para crecimiento urbano para la gente y el medioambiente; la planificación de los recursos de agua tiene que abarcar la necesidad de agua para el crecimiento urbano también como las necesidades ambientales (Marshall et al. 2010, p. 1). El uso eficiente del agua, la reutilizacion de agua, la captura de agua, y la compra de los derechos de aguas superficiales son todos los metodos en los cuales la disponibilidad de agua se puede incrementar para el beneficio de *L. schaffneriana* subsp. *recurva*. Estas actividades tendrán beneficios adicionales para a muchas otras especies de plantas y animals listadas y no listadas las cuales ocurren en el mismo lugar, servicios de ecosistemas producidas por las cuencas saludables, y beneficios económicos como los del aumento de turismo.

De las tres cuencas en los Estados Unidos que sostienen *L. schaffneriana* subsp. *recurva*, la de San Pedro sostiene la mayor cantidad. Los estudios estiman que el agotamiento de la Subcuenca Sierra Vista, la cual contiene el Rio San Pedro alto, es de 4,600 acre-pies por año (Upper San Pedro Partnership 2011). Hemos desarrollado un estimado de recursos de agua necesarios para la recuperación, basado en la mejor información disponible, y hemos incluido una meta de 1,000 acre-pies por año para la recuperación de este taxón a través de todo su rango. Aunque al final esta puede ser inadecuada para cumplir con las necesidades de agua del taxón a través de todo su rango, no es probable que se podía conseguir más acre-pies de agua anualmente por medio de cualquier combinación de métodos; simplemente puede ser que no hay suficiente derechos de agua, ahorros de conservación, u otros recursos de agua disponible (falta de precipitación, falta de derechos de agua, falta de vendedores disponibles, falta de oportunidades de conservación en las áreas adecuadas, Etc.). Así que utilizamos los 1,000 acre-pies por año como un estimado realista. No se sabe si todos los métodos descritos abajo se necesitaran o aun si se pueden implementar para reclasificar el taxón a amenazada o quitarlo de la lista. Asuntos que se tratan

del agua son complejos y los aspectos políticos, sociales, económicos, y ambientales del agua están constantemente cambiando, y pueden afectar el alcance y la escala de la implementación de estas acciones de recuperación. Además, las acciones tomadas para mejorar el hábitat acuática para *Spiranthes delitescens*, *Lithobates chiricahuensis*, *Thamnophis eques megalops*, *Cyprinella formosa*, *Cyprinodon macularius*, *Gila intermedia*, *Poeciliopsis occidentalis occidentalis*, *Ictalurus pricei*, *Gila purpurea*, *Poeciliopsis occidentalis sonoriensis*, *Empidonax traillii extimus*, y *Coccyzus americanus* beneficiará a *L. schaffneriana* subsp. *recurva*; así que puede ser que los costos listados arriba no reflejan los costos actuales de la recuperación, tales como los costos pueden estar distribuidos por una variedad de esfuerzos con objetivos de restauración de áreas ribereñas y acuáticas, reduciendo el costo de recuperación por especie.

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Part I. Background

1. Overview

Lilaeopsis schaffneriana ssp. *recurva* was listed as endangered under the Act on January 6, 1997 (62 FR 665) and 83.2 kilometers (km)(51.7 miles (mi)) of streams and rivers in Cochise and Santa Cruz counties, Arizona were designated as critical habitat on July 12, 1999 (64 FR 37441). The decision to list the taxon was based upon the limited number of wetland habitats in southern Arizona and northern Sonora, Mexico, suitable for this plant, and threats including the degradation and destruction of habitat resulting from livestock overgrazing, non-native plant invasion, water diversions, dredging, and groundwater pumping. Other threats include catastrophic flooding, post-fire erosion and sedimentation, and drought exacerbated by climate change.

A draft Recovery Plan, written by contractors, was sent for review to the Service on October 28, 2011. Due to other higher priorities, it was not finalized at that time. The first 5-year status review for *L. schaffneriana* ssp. *recurva* was signed on August 21, 2014 (Service 2014c, entire). Based on the static or declining status of the species across its range and continued threats, it was recommended in the 5-year Review that the taxon remain listed as endangered. The recovery priority number for *L. schaffneriana* ssp. *recurva* is 3C, meaning that the listed entity is a subspecies, the level of threat is high, the potential for recovery is high, and there is a conflict with some form of economic activity (groundwater withdrawal for mining, agriculture, Fort Huachuca, municipal use, and private wells).

2. Description

Lilaeopsis schaffneriana ssp. *recurva* is a semi-aquatic to fully aquatic herbaceous perennial (Figure 1). The root system is comprised of both long horizontal rhizomes and connected shorter vertical rhizomes. Hollow linear leaves that taper to a point are produced singly or in clusters at the top of short rhizomes. The leaves vary greatly in length from 2.5 to 33 centimeters (cm) (0.98 to 12.99 inches (in)) depending on their habitat, with shorter leaves typically found in drier environments and longer leaves when the plant is submerged in water (Coulter and Rose 1902, p. 125; Affolter 1985, p. 51; Service 2014a, p. 4). The leaves are round or elliptical in cross section, 0.5 to 5.5 millimeters (mm) (0.02 to 0.2 in) in diameter, and contain 6 to18 distinctive septa (thin partitions) along their length (Affolter 1985, p. 51; Arizona Rare Plant Guide Committee 2001, unpaginated; Service 2014, p. 4). Umbels (umbrella-like flower structures) are borne on stalks shorter than the leaves and contain three to ten 1.0 to 2.0 mm (0.04 to 0.08 in) wide perfect

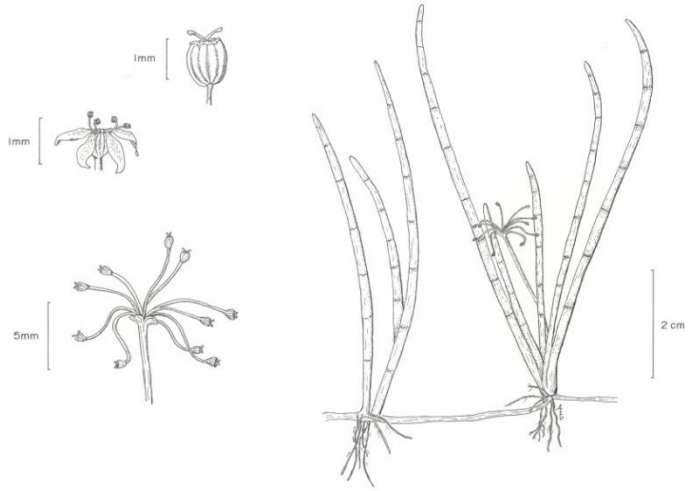

Figure 1. Illustration of *Lilaeopsis schaffneriana* ssp. *recurva* (Arizona Rare Plant Guide Committee 2001).

(containing male and female parts) flowers with five white to slightly maroon tinted petals and maroon anthers (Affolter 1985, p. 51). Fruits are spherical and dry, 1.6 to 2.3 mm (0.6 to 0.09 in) long by 1.2 to 2.0 mm (0.04 to 0.08 in) broad, with five distinct spongy ribs that make the seed buoyant and easily dispersed by water (Affolter 1985, p. 57). Flowering has been observed episodically from March through October, peaking in July and occurring with abundance irregularly (Warren et al. 1991, p.15).

3. Terminology

Because this taxon is clonal in nature and it is not practicable to identify individuals, the term "occurrence" is used herein to denote concentrations of this taxon within a distinct locality that are relatively distant from other concentrations. Occurrences are more likely to share underground root systems, and are often separated from one another by morphological or hydrological features. Within occurrences, clusters of stems separated by areas without stems are denoted herein as "patches". An occurrence can consist of one to many patches; patches can have one or a few stems or form carpets of stems.

4. Taxonomy

Lilaeopsis schaffneriana ssp. *recurva* is a member of the Apiaceae (carrot family). Within the Apiaceae, *Lilaeopsis* is in tribe Oenantheae and subfamily Apioideae (Bone et al. 2011, p. 789). The genus is considered to be taxonomically difficult because all members of the genus have similar simplified vegetative morphology of linear, hollow, transversely septate (divided) leaves. These characteristics, however, are unlike those of most other genera in this family. *Lilaeopsis* is a genus of 15 perennial, rhizomatous herbs of damp, marshy, or truly aquatic habitats found in temperate regions of North and South America and Australasia (Affolter 1985, p. 1; Bone et al. 2011, p. 789). *Lilaeopsis schaffneriana* is found in southeastern Arizona, central and northern Mexico, and northwestern South America (Bone et al. 2011, p. 790).

The first mention of this taxon was in 1853 when Schlechtendal named it *Crantzia schaffneriana* from a specimen collected in Mexico (Affolter 1985, p. 3). Apparently due to inadequate descriptions, the species was merged into *Crantzia lineata* and the genus was considered monotypic (Affolter 1985, p. 3). In 1891, Greene published the genus name *Lilaeopsis* to replace *Crantzia* (Affolter 1985, p. 3) and, in 1897, *Crantzia schaffneriana* was transferred to *Lilaeopsis* based on much better specimens (Coulter and Rose 1897, pp 47-49). In his 1927 revision of the genus, A.W. Hill separated the material collected in Arizona as the species *L. recurva* (named for its re-curved pedicels); separating it from that of Mexico and Chile which he named *L. schaffneriana* (Affolter 1985, p. 53). Affolter (1985, pp. 53-54), with many more samples at his disposal, determined that the features separating *L. recurva* and *L. schaffneriana* were not valid and reduced *L. recurva* to subspecies status, i.e., *L. schaffneriana* subsp. *recurva*. The subspecies status was used because of apparent differences in fruit morphology and geographic distribution (Affolter 1985, p. 56). This differentiation is maintained in the 2011 revision of the genus by Bone et al. (2011, p. 800).

In general, researchers consider plants west of the Continental Divide in Sonora to be ssp. *recurva* and those to the east, ssp. *schaffneriana* (64FR 37441, p. 37442). Due to the work of J.

Rorabaugh and others, we are aware of additional small occurrences of *L. schaffneriana* to the south and east of this divide at Rio Casas Grandes, Rio Santa Clara, Rio Papogochic, and Rio Conchos. We are excluding these occurrences from this document due to the uncertainty of the subspecies these plants represent. Genetic analysis is warranted to better understand the relationship of occurrences within and between localities in southeastern Arizona, northern Sonora, and northwestern Chihuahua, Mexico.

5. Historical Distribution

The type specimen of *L. schaffneriana* ssp. *recurva* was collected in the Santa Cruz Valley of southern Arizona near Tucson on May 19, 1881, in an area that is now encompassed by the City of Tucson and no longer provides suitable habitat for the species (Affolter 1985, p. 61). The following history was determined using the Southwest Environmental Information Network (SEINET observations). It was not collected again until September 28, 1947, by L.N. Gooding in Bear Canyon of the Huachuca Mountains. Gooding made six additional collections through 1961, documenting it also from the San Pedro River and Garden Canyon in the Huachuca Mountains. Additional collections were made by other researchers from Sonoita Creek, the Huachuca Mountains, and the San Pedro River in the 1960s. In the 1970s, additions to the range included collections from the San Rafael Valley and Canelo Hills; in the 1980s, San Bernardino National Wildlife Refuge was added to the list of known locations. In the 1990s, the taxon was collected from Empire Gulch and northern Sonora, Mexico, in the 2000s, it was documented from the new locations of Bingham Cienega and the Babocomari Ranch, and in the 2010s, it was found further south in Arizona along the San Pedro River. Figure 2 represents the general distribution of the taxon by watershed across its range; locations believed to be extirpated are delineated, as are locations where the plant has not been seen in recent history but where a seedbank may still persist. Figure 3 represents the designated critical habitat of the taxon in the United States.

6. Current Distribution and Abundance

Within the Santa Cruz, San Pedro, Rio Yaqui watersheds in southern Arizona, we are aware of 17 locations supporting extant occurrences of *L. schaffneriana* ssp. *recurva*, 8 locations where all *L. schaffneriana* ssp. *recurva* occurrences are considered extirpated, and 6 locations where no occurrences have been relocated in recent years. Within the Santa Cruz, San Pedro, Rio Yaqui, Rio Sonora, and Rio Concepcion watersheds in Sonora, Mexico, we are aware of 21 locations supporting *L. schaffneriana* ssp. *recurva* occurrences, though most of these locations have not been revisited in recent years. Many of these locations were documented after the plant was listed under the Endangered Species Act (Act), extending the known geographic range to the north and west in Arizona, and expanding the previous elevation limits of 1,148 to 2,133 meters (3,500 to 6,500 feet) known at the time of listing, to the current known range of 610 to 2,166 meters (2,001 to 7,100 feet) (Vernadero 2011b, p. 3; Vernadero Group and the Desert Botanical Garden 2012, p. A-16). There are no occurrences that appear to be increasing in size and many are reported from single patches among competing vegetation or in aquatic habitat that is in danger of being lost to groundwater pumping or drought. Numerous other occurrences have not been relocated in many years and are believed extirpated due to degradation and contraction of suitable habitat.

Individual *L. schaffneriana* ssp. *recurva* plants are difficult to identify due to their clonal reproduction and clustered growth habit. Measurements of density and frequency have been collected in only a portion of the range, and monitoring data have been collected using different, though sometimes overlapping, methodologies. Density by category (clumped, scattered-patchy, scattered-even, sparse, moderate, or dense) has been recorded by some surveyors, while others use the number of detections divided by the number of sampling points, still other surveyors report only the area of the patch with no indication of density. In addition, the taxon is difficult to detect due to its diminutive size and ability to persist through below-ground structures which enable it to rapidly expand and contract in size between years, seasons, or both, in response to local environmental conditions. As a result, it is difficult to compare occurrences or develop an overall estimate of population size or density by occurrence, watershed, or across the entire range of the taxon.

To allow a comparison between and among known occurrences of *L. schaffneriana* ssp. *recurva* across their range, we used existing geographical information system data (points and polygons) developed by the Arizona Natural Heritage Program (Table 1). These data were developed using information from herbarium collections, reports, and other documentation depicting locations where *L. schaffneriana* ssp. *recurva* occurs or has occurred historically. Although the unit of measure for this comparison was acres, the data do not represent actual acres of land occupied by the taxon because density and distribution within polygons varies both spatially and temporally. We use these data simply to illustrate the general distribution of *L. schaffneriana* ssp. *recurva* on the landscape. The greatest quantities of *L. schaffneriana* ssp. *recurva* are found within the San Pedro River, the western Huachuca Mountains, and Cienega Creek (Table 1). We used the percentages developed in Table 1, along with density and distribution data for *L. schaffneriana* ssp. *recurva* to determine recovery criteria.

In the United States, *L. schaffneriana* ssp. *recurva* occurs on lands administered by the United States Army Fort Huachuca, the Forest Service, the Bureau of Land Management, the Service, Arizona State Parks, Pima County, The Nature Conservancy, and private landowners. In Mexico, most *L. schaffneriana* ssp. *recurva* occurs on private lands (Anderson 2006, entire). The current status and trends of the occurrences within the United States and Mexico are summarized in Table 2 and discussed in detail in Appendix A. It is hypothesized that the distribution of *L. schaffneriana* ssp. *recurva* in the Santa Cruz watershed consists of persistent remnants of a formerly larger occurrence (64 FR 37441, p. 37443). Although occurrences may be considered ephemeral and long-term viability may be considered low, sites that still contain functioning perennial waters and that have historically supported *L. schaffneriana* ssp. *recurva*, but currently do not, should not be considered unoccupied without further analysis and subsequent surveys.

7. Habitat

Lilaeopsis schaffneriana ssp. *recurva* inhabits cienegas, rivers, streams, and springs, generally in perennial, shallow, and slow-flowing or quiet waters or in active stream channels containing refugial sites where most plants can escape the effect of scouring floods (62 FR 665, p. 667;

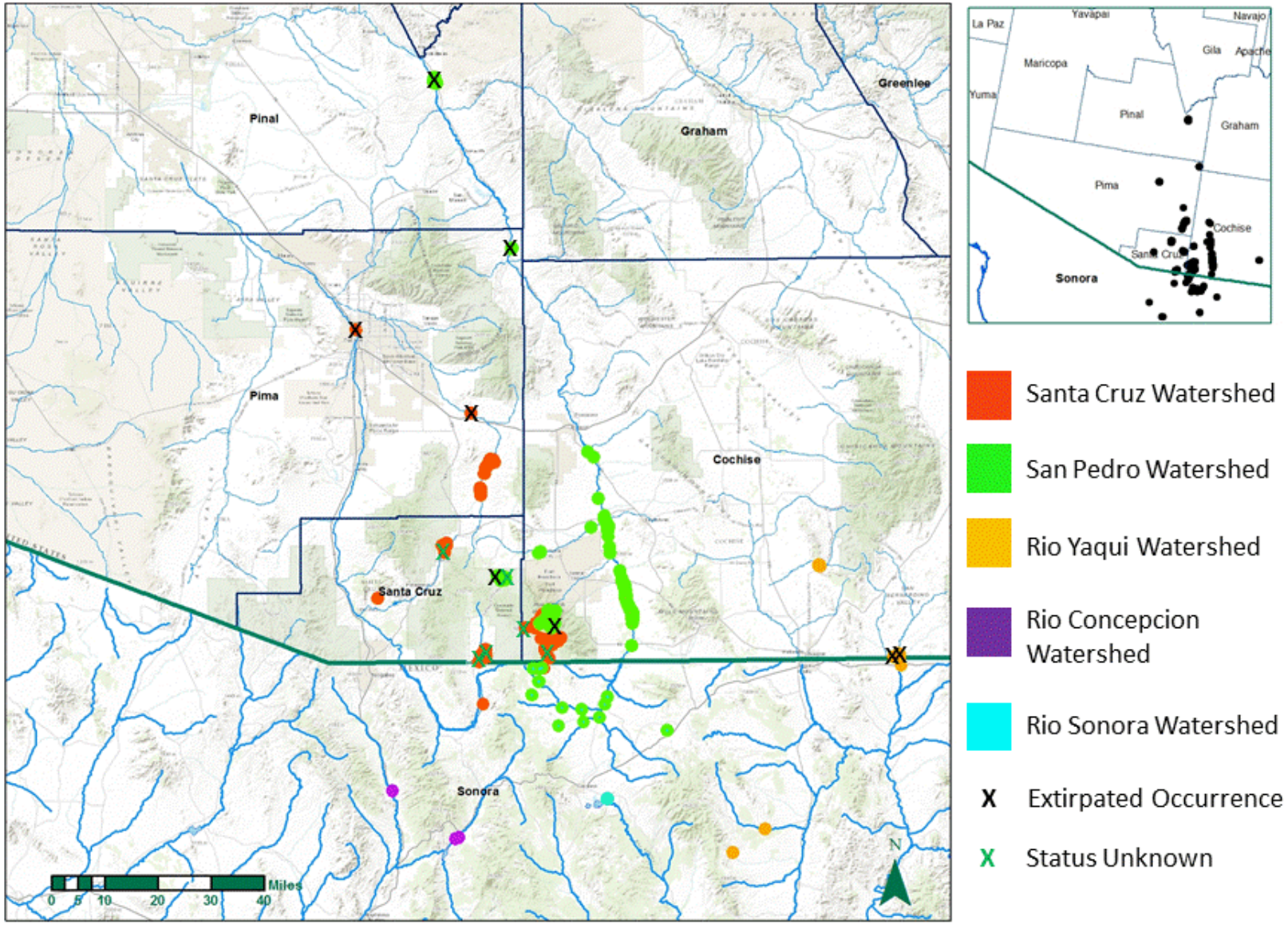

Figure 2. Range-wide distribution and status of *Lilaeopsis schaffneriana* ssp. *recurva* by watershed in southern Arizona and northern Sonora, Mexico.

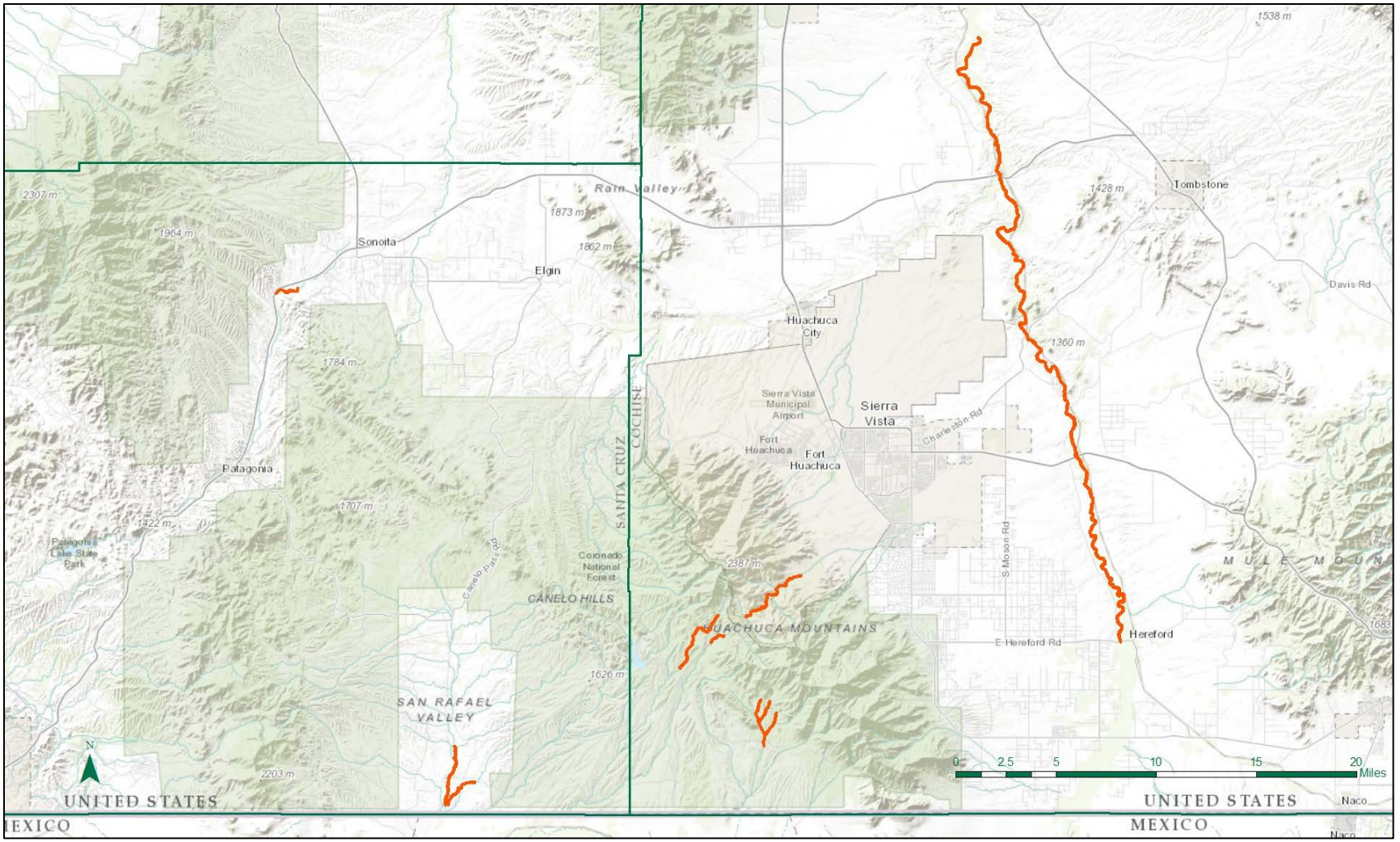

Figure 3. Range-wide distribution of *Lilaeopsis schaffneriana* ssp. *recurva* designated critical habitat totaling 83.2 kilometers (51.7 miles) of streams or rivers in Cochise and Santa Cruz counties, Arizona.

64 FR 37441-37442); see Figure 4 which depicts some of these habitats. Historically, drainages in southeastern Arizona consisted of broad, shallow waterways in valley bottoms that gradually collected overland flow from large watersheds. The San Pedro River, for example was reported to be a meandering marshy creek where beaver and fish were described as plentiful (BLM 1993, p. 7). *Lilaeopsis schaffneriana* ssp. *recurva* appears to be adapted to this type of hydrological regime and resulting conditions. During larger flood events, small, weakly rooted clumps of the plant may tear off, float downstream, and are deposited elsewhere in the drainage. Some of these clumps survive if appropriate habitat conditions are present.

Historically, side channels and overflow depressions were usually hydrologically linked to the main channel by subsurface flow even when surface water was lacking, and likely served as important refugia for *L. schaffneriana* ssp. *recurva* and a host of other riparian species. For the last 150 years almost all of the drainages in southeastern Arizona have been drastically altered by anthropogenic change and, today, most of these drainages consist of deeply incised channels that are disconnected from the former broad floodplains (Nichols 2007, pp. 46, 52). Surface and groundwater development has disrupted aquatic habitat connectivity that once provided opportunities for expansion into new, downstream habitats after floods. Accordingly, protection of *L. schaffneriana* ssp. *recurva* habitat must include protection of the stability of the hydrologic system supporting the habitat (Haas and Frye 1997, pp. 10, 12-12). Because many watercourses are incised, scouring during flood events is much more intense and there are few off-channel habitats suitable for new colonization. Drought and increased pumping of groundwater have been correlated with the loss of perennial flow in many drainages throughout the range of the taxon.

Found between 610 and 2,170 m (2,001 and 7,060 ft) elevation in the United States, the range of the taxon crosses the Sky Island Region of southeastern Arizona and adjacent portions of Sonora, Mexico where it reaches as high as 2,240 m (7,349 ft) elevation (Titus and Titus 2008c, p. 459; Vernadero 2011b, p. 3; Vernadero Group and the Desert Botanical Garden 2012, p. A-16). *Lilaeopsis schaffneriana* ssp. *recurva* is found in riparian soils such as Glendale silt-loam. The Glendale series consists of deep soils formed in stratified alluvium on flood plains, stream terraces, and alluvial fans (NCSS 2012, entire). Plant communities in which *L. schaffneriana* ssp. *recurva* occur are described as: 1) Warm-Temperate Wetlands, 2) Sonoran Riparian Deciduous Forest and Woodlandss, and 3) Sonoran and Sinaloan Interior Marshlands and Submergent Communities (Minckley and Brown 1994, pp. 248-249; 269-273, 282-283). These classifications encompasses a wide range of marshland communities that are inhabited by *Schoenoplectus pungens* and other *Schoenplectus* spp. (bulrush), *Typha domingensis* (cattail), *Eleocharis macrostachya* and other *Eleocharis* spp. (spikerush), *Juncus* spp. (rush), *Carex* spp. (sedge), *Cynodon dactylon* (Bermuda grass), *Cyperus odoratus* (fragrant flatsedge), and *Paspalum dilatatum* (dallisgrass). *Lilaeopsis schaffneriana* ssp. *recurva* is generally found along the margins of these habitats in 0-15 cm of water. The taxon occurs both in full sun and in understory shade of Fremont cottonwood-Goodding willow (*Populus fremontii-Salix gooddingii*) forests (Simms pers. comm. October 26, 2011).

Watershed	Location	Unit	Percent of Watershed	Percent of Total Range
San Pedro	San Pedro River	1,503	71.5	43.9
	Babocomari River and tributaries	251	11.9	7.3
	Eastern Huachuca Mountains	227	10.8	6.6
	Sonora, Mexico	120	5.7	3.5
				61.4
Santa Cruz	Western Huachuca Mountains	556	48.6	16.3
	Cienega Creek	415	36.2	12.1
	San Rafael Valley (uplands and mainstem river)	90	7.9	2.6
	Sonoita Creek	68	5.9	2.0
	Santa Cruz River	8	0.7	0.2
	Sonora, Mexico	8	0.7	0.2
				33.5
Rio Yaqui	Black Draw	72	50.7	2.1
	Leslie Canyon	46	32.4	1.3
	Sonora, Mexico	24	16.9	0.7
				4.2
Rio Concepcion	Sonora, Mexico	24	100	**0.7**
Rio Sonora	Sonora, Mexico	8	100	**0.2**

Table 1. Units derived from acreages (points and polygons) in geographic information systems provide a picture of the overall distribution of occupied and formerly occupied *L. schaffneriana* ssp. *recurva* habitat throughout the United States and Mexico. Units do not represent actual acres of land occupied by the taxon because density and distribution within polygons varies both spatially and temporally.

Believed Extirpated	Believed Extant	Unknown	Location	Jurisdiction
	2 occurrences; scattered patches / mats (2013)		Garden Canyon	Fort Huachuca
1 occurrence – 2002	1 occurrence; 1 patch (2013)		Sawmill Canyon	Fort Huachuca
	1 occurrence; 1 patch (2013)		McClure Canyon	Fort Huachuca
	1 occurrence; ? patches (2013)		Huachuca Canyon	Fort Huachuca
	multiple occurrences; multiple patches (2013)		Scotia Canyon	U.S. Forest Service
	multiple occurrences; multiple patches - 2013		Sunnyside Canyon	U.S. Forest Service
	multiple occurrences; few patches /singles (2013)		Bear Canyon	U.S. Forest Service
	1 occurrence; multiple patches (2014)		Lone Mt Canyon	U.S. Forest Service
	1 occurrence; 1 large patch (2014)		Wakefield Mine springbox	U.S. Forest Service
		1 occurrence; one patch (2007; not relocated in 2014)	Parker Canyon Lake	U.S. Forest Service
1 occurrence; ? patches (2003; not relocated in 2013)			Freeman Spring	U.S. Forest Service
	1 occurrence; 1 patch (2013)		Sycamore Spring	U.S. Forest Service
	1 occurrence – multiple patches (2014)		Mud Spring	U.S. Forest Service
	multiple occurrences; multiple patches (2013)		Las Cienegas NCA	U.S. Bureau of Land Management
	multiple occurrences; multiple patches (2010)		San Pedro River	U.S. Bureau of Land Management
	1 occurrence; multiple patches		Leslie Canyon NWR	U.S. Fish and Wildlife Service
1 occurrence; ? patches (1990)			San Bernardino NWR house pond	U.S. Fish and Wildlife Service
1 occurrence; 4 patches (1991)			San Bernardino Black Draw	U.S. Fish and Wildlife Service
1 occurrence; 2 patches (2002)			Bingham Cienega	Pima County
1 occurrence; 1 patch (2001; not relocated in 2013)			Lower Cienega Creek	Pima County
		multiple occurrences; ? patches (2001; not relocated in 2013)	San Rafael Ranch SNA	Arizona State Parks
	1 occurrence; 1 patch (2008)		Sonoita Creek NA	Arizona State Parks
		multiple occurrences; ? patches (2002; not relocated in 2013)	O'Donnell Creek	The Nature Conservancy and U.S. Forest Service

Believed Extirpated	Believed Extant	Unknown	Location	Jurisdiction
		multiple occurrences; ? patches (1989; not relocated in 2013)	Turkey Creek	Private
		3 occurrences; multiple patches (2002; not relocated in 2014)	Joaquin Canyon	Private and U.S. Forest Service
	2 occurrences; multiple patches (2013)		Upper Sonoita Creek	Private
		1 occurrence; ? patches (1977)	Monkey Spring	Private
	2 occurrences – 8 patches (2006); 1 patch (2013)		Babocomari River	Private
1 occurrence; ? patches (1967; not relocated in ~2002)			Winkelman	Private
1 occurrence; ? patches (1881)			Tucson	Private
		unknown (2007)	Arroyo el Tigre	Private; Sonora, Mexico
		numerous patches (2006)	Arroyo los Fresnos	Private; Sonora, Mexico
		abundant (2006)	cienega near the Casa Grande	Private; Sonora, Mexico
		1occurrence; sparse small patches (2006)	Las Nutrias	Private; Sonora, Mexico
		1 occurrence; small patches (2006)	Las Pamitas	Private; Sonora, Mexico
		1occurrence;1 very small patch (2006)	Ojo de Aqua	Private; Sonora, Mexico
		occurs sparingly along 6 km (3.7 mi) of river (2014)	Rancho el Aribabi along the Rio Cocospera	Private; Sonora, Mexico
		1occurrence;1 small patch (2006)	Arroyo los Alisos	Private; Sonora, Mexico
		uncommon (2006)	Cienega Los Fresnos	Private; Sonora, Mexico
		1occurrence;1 small patch (2006)	La Cieneguita	Private; Sonora, Mexico
		1occurrence;1 small patch (2006)	Portrero del Alamo	Private; Sonora, Mexico
		1occurrence; frequent patches (2006)	Rio Casa Blanca	Private; Sonora, Mexico
		1 occurrence; patchy (2006)	Rio San Pedro	Private; Sonora, Mexico
		1 occurrence; scattered plants (2006)	Rio San Rafael	Private; Sonora, Mexico
		1occurrence; dense patches (2006)	Villa Verde	Private; Sonora, Mexico
		uniknown (1990)	Arroyo el Tapiro	Private; Sonora, Mexico

Believed Extirpated	Believed Extant	Unknown	Location	Jurisdiction
		uniknown (1990)	La Cienega la Atascosa	Private; Sonora, Mexico
		unknown (1990)	La Sauceda	Private; Sonora, Mexico
		numerous plants (1994)	Mababi Spring	Private; Sonora, Mexico
1 occurrence; 2 small patches (1988)			Rio San Bernardino	Private; Sonora, Mexico
		unknown (2005)	Santa Cruz River south of the town of Santa Cruz	Private; Sonora, Mexico

Table 2. Status of *Lilaeopsis schaffneriana* ssp. *recurva* occurrences and patches from locations in the United States and Sonora, Mexico, along with the year they were last seen. Observations from Mexico were primarily from one-time surveys; the current status of *L. schaffneriana* ssp. *recurva* at these locations is unknown.

a)

b)

Figure 4. Examples of *Lilaeopsis schaffneriana* ssp. *recurva* growing in a) slow moving water in Scotia Canyon and b) a scoured stream edge on the San Pedro River. Photos by J. Crawford, USFWS, October 18, 2011, and May 9, 2014, respectively.

8. Reproduction

Based on greenhouse observations, flowering can begin within three months after germination (Titus and Titus 2008a). The length of time a flower persists is unknown but has been relatively short (two to five days) in greenhouse observations. Flowering has been observed episodically between March and October, peaking in July and occurring with abundance irregularly (Warren et al. 1991, p.15). In a wild occurrence at Bingham Cienega Preserve, flowering was observed in mid-May with hundreds of flowers per 1 m^2 (Titus and Titus 2008c). In plugs that had been outplanted from the greenhouse to Finley Tank spring runs, flowers were observed in July, 1.5 years after plugs were outplanted, and flowers and fruits were also observed the following September and May (Titus and Titus 2008a). Flowers typically produced from five to seven seeds (Titus and Titus 2011, p. 19).

The pollination biology of the species is unknown. It is presumed to be insect pollinated due to floral features and the predominance of insect pollination in the Apiaceae. Radke (pers. comm. April 22, 2014) documented a *Formica* ant species feeding on the nectar of *L. schaffneriana* ssp. *recurva* flowers along the San Pedro River in both 2012 and 2013; he believes this may be an important pollinator for the taxon. Whether or not the species is an obligate outcrosser or is self-compatible is unknown, however experiments suggest that most if not all *Lilaeopsis* spp. are self-compatible (Affolter 1985, p. 22) and self-compatibility is common in the Apiaceae (Schlessman and Graceffa 2002, p. 410).

As the fruits of most *Lilaeopsis* species, including this taxon, mature, the peduncles and pedicels re-curve and are pressed directly against the soil allowing fruits to go underwater or cause them to be buried in the mud or sand (Affolter 1985, p. 27). This technique insures that some fruits remain in suitable habitat (Affolter 1985, p. 27). Most *Lilaeopsis* sp. seeds are spongy, making them buoyant and easily dispersed by water and birds, a trait believed to be responsible for the distribution of the genus throughout its extensive range (Affolter 1985, p. 57; Bone et al. 2011, pp. 790, 802). Germination in *L. schaffneriana* ssp. *schaffneriana* occurs one to two weeks after seeds disperse (Gori 1995, p. 3). Similarly, Titus and Titus (2008a, p. 317) found *L. schaffneriana* ssp. *schaffneriana* to have a high germination rate (90%) in a greenhouse study with seed less than one year old. The seeds in this study were not cold stratified (a cold treatment that simulates natural winter conditions), so stratification does not appear to be a pre-requisite for germination (Titus and Titus 2008a, p. 317). The taxon reproduces both sexually via seed and asexually through rhizome spread and fragmentation. Clonal establishment following flooding events is thought to be important for maintaining diversity in the taxon (Vernadero and The Desert Botanical Garden 2012, p. i).

Although the research of Bone et al. (2011, pp. 792, 796-797) found little difference between *L. schaffneriana* ssp. *recurva* and *L. schaffneriana* ssp. *schaffneriana* at a higher-order genetic level, researchers with the Desert Botanical Garden in Phoenix, using the more sensitive genetic analysis tool of microsatellites, detected differences within and among *L. schaffneriana* ssp. *recurva* occurrences (Vernadero and The Desert Botanical Garden 2012, p. 9; Fehlberg and Allen 2014, p. 7). In these studies, occurrences in close geographic proximity to one another were typically most similar genetically, although some distant occurrences exhibited similarity (Vernadero and The Desert Botanical Garden 2012, p. i; Fehlberg and Allen 2014, p. 7). Genetic similarity suggests there is either current or historical connectivity among occurrences

(Vernadero and The Desert Botanical Garden 2012, p. i; Fehlberg and Allen 2014, p. 8). Results of these studies indicate that conservation of large numbers of genetically distinct occurrences may contribute to the preservation of genetic diversity and avoid the effects of genetic drift (Vernadero and The Desert Botanical Garden 2012, p. 13; Fehlberg and Allen 2014, p. 9). These studies also recommend maintenance of dispersal pathways and the reduction of habitat fragmentation to facilitate downstream dispersal of detached clumps via stream currents (Vernadero and The Desert Botanical Garden 2012, p. 14; Fehlberg and Allen 2014, p. 10). In addition, these findings show the need to exercise caution in introducing new occurrences to avoid the introduction of foreign alleles and potential effects of outbreeding (Fehlberg and Allen 2014, p. 9).

Despite the importance of vegetative reproduction to the taxon, equally important is the seedbank, which can allow for recolonization following drought if hydric conditions return. It has been suggested that seed from this taxon may persist for five to ten years in drought situations (Titus and Titus 2008a, p. 319; Titus and Titus 2008b, p. 398; Titus and Titus 2008c, p. 463). At Bingham Cienega, *L. schaffneriana* ssp. *recurva* seeds were detected in the seedbank samples with densities of 0, 10$\pm$25 and 51$\pm$72 seeds (mean$\pm$sd) per 1 m^2 at three sampling dates (Titus and Titus 2008b). This was a very small portion of the total seedbank, which was dominated by *Eleocharis macrostachya, Schoenoplectus pungens,* and *Typha domingensis*. At the Audubon Research Ranch reintroduction site, buried *L. schaffneriana* ssp. *recurva* seeds were detected two years after outplanting, indicating quick seedbank establishment (Titus and Titus 2008a). When referring to seedbanks around ponds and springs at San Bernardino National Wildlife Refuge, former Refuge Manager Kevin Cobble stated "it just took putting permanent water on bare soil and they [*L. schaffneriana* ssp. *recurva*] would appear (K. Cobble, pers. comm. April 14, 2014)."

9. Ecology

Lilaeopsis schaffneriana ssp. *recurva* competes poorly with other wetland plant species, making intermediate levels of disturbance from flooding, fire, grazing, or other sources necessary to reduce competition and promote dispersal and the preservation of genetic diversity (62 FR 665, pp. 671, 676; Vernadero and the Desert Botanical Garden 2012, p. 13). As *L. schaffneriana* ssp. *recurva* possesses weak and shallow roots, the need to be able to compete for sunlight, water, and nutrients must be balanced with some unknown extent of companion plants that enable bank stability along riparian channels. Refugial sites such as backwaters in active stream channels (62 FR 665, p. 667; 64 FR 37441, p. 37442) or cobble pavement in ephemeral streams afford an escape from scouring floods and hoof action, respectively (Service 2014a, p. 5). The likelihood of fire in *L. schaffneriana* ssp. *recurva* wetland habitat is minimal due to the presence of both water and higher humidity than adjacent uplands; fire may occur in these areas, however, during dry periods. The response of *L. schaffneriana* ssp. *recurva* to fire is unknown, though it is suspected that low to moderate severity fire would not negatively impact plants over the long-term due to their ability to resprout from rhizomes. Unnatural high severity fire on site or in the uplands, however, could damage rhizomes and seedbanks directly or bury plants due to erosion and sedimentation (Service 2014c, pp. 32-33).

Competition for sunlight, water, and nutrients interferes with *L. schaffneriana* ssp. *recurva* growth and reproduction. In a monitoring study of *L. schaffneriana* ssp. *recurva* at Bingham

Cienega, potentially competing vegetation, in this case bulrush (*Schoenoplectus pungens*), was clipped at ground level in treatment plots (Titus and Titus 2008c, p. 461). Results of the experiment showed that *L. schaffneriana* ssp. *recurva* in clipped plots had more leaves and produced flowers, whereas no flowers were present in control plots. Transplant studies by Titus and Titus (2008a, p. 318) at Finley Tank on the Audubon Research Ranch and Warren (1991, p. 5) at San Bernardino National Wildlife Refuge found that the success of transplants was partially related to competitive effects of surrounding vegetation and that *L. schaffneriana* ssp. *recurva* is susceptible to competition from wetland emergent species including *Schoenoplectus* sp., *Eleocharis* sp., *Carex pellita*, and others. In dry years, this effect can be exacerbated; in a 2004 monitoring effort at Garden Canyon, it was noted that drier local conditions had led to increased colonization by more drought-tolerant species including *Muhlenbergia rigens* (deergrass), which purportedly led to increased competition for sunlight and other resources (EEC 2004, p. 9). In a 2008 monitoring effort at Garden Canyon, researchers indicated that increased competition, with both native and non-native plants had a noticeable effect on the detectability of *L. schaffneriana* ssp. *recurva* (Vernadero Group 2009, p. 10).

Invasive non-native plants have increased their presence within aquatic habitat of southeastern Arizona, and this invasion and expansion of infestations are expected to continue. Invasive non-native plants are of concern because they often quickly colonize an area and aggressively compete with native species for sunlight, water, and nutrients. Commonly associated invasive non-native species in *L. schaffneriana* ssp. *recurva* habitat include *Sorghum halepense* (Johnsongrass), *Hordeum jubatum* (foxtail), *C. dactylon*, *Nasturtium officinale* (watercress), and *Rubus discolor* (Himalayan blackberry) (EEC 2004, p. 12; Titus and Titus 2008a, p. 317; Titus and Titus 2008a; Vernadero Group 2011a, p. I; L. Kennedy pers. comm. February 3, 2014). The removal of more aggressive stoloniferous or rhizomatous competitors with *L. schaffneriana* ssp. *recurva* appears to be a principle component in stimulating plant growth (Haas and Frye 1997, p. 12). For examples of *L. schaffneriana* ssp. *recurva* competitive interactions with invasive non-native and native plants refer to the recently finalized 5-year review (Service 2014c, entire).

10. Reasons for Listing and Current Threats

In determining whether to list, delist, or reclassify a species under section 4(a) of the Act, we evaluate the threats to the species based on the five categories outlined in section 4(a)(1) of the Act: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence. The primary constituent elements of critical habitat for *L. schaffneriana* ssp. *recurva* include: 1) sufficient perennial base flows to provide a permanently or nearly permanently wetted substrate for growth and reproduction of *L. schaffneriana* ssp. *recurva*; 2) a stream channel that is relatively stable, but subject to periodic flooding that provides for rejuvenation of the riparian plant community and produces open microsites for *L. schaffneriana* ssp. *recurva* expansion; 3) a riparian plant community that is relatively stable over time and in which non-native species do not exist or are at a density that has little or no adverse effect on resources available for *L. schaffneriana* ssp. *recurva* growth and reproduction; and 4) in streams and rivers, refugial sites in each watershed and in each reach,

including but not limited to springs or backwaters of mainstem rivers, that allow each occurrence to survive catastrophic floods and recolonize larger areas.

Habitat degradation over historical time has resulted in decreased number and size of *L. schaffneriana* ssp. *recurva* occurrences, potentially decreasing genetic diversity, and making the taxon more vulnerable to extinction as a result of stochastic events (Vernadero Group and the Desert Botanical Garden 2012, p. 13). The clonal nature of the taxon may also reduce genetic diversity, increasing vulnerability. For instance, the restriction of *L. schaffneriana* ssp. *recurva* to a relatively small area in southeastern Arizona and adjacent areas of Mexico increases the chance that a single environmental catastrophe, such as a severe tropical storm or drought, could eliminate appreciable numbers of occurrences. Occurrences are in many cases isolated, as well, which makes the chance of natural recolonization after extirpation less likely. Threats identified through research and section 7 consultations that could potentially impact *L. schaffneriana* ssp. *recurva* include: aquatic habitat degradation (Factor A); wildfire and resulting sedimentation (Factor A); invasive non-native plant competition (Factor A); livestock grazing (Factor A); recreation (Factor A); and the effects of drought and climate change (Factor E). A list of threats and associated recovery objectives, criteria, and actions can be found in Table 3.

Factor A: Present or Threatened Destruction, Modification or Curtailment of Habitat or Range

Aquatic Habitat Degradation
– All four primary constituent elements of critical habitat are impacted by this threat.

Groundwater pumping may lead to perennial reaches becoming intermittent or ephemeral and to springs drying out, resulting in the loss of *L. schaffneriana* ssp. *recurva* occurrences (Warren et al. 1991, p. 7; 60FR 16836, p. 16838; Service 2014b, pp. 148-149). Along the upper San Pedro River, Stromberg et al. (1996, pp. 124–127) found that wetland herbaceous species are the most sensitive to the effects of a declining groundwater level. Webb and Leake (2005, pp. 302, 318–320) described a correlative trend regarding vegetation along southwestern streams from historically being dominated by marshy grasslands to currently being dominated by woody species that are more tolerant of declining water tables due to their deeper rooting depths.

Over the past decade, Fort Huachuca has pursued a rigorous water use reduction plan to reduce groundwater consumption in the Sierra Vista subbasin (Harris et al. 2001, p. 15-5; Service 2014b, p. 27). Their efforts have focused primarily on reductions in groundwater demand both on-post and off-post and increased artificial and enhanced recharge of the groundwater system. In addition, Fort Huachuca and the City of Sierra Vista have increased the amount of water recharged to the regional aquifer through construction of effluent recharge facilities and detention basins that not only increase stormwater recharge, but mitigate the negative effects of increased runoff from urbanization. The total net effect of all the combined efforts initiated by Fort Huachuca has been to reduce the net groundwater consumption by approximately 2,272 acre feet per annum (71 percent) since 1989 (Service 2007, pp. 41–42). Despite these efforts, residential water demand continues (Harris et al. 2001, p. 15-5) and the effect of increased water demand and withdrawals may be exacerbated by the current, long-term drought throughout the region (see Drought and Climate Change section below).

A 2007 computer model developed by the United States Geological Survey simulated the response of groundwater pumping in the San Pedro Basin from 1902 to 2003 (Pool and Dickinson 2007, entire). This model reflects a more than 100 foot drop in groundwater levels in the Sierra Vista area as a result of intensive pumping from the Fort Huachuca, the Mexicana de Cananea (one of the largest open-pit copper mines in the world), agricultural irrigation in Arizona and Sonora, municipal use, and domestic wells in unincorporated areas (Varady et al. 2000, p. 232; Harris et al. 2001, p. 15-5; 60 FR 16836, p. 16838; Pool and Dickinson 2007, pp. 2, 15, 37; Lacher Hydrological Consulting 2012, p. 1). Lacher Hydrological Consulting (2012, p. 2) modified the model to project future groundwater declines in the regional aquifer, finding that, without mitigation, groundwater levels would decline an additional 21.3 m (70 ft) between 2000 and 2100. This further reduction in groundwater dependent base flows would result in reduced discharge to riparian vegetation, including hydric herbaceous perennials such as *L. schaffneriana* ssp. *recurva*.

Elsewhere in *L. schaffneriana* ssp. *recurva* habitat, the Rosemont Copper Mine is proposed to be constructed in the northeastern area of the Santa Rita Mountains in Santa Cruz County, Arizona. This mine, if built as proposed, would include a mine pit that will be excavated to a depth greater than that of the regional aquifer and water will drain from storage in the aquifer into the pit (Service 2013c, p. 238). The need to dewater the pit during mining operations would result in ongoing water removal via pumping of aquifer water storage. Upon cessation of mining, a pit lake would form, and evaporation from this water body will continue to remove water from storage in the regional aquifer (Service 2013c, p. 238). This aquifer contributes to the base flow for Cienega Creek and its tributaries, an area immediately east of the proposed project site which is designated as the Bureau of Land Management's Las Cienegas National Conservation Area. Cienega Creek and its tributary, Empire Gulch, support numerous occurrences and more than 100 patches of *L. schaffneriana* ssp. *recurva*.

Several groundwater models have been developed to analyze potential effects from the proposed mine on groundwater withdrawals throughout the affected area, including Cienega Creek and Empire Gulch. Independent models used in the Service's 2013 Biological Opinion analysis for the project indicated that, while some individual patches would fail to persist in Cienega Creek over time, the proposed action (construction of the Rosemont Mine) would not likely result in large reductions of perennial stream reaches and *L. schaffneriana* ssp. *recurva* would be unlikely to be extirpated from the Cienega Creek watershed (Service 2013c, p. 326). This model, however, did not consider the cumulative impact of drawdowns on base flow in Cienega Creek in combination with similar effects to its tributaries. Multiple agencies and organizations have developed groundwater models to analyze potential effects from the proposed mine on groundwater withdrawals throughout the affected area; these analyses are ongoing.

Sand and gravel mining within the watersheds that support *L. schaffneriana* ssp. *recurva* in the United States has occurred and probably will continue (60 FR 16836, p. 16841). No mining occurs within the San Pedro Riparian National Conservation Area (60 FR 16836, p. 16841). Sand and gravel mining removes riparian vegetation and destabilizes the ecosystem, which could cause degradation of *L. schaffneriana* ssp. *recurva* habitat or patch losses upstream or downstream from the mining (60 FR 16836, p. 16841). These mines also pump groundwater for

processing, and could locally affect groundwater reserves and perennial stream base flows (60 FR 16836, p. 16841). In addition, flood control projects that permanently alter stream flow characteristics may reduce or eliminate stream sinuosity and associated pool and backwater habitats that are critical to *L. schaffneriana* ssp. *recurva.*

In summary, the best available scientific and commercial information indicates that any reduction in the presence or availability of water in its habitat is a threat to *L. schaffneriana* ssp. *recurva*. The *L. schaffneriana* ssp. *recurva* occurrences in Cienega Creek and the San Pedro River are two of three major strongholds for this taxon and historical, current, and potential future dewatering is a serious threat to both areas. The third stronghold is the Huachuca Mountains where drought and climate change pose greater threats to *L. schaffneriana* ssp. *recurva* than groundwater pumping. Many more isolated occurrences of *L. schaffneriana* ssp. *recurva* have already become ephemeral or been lost due to perennial waters becoming ephemeral or ephemeral waters drying completely.

Wildfire and Associated Sedimentation and Scouring
– Primary constituent elements numbers 2-4 of critical habitat are impacted by this threat.

Fire burns less commonly in the wetland habitat of *L. schaffneriana* ssp. *recurva* than in other systems due to high humidity and presence of water in these areas (Service 2009a, p. 21). Fires in adjacent upland habitats have the potential to be more intense and more frequent then they were historically due to a variety of land management actions, coupled with recent drought conditions (Westerling et al. 2006, p. 940; FireScape 2014, entire). Such fires have severe indirect effects on *L. schaffneriana* ssp. *recurva* and its habitat including increased runoff of floodwaters, deposition of debris and sediment originating in the burned area, and potential for scouring and/ or burying of *L. schaffneriana* ssp. *recurva* individuals and habitat (Service 2014b, p. 145). Since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average of the period 1970 to 1986 (Westerling et al. 2006, p. 941). The timing, frequency, extent, and destructiveness of wildfires are likely to increase (Westerling et al. 2006, p. 943) and with them changes in vegetation community composition and structure, increased presence of invasive non-native plants, and alterations in the hydrologic and nutrient cycles (Griffis et al. 2000, p. 243; Crawford et al. 2001, p. 265; Hart et al. 2005, p. 167; Smithwick et al. 2005, p. 165; Stephens et al. 2014, p. 42).

Post-fire flooding and associated sedimentation can strip out, bury, or stunt growth of *L. schaffneriana* ssp. *recurva* patches, or transform habitat from wet or marshy to dry, sandy, or gravelly (Service 2009a, p. 24; Service 2013a, p. 4). For example, Freeman Spring is an area reported historically to contain springy soils and support *L. schaffneriana* ssp. *recurva* (Service 2013a, p. 4). Today, 10 years post-Ryan Fire and subsequent flooding and deposition, the taxon and the habitat no longer exist at this location and are being replaced with a thick sediment layer and prominence of more drought resistant species such as *M. rigens* (Service 2013a, p. 4). Similarly, in 1998, a large culvert was installed by Santa Cruz County on the Cimarron Road to reduce sedimentation and alteration of habitat occupied by *L. schaffneriana* ssp. *recurva*. The mitigation measure was unsuccessful and sedimentation buried the plants, extirpating this occurrence below the road (Service 1999, p. 235). In McClure Canyon on Fort Huachuca, an occurrence of *L. schaffneriana* ssp. *recurva* has shifted downslope due to the previously

occupied habitat being covered in post-fire sediment (Vernadero Group 2010, p 12). In 2007, a flood at Twin-2Overflow on the San Bernardino National Wildlife Refuge resulted in the covering of *L. schaffneriana* ssp. *recurva* in sediment; as of 2014, no plants had grown through or around the sediment (Radke, pers. comm. Nov 3, 2014). In this instance, the sediment load was not the result of a fire (Radke, pers. comm. Nov 3, 2014).

In 2009, the Huachuca FireScape project was created with participants from Fort Huachuca, the Coronado National Forest, and Coronado National Memorial (FireScape 2014, entire). This group works together to reduce the extent of fires by coordinating prescribed burns and thinning on over 161,874 ha (400,000 ac) across southeastern AZ (FireScape 2014, entire). In addition, Fort Huachuca's Integrated Wildfire Management Plan (Gebow and Hessil 2006, entire) and the San Bernardino and Leslie Canyon National Wildlife Refuges Fire Management Plan (Service 2006, p. 3) provide a planning framework for reducing the risk of fire and fire suppression effects on listed species. These combined efforts will help reduce, but not eliminate, the risk of catastrophic fire in and near *L. schaffneriana* ssp. *recurva* habitat.

At lower elevations, the spread of non-native invasive grasses has been increasing in recent decades. For example, Eragrostis species are now considered common or dominant on 1.5 million acres or more of the grasslands of the sky island region (Bodner et al. 2013, p. 403). In 2014, the South African *Melinis repens* (natal grass) was noted in great prevalence in several southern Arizona locations (Service 2014d, pp. 1-2; Service 2014e, p. 3); previously it was reported as widespread in Sonora and rapidly increasing (Van Devender and Reina 2005, p. 1). These non-native grasses not only out-compete native grassland species, but they have a completely different fire regime than the native grasses, tending to form dense stands that promote higher intensity fires more frequently (Bodner et al. 2013, p. 403; Van Devender et al. 1997, p. 4).

In summary, although the direct impacts of fire are potentially reduced due to high humidity and the presence of water within its habitat, the indirect impact of fire on *L. schaffneriana* ssp. *recurva*, including post-fire flooding and sedimentation, may be great. High severity fire and flooding are both expected to increase in the future. Landscape managers have teamed up to help lower the risk of catastrophic fires in the sky island region of southeastern Arizona. However, it will take some time before the benefits from these efforts will be realized. For example, as recently as 2014, a fire occurred on Fort Huachuca and Coronado National Forest lands within 0.4 km (0.25 mi) of a known occurrence of *L. schaffneriana* ssp. *recurva* in Sawmill Canyon. Such fires will likely continue into the future with potential impacts to *L. schaffneriana* ssp. *recurva* and its habitat. The spread of non-native invasive grasses will likely continue to increase fire risk at lower elevations.

Plant Competition

– All four primary constituent elements of critical habitat are impacted by this threat.

Lilaeopsis schaffneriana ssp. *recurva* is most abundant in areas with ample sunlight and low competition with other native and non-native species (Titus and Titus 2008c, p. 459). In a clipping experiment, *L. schaffneriana* ssp. *recurva* leaf number and length, as well as flower production increased when interspecific competition for sunlight, water, and nutrients was

removed (Titus and Titus 2008c, p. 462). At Cienega Spring on the San Bernardino National Wildlife Refuge newly transplanted *L. schaffneriana* ssp. *recurva* were eliminated in one location that exhibited intense competition with native Eleocharis sp. and Schoenoplectus sp. (Johnson et. al. 1992, p. 7). Similarly, following a 2005 attempt to establish *L. schaffneriana* ssp. *recurva* at San Bernardino National Wildlife Refuge *L. schaffneriana* ssp. *recurva* was outcompeted by other wetland plants (Service 2009a, p. 18). In a 2008 monitoring effort at Garden Canyon, researchers indicated that increased competition, with both native plants and *N. officinale*, had a noticeable effect on the detectability of *L. schaffneriana* ssp. *recurva* (Vernadero Group 2009, p. 10). They also noted that *N. officinale* went from a status of "present" in 2002 to "a major threat" in 2009 when Garden Canyon was reported to be "now choked by a recent invasion of watercress" (Vernadero Group 2010, p. 12). In 2014, *L. schaffneriana* ssp. *recurva* was noted to be small and sparse when growing among dense *C. dactylon*, yet, tall and dense growing just feet away without this competition (Service 2014a, p. 4).

Sorghum halepense (Johnson grass) is a Mediterranean, perennial, invasive non-native grass hybrid between *S. bicolor* and *S. propinquum* (Rout et al. 2013, p. 328). With rhizomes 1.5 m (4.9 ft) deep (Stromberg 2013, p. 4), height of up to 2 m (6.6 ft) (Gould 1988, p. 310), and leachates (solution produced by leaching) produced by the foliage and the roots which inhibit growth of other plants (Rout et al. 2013, pp. 327-328), this highly competitive and rapidly spreading species is now dominant on many floodplains in the southwestern United States (Stromberg 2013, p. 4). Although considered a mesophyte (not adapted to wet or to dry conditions) by Stromberg (2013, p. 4), others consider its distribution riparian (Hendrickson and Minckley 1985, p. 6) or most common in ecosystems with moist to mesic moisture regimes (FEIS 2004, entire). In the Cienega Creek watershed, *S. halepense* is a common, invasive, non-native perennial grass most often associated with cienega wetlands or along stream channels and gravel bars (Tiller et al. 2013, p. 423).

In 1996, researchers noted that in Leslie Canyon, *L. schaffneriana* ssp. *recurva* coexists with invading *S. halepense* (Haas and Frye 1997, p. 6). They also note that the removal of more aggressive stoloniferous or rhizomatous competitors to *L. schaffneriana* ssp. *recurva* appears to be a principle component in stimulating plant growth (Haas and Frye 1997, p. 12). In several reports on the endangered *Spiranthes delitescens* at the Canelo Hills Cienega Preserve, a site also known to contain *L. schaffneriana* ssp. *recurva*, researchers suggest declines in *S. delitescens* may be due, in part, to an increase in *S. halepense* and have recommended control of this invasive grass (Gori 1993, pp 1-2; Gori 1994, p. 6; Gori and Backer 1999a, p. 1). The Nature Conservancy has made control of this invasive non-native taxon a priority, and currently there are some patches that they continue to work to eradicate, or at a minimum, keep from spreading further (Miller pers. comm. November 23, 2013).

Neighboring Turkey Creek and Freemont Springs, locations known to historically support *L. schaffneriana* ssp. *recurva*, were visited in 2013 and large stands of *S. halepense* were present in both locations; in addition, *Arundo donax* (giant reed) was discovered in one location within Turkey Creek (Service 2013a, p. 2). Also in 2013, *S. halepense* was noted to be present in large quantities in the vicinity of known occurrences of *L. schaffneriana* ssp. *recurva* in the San Rafael Valley. In one of these locations, Sheehy Spring, a patch of *R. discolor* was also noted to have

increased in size since first reported years ago and could become a threat to *L. schaffneriana* ssp. *recurva* in the future (Service 2013b, p. 1).

Cover of invasive non-native plants such as *C. dactylon* and *N. officinale* in streams in the Huachuca Mountains and along the banks and within the San Pedro River pose a threat to *L. schaffneriana* ssp. *recurva* (Vernadero Group 2011a, p. i). In 2004, monitoring of *L. schaffneriana* ssp. *recurva* found common associates included *S. halepense, Hordeum jubatum* (foxtail), and *C. dactylon* (EEC 2004, p. 12). In an examination of the seedbank at the Finley Tank introduction site, a large number of competing seeds were present in some of the seedbank samples, particularly those of *C. dactylon* (Titus and Titus 2008a, p. 317). At the southern spring in Finley Tank, *R. discolor* was removed prior to the introduction effort by the 2002 Ryan wildfire and, as predicted, is once again a problem at this location (Titus and Titus 2008a; L. Kennedy pers. comm. February 3, 2014). A researcher at the Appleton-Whittell Research Ranch noted that, if left untreated, *R. discolor* could become a problem in the north spring where *L. schaffneriana* ssp. *recurva* occurs (Kennedy pers. comm. February 3, 2014).

In summary, the best available scientific and commercial information indicates that *L. schaffneriana* ssp. *recurva* benefits from low to moderate intensity flooding, fire, or other form of disturbance that lessens native and non-native plant competition. This competition also enables bank stability along riparian channels, another necessity for *L. schaffneriana* ssp. *recurva* which has shallow, weak roots and can be removed easily in high intensity flooding. Therefore, in order for *L. schaffneriana* ssp. *recurva* to persist or expand, a balance must be reached between *L. schaffneriana* ssp. *recurva* and its associates such that both protection of the substrate and reduction of competition are achieved. Invasive non-native plants have increased their presence within aquatic habitat of southeastern Arizona, and this invasion and expansion of infestations are expected to continue. Through monitoring at several locations, these interactions are being recorded, watched, and when possible, action taken to reduce this stressor. Because *L. schaffneriana* ssp. *recurva* is sensitive to competition from both native and non-native herbaceous plants, the added stressor of more competition from species such as *S. halepense*, *C. dactylon*, *N. officinale*, and *R. discolor* will likely lead to a decrease in the presence of *L. schaffneriana* ssp. *recurva.*

Livestock Grazing

– Primary constituent elements numbers 2 and 3 of critical habitat are impacted by this threat.

Lilaeopsis schaffneriana ssp. *recurva* is affected by livestock grazing in the following ways: 1) trampling, 2) direct impacts from construction of range improvement projects, 3) changes in stream geomorphology that lead to erosion, sedimentation, and downcutting, and 4) watershed degradation and resulting adverse effects to stream hydrology, (Service 1999, p. 237; Anderson 2006, p. 28). Observations of *L. schaffneriana* ssp. *recurva*'s response to grazing indicate the taxon is capable of experiencing light to moderate grazing with negligible impact (Simms pers. comm. October 26, 2011; Anderson 2006, pp. 22, 31; Edwards pers. comm. February 21, 2001; Rorabaugh 2013, entire).

Grazing during dry periods when cattle spend a disproportionate amount of their time, if not controlled, in riparian areas may result in harmful effects to *L. schaffneriana* ssp. *recurva* and

other riparian obligates (Edwards pers. comm. February 21, 2001; Service 2002a, pp. 76-77; Krueper 1996, p. 287; Malcom and Radke 2008, p. 81; Service 2014a, pp. 3, 6-7). In such instances, severe and widespread trampling may occur; roots and soil structure can be damaged; vegetation species composition and structure can shift; soil can become compacted; stream banks can be degraded; runoff and soil erosion from storm events may increase with higher peak flows; and stream entrenchment may occur; all of which would have harmful effects on *L. schaffneriana* ssp. *recurva* habitat and existing occurrences (Service 2002a, p. 138; Krueper 1996, pp. 287-288; Simms pers. comm. October 26, 2011).

With the onset of earlier springtime temperatures (Cayan et al. 2005, entire) and continuing drought conditions (Weiss and Overpeck 2005, p. 2074; Archer and Predick 2008, p. 24), the period of winter vegetation dormancy and water availability has decreased in recent years. In Sunnyside Canyon, Lone Mountain Canyon and its tributaries, Bear Canyon, and Scotia Canyon, the current Coronado National Forest Grazing Management Plan recommends grazing in winter months only when adequate water is available to disperse cattle and reduce impact on riparian areas (Service 2002b, pp. 144-146). This stipulation should be amended to include more areas that support *L. schaffneriana* ssp. *recurva* and implementation enforced.

Over-grazing of riparian areas has been shown to reduce the occurrence of *L. schaffneriana* ssp. *recurva* and damage its habitat (Falk 1998, p. 2; Dupée 1999, entire). Falk (1998, p. 2) noted that along the *L. schaffneriana* ssp. *recurva* monitoring transects, seven areas in Bear Canyon and four areas in Scotia Canyon showed evidence of bank instability or trampling from livestock use. Six of seven areas containing *L. schaffneriana* ssp. *recurva* in Bear Canyon, and one of four in Scotia Canyon, no longer contained plants in 1995, providing some evidence that habitat degradation did occur and possibly contributed to patch extinction in localized areas. In Leslie Creek, researchers quantified the impacts of a single cow on individual *L. schaffneriana* ssp. *recurva* and concluded that even a small number of livestock left in one place could eradicate the taxon in that area (Malcom and Radke 2008, p. 81). Researchers studying the effects of livestock removal at Cottonwood Spring concluded that two years following livestock removal, streamside and aquatic vegetation, and thus channel stability, were increased, all of which provided a benefit to *L. schaffneriana* ssp. *recurva* (Gori and Backer 1999b, p. 3). In the spring of 2014, *L. schaffneriana* ssp. *recurva* growing outside of cattle exclosures were diminished in size and quantity compared to those plants inside exclosures (Service 2014a, pp. 3-7).

In summary, the best available scientific and commercial information indicates that periodic disturbance removes competing vegetation and allows recolonization or expansion of *L. schaffneriana* ssp. *recurva* occurrences (Service 1999, p. 237). In instances where natural disturbance is low or infrequent, occasional trampling and grazing by domestic livestock could improve habitat for *L. schaffneriana* ssp. *recurva*; excessive livestock use, however, can be detrimental to the taxon and its habitat (Falk 1998, p. 2; Service 1999, p. 237; Service 2002a, p. 137; Malcom and Radke 2008, p. 81; Service 2014a, pp. 3, 6-7).

Recreation

– Primary constituent elements numbers 2, 3, and 4 of critical habitat are impacted by this threat.

Riparian areas and cienegas offer important recreational opportunities for the residents of

southern Arizona and northern Sonora (62 FR 665, p. 683). This visitation is expected to increase in the future with increases in human population, as well as drought conditions and the desire to be near water. Recreational activities, if poorly managed, can result in soil compaction, streambank destabilization, erosion and sedimentation, increases in the presence of invasive non-native plant species, and trampling of *L. schaffneriana* ssp. *recurva* and other riparian plant species, thus reducing habitat quality.

In summary, the best available scientific and commercial information indicates that *L. schaffneriana* ssp. *recurva* can be impacted by poorly managed recreational activities.

Factor B: Overutilization for commercial, recreational, scientific, or educational purposes

While *L. schaffneriana* ssp. *recurva* is collected periodically for genetics studies, herbarium specimens, and for plugs for reintroduction efforts, these collections are monitored through a permit process to ensure over-collection is not a threat to the taxon or the primary constituent elements of critical habitat. In addition, *L. schaffneriana* ssp. *recurva* has the ability to reproduce vegetatively and can resprout following removal of vegetative material. Therefore, we find overutilization is not a threat to the taxon.

Factor C: Disease or predation
– There are no primary constituent elements of critical habitat that are impacted by this threat.

There is no evidence to suggest that disease is a threat to *Lilaeopsis schaffneriana* ssp. *recurva* or its primary constituent elements of critical habitat. Although javelina have been observed eating *L. schaffneriana* ssp. *recurva* at San Bernardino National Wildlife Refuge (Johnson 1991 p. 8), predation by native wildlife does not seem to have a large impact on the taxon. Domestic livestock are not known to consume *L. schaffneriana* ssp. *recurva*. Therefore, we find disease or predation is not a threat to the taxon.

Factor D: Inadequacy of existing regulatory mechanisms
– There are no primary constituent elements of critical habitat that are impacted by this threat.

Land Management and the Forest Service. The 2008, Bureau of Land Management Manual 6840, Special Status Species Management, states, in part, that they will develop and implement plans and programs that will conserve listed species and the ecosystems upon which they depend, monitor and evaluate ongoing management activities to ensure conservation objectives, ensure that all activities affecting the occurrences and habitats of listed species are designed to be consistent with recovery needs and objectives, and ensure that all actions authorized, funded, or carried out by the Bureau of Land Management are in compliance with the Act (Bureau of Land Management 2008, entire).

The 2005 Forest Service Manual chapter 2670, Threatened, Endangered, and Sensitive Plants and Animals, states, in part, that National Forest system habitats and activities will be managed for listed threatened or endangered species to achieve recovery objectives so that listing under the Act is no longer necessary (USFS 2005, p. 4). In addition, the Forest Service, Coronado National Memorial, and Fort Huachuca are participating in the Huachuca FireScape project to

reduce the risk of catastrophic fire and sedimentation impact in the sky islands of southeastern Arizona (FireScape 2014). Other land management agencies maintain fire management plans aimed at reducing threats from catastrophic fire which would benefit listed species.

On non-Federal lands, the Arizona Native Plant Law provides some protection for this taxon within Arizona. *Lilaeopsis schaffneriana* ssp. *recurva* is protected under the Arizona Native Plant Law as a highly safeguarded plant, which makes it unlawful for any person to destroy, dig up, cut, collect, mutilate, harvest or take, and place into possession any of these plants on non-Federal lands (Arizona Revised Statutes 2009, chapter 7). However, the Arizona Native Plant Law does not prohibit landowners from removing or destroying protected plants on their property, but they are required to notify the Arizona Department of Agriculture 20 to 60 days prior to destruction of a protected native plant.

Critical habitat designation provides an added layer of protection to the habitat of *L. schaffneriana* ssp. *recurva* for projects with a Federal nexus, such as Federal permitting or funding, or occurrence on Federal lands; seven critical habitat units have been designated for this taxon (64FR 37441, p. 37444; refer to Figure 3).

Lilaeopsis schaffneriana ssp. *recurva* is not included on the Mexican government's list of protected species (SEMARNAT 2010) or on the CITES list (CITES 2014, p. 673). However, it occurs in two Federally-designated protected areas (Rancho El Aribabi and Arroyo El Tigre on the Bosque Nacional y Refugio de Vida Silvestre Los Ajos-Bavispe, Sonora) and other lands, including Rancho Los Fresnos, Sonora, where the landowners work to protect the habitat from a variety of threats. Collectively, these areas represent 8 of the 21 localities known to support *L. schaffneriana* ssp. *recurva* in Sonora.

In summary, the best available scientific and commercial information indicates that the status of *L. schaffneriana* ssp. *recurva* as a listed endangered species with critical habitat designated under the Act, a Bureau of Land Management and Forest Service sensitive species, and a highly safeguarded plant under Arizona State Law, afford some protection to the taxon within the United States. Federal designations and private reserves provide some level of protection to occurrences in Sonora, Mexico. There are no regulations in place that address threats to *L. schaffneriana* ssp. *recurva* and its habitat from drought and the effects of climate change. Therefore, we find current regulatory mechanisms are not a threat to the taxon, though we believe that regulations designed to protect the species and its habitat will have little impact to alleviate the threats caused by drought or the effects of climate change.

Factor E: Other natural or manmade factors affecting its continued existence:

Drought and Climate Change
– All four primary constituent elements of critical habitat are impacted by this threat.

Southeastern Arizona and much of the American Southwest have experienced serious drought in recent decades (Bowers 2005, p. 421; Garfin et al. 2013, p. 3; CLIMAS 2014, entire) and precipitation is projected to be less in the future with climate change (Seager et al. 2007, p. 1181; Karl et al 2009, pp. 24, 33). Most climate change scenarios predict that the American southwest will also get warmer during the 21st century (Overpeck et al. 2012, p. 5; Karl et al. 2009, p. 129).

The most recent water year in review (October 2011 to September 2012) indicated that drought conditions and above average temperatures were abundant throughout the southwest (CLIMAS 2012, entire). This continued into 2014, when by June, it was reported that, similar to 2013, 76 percent of Arizona was experiencing severe drought and water reservoir storage levels dropped to 46 percent (CLIMAS 2014, p. 1).

Instrumental and paleo-climatic records from the Southwest indicate the region has a history of multi-year and multi-decade drought (Hereford et al. 2002, p. 1; Karl et al. 2009, p. 130; Garfin et al. 2013, p. 3). *Lilaeopsis schaffneriana* ssp. *recurva* evolved in the Southwest and has persisted in many locations throughout its range through historical droughts such as those of the 1950s, yet, given the severity and persistence of the present multi-decade drought, it is unknown how long *L. schaffneriana* ssp. *recurva* will maintain viability in de-watered habitat. It has been suggested that seed from this taxon may persist for five to ten years in such situations (Titus and Titus 2008a, p. 319; Titus and Titus 2008b, p. 398; Titus and Titus 2008c, p. 463).

In recent decades there has also been a shift toward earlier spring onset across the western United States (Cayan et al. 2005, p. 3). Spring onset has important consequences for plant phenology; if leaf or flower buds are initiated earlier, they will be more vulnerable when frost occurs (Inouye 2008, p. 354). Many plant species have frost-sensitive buds, ovaries, and leaves, and can produce fewer flowers and seeds due to frost damage during times of the year when frost is unusual (Inouye 2000, p. 457). Although *L. schaffneriana* ssp. *recurva* is one of the earliest flowering species, we are unaware of frost damage to this taxon. Another concern of an earlier spring is an increased fraction of precipitation falls as rain, resulting in a reduced snow pack, an earlier snowmelt, and decreased summer base flow (Christensen et al. 2004, p. 340; Regonda et al. 2005, p. 373). Earlier snowmelt and warmer air temperatures can lead to a longer dry season. Warmer air temperatures lead to increased evaporation, increased evapotranspiration, and decreased soil moisture. These three factors would lead to decreased streamflow even if precipitation increased moderately (Garfin 2005, p. 43). The effect of decreased streamflow is that streams become smaller, intermittent or dry, and thereby reduce the amount of habitat available for aquatic species such as *L. schaffneriana* ssp. *recurva*.

Many springs (Robinson 2010, p. 6; Ehret 2008, p.2), cienegas (Fonseca pers. comm. January 17, 2014), creeks (Bureau of Land Management 2012, entire), and rivers (Turner and Richter 2011, pp. 2-3) that have been perennial in the past are now intermittent, have more dry reaches, or have dried up entirely. As a result, many occurrences of *L. schaffneriana* ssp. *recurva* have become reduced in density or distribution, become ephemeral, or are now presumed extirpated (see the San Bernardino National Wildlife Refuge, Bingham Cienega, Freeman Spring, Leslie Canyon National Wildlife Refuge, Lower Cienega Creek, Tucson, and Winkelman sections in Appendix A). Reduced water flow can reduce the ability of *L. schaffneriana* ssp. *recurva* to grow, reproduce, and expand to new locations. Even if *L. schaffneriana* ssp. *recurva* can survive long periods of drought as seeds or rhizomes (Haas and Frye 1997, p. 12), at some point increasing aridity would eliminate the plant, including seed stock and rhizomes, from intermittent reaches (Service 1999, p. 237). For example, no *L. schaffneriana* ssp. *recurva* have been seen in Bingham Cienega since 2002 when the area was experiencing drought (Titus and Titus 2008c, p. 462); similarly, the decline and loss of *L. schaffneriana* ssp. *recurva* in Leslie Canyon in recent

years was directly related to the reduction in rainfall and a lowering of the water table (Terry 2012, entire).

In addition, in a warmer environment, an enhanced hydrologic cycle is expected; rainfall events are to be less frequent, but more intense, and larger flood events more common (Karl et al. 2009, p. 24). Such large floods can destroy *L. schaffneriana* ssp. *recurva* patches, and even entire occurrences, if no niches in backwaters are present to ensure recolonization. For example, in September, 2014, Hurricane Odile hit the southeastern portion of Arizona leading to substantial rain and causing widespread flooding which severely impacted many *L. schaffneriana* ssp. *recurva* occurrences in the Huachuca Mountains and elsewhere. It is unknown at this time if any patches remain in several locations.

In summary, the best available scientific and commercial information indicates that there is a reasonable likelihood that the current drought and rise in temperatures will continue for many more years. The limited number of occurances increases the chance that a single environmental catastrophe could decrease and/or eliminate the taxon. It is unknown how long *L. schaffneriana* ssp. *recurva* can remain dormant during an extended drought. The projected drought will likely contain periods of high year-to-year precipitation variability characteristic of Southwest climate. Whether this variability will be enough to preserve occurrences of *L. schaffneriana* ssp. *recurva* remains unknown. Earlier spring onset and more intense storm events will likely continue to have negative impacts on the taxon.

Table 3. Threats tracking table for *Lilaeopsis schaffneriana* ssp. *recurva*.

Listing Factors	Threats	Primary Constituent Elements*	Recovery		Recovery Actions
			Objectives	Criteria	
A	Aquatic habitat degradation	1, 2, 3, 4	1, 2, 3, 4, 5	1, 2, 3	1.1, 1.2, 2.1, 2.2, 2.3, 3.1, 3.2, 4.1, 4.2, 4.4, 5.1, 5.2, 5.3, 6.1, 6.2, 6.3
A	Wildfire and resulting sedimentation	2, 3, 4	1, 2, 4, 5, 6	1, 2, 3	1.2, 4.1, 4.2, 4.4, 5.1, 5.2, 5.3, 6.1, 6.2, 6.3
A	Competition from invasive non-native plants	1, 2, 3, 4	3, 4, 5, 6	1, 2, 3	3.1, 3.2, 4.1, 4.2, 4.4, 5.1, 5.2, 5.3, 6.1, 6.2, 6.3
A	Livestock grazing	2, 3	3	3	1.2, 3.1, 3.2, 5.1, 6.1, 6.2, 6.3
A	Recreation	2, 4	3, 4, 5, 6	1, 2, 3	3.1, 3.2, 4.1, 4.2, 4.4, 5.1, 5.2, 5.3, 6.1, 6.2, 6.3
E	Effects of drought and climate change	1, 2, 3, 4	1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5	1.1, 1.2, 2.2, 2.3, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2, 5.3, 6.1, 6.2, 6.3

*The four primary constituent elements are described in section I.10.

Past Conservation Efforts

The following are conservation efforts that have occurred since *L. schaffneriana* ssp. *recurva* was listed in 1997:

1) There has been success in establishing *L. schaffneriana* ssp. *recurva* in locations with suitable habitat within the historical range of the taxon (e.g. Audubon Research Ranch, Las Cienegas National Conservation Area, Fort Huachuca, and on the San Pedro Riparian National Conservation Area). Other attempts to establish this taxon have ultimately failed (e.g. Sonoita Creek). Still other attempts have had mixed results (e.g. San Bernardino and Leslie Canyon National Wildlife Refuges).

2) Since 1990, the Nature Conservancy has held a conservation easement on one private property on Sonoita Creek that supports *L. schaffneriana* ssp. *recurva* (Killeen pers. comm. April 29, 2014). Although the easement is not set up for *L. schaffneriana* ssp. *recurva*, the taxon benefits from this land protection. Several additional conservation easements on the Babocomari River are held by The Nature Conservancy, Fort Huachuca, and the Bureau of Land Management; collectively these easements protect several miles of perennial water in the Babocomari River (Duncan pers. comm. April 29, 2014). In 1999, Arizona State Parks purchased 1,440 ha (3,557 ac) of land in the San Rafael Valley including the Santa Cruz River which supports small occurrences of *L. schaffneriana* ssp. *recurva*. One management goal of the San Rafael State Natural Area is to protect, preserve, and enhance habitat for federally listed threatened and endangered species (Arizona State Parks 2013, p. 9). The land is rested from livestock grazing, protected from development through an easement, and is managed to minimize the impacts of invasive non-native species. In 2013, the Arizona Land Trust protected 3.2 km (2 mi) of Sonoita Creek on the Circle Z Ranch, including perennial stretches. Although no *L. schaffneriana* ssp. *recurva* have been surveyed for or documented on this property, the taxon has been found upstream and potential habitat exists for the taxon on this protected ranch.

3) In Sonora, Mexico, Rancho El Aribabi is a federally-designated private reserve, which recognizes ecological values and also precludes mineral entry. The Ranch, which contains an occurrence of *L. schaffneriana* ssp. *recurva*, is managed for its ecological values and ecotourism. Similarly, Rancho Los Fresnos, which also supports an occurrence of *L. schaffneriana* ssp. *recurva*, is owned and managed for its ecological values by the conservation organization Naturalia. Livestock have been removed from the property and management includes the use of prescribed burning. At Rancho San Bernardino, in Sonora, the Cuenca los Ojos Foundation actively manages lands known to have historically supported and may currently support *L. schaffneriana* ssp. *recurva*. Management includes extensive restoration of grasslands and waterways, resulting in the many-fold increase in extent of perennial water in Rio San Bernardino and creating habitat for the taxon.

4) There are three conservation plans currently in place that provide some benefit to *L. schaffneriana* ssp. *recurva*. First, the 2008 Malpai Borderlands Habitat Conservation Plan ensures no cattle grazing occur within San Bernardino National Wildlife Refuge, thereby protecting *L. schaffneriana* ssp. *recurva* from trampling and overgrazing impacts (MBHCPTWG

and Lehman 2008, p. 105). Second, the 2009 Leslie Canyon Watershed Safe Harbor Agreement incorporates management actions related to the recovery of the taxon, including its propagation and establishment in existing aquatic habitats, the maintenance of wetland levels, and the exclusion of humans and livestock that may excessively trample the taxon (Service 2009b, p. 7). Lastly, although most *L. schaffneriana* ssp. *recurva* occur outside of Pima County, the Draft Pima County Multi-Species Conservation Plan includes monitoring of a) *L. schaffneriana* ssp. *recurva* every two to three years, b) habitat conditions at Bingham Cienega, and c) post restoration efforts (Pima County 2012, pp. 70, 81). In addition, Pima County's Office of Sustainability and Conservation has recently expressed an interest in introducing patches of *L. schaffneriana* ssp. *recurva* into a new site for conservation purposes.

5) Fort Huachuca participates in water conservation efforts, effluent reuse or recharge, the purchase of conservation easements, and storm water recharge; all which benefit *L. schaffneriana* ssp. *recurva* and its habitat (Service 2014b, p. 21). Fort Huachuca personnel monitor *L. schaffneriana* ssp. *recurva* both on the Fort and on the San Pedro National Conservation Area regularly (Service 2014b, p. 20). Fort Huachuca has an Integrated Natural Resource Management Plan which describes the taxon and its threats (ENRD 2010, entire), as well as an Endangered Species Management Plan (ENRD 2006, entire), which also describes conservation goals and management prescriptions. There is limited horse grazing on three pastures within Fort Huachuca and no cattle grazing is permitted (ENRD 2010, pp. 41, 47). Measures are taken to ensure recreational trampling does not occur on Fort Huachuca (Service 2014b, p. 21). In addition, transplanting of *L. schaffneriana* ssp. *recurva* plugs has occurred in the past and may continue in the future (ENRD 2010, p. 77; Service 2014b, p. 21).

6) The Bureau of Land Management manages the Las Cienegas National Conservation Area, which encompasses much of the upper Cienega Creek watershed, an area supporting multiple patches of *L. schaffneriana* ssp. *recurva*. The area was set aside to conserve, protect, and enhance natural resources of the area in accordance with a comprehensive management plan that includes assurance that riparian and wetland sites are properly functioning (Bureau of Land Management 2003, pp. 7-9). The Bureau of Land Management also conducts periodic monitoring of *L. schaffneriana* ssp. *recurva* along upper Cienega Creek and has plans for introducing *L. schaffneriana* ssp. *recurva* plugs at up to 11 locations over a 10 year period (Service 2008, p. 3). In addition, to protect these sensitive riparian and wetland habitats, the Bureau of Land Management designated this area as the Empire-Cienega Area of Critical Environmental Concern. The goal of the designation is to protect and enhance watershed, grassland, and threatened/endangered wildlife resources, emphasizing total ecosystem management (Bureau of Land Management 2003, p. A6-1).

7) The Bureau of Land Management manages the San Pedro Riparian National Conservation Area which is a 56,431 acre area designated by Congress in 1988 as the nation's first Riparian National Conservation Area. It was created to conserve, protect, and enhance the riparian area and the aquatic, wildlife, archaeological, paleontological, scientific, cultural, educational, and recreational resources of the Conservation Area. Management has been guided by the San Pedro Management Plan since it was first approved in 1989, as well as the Safford District Resource Management Plan written in 1993. These documents were created prior to the listing of *L. schaffneriana* ssp. *recurva* and do not cover this species specifically, however the

stated goal of the San Pedro Management Plan, which is consistent with the Safford District plan, is the conservation, protection, and enhancement of the riparian ecosystem and related habitat and wildlife within the San Pedro Riparian National Conservation Area (Fredlake et al. 1993, p. 11). A new Resource Management Plan is currently being drafted which will include management actions specific to *L. schaffneriana* ssp. *recurva*.

8) Between February, 1997 and November, 2014, there have been 46 section 7 consultations involving *L. schaffneriana* ssp. *recurva*. The consultations included measures to reduce adverse effects on the taxon and resulted in non-jeopardy determinations.

Part II. Recovery

1. Recovery Strategy

The recovery strategy for is to provide conservation and restoration of the taxon and its habitat to the extent that will allow stable, self-sustaining occurrences to persist throughout its range within the United States with some level of connectivity and opportunities for expansion and dispersal. Our recovery strategy entails minimizing or ameliorating the most significant long-term threats to the continued existence of the species which are: 1) aquatic habitat degradation; 2) the effects of drought and climate change; 3) wildfire and resulting sedimentation and scouring; 4) invasive non-native plant competition; and 5) livestock grazing.

Our strategy to recover *L. schaffneriana* ssp. *recurva* is to: 1) protect and restore upland and aquatic habitats that contribute to, support, or could support *L. schaffneriana* ssp. *recurva*; 2) conserve occurrences and their seedbanks, augment existing occurrences, establish new occurrences in appropriate habitat, and maintain plants in botanical gardens and seed at proper storage facilities; 3) remove and manage invasive non-native plants and areas where livestock congregate that further stress *L. schaffneriana* ssp. *recurva*; 4) use standardized monitoring methods over the long-term to determine trends and impacts from management actions and adapt management accordingly; 5) encourage research to improve our understanding of *L. schaffneriana* ssp. *recurva* and its habitat in the United States and Mexico; and 6) develop partnerships within the region where *L. schaffneriana* ssp. *recurva* grows, and work with a variety of land owners in the United States and Mexico to adopt management actions that will encourage conservation of *L. schaffneriana* ssp. *recurva*.

2. Recovery Goal

The ultimate goal of this recovery plan is to outline specific actions that, when implemented, will sufficiently reduce the threats to *L. schaffneriana* ssp. *recurva*, ensure its long-term viability in the wild, and allow for its removal from the list of threatened and endangered species.

3. Recovery Objectives

To meet the recovery goal, the following objectives have been identified:

1) Protect and restore functional aquatic habitat and reduce dewatering threats to known and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and habitat.
2) Conserve existing and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and their seedbanks, establish new occurrences in appropriate habitat, establish plants at botanical gardens for research, recovery, and educational purposes, and maintain seeds for conservation and recovery at seed storage facilities.
3) Remove stressors related to invasive plants, unmanaged livestock grazing, and small population size to *L. schaffneriana* ssp. *recurva* occurrences and their habitats.
4) Develop a standardized monitoring technique based on existing protocols; monitor *L. schaffneriana* ssp. *recurva* occurrences, threats, and outcomes from management actions allowing for adaptive management.

5) Encourage scientific study to improve our understanding of *L. schaffneriana* ssp. *recurva* geography, ecology, viability, genetics, propagation, restoration, and threats in the United States and Mexico.
6) Develop public outreach, collaborative partnerships, agency management plans, and agreements with private land owners in the United States and Mexico that encourage *L. schaffneriana* ssp. *recurva* conservation.

4. Recovery Criteria

An endangered species is defined in the Act as a species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. When we evaluate whether or not a species warrants downlisting or delisting, we consider whether the species meets either of these definitions. A recovered species is one that no longer meets the Act's definitions of threatened or endangered due to amelioration of threats and no longer needs the protections of the Act. Determining whether a species should be downlisted or delisted requires consideration of the same five categories of threats that were considered when the species was listed and which are specified in section 4(a)(1) of the Act.

Recovery criteria are conditions that, when met, are likely to indicate that a species may warrant downlisting or delisting. Thus, recovery criteria are mileposts that measure progress toward recovery. Because the appropriateness of delisting is assessed by evaluating the five threat factors identified in the Act, the recovery criteria below address the applicable factors identified at the time the taxon was listed. These recovery criteria are our best assessment at this time of what needs to be completed so that the species may be removed from the list of threatened and endangered species. Because we cannot envision the exact course that recovery may take and because our understanding of the vulnerability of a species to threats is very likely to change as more is learned about the taxon and its threats, it is possible that a future status review may indicate that delisting is warranted although not all recovery criteria are met. Conversely, it is possible that the recovery criteria could be met and a future status review may indicate that delisting is not warranted.

To downlist *L. schaffneriana* ssp. *recurva* from endangered to threatened status, the following must occur:

1) A minimum cumulative extent of 2,000 m^2 (0.5 acre / 0.2 hectare) of naturally occupied habitat exists in the San Pedro Watershed, 20% of which occurs in tributary streams, springs, or cienegas; **and** a minimum of 2,000 m^2 (0.5 acre / 0.2 hectare) in the Santa Cruz Watershed, 90% of which occurs in tributary streams, springs, or cienegas, distributed among the areas of Cienega Creek (35%), Sonoita Creek (10%), the San Rafael Valley uplands and mainstem (10%), and the western Huachuca Mountains (35%); **and** a minimum of 125 m^2 (0.03 acre / 0.01 hectare) exists in the Rio Yaqui Watershed; this level of occupancy is sustained or improved for a minimum of 10 years over a 15 year period.
2) At least 3 separate introduced occurrences with a minimum cumulative extent of 150 m^2 (0.037 acre / 0.015 hectare) of occupied habitat are placed in each of the 3 United States watersheds and are stable or increasing over a 10 year period;

3) Threats to the taxon and its habitat have been managed and reduced, and and long-term management is in place for a minimum of 20 years to ensure the persistence of occurrences with minimum cumulative extent (as reflected by the achievement and maintenance of downlisting criteria 1 and 2 measured above) in each of the three United States watersheds;
4) A living collection of as many plugs as resources allows, collected from genetically distinct regions (e.g. Fort Huachuca/SPRNCA north; San Rafael / Las Cienegas/Sonoita; SPRNCA south/SanBernardino), from both the San Pedro and the Santa Cruz watersheds is maintained in at least one botanical garden in southern Arizona for recovery and educational purposes; and
5) Seeds of *L. schaffneriana* ssp. *recurva* are collected following Center For Plant Conservation guidelines, which include collecting from no more than 10 percent of the standing seed crop from 50 individual seed bearing plants per population (if the population size permits), and collecting from a variety of microsites and physical characteristics within the stand of plants. These seeds are stored at both the Agricultural Research Service National Center for Genetic Resources Preservation in Fort Collins, Colorado and stored according to protocols at a local facility such as the Desert Botanical Gardens in Phoenix, Arizona, for long-term conservation and recovery purposes.

To delist *L. schaffneriana* ssp. *recurva*, the criteria for down-listing must be met and occurrences are stable or increasing a minimum of 20 years over a 30 year period.

5. Justification for Recovery Criteria

To determine downlisting and delisting criteria, we utilized monitoring data from the San Pedro River (cover has ranged from 326 m^2 to 2,281 m^2 [0.08 acre / 0.03 hectare to 0.56 acre / 0.23 hectare] between 2001 and 2013) and Las Cienegas National Conservation Area (1,455 m^2 [0.36 acre / 0.15 hectare] in 2011) in combination with percentage of occupancy by watershed (refer to Table 1) and personal knowledge of the plant and the systems in which it grows. As *L. schaffneriana* ssp. *recurva* cover has fluctuated between wetter and drier years, an additional temporal component was added to these criteria in order to account for long-term persistence of necessary water resources which support *L. schaffneriana* ssp. *recurva*. Because of this component of the criteria, restoration of regularly occurring water sources will likely be necessary in order to meet water needs over a sustained period. Given that ten years is considered the maximum amount of time that *L. schaffneriana* ssp. *recurva* seeds are thought to persist, we selected a 15 year period to provide a buffer in time to accommodate dynamic environmental conditions and innate seed characteristics that drive the span of reproduction.

The importance of preventing excessive water drawdown and increasing water recharge into the San Pedro, Santa Cruz, and Rio Yaqui watersheds in the United States cannot be understated in the recovery of this and co-occurring listed species. Arizona is an arid state with finite water supplies, a population expected to double by 2050, and ongoing drought (ADWR 2014, entire; Marshall et al. 2010, p. 1). There is a potential for a long-term imbalance between available water supplies and projected water demands over the next 100 years if no action is taken (ADWR 2014, entire). A clean and sustainable water supply is essential for humans and the environment; water resources planning must embrace the need for water for urban growth, as well as environmental water needs (Marshall et al. 2010, p. 1). Using water more efficiently,

reusing water, capturing water, and purchasing surface water rights are all methods whereby water availability can be increased for the benefit of *L. schaffneriana* ssp. *recurva*, and would have added benefit to many other co-occurring listed and unlisted plant and animal species, ecosystem services provided by healthy watersheds, and economic benefits such as from increased tourism.

6. Stepdown Recovery Outline

The stepdown outline lists actions, including site-specific management actions, required to meet the recovery objectives of this Recovery Plan. Please refer to Table 3 for a clear association among threats, primary constituent elements that define critical habitat, and recovery actions that will address both.

1. **Protect and restore functional aquatic habitat and reduce dewatering threats to known and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and habitat.**
   1.1. Maintain or enhance groundwater hydrography by reducing water withdrawal, increasing water conservation and recharge.
      a. Acquire surface water rights and convert them to in-stream uses or apply for rights anew and defend them in a court of law.
      b. Acquire conservation easements to protect larger lands from being subdivided into smaller lots with increased residential pumping per acre.
      c. Encourage incentive programs to reduce water use across the range of *L. schaffneriana* ssp. *recurva*.
      d. Upgrade wells and check for leaks to reduce water loss.
      e. Promote stormwater recapture projects.
      f. Promote use of treated effluent to offset outdoor irrigation.

   1.2. Manage lands to increase watershed health, thus reducing downcutting, headcuts, scouring floods, and sedimentation, and increasing infiltration and perennial flow to rivers, streams, springs, and cienegas.
      a. Remove invading trees and shrubs in upland grasslands; reduce heavy fuel loads in upland forests; create in-channel structures in upland tributaries; and introduce beaver where appropriate.
      b. Maintain low to moderate intensity disturbance regimes that reduce competing vegetation, yet allow for *L. schaffneriana* ssp. *recurva* establishment and growth.

2. Conserve existing and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and their seedbanks, establish new occurrences in appropriate habitat, and establish plants at botanical gardens for research, recovery, and educational purposes.
   2.1. Protect known and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and associated habitat, including unoccupied, intervening drainages that provide connectivity among occurrences.
      a. Acquire private lands and associated surface water rights which support occurrences and manage for the protection of the taxon.
      b. Develop conservation agreements and easements for protection of occurrences on private lands.

c. Develop and monitor conservation mitigation banking to promote the protection of high quality *L. schaffneriana* ssp. *recurva* habitat.

2.2. Establish introduced *L. schaffneriana* ssp. *recurva* occurrences into appropriate habitat using appropriate genetic stock to increase the redundancy (number of occurrences) and resiliency (size of occurrences) of the taxon. This includes surveying for and locating potential donor sites, working with landowners and managers to complete all necessary compliance and approvals, growing out propagules (if necessary), transporting plants, developing/utilizing transplant protocols, and monitoring results.

2.3. Maintain plants in captivity at botanic garden and seeds at seed storage facilities.

3. Remove stressors to *L. schaffneriana* ssp. *recurva* occurrences and their habitats.

3.1. Protect occupied habitats and watersheds from congregating livestock and recreation activities, especially during dry periods.

3.2. Control invasive non-native plants and prevent their spread in *L. schaffneriana* ssp. *recurva* habitat.

4. Develop a standardized monitoring technique based on existing protocols; monitor *L. schaffneriana* ssp. *recurva* occurrences, threats, and outcomes from management actions allowing for adaptive management.

4.1. Develop a range-wide standardized monitoring approach based on existing approaches (see Cienega Creek National Conservation Area and the San Pedro National Conservation Area as examples) that will be adopted by all land managers, land owners, and conservation partners which will enable an understanding of current status and knowledge of when recovery criteria have been met. This will include: 1) timing of survey, 2) protocol for measuring square meters covered by the plant, and 3) assessing the health of occurrences, as well as, threats.

4.2. Monitor natural and augmented occurrences at least every three years.

4.3. Monitor effects of climate change and groundwater pumping in areas most likely to be affected by those threats.

4.4. Review the status of the taxon periodically to assess the effectiveness of management and recovery actions.

5. Encourage scientific study to improve our understanding of *L. schaffneriana* ssp. *recurva* geography, ecology, viability, genetics, propagation, restoration, and threats in the United States and Mexico.

5.1. Identify information gaps, compatible land uses, and appropriate management actions that promote the conservation of the taxon.

5.2. Conduct surveys in appropriate habitat to better understand the range of the taxon.

5.3. Conduct research into biology, ecology, and genetics of the taxon.

6. Develop public outreach, collaborative partnerships, agency management plans, and agreements with private land owners in the United States and Mexico that encourage *L. schaffneriana* ssp. *recurva* conservation.

6.1. Work with others to increase public outreach regarding stressors, threats, and conservation measures relating to *L. schaffneriana* ssp. *recurva* in both the United States and Mexico.

6.2. Develop collaborative partnerships and agreements with private land owners that result in management plans or that otherwise encourage *L. schaffneriana* ssp. *recurva* conservation in the United States and Mexico.

6.3. Develop a recovery implementation team comprised of species experts, agency and non-government agency partners, landowners, and stakeholders to meet regularly, review progress, discuss problems, and revise this plan as needed.

7. Recovery Narrative

1. Protect and restore functional aquatic habitat and reduce dewatering threats to known and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and habitat.

1.1 Maintain or enhance groundwater hydrography by reducing water withdrawal, increasing water conservation and recharge.

a. Acquire surface water rights and convert them to in-stream uses or apply for rights anew and defend them in a court of law.

The acquisition of surface water rights to change the consumptive use (municipal, agricultural, and industrial) to in-stream use results in long-term legal protection of stream flow.

b. Acquire conservation easements to protect larger lands from being subdivided into smaller lots with increased residential pumping per acre.

Land and water conservation organizations may acquire conservation easements on larger properties containing or in the vicinity of perennial waterways throughout the range of *L. schaffneriana* ssp. *recurva*. Such easements would prevent the subdivision of land and future groundwater withdrawals for residential water use. In addition, easements may be purchased to retire agricultural groundwater use providing direct benefit to stream flow. Easements may also provide sites for enhancing recharge.

c. Encourage incentive programs to reduce water use across the range of *L. schaffneriana* ssp. *recurva*.

Present opportunities for municipalities whose water use may affect the taxon to create incentive programs to reduce the use of water for household consumption and landscaping purposes. These programs could include the installation of low-flow or dual flush toilets and water-saving shower heads, as well as, the repair of leaky faucets. Other incentives could include the removal of lawns, the promotion of xeric landscaping, and the promotion of grey water systems for watering lawns and other plants and flushing toilets.

d. Upgrade wells and check for leaks to reduce water loss.

Present opportunities for municipal and private water providers to reduce the direct loss of water through discovering and repairing leaks, as well as indirect loss of water due to evaporation.

e. Promote storm water recapture projects.

Agencies, municipalities, and land owners would be encouraged to capture urban rainfall runoff through such devices as rooftop capture for landscaping or dry well capture and storm water detention basins for recharge.

f. Promote use of treated effluent to offset outdoor irrigation.

Treated effluent should be used to replace irrigation with groundwater or surface water in parks, golf courses, and other such large scale landscaping.

1.2 Manage lands to increase watershed health, thus reducing downcutting, headcuts, scouring floods, and sedimentation, and increasing infiltration and perennial flow to rivers, streams, springs, and cienegas.

a. Remove invading trees and shrubs in upland grasslands; reduce heavy fuel loads in upland forests; create in-channel structures in upland tributaries and; introduce beaver where appropriate.

Managers should focus on watershed health including promotion of perennial flow. Enhanced hydrograph would increase the amount of available habitat for *L. schaffneriana* ssp. *recurva* including the establishment of functioning corridors that reconnect isolated habitat fragments. Such management activities as described above will improve regional and alluvial groundwater conditions and reduce erosion and sedimentation. In addition, cienega habitats that were common historically and have since been largely destroyed may benefit from the reintroduction of beaver which can help recreate areas with cienega-like characteristics (BLM 1993, p. 7; Service 1998, p. 31).

b. Maintain disturbance regimes that reduce competing vegetation and allow for *L. schaffneriana* ssp. *recurva* establishment and growth.

Management of ecosystems that support *L. schaffneriana* ssp. *recurva* should include the promotion of upland and riparian forest health such that regular disturbance is low to moderate intensity and ecosystems are resilient to periodic high intensity flooding. Management may include thinning and prescription fire, removal of non-native or encroaching vegetation, or similar treatments as appropriate. Creation and maintenance of niches where *L. schaffneriana* ssp. *recurva* can survive high intensity flooding and enable recolonization are essential.

2. **Conserve existing and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and their seedbanks, establish new occurrences in appropriate habitat, and establish plants at botanical gardens for research, recovery, and educational purposes.**

2.1. Protect known and newly discovered *L. schaffneriana* ssp. *recurva* occurrences and associated habitat, including unoccupied, intervening drainages that provide connectivity among occurrences.

a. Acquire private lands and associated surface water rights which support occurrences and manage for the protection of the taxon.

The protection of *L. schaffneriana* ssp. *recurva* on privately-owned lands may occur through the purchase and management of said lands by government agencies or other conservation partners. Management of said property would prohibit habitat conversion to non-aquatic uses or the diversion or pumping of water within *L. schaffneriana* ssp. *recurva* habitat. Managers of such lands would develop and implement management plans promoting the conservation of *L. schaffneriana* ssp. *recurva*. Potential sources of funding for the purchase of such properties include section 6 acquisition funds for habitat conservation plans, bond monies through county governments, or Wildlife Refuge acquisition funds.

b. Develop conservation agreements and easements for protection of occurrences on private lands.

Conservation agreements are voluntary agreements between the Service and one or more public or private parties whereby threats and measures to address the threats are identified and implemented to conserve the taxon. In addition, the protection of *L. schaffneriana* ssp. *recurva* on privately-owned lands may occur through the voluntary donation or sale of a conservation easement by a willing landowner to a qualified non-profit organization or branch of government. The deed of easement must identify compatible and incompatible land uses and other management considerations for the taxon and its habitat. At a minimum, the deed of easement must prohibit habitat conversion to non-aquatic uses or the diversion or pumping of water within *L. schaffneriana* ssp. *recurva* habitat. Such lands must be covered by a management plan with best management practices that benefit *L. schaffneriana* ssp. *recurva*. With Conservation agreements and or easements in place, additional funding to support conservation may be more easily attained.

c. Develop and monitor conservation mitigation banking to promote the protection of high quality *L. schaffneriana* ssp. *recurva* habitat.

The development of conservation mitigation banks could aid in the protection of high quality *L. schaffneriana* ssp. *recurva* habitat that is being lost to dewatering and other threats and stressors. Such banks offer a market framework where the purchase of conservation bank credits for section 7 project related impacts can be offset through a one-time credit purchase.

2.2. Establish introduced *L. schaffneriana* ssp. *recurva* occurrences into appropriate habitat using appropriate genetic stock to increase the redundancy (number of occurrences) and resiliency (size of occurrences) of the taxon.

Lilaeopsis schaffneriana ssp. *recurva* has been proven to grow with ease in artificial environments and to transplant easily into the wild. Care should be given to ensure appropriate genetic stock is collected based on the area into which plants are to be introduced. In addition, care should be given to transplant into environments that can be expected to maintain water, at least throughout the majority of the year, over the foreseeable future, and have minimal threats or stressors. Therefore this task includes surveying for and locating potential establishment and donor sites, working with landowners and/or managers to complete all compliance and approvals, growing out propagules (if necessary), transporting plants to the new location, developing and or utilizing accepted protocols for transplanting and monitoring results. Such recovery projects could involve the public, including school groups.

2.3. Maintain plants in captivity at botanic garden and seeds at seed storage facilities.

It is important for research, education, and conservation purposes to maintain individual *L. schaffneriana* ssp. *recurva* plants from a variety of locations, representing genetically distinct occurrences. Vegetative material generated in greenhouse settings can be used for the reestablishment of occurrences should they become locally extirpated. Vegetative material could also be used in experiments regarding response to contaminants, propagation and transplanting techniques, and other pertinent studies. In addition, ensure that seed is collected following the Center for Plant Conservation guidelines, is collected across both wet and dry years, and from a variety of geographic areas to ensure maximum genetic variability. Seed should be stored at both the Agricultural Research Service National Center for Genetic Resources Preservation in Fort Collins, Colorado and stored according to protocols at a local facility such as the Desert Botanical Gardens in Phoenix, Arizona. In accordance with protocol, seed would be tested regularly for viability and replacement as necessary. Seeds would be used for research, seed banking, augmentation, and reintroduction.

3. Remove stressors to *L. schaffneriana* ssp. *recurva* occurrences and their habitats.

3.1. Protect occupied habitats and watersheds from congregating livestock and recreation activities, especially during dry periods.

High levels of livestock use can accelerate erosion and sedimentation of *L. schaffneriana* ssp. *recurva* habitat. In particular, high levels of livestock can occur during periods of drought when livestock congregate around drying pools. It is important to work with land managers, leasees, and land owners to remove livestock from such areas at times when adequate water is unavailable to disperse cattle and thus reduce impacts.

3.2. Control invasive non-native plants and prevent their spread in *L. schaffneriana* ssp. *recurva* habitat.

Although both native and non-native plants compete for nutrients, water, and light, the additional competition caused by non-native plants puts undue stress on *L. schaffneriana* ssp. *recurva* and its habitat. Efforts should be made to prevent further introduction or spread of non-natives in systems that support *L. schaffneriana* ssp. *recurva*. Whenever possible, established non-native plants should be removed from systems that support *L. schaffneriana* ssp. *recurva*.

4. Develop a standardized monitoring technique based on existing protocols; monitor *L. schaffneriana* ssp. *recurva* occurrences, threats, and outcomes from management actions allowing for adaptive management.

4.1. Develop a range-wide standardized monitoring approach based on existing approaches (see Cienega Creek National Conservation Area and the San Pedro National Conservation Area as examples) that will be adopted by all land managers, land owners, and conservation partners which will enable an understanding of current status and knowledge of when recovery criteria have been met. This will include: 1) timing of survey, 2) protocol for measuring square meters covered by the plant, and 3) assessing the health of occurrences and threats. Introduced and augmented occurrences should be monitored at least every three years.

Currently there is no standard protocol for monitoring *L. schaffneriana* ssp. *recurva*, with different land management agencies using different protocols. Divergent methods make data analysis difficult, at best. To evaluate changes in habitat, species occurrence size and distribution, extent of occurrences per the recovery criteria, level of threats at each occurrence, and demographic processes of *L. schaffneriana* ssp. *recurva* occurrences throughout the range, repeated measurements at least every three years are needed.

4.2. Monitor natural and augmented occurrences at least every three years.

By repeatedly monitoring occurrences, we can determine if the recovery criteria are being met and adapt management accordingly. Several land management agencies already conduct regular monitoring of established plots and survey areas; it is critical that this monitoring continue, as it provides needed long-term data allowing managers to make informed decisions based on trends. Additional monitoring for long term trends should be established throughout the range of the taxon.

4.3. Monitor effects of climate change and groundwater pumping in areas most likely to be affected by those threats.

Much of the range of *L. schaffneriana* ssp. *recurva* is impacted by climate change and drought, as well as groundwater pumping. This taxon is particularly vulnerable to even small losses in groundwater availability. Therefore, it is important to monitor water availability through time, in addition to monitoring the response of *L. schaffneriana* ssp. *recurva*.

4.4. Review the status of the taxon periodically to assess the effectiveness of management and recovery actions.

Management actions must be monitored to assess their effectiveness or discover unintended consequences. Management plans shall be modified if they are unsuccessful at providing protection and promoting recovery of *L. schaffneriana* ssp. *recurva* and its habitat. This will facilitate the implementation of an adaptive management approach to recovery.

5. Encourage scientific study to improve our understanding of *L. schaffneriana* ssp. *recurva* geography, ecology, viability, genetics, propagation, restoration, and threats in the United States and Mexico.

5.1. Identify information gaps, compatible land uses, and appropriate management actions that promote the conservation of the taxon.

It is important to identify gaps in our current understanding of the taxon and how it relates to certain land management practices. Such information will inform better management of the taxon for its continued protection and recovery.

5.2. Conduct surveys in appropriate habitat to better understand the range of the taxon.

There is potential habitat in both the United States and Mexico that has not been surveyed for the presence of *L. schaffneriana* ssp. *recurva.* Additional surveys are needed and repeat measures conducted to confirm continued presence at known locations.

5.3. Conduct research into biology, ecology, and genetics of the taxon.

Although we currently know more about *L. schaffneriana* ssp. *recurva* then at the time of listing, there remains a great deal of biology, ecology, and genetics that we still do not understand. The following research to help recover this species is needed:
a) how long this taxon is able to withstand dewatering,
b) how it interacts with invasive native and non-native plants,
c) its tolerance to grazing and trampling,
d) its ability to come back following floods of various intensity,
e) how the two varieties in Mexico are related genetically,
f) what are the major pollinators of the taxon, and
g) many other questions, would aid in the management and recovery of the taxon.

6. Develop public outreach, collaborative partnerships, agency management plans, and agreements with private land owners in the United States and Mexico that encourage *L. schaffneriana* ssp. *recurva* conservation.

6.1. Work with others to increase public outreach regarding stressors, threats, and conservation measures relating to *L. schaffneriana* ssp. *recurva* in both the United States and Mexico.

Work with both United States and Mexican government agencies, academic institutions, non-government organizations, and private citizens to promote public outreach and ultimately recovery of the taxon throughout its range.

6.2. Develop collaborative partnerships and agreements with private land owners that result in management plans or that otherwise encourage *L. schaffneriana* ssp. *recurva* conservation in the United States and Mexico.

Develop partnerships with both United States and Mexican government agencies, academic institutions, non-government organizations, and private citizens to promote study, conservation, and recovery of the taxon throughout its range. The creation and adherence to management plans that address threats are necessary to protect the taxon and its habitat. Plans should include prescriptions to protect *L. schaffneriana* ssp. *recurva* from habitat degradation, invasive non-native plant species, and that address the timing and duration of livestock grazing.

6.3. Develop a recovery implementation team comprised of species experts, agency and non-government agency partners, landowners, and stakeholders to meet regularly, work on recovery actions, review progress, discuss problems, and revise this plan as needed.

This plan may need to be revised to address changing conditions, incorporate new findings, and update recovery actions. To ensure plan use and usefulness, the involvement of an implementation team is suggested. Recovery actions such as restoring watersheds, introducing plugs into suitable habitat, and purchasing water rights and easements are essential to the recovery of this taxon.

Part III. Implementation

The following implementation schedule is comprised of three overarching elements that then tier down to individual recovery actions for implementation. The implementation schedule outlines actions and estimated costs for this draft recovery plan. It is a guide for meeting the objectives discussed in Chapter II. This schedule also prioritizes actions, provides an estimated timetable for performance of actions, and proposes the responsible parties for actions. For the sake of brevity in the Implementation Schedule, annual costs are shown for the first 5 years, along with an estimated total cost over a twenty year period. Actions are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions. The most detailed actions are assigned a priority number for implementation. The actions in the Implementation Schedule, when accomplished, should result in the recovery and conservation of the species.

Key to Terms and Acronyms Used in the Recovery Action Narrative and Implementation Schedule:

Priority numbers are defined per Service policy (Service 1983) as:

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2: An action that must be taken to prevent a significant decline in the species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Definition of Action Durations:

C = Continual - An action that may not be currently underway, but will be implemented throughout the 20 year recovery period on a routine basis, once initiated.

I = Initial – An action that will be done initially once the recovery plan is adopted.

P = Periodic – An action that will be done periodically or on a rotating basis, such as monitoring.

5 = Every 5 years – An action that will be done every five years, such as the review of the status of the species.

TBD: To Be Determined.

Responsible Parties:

ALWT	Arizona Land and Water Trust
ASDM	The Arizona Sonora Desert Museum
ASU	Arizona State University
BLM	Bureau of Land Management
DBG	The Desert Botanical Garden
FTH	United States Army Fort Huachuca
FWS	U.S. Fish and Wildlife Service
GOV	State or local governments and municipalities
NGO	Non-government organization
PVT	private citizens
SNAT	Secretaría de Medio Ambiente y Recursos Naturales
TNC	The Nature Conservancy
UA	University of Arizona
USFS	United States Forest Service
USGS	United States Geological Survey
UNAM	Universidad Nacional Autónoma de Mexico
USON	Universidad de Sonora

Responsible parties are those agencies who may voluntarily participate in implementation of particular actions listed within this draft recovery plan. Responsible parties may willingly participate in project planning, or may provide funding, technical assistance, staff time, or any other means of implementation; however, responsible parties are not obligated to implement any of these actions. Other parties are invited to participate in the recovery of *L. schaffneriana* ssp. *recurva*, as well.

Implementation Schedule.

Costs are shown in 1,000s of dollars; Total Cost is shown for a 20 year period. Total cost over a 20 year period is $52,006,000.

The importance of preventing excessive water drawdown and increasing water recharge into the San Pedro, Santa Cruz, and Rio Yaqui watersheds in the United States cannot be understated in the recovery of this and co-occurring listed species. Arizona is an arid state with finite water supplies, a population expected to double by 2050, and ongoing drought (ADWR 2014, entire; Marshall et al. 2010, p. 1). There is a potential for a long-term imbalance between available water supplies and projected water demands over the next 100 years if no action is taken (ADWR 2014, entire). A clean and sustainable water supply is essential for humans and the environment; water resources planning must embrace the need for water for urban growth, as well as environmental water needs (Marshall et al. 2010, p. 1).

Using water more efficiently, reusing water, capturing water, and purchasing surface water rights are all methods whereby water availability can be increased for the benefit of *L. schaffneriana* ssp. *recurva*, and would have added benefit to many other co-occurring listed and unlisted plant and animal species, ecosystem services provided by healthy watersheds, and economic benefits such as from increased tourism. It is unknown if all of the below-listed methods will need to be or even can be employed to down-list or de-least this taxon. Issues surrounding water are complex and the political, social, economic, and environmental aspects of water are constantly changing, and may affect the scope and scale of the implementation of these recovery actions. In addition, actions taken to improve aquatic habitats for *Spiranthes delitescens* (Canelo Hills ladies' tresses),Chiricahua leopard frog (*Lithobates chiricahuensis*), Northern Mexican gartersnake (*Thamnophis eques megalops*), beautiful shiner (*Cyprinella formosa*), desert pupfish (*Cyprinodon macularius*), Gila chub (*Gila intermedia*), Gila topminnow (*Poeciliopsis occidentalis occidentalis*), Yaqui catfish (*Ictalurus pricei*), Yaqui chub (*Gila purpurea*), Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis*), southwestern willow flycatcher (*Empidonax traillii extimus*), and yellow-billed cuckoo (*Coccyzus americanus*) would benefit *L. schaffneriana* ssp. *recurva*; therefore costs listed below may not reflect the actual cost of recovery as such costs may be distributed across a variety of efforts targeting riparian and aquatic restoration, reducing the recovery cost per species.

Implementation Schedule for *Lilaeopsis schaffneriana* ssp. *recurva*

Priority Number	Action Number	Action Description	Action Duration (Years)	Responsiblity Parties	Total Cost ($1,000s)	Cost ($1,000s); Time Frames (Years)				
						1-5	6-10	11-15	16-20	
1	1.1a	Acquire surface water rights and convert them to in-stream uses or apply for rights anew and defend them in a court of law.	C	ALWT BLM FTW FWS GOV PVT TNC USFS	12,000	3,000	3,000	3,000	3,000	Acquire surface water rights (~$1,000/acre foot).
1	1.1b, 2.1b	Acquire conservation easements to protect larger lands from being subdivided into smaller lots with increased residential pumping per acre.	C	ALWT BLM FTW FWS GOV TNC USFS	9,200	2,300	2,300	2,300	2,300	Acquire conservation easements (~$1,500/acre).
1	1.1c	Encourage incentive programs to reduce water use across the range of *L. schaffneriana* ssp. *recurva*.	C	FTW GOV	3,900	975	975	975	975	Promote and implement water saving incentive programs (~195,000/year).
1	1.1d	Upgrade wells and check for leaks to reduce water loss.	C	ALWT BLM FTW GOV PVT TNC USFS	500	125	125	125	125	Promote and implement well upgrades and repairs (~25,000/year).
1	1.1e	Promote storm water recapture projects.	C	FTW GOV	2,200	550	550	550	550	Promote and implement storm water recapture (~$110,000/year).
1	1.1f	Promote use of treated effluent to offset outdoor irrigation.	C	FTW GOV	2,200	550	550	550	550	Promote and implement effluent treatment (~$110,000/year).

Priority Number	Action Number	Action Description	Action Duration	Responsiblity	Total Cost	Cost ($1,000s); Time Frames (Years)				
1	1.2a	Remove invading trees and shrubs in upland grasslands; reduce heavy fuel loads in upland forests; create in-channel structures in upland tributaries and; introduce beaver where appropriate.	C	ALWT BLM FTH FWS PVT TNC USFS	5,000	2,000	1,500	1,000	500	In 2014, the Arizona Water Protection Fund provided grants for management and restoration work on the San Pedro ($396,409) and Babocomari ($118,125) Rivers. We used these projects to estimate the cost and scale of similar projects that would benefit the taxon.
1	1.2b	Maintain disturbance regimes that reduce competing vegetation and allow for L. schaffneriana ssp. recurva establishment and growth.	C	ALWT BLM FTH FWS PVT TNC USFS	5,000	2,000	1,500	1,000	500	In 2014, the Arizona Water Protection Fund provided grants for management and restoration work on the San Pedro ($396,409) and Babocomari ($118,125) Rivers. We used these projects to estimate the cost and scale of similar projects that would benefit the taxon.
2	2.1a	Acquire private lands and associated surface water rights which support occurrences and manage for the protection of the taxon.	C	BLM FWS TNC USFS	10,000	3,000	3,000	3,000	1,000	In 2014, The Nature Conservancy had for sale a 452.58 acre property which includes 6 miles of the San Pedro River at a cost of $1,035,000. We used this property to estimate the cost of similar property purchases as they may come available across the range of the taxon.

Priority Number	Action Number	Action Description	Action Duration	Responsiblity	Total Cost	Cost ($1,000s); Time Frames (Years)				
3	2.1c	Develop and monitor conservation mitigation banking to promote the protection of high quality *L. schaffneriana* ssp. *recurva* habitat.	C	ALWT FWS GOV Private TNC	55	15	14	13	13	We based this cost on the cost of private conservation bank development and monitoring for the Pima pineapple cactus (*Coryphantha scheeri* var. *robustispina*) of southern Arizona.
2	2.2	Establish introduced *L. schaffneriana* ssp. *recurva* occurrences into appropriate habitat using appropriate genetic stock to increase the redundancy / resiliency of the taxon.	C	ALWT BLM FTH FWS GOV TNC USFS	100	30	30	30	10	We based this cost on propagation of the taxon in greenhouses. Planting with volunteer assistance, as well as direct planting (no green-house time), will reduce cost.
2	2.3	Maintain plants in captivity at botanic garden and seeds at seed storage facilities.	C	ASDM DBG	202	50.5	50.5	50.5	50.5	We based this cost on estimates from two botanical gardens to care for 40 plants; costs to care for seeds are ~$100/year and are incorporated into the 20 year total.
2	3.1	Protect occupied habitats and watersheds from congregating livestock and recreation activities, especially during dry periods.	C	ALWT BLM PVT TNC USFS	300	75	75	75	75	We based this cost on two people ($32/hour, 30 days/year) checking and maintaining throughout the range of the taxon: a) pasture and exclosure fences, b) occurrences, especially during the driest times of the year, and c) enforcing cattle removal if necessary.

Priority Number	Action Number	Action Description	Action Duration	Responsiblity	Total Cost	Cost ($1,000s); Time Frames (Years)				
2	3.2	Control invasive non-native plants and prevent their spread in *L. schaffneriana* ssp. *recurva* habitat.	C	ALWT BLM FTH FWS GOV PVT TNC USFS	650	300	200	100	50	We based this cost on a USFS estimate of treating exotic invasive plants with herbicide ($200/acre) and ~ 3,236 acres of land surrounding known occurrences of the taxon in the US. Volunteer labor for hand pulling efforts may also be necessary for maintenance.
2	4.1	Develop a range-wide standardized monitoring approach based on existing approaches that will be adopted by all land managers which will enable an understanding of the current status and knowledge of when recovery criteria have been met.	I P	ALWT BLM FTH FWS GOV PVT TNC USFS	15	10	0	0	5	We based this cost on time for interagency personnel to attend meetings and develop methodology in the field; also will need input of statistician and periodic review of effectiveness of methodology for answering questions ($32/hour, 20 people, 3 days total)
2	4.2	Monitor natural and augmented occurrences at least every three years.	P	BLM FTH FWS TNC USFS	200	50	50	50	50	We based this cost on the cost of personnel and travel to monitor occurrences on a rotating basis, with at least some occurrences being monitored each year ($32/hour, 10 hours/day, 3 people, $50 gas per trip, 10 days/year).

Priority Number	Action Number	Action Description	Action Duration	Responsiblity	Total Cost	Cost ($1,000s); Time Frames (Years)				
2	4.3	Monitor effects of climate change and groundwater pumping in areas most likely to be affected by those threats.	P	BLM FTH FWS GOV TNC USFS USGS	40	10	10	10	10	We based this cost on the cost of personnel and travel to periodically monitor groundwater pumping and drought ($32/hour, 10 hours/day, 3 people, $50 gas per trip, 10 days/year).
2	4.4	Review the status of the taxon periodically to assess the effectiveness of management and recovery actions.	P	ALWT BLM FTH FWS GOV PVT TNC USFS	22	5.5	5.5	5.5	5.5	We based this cost on time for interagency personnel to analyze data and attend meetings to discuss management effectiveness ($32/hour, 20 people, 1 8-hour day / review, $50gas / every 2 people/ review).
2	5.1	Identify information gaps, compatible land uses, and appropriate management actions that promote the conservation of the taxon.		ALWT ASDM ASU BLM DBG FTH FWS GOV PVT SNAT TNC UA USFS USON UNAM	90	30	30	30		We based this cost on the average cost of scientific studies of Arizona's rare plants that have been funded through our section 6 program. Anticipating one study per 5 year period for the first 15 years of recovery, at an average cost of $30,000 per study.

Priority Number	Action Number	Action Description	Action Duration	Responsiblity	Total Cost	Cost ($1,000s); Time Frames (Years)				
2	5.2	Conduct surveys in appropriate habitat to better understand the range of the taxon.		ALWT ASDM ASU BLM DBG FTH FWS GOV PVT SNAT TNC UA USFS USON UNAM	60	30	30			We based this cost on the average cost of scientific studies of Arizona's rare plants that have been funded through our section 6 program. Anticipating one study per 5 year period for the first 10 years of recovery, at an average cost of $30,000 per study.
2	5.3	Conduct research into biology, ecology, and genetics of the taxon.		ALWT ASDM ASU BLM DBG FTH FWS GOV PVT SNAT TNC UA USFS USON UNAM	150	60	30	30	30	We based this cost on the average cost of scientific studies of Arizona's rare plants that have been funded through our section 6 program. Anticipating two studies in the first 5 year period and one study per 5 year period of recovery thereafter, at an average cost of $30,000 per study.

Priority Number	Action Number	Action Description	Action Duration	Responsiblity	Total Cost	Cost ($1,000s); Time Frames (Years)				
2	6.1	Work with others to increase public outreach regarding stressors, threats, and conservation measures relating to *L. schaffneriana* ssp. *recurva* in both the United States and Mexico.	C	ALWT BLM FTH FWS GOV NGO PVT SNAT TNC USFS	50	12.5	12.5	12.5	12.5	We estimated this cost based on the cost of creating outreach materials, conservation agreements and management plans, as well as developing relationships through presentations and field trip participation ($32/hour, 8 hour days, 10 / year, 1 person, printing, gas, and other costs).
2	6.2	Develop collaborative partnerships and agreements with private land owners that result in management plans or that otherwise encourage *L. schaffneriana* ssp. *recurva* conservation in the United States and Mexico.	C	ALWT BLM FTH FWS GOV NGO PVT SNAT TNC USFS	50	12.5	12.5	12.5	12.5	We estimated this cost based on the cost of creating outreach materials, conservation agreements and management plans, as well as developing relationships through presentations and field trip participation ($32/hour, 8 hour days, 10 / year, 1 person, printing, gas, and other costs).
3	6.3	Develop a recovery implementation team comprised of species experts, agency and non-government agency partners, landowners, and stakeholders to meet regularly, review progress, discuss problems, and revise this plan as needed.	5	ALWT ASDM DBG FTH FWS GOV NGO PVT TNC USFS	22	5.5	5.5	5.5	5.5	We based this cost on time for interagency attend meetings to discuss recovery (costs include travel to central location, hotel rooms, and per diem).

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Appendix A - Status and trends of the occurrences within the United States and Mexico as of November 2014

(slightly modified from the August 2014 *Lilaeopsis schaffneriana* ssp. *recurva* Five Year Review)

United States Army Fort Huachuca:

Lilaeopsis schaffneriana ssp. *recurva* occurs in four canyons on Fort Huachuca, all of which are monitored regularly by Fort Huachuca personnel and discussed individually below. Inventory, monitoring, and management of this taxon have been implemented on Fort Huachuca since 1999 (Brewer pers. comm. May 2, 2014). In addition, Fort Huachuca has conducted an inventory of all potential *L. schaffneriana* ssp. *recurva* habitat on the installation every four years. The inventory encompasses 16 marshland sites (inventory segments), originally identified during the 1999 installation-wide inventory of potential water umbel habitat, which are surveyed to determine presence, distribution, and percentage of critical habitat occupied by *L. schaffneriana* ssp. *recurva* using Service approved methodology (Vernadero Group 2010, p. iii). Inventory surveys were conducted in 1999 and subsequently in 2002, 2005, 2009 (Vernadero Group 2010, pp. iii-1), and 2013 (Brewer pers. comm. January 17, 2014). Monitoring surveys have been conducted in 2000, 2001, 2003, 2004, 2006, 2008, and 2011 (ENRD 2012, p. 1). Although occurrences were last inventoried in 2013 following a heavy monsoon season, no report was completed at the time of this review (Brewer pers. comm. January 17, 2014). The most recent monitoring report identified that the percent of transect occupied generally increased between 2008 and 2011 (the dates for which data comparison is possible). Although the percentage of occupied habitat has decreased over the years, the general distribution has been consistent since 1999 (Vernadero Group 2009, p. 2; Directorate of Public Works 2013, p. 2). Monitoring results suggest that water umbel has become either less prevalent or more difficult to detect as time passes (or perhaps some combination of the two) (Vernadero 2010).

Garden Canyon – *Lilaeopsis schaffneriana* ssp. *recurva* was first noted in Garden Canyon in 1958 (Gooding 1958, entire). Warren et al. (1991, p. 19) noted two separate occurrences in this canyon; one having widely scattered patches, the other, thick mats. Multiple patches of *L. schaffneriana* ssp. *recurva*, primarily located between upper Garden Canyon pond and the upper Garden Canyon picnic area, are monitored regularly (e.g. EEC 2001, entire; EEC 2002, entire; ENRD 2005, entire; Vernadero Group 2009, entire; Vernadero Group 2010, entire; Directorate of Public Works 2013, entire). Areas below middle Garden Canyon Picnic area do not contain suitable habitat for *L. schaffneriana* ssp. *recurva* (Vernadero Group 2010, p. 10). Much of the Canyon contains high cover of bunchgrasses and marshland species, including the invasive exotic *Nasturtium officinale* (watercress), making detection difficult and some historical occurrences have not been relocated in recent years (Vernadero Group 2009, p. 10). This canyon supports the greatest extent of *L. schaffneriana* ssp. *recurva* on Fort Huachuca (ENRD 2012, p. 8). In July 2014, a monsoon-related flood within Garden Canyon removed 2 of 14 monitored patches of *L. schaffneriana* ssp. *recurva* along with nearby competing vegetation (Brewer pers. comm. July 17, 2014).

Sawmill Canyon – A single occurrence of *L. schaffneriana* ssp. *recurva* was documented in this tributary of Garden Canyon in 1979 (Yatskievych 1979, entire). In 1991, Warren et al. (p. 19) reported this occurrence contained five small patches. In 2000, the staff at Fort Huachuca set up a permanent monitoring transect in the Sawmill Canyon *L. schaffneriana* ssp. *recurva*

occurrence. In 2004, EEC (p. 4) reported Sawmill Canyon supports a Madrean montane marshland dominated by deergrass. In 2009, this occurrence was reported to have a patch size of 4.15 by 2.7 m (13.6 by 8.9 ft) (Vernadero Group 2009, p. 6). As of the 2013 surveys, this occurrence was 4.62 by 1.24 m (15.2 by 4.1 ft) (Directorate of Public Works 2013, p. 2; Brewer pers. comm. May 2, 2014). A second occurrence was detected in 2002, but has not been detected since (EEC 2004, p. 9; ENRD 2006, p. 3; Vernadero Group 2009, p. 13).

McClure Canyon – A single occurrence containing a single patch of *L. schaffneriana* ssp. *recurva* 3.62 by 2.76 m (11.9 by 9.1 ft) across was documented in McClure Canyon in 1997 (Vernadero Group 2009, p. 3). The patch has been documented in subsequent years of survey, including 2013 (Vernadero Group 2009, p. 9; Directorate of Public Works 2013, p. 2). This occurrence is near McClure Spring in a small pool surrounded by *Muhlenbergia rigens* (deergrass - a native, warm-season, perennial bunchgrass, and a possible competitor), *Carex ultra* (Cochise sedge), and *Eleocharis* sp. (spikerush) (Vernadero Group 2009 p. 2). The exact location of the *L. schaffneriana* ssp. *recurva* patch has shifted downslope; the previous site now is filled with sediment (Vernadero Group 2010, p 12).

Huachuca Canyon – A single occurrence of *L. schaffneriana* ssp. *recurva* that likely dispersed from transplanted plugs (small containerized plants with roots encased in potting soil) was documented in Huachuca Canyon in 2013 (see Introduced and Augmented Populations section below; Directorate of Public Works 2013, p. 2).

United States Forest Service:
Lilaeopsis schaffneriana ssp. *recurva* occurring on Forest Service lands are monitored periodically by Forest Service personnel. The last monitoring in Scotia, Sunnyside, and Bear Canyons occurred in the fall of 2013; no report was completed at the time of this review (Kraft pers. comm. November 22, 2013). While some Forest Service occurrences seem to be stable, others are in decline or are now considered extirpated.

Scotia Canyon – *Lilaeopsis schaffneriana* ssp. *recurva* was first noted in Scotia Canyon in 1988 where it was documented from an upper and lower portion of the canyon, separated by a dry middle section (Gori et al. 1990). Monitoring of permanent transects began in 1989 along the upper section (Gori et al. 1990); in 1995, the Forest Service began monitoring plants in both the upper and lower sections and this continued in 2013. In 2003, *L. schaffneriana* ssp. *recurva* was found throughout reach 2 of this canyon where there were reported marshy areas and shallow pools, though the banks were lined with *M. rigens* (Stefferud and Stefferud 2004, p. 511). Significant flows from the 2013 monsoon season scoured this canyon and because of this, larger patches of *L. schaffneriana* ssp. *recurva* were not as prevalent in the lower canyon portion as in previous years of survey; the flood also removed competing vegetation (Kraft pers. comm. February 26, 2014). Patches were found at roughly the same frequency in 2013 as in past surveys (Kraft pers. comm. November 22, 2013). In late August, 2014, severe monsoon flooding again caused scouring within Scotia Canyon. At the time of writing, the impact to the patches of *L. schaffneriana* ssp. *recurva* in Scotia Canyon is unknown. Plants in this canyon have historically represented some of the densest occurrences of *L. schaffneriana* ssp. *recurva* known (Service 2001, p. 7; Falk 1998, p. 1).

Sunnyside Canyon – *Lilaeopsis schaffneriana* ssp. *recurva* was first noted in Sunnyside Canyon in 1991 (McLaughlin 1991, entire); the plants were surveyed in 2000, followed by every other year through 2007, then again in 2013 (Service 2001, p. 2; Deecken pers. comm. September 7, 2013). In 2013, significant flows from the monsoon season scoured this canyon, although larger patches of *L. schaffneriana* ssp. *recurva* were found, the overall extent of *L. schaffneriana* ssp. *recurva* in this canyon is believed to have contracted from previous years (Kraft pers. comm. November 22, 2013). In late August 2014, severe monsoon flooding again caused scouring within Sunnyside Canyon. At the time of writing, the impact to the patches of *L. schaffneriana* ssp. *recurva* in Sunnyside Canyon is unknown. In 2003, the Stefferuds reported competition from *M. rigens* was moderately high (Stefferud and Stefferud 2004, p. 542); in 2013, it was said to be high in a few places (Kraft pers. comm. November 22, 2013).

Bear Canyon – *Lilaeopsis schaffneriana* ssp. *recurva* was first collected in Bear Canyon in 1949 (Gooding 1949, entire). In 1989, Warren et al. (p. 60) noted that *L. schaffneriana* ssp. *recurva* occurred in two small patches within Bear Creek and was not doing as well as in its tributary canyons that contained less rocky habitat with a lower stream gradient. In 2013, *L. schaffneriana* ssp. *recurva* was found in Bear Canyon where there was substrate for rooting, both as a few large patches and as singular plants in several instances (Kraft pers. comm. November 22, 2013). In 2013, *M. rigens* competition was high in portions of the canyon (Kraft pers. comm. November 22, 2013).

Lone Mountain Canyon – A single *L. schaffneriana* ssp. *recurva* occurrence of medium to high density was reported at the confluence of Lone Mountain Canyon and Bear Creek in 1988, 1990, and 1997 (Gori et al. 1990, p. 65; Warren et al. 1989, p. 60). The winter of 1999 was very dry; heavy use by congregating cattle on *L. schaffneriana* ssp. *recurva* habitat in Lone Mountain Canyon and associated tributaries was observed (Service 2002b, p. 146). This same year, the Forest Service proposed the creation of a livestock exclosure fence encompassing 2.8 hectares (7 acres) of canyon bottom near the confluence with Bear Canyon to protect the plants (Service 1999, p. 240). The Forest Service also decided that winter grazing outside of the exclosure in this canyon would be permitted only when sufficient water was available to promote cattle dispersal (Service 1999, p. 240).

The timing of when the Lone Mountain Canyon exclosure was erected is not known by this author, however a 2003 Grazing Authorization and Allotment Management Plan for the Lone Mountain Allotment indicates an exclosure *would be* established on behalf of *L. schaffneriana* ssp. *recurva* in Lone Mountain Canyon at the confluence with Bear Canyon (USFS 2003, p. 5). In 2004, Stefferud and Stefferud (p. 335) reported the exclosure fencing around the *L. schaffneriana* ssp. *recurva* in the wetted area of Lone Mountain Canyon near the confluence with Bear Creek was torn down and extensive cattle grazing occurred. They reported many areas that were completely denuded of vegetation and littered with fecal material; green plants in the riparian area were mostly grazed to the root crown or trampled (Stefferud and Stefferud 2004, p. 335).

In 2014, areas both inside and outside of the (intact) exclosure were visited and *L. schaffneriana* ssp. *recurva* was found in both locations. Inside the exclosure, it occurred in multiple small patches in slow-moving shallow water along a narrow waterway and growing among moss and

other aquatic and semi-aquatic wetland vegetation (Service 2014a, p. 5). Approximately 250 m (829 ft) upstream and outside of the exclosure, approximately 10 small patches of *L. schaffneriana* ssp. *recurva* were found growing among the river cobble in an area containing other aquatic habitat indicators, but which was drying out and had no water or wet soil present. Approximately 10 m (33 ft) further upstream from this location, four additional patches were located growing on the slumping edges of a water-filled mud hole heavily utilized by livestock (Service 2014a, p. 6). These plants were small in stature and the patches very sparse, occurring within the hoof-prints of cattle, with adjacent cow pies and slumping stream banks (Service 2014a, p. 6). In July, 2014, this site was revisited following monsoon-related flooding. The mud hole had been filled with sediment and no *L. schaffneriana* ssp. *recurva* were discovered, though it is possible they could grow through the sediment (Kraft pers. comm. July 30, 2014).

Wakefield Mine springbox – An occurrence was discovered by US Forest Service personnel in 2008 at the springbox of the Wakefield Mine and was revisited in 2014 (Kraft, pers. comm. July 30, 2014). The springbox overflows creates two shallow pools and a perennial "stream" approximately 50 m (164 ft) in length. In 2014, *L. schaffneriana* ssp. *recurva* occurred in the pools and along the "stream" in one large patch.

Parker Canyon Lake – First collected in 1968, this occurrence was not visited again until 2007 when some small plants were noted near the inlet channel with Merrit Canyon along the lake margin (AZGF Heritage 2011, entire; Rorabaugh 2013, p. 1). In March of 2014, researchers combed the inlet channels of both Merrit Canyon and Collins Canyon (Service 2014a, pp. 1-2). Although no *L. schaffneriana* ssp. *recurva* was detected at this time, other aquatic habitat indicators were found among the thick thatch of dried aquatic vegetation. Because the winter of 2013-2014 was particularly warm and dry and the lake level was down, it is probable *L. schaffneriana* ssp. *recurva* still occurs at the Merrit Canyon inlet, and possibly the Collins Canyon inlet as well. Further searches should be conducted in a wet year and reduction of the dead thatch is recommended.

Freeman Spring – In September 1998, *L. schaffneriana* ssp. *recurva* was discovered at Freeman Spring (Service 1999, p. 241). In October 1998, the site was reported to be severely overgrazed, with utilization over 70% and the spring site trampled with little vegetative growth on the banks; the site was fenced from cattle in 1998 (Service 1999, p. 242). In 1999, the *L. schaffneriana* ssp. *recurva* occurrence at Freeman Spring was thought to be small and the habitat reported to be primarily exposed bedrock with a lack of soil, not capable of supporting a large stable occurrence of *L. schaffneriana* ssp. *recurva* (64FR37441, 1999 p. 34777; Lefevre 1999, entire). This occurrence was deemed important, though not essential to the conservation of the taxon (64 FR 37441, p. 34777).

In 2004, Stefferud and Stefferud noted Freeman Spring was a seep with *L. schaffneriana* ssp. *recurva* present. They noted the reach likely once had cienega attributes before erosional downcutting of the channel (Stefferud and Stefferud 2004, p. 249). In 2007, Ehret et al. (2007, p. 1) noted the presence of cienega habitat from Freeman Spring downstream for approximately 48 m (157 ft). In 2008, Freeman Spring was reported to be completely dry due to the drought (Ehret 2008, p. 1). Although these biologists were focused on quantifying fish habitat, they did note vegetation in their reports and no *L. schaffneriana* ssp. *recurva* were mentioned in either 2007 or

2008. In 2010, personnel from the National Audubon Society's Appleton-Whittell Ranch communicated that Freeman Springs tends to dry every year during the early summer (Robinson 2010, p 6). A December site visit in 2013 revealed a single small pool at Freeman Springs with no *L. schaffneriana* ssp. *recurva* present and no potential habitat available (Service 2013a, p. 4).

Sycamore and Mud Springs – In 1993, a herbarium specimen was collected from the outlet of Sycamore Spring; associates included *Muhlenbergia* sp. and *Juncus* sp., but no *Cynodon dactylon* (Bermuda grass), a non-native, invasive species, was listed (Fishbein 1993, entire). No specimens have been collected from Mud Spring. In 1999, the *L. schaffneriana* ssp. *recurva* occurrences at Sycamore and Mud Springs were thought to be small and the habitat not capable of supporting a large stable occurrence (64 FR 37441, 1999 p. 34777). These occurrences were deemed important, though not essential to the conservation of the taxon (64 FR 37441, p. 34777). In 2003, reach 2 of Sycamore Canyon, containing Sycamore Spring, supported *L. schaffneriana* ssp. *recurva* along with *C. dactylon*, *M. rigens*, *Carex* spp. and other riparian vegetation that was badly damaged, hedged, and cropped by past and present livestock grazing (Stefferud and Stefferud 2004, p. 557). This same survey found the exclosure fence around Mud Spring that was intended to protect *L. schaffneriana* ssp. *recurva* was in disrepair (Stefferud and Stefferud 2004, p. 558). At Mud Spring, cattle heavily impacted the area, and the only riparian plants found were grasses, *Eleocharis* sp. and *Carex* spp. (Stefferud and Stefferud 2004, p. 558).

L. schaffneriana ssp. *recurva* has been seen regularly in visits by the Forest Service to Sycamore Spring (Kraft pers. comm. February 26, 2014). The area is noted to have had intensive grazing in the past, but this has improved in recent years (Kraft pers. comm. February 26, 2014). In 2014, a survey of Mud Spring revealed many patches of *L. schaffneriana* ssp. *recurva* occurring outside and inside of an erect bullfrog fence. Patches outside the exclosure occurred in two separate spring runs, one of which was heavily impacted by livestock trampling (Service 2014a, p. 3). These patches were small in stature and sparse, but appeared healthy otherwise. Patches within the exclosure on the south and southeast edges of the spring pool were small and sparse, growing among thick *C. dactylon* (Service 2014a, p. 4). Patches on the north and northwest edges of the spring pool and within the water there were dense, over 30 cm tall (11.8 in), and healthy with little competition from other vascular plants (Service 2014a, p. 3).

O'Donnell Canyon – see The Nature Conservancy below.

Joaquin Canyon – In July 2001, Deecken (2002, entire) surveyed Joaquin Canyon as part of the Lone Mountain Land Exchange. He noted that no *L. schaffneriana* ssp. *recurva* were observed in the portion of the canyon north of FS61, however he did find two new occurrences, each containing several patches, in an area to the south of FS61 and east of FS196 (Deecken 2002, p. 2). These occurrences are north of the Cave Canyon confluence occurrence now in private ownership (see Private –Joaquin Canyon section below). The site was described as intermittent riparian stream bottom with a few perennial small pools and less than ten percent canopy cover of riparian trees. Tom Deecken recalls these plants were mostly in areas where water was quite shallow and were most susceptible to drought conditions (Deecken pers. comm. February 2014a, b). In 2003, this area was described as having surface water in wide shallow glides, pools, and marshy areas, with sparse vegetation that was severely hedged by livestock; no *L. schaffneriana* ssp. *recurva* was noted at that time (Stefferud and Stefferud 2004, p. 293). In 2014, this site was

revisited and two locations containing species of aquatic habitats were located (Service 2014a, pp. 2-3). A single puddle of water approximately 10 cm (4 in) across was found, but no *L. schaffneriana* ssp. *recurva* was detected (Service 2014a, pp. 2-3). The winter of 2013-2014 was very warm and dry; it is likely *L. schaffneriana* ssp. *recurva* still occurs at these locations within Joaquin Canyon and a survey in a wetter year should be conducted.

United States Bureau of Land Management:
Lilaeopsis schaffneriana ssp. *recurva* occurring on Bureau of Land Management lands are monitored regularly by Bureau personnel. The Las Cienegas National Conservation Area and the San Pedro River represent two of the densest occurrences of *L. schaffneriana* ssp. *recurva* known.

Las Cienegas National Conservation Area – There are multiple occurrences of *L. schaffneriana* ssp. *recurva* from Empire Gulch, Gardner Canyon, Mattie Canyon, and Narrows Powerlines Road areas in Cienega Creek that have been detected as early as 1991, though these were not considered in the critical habitat designation of 1999 (Figures 1 and 2; Rebman 1991, entire; Warren pers. comm. April 4, 1996; 64 FR 37441, entire). In addition, there is one occurrence nearby the Narrows in Fresno Canyon on State Land. All of these occurrences are monitored regularly by personnel of the Bureau of Land Management and were last measured in full in 2011 when approximately 100 patches were detected over a 12.9 km (8 mi) section of creek (Bureau of Land Management 2011, entire). In 2014, a partial survey was conducted with similar results, though the area was reported to be drier than in the past (Radke pers. comm. June 16, 2014). This area may be impacted in the future through groundwater draw-down from the proposed Rosemont Mine adjacent Cienega Creek on the west.

San Pedro River – In 1878, the St. David area of the San Pedro River was described as marshy, though an earthquake in 1887 dried some marshy areas and created new springs (Geraghty and Miller 1995, p. 9). Severe flooding began as early as 1881 and by 1908, the San Pedro River channel was entrenched up to 10 m (33 ft) below the former floodplain; river channel expansion decreased after 1955 (Hereford 1993, p. iv). From 1957 to 1967, daily rainfall was above average, improving conditions for growth and establishment of vegetation (Hereford 1993, p. iv). Despite this, the two *L. schaffneriana* ssp. *recurva* occurrences at Zinn Pond in the St. David area along the San Pedro River that were first detected in 1951 were last seen in 1953 and are believed extirpated (Gooding 1951, entire; Warren and Reichenbacher 1991, p. 18; Johnson et al. 1992, p. 6; 64FR 37441, p. 37443).

There are multiple occurrences of *L. schaffneriana* ssp. *recurva* for roughly 55 km (34 mi) along the San Pedro River near Sierra Vista in the San Pedro Riparian National Conservation Area. Personnel of Fort Huachuca monitor these occurrences. They were last measured in 2010, when it was noted that most occurrences were sparsely populated, that competitive exotic plants threatened *L. schaffneriana* ssp. *recurva*, and that erosion was noticeable between the dry 2009 and wetter 2010 (Vernadero Group 2011a, pp. 11, 21, 22). They also noted that the greatest quantity of *L. schaffneriana* ssp. *recurva* occurred south of Hwy 90 and that areas of higher concentrations remain higher from one monitoring period to the next (Vernadero Group 2011a, p. 21). This area is impacted through groundwater draw-down from Fort Huachuca, the city of Sierra Vista, agriculture use, and the Cananea Mine in Sonora.

U.S. Fish and Wildlife Service:
Lilaeopsis schaffneriana ssp. *recurva* occurring on U.S. Fish and Wildlife Service lands are monitored periodically by Service personnel. The last monitoring occurred in 2013 when a few plants were relocated on Leslie Canyon National Wildlife Refuge and no plants were relocated on the San Bernardino National Wildlife Refuge.

Leslie Canyon National Wildlife Refuge – Haas and Frye (1997, p. 6) reported a single natural occurrence of *L. schaffneriana* ssp. *recurva* in Leslie Canyon National Wildlife Refuge. The refuge manager at that time does not recall this occurrence, but reports transplanting plugs into two locations within Leslie Canyon (Cobble pers. comm. April 14, 2014; see Introduced and Augmented Occurrences section below). Drying of Leslie Creek during the summer of 2002 led to the disappearance of some previously existing, large, healthy patches of *L. schaffneriana* ssp. *recurva* on the refuge, though some patches likely persisted until 2012, during which the streambed became completely dry and no plants were seen. This changed in 2013 when groundwater levels rose enough so that flow resumed in Leslie Creek, and individual plants (probably sprouting from an existing seedbank rather than from surviving rhizomes) were documented at scattered locations along Leslie Creek during an October 31 refuge-conducted survey for the taxon. (Radke pers. comm., April 22, 2014). Several small patches along Leslie Creek remained healthy through 2014.

San Bernardino National Wildlife Refuge – In 1981, a single occurrence of *L. schaffneriana* ssp. *recurva* was discovered at House Pond located on the privately owned Slaughter Ranch adjacent to San Bernardino National Wildlife Refuge, but is believed to have been destroyed when the pond was dredged around 1990 (Warren et al. 1991, p. 7; Johnson et al. 1992, p. 6). Former Refuge Manager Kevin Cobble reported finding *L. schaffneriana* ssp. *recurva* in wet areas of Ramsower Draw at the upstream side of this pond in the 1990s and suspects it might still be present (pers. comm., April 14, 2014). He also reports finding *L. schaffneriana* ssp. *recurva* at Mesquite Pond and Twin-2 Pond following rehabilitation of these sites, as well as at a fourth pond, possibly Cienega Pond, and Cottonwood Spring (pers. comm. April 14, 2014). In working on these ponds, Cobble suspected a seedbank was responsible for these occurrences, stating that "it just took putting permanent water on bare soil and they would appear." However, multiple surveys of these aquatic habitats by refuge staff since 2003 have not documented the taxon, likely due to resulting plant succession and competition with other species (Radke pers. comm., April 22, 2014).

One occurrence of *L. schaffneriana* ssp. *recurva* at Black Draw comprising four patches was first noted in 1989, co-occurring with *Sorghum halepense* and surviving with 4-6 months per year of zero surface flow (Haas and Frye 1997 p. 6). This occurrence was last documented in 1991 (Warren et al. 1991, p. 7; Warren and Reichenbacher 1991, p. 18) and was, at that time, considered unstable due to human-induced watershed deterioration and climate-induced periodic drying (Johnson et al. 1992, pp. 3, 4, and 6). Johnson et al. (1992, p. 6) also noted that the occurrence of *L. schaffneriana* ssp. *recurva* along the San Bernardino River in Mexico was extirpated. Here, on the Rio San Bernardino side of the border, the river became incised, with streamside cienegas drained and much watershed deterioration occurred due to cattle grazing by the 1960s (Service 1999, p. 291). Roughly 24 km (15 mi) further south in Sonora, Mexico, Jim

Rorabaugh photographed *L. schaffneriana* ssp. *recurva* near the confluence of the Rio San Bernardino and Cajon Bonito during April 2008 (Rorabaugh pers. comm. April 29, 2008), and Peter Warren stated that *L. schaffneriana* ssp. *recurva* "is common along the Rio San Bernardino" (Warren pers. comm. April 28, 2008). Much restoration work has been done in both the United States and in Mexico in the past few decades to reduce scouring floods and headcutting, resulting in increased water-holding capacity and positive riparian vegetation response (Radke pers. comm. October 21, 2013).

Pima County:
Lilaeopsis schaffneriana ssp. *recurva* occurring on Pima County lands are monitored periodically by County personnel. No plants have been found in recent years and are presumed extirpated from both Bingham Cienega and Lower Cienega Creek.

Bingham Cienega – In 2001, two patches of *L. schaffneriana* ssp. *recurva* in one occurrence were discovered at Bingham Cienega (Titus 2001, entire); by 2002, the plants were no longer present due to the drought (Titus and Titus 2008c, p. 458). The cienega has fluctuated in discharge and extent over the years, with it being reduced to a small mud hole during the 1952 to 1953 drought (Fonseca 1998 p. 113). Although 11.3 ha (28 ac) of wetlands were reported to occur at Bingham Cienega in 1998 (Fonseca 1998, p. 113), the area has remained mostly dry since 2003 and has undergone repeated fires and resulting sediment deposition (Titus and Titus 2008c, p. 460; Fonseca pers. comm. January 17, 2014). This occurrence is now considered extirpated.

Lower Cienega Creek in Cienega Creek Preserve – A single *L. schaffneriana recurva* occurrence was detected in lower Cienega Creek in 2001 when researchers noted a few leaves that did not persist beyond the season in which they were discovered (EEC 2001, p. 9). A survey in June 2006 revealed no *L. schaffneriana* ssp. *recurva* at this site and a deeply entrenched stream channel 2.1 to 2.7 m (7 to 9 ft) below the former marsh (Titus and Titus pers. comm. June 20, 2006). A 2013 survey indicated no plants at this location and *L. schaffneriana* ssp. *recurva* is believed to be extirpated (Powell pers. comm. October 1, 2013).

State Parks:
Lilaeopsis schaffneriana ssp. *recurva* occurring on State Parks lands are not monitored and have not been seen in recent years.

San Rafael Ranch State Natural Area – Historically, *L. schaffneriana* ssp. *recurva* has occurred in low densities at Sharp and Heron Springs, as well as along the Santa Cruz River near the border with Mexico (McGill 1978, entire; Warren et al. 1991, pp. 7, 12). Both springs are reported to support similar cienega habitat and have slow moving water in marshy drainages (Warren et al. 1991, p. 12). In 2013, these sites were visited and while habitat exists for this taxon at each location, only a few plants were found at the Santa Cruz River occurrence (Service 2013b, entire). All locations likely still support *L. schaffneriana* ssp. *recurva* in small quantities, but they were undetectable due to quantity of competing understory vegetation and possibly due to the time of year when the survey was conducted. Johnson et al. (1992, p. 7) note that *L. schaffneriana* ssp. *recurva* appears to grow year-round in the absence of killing frost, while other aquatic plants tend to die off during the winter allowing this plant to more effectively colonize

open space following low-level disturbance (Johnson et al. 1992, p 7). Throughout much of its range, however, killing frosts are common and *L. schaffneriana* ssp. *recurva* becomes difficult to detect after the first frost (Service 2011, p. 1; Service 2013a pp. 2-3; Service 2013b pp. 1, 3).

Sonoita Creek Natural Area – Fresno Canyon supported one small occurrence of *L. schaffneriana* ssp. *recurva* near the confluence with Coal Mine Canyon. This occurrence was discovered in 2008 and has not been revisited (Rorabaugh 2013, p. 1).

The Nature Conservancy:
Lilaeopsis schaffneriana ssp. *recurva* occurring on The Nature Conservancy's Canelo Hills Preserve historically were monitored by Conservancy personnel. No plants have been reported there or in the adjacent O'Donnell Creek since 2002.

O'Donnell Creek – *Lilaeopsis schaffneriana* ssp. *recurva* had been found historically in a spring-fed cienega near the bunkhouse at the old Ewing Ranch, now The Nature Conservancy's Canelo Hills Preserve (Titus pers. comm. February 27, 2014a). Priscilla Titus (pers. comm. February 27, 2014) remembers this as a well-known and large patch situated among a few small willows and in close proximity to another well-known patch occurring on adjacent private property. At this location in the fall of 2013, the soil was dry to the touch and a nearby dying cottonwood and field of *Juncus* sp. stood testament to historical water availability (Service 2013a, p. 3). No *L. schaffneriana* ssp. *recurva* were present (nor were there any *Spiranthes delitescens* (Canelo Hills ladies' tresses orchid), which historically co-occurred with *L. schaffneriana* ssp. *recurva* at this site), and it is doubtful this area could support these species again without intervention.

Historically, there were multiple occurrences of *L. schaffneriana* ssp. *recurva* both on private and Forest Service lands within O'Donnell Creek (Correll 1970a, entire). On February 14, 2002, Priscilla Titus noted one occurrence was a very small clump in flowing water near, or within, the Forest Service boundary (Titus pers. comm. February 27, 2014a). In the fall of 2013 on lands in O'Donnell Creek administered by The Nature Conservancy and the Forest Service, there were pockets of suitable habitat for *L. schaffneriana* ssp. *recurva*, though no plants were found (Service 2013a, p. 3). Further surveys are recommended.

Private Lands:
Lilaeopsis schaffneriana ssp. *recurva* occurring on private lands are not monitored and, with the exception of Upper Sonoita Creek where umbel has been seen recently, their current status is unknown.

Turkey Creek – First detected in 1989, the *L. schaffneriana* ssp. *recurva* occurrence within Turkey Creek was thought to be small and the habitat not capable of supporting a large stable occurrence (Gori et al. 1990, p. 64; Warren et al. 1991, p. 7; 64FR37441, 1999, p. 37444). Although, historically, Turkey Creek was considered habitat for a number of native fishes, on a few occasions in recent years this creek has gone dry or mostly dry (Robinson 2010, p.5). In the fall of 2013, Turkey Creek was intermittent with a few small pools; there was extensive understory cover, including the exotic *S. halapense*, and no *L. schaffneriana* ssp. *recurva* was found (Service 2013a, p. 2). Because habitat does still occur here, the plant may also still occur

in this creek, though in low frequency and cover, making detectability among the grasses and sedges difficult (Service 2013a, p. 2). Further surveys are recommended.

Joaquin Canyon – In 1998, the Service proposed a 0.64 km (0.4 mi) reach of Joaquin Canyon managed by the Forest Service as critical habitat for *L. schaffneriana* ssp. *recurva*; this reach began at the confluence with Cave Canyon and ran north (Map Unit 7; 63FR 71838, p. 71842). Because the stream channel in this reach is largely bedrock and not easily disturbed, the Service considered this area as not requiring special management consideration or protection, and the area was removed from consideration for designation as critical habitat (64FR 37441, p. 37445). In August 2001, a Biological Opinion for the Lone Mountain Land Exchange noted that most of Joaquin Canyon had perennial flow and supported 922 m (0.57 mi) of stream bottom occupied by *L. schaffneriana* ssp. *recurva* that was disposed of by the Forest Service and placed into private ownership (Service 2001, pp. 6-7). Due to the private status of the land, this occurrence has not been revisited and the status remains unknown.

San Rafael Ranch – Historically, *L. schaffneriana* ssp. *recurva* has occurred in low densities at Sheehy Spring which has slow moving water in a marshy drainage (McGill 1978, entire; Warren et al. 1991, pp. 7, 12). In 2013, this site was visited and while habitat exists for this taxon at this location, no plants were found (Service 2013b, entire). This location likely still supports *L. schaffneriana* ssp. *recurva* in small quantities, but they were undetectable due to quantity of competing understory vegetation and possibly due to the time of year when the survey was conducted. Johnson et al. (1992, p. 7) note that *L. schaffneriana* ssp. *recurva* appears to grow year-round in the absence of killing frost, while other aquatic plants tend to die off during the winter allowing this plant to more effectively colonize open space following low-level disturbance (Johnson et al. 1992, p 7). Throughout much of its range, however, killing frosts are common and *L. schaffneriana* ssp. *recurva* becomes difficult to detect after the first frost (Service 2011, p. 1; Service 2013a pp. 2-3; Service 2013b pp. 1, 3).

Upper Sonoita Creek – There are two occurrences of *L. schaffneriana* ssp. *recurva* in Upper Sonoita Creek. In 1988, the upper *L. schaffneriana* ssp. *recurva* occurrence was reported at low density across a 0.8 km (0.5 mi) stretch of creek (Gori et al. 1990, p. 65). In 1994 and 1996, transects in the upstream and downstream occurrences revealed *L. schaffneriana* ssp. *recurva* was more abundant upstream in the more stable site (Holdsworth and Gori 1996, p. 1). Yearly conservation easement site visits by personnel of The Nature Conservancy between 2006 and 2013 detected *L. schaffneriana* ssp. *recurva* easily and abundantly in this upstream location, with greater abundance in the northern area of the occurrence (Killeen pers. comm. October 25, 2013).

The downstream occurrence, which begins at Cottonwood Spring and extends downstream, was characterized as having a high density of plants in 1988, prior to a flood which removed *L. schaffneriana* ssp. *recurva* below Hog Canyon (Gori et al. 1990, p. 65). By 1989, the taxon had recolonized the area and was once again found to support a high density of plants (Gori et al. 1990, p. 65). In 1992, the Service, The Nature Conservancy, and the property owner of Cottonwood Spring began a cooperative project under the Partners in Wildlife Program. This project involved excluding domestic livestock from Cottonwood Spring and the riparian area,

which had been grazed since the late 1800s, and stabilizing two active headcuts (Holdsworth and Gori 1996, p. 1).

Between 1994 and 2005, surface water in the stream channel, the number of pools, and presence of *L. schaffneriana* ssp. *recurva* were monitored post-restoration (Holdsworth and Gori 1996, p. 1). Results indicate a decrease in both water availability and presence of *L. schaffneriana* ssp. *recurva* between 1994 and 2005 (The Nature Conservancy1994-2005, entire). Although not monitored since, in 2013, the downstream portion of Cottonwood Spring was dominated by *M. rigens* and *L. schaffneriana* ssp. *recurva* was difficult to detect (Killeen pers. comm. October 25, 2013). Continuation of this monitoring is highly recommended by the Service. In addition, in February 2014, the Service was informed that in 2013, a private land owner with a back hoe may have altered the habitat at this spring; impacts to *L. schaffneriana* ssp. *recurva* and a variety of other listed species are unknown and should be investigated (Killeen pers. comm. February 6, 2014).

Monkey Spring – Herbarium collections were made five times between 1965 and 1977 documenting the occurrence of *L. schaffneriana* ssp. *recurva* in Monkey Spring (Minckley 1965 and 1967, entire; Pinkava 1967, entire; Correll 1970b, entire; Reeves 1977, entire). Warren et al. (1991b, p 18) were unable to relocate this occurrence and concluded *L. schaffneriana* ssp. *recurva* had been extirpated from the spring. Although this site has not been revisited by botanists in recent years, in February of 2010 and again in June of 2012, fish researchers collected Gila topminnow (*Poeciliopsis occidentalis)* from this spring (Marsh and Associates 2010, entire; Marsh and Associates 2012, entire). Their memoranda of the trips included photographs of Monkey Spring which show potential *L. schaffneriana* ssp. *recurva* habitat, including slow-moving water and hydrophytic plants. Therefore, as of 2012, the site still held some potential of supporting *L. schaffneriana* ssp. *recurva* and should be visited to look for *L. schaffneriana* ssp. *recurva* if this can be arranged with the land owner.

Babocomari River – In May of 2006, a single occurrence containing seven patches of *L. schaffneriana* ssp. *recurva* was discovered on the Babocomari River within the Babocomari Ranch (Titus and Titus 2006a, p. 1). These patches were re-visited in October, 2006, following a significant flood event resulting in intense scouring and sediment deposition. All but one patch was relocated and appeared in good condition, and two additional patches were discovered (Titus and Titus 2006b, p. 1). Herbarium collections were made of *L. schaffneriana* ssp. *recurva* from this location in 2008 (Titus 2008, entire; Titus and Anderson 2008, entire). Continued monitoring of this occurrence is warranted.

An unpublished note in the Service files states that, in 1998, *L. schaffneriana* ssp. *recurva* was possibly seen in Lyle Canyon (a tributary of the Babocomari) by the then manager of the Audubon Research Ranch, Bill Brannon. This potential occurrence has not been revisited or confirmed.

In 2013, an employee of the Bureau of Land Management discovered a single, small patch of *L. schaffneriana* ssp. *recurva* during one of several five-mile river surveys. The employee noted the plant was found in a heavily grazed area, roughly 6.4 km (4 mi) from the confluence with the San Pedro River.

Winkelman area – A 1967 herbarium specimen collected from the edge of a drying pool in the San Pedro River, 9.7 km (6 mi) south of Winkelman, documents an historical occurrence of *L. schaffneriana* ssp. *recurva* (Crutchfield 1967, entire). At some time close, but prior to, 2003, on several occasions, Priscilla Titus and others surveyed the Dudleyville Preserve, an area roughly 9.7 km (6 mi) south of Winkelman on the San Pedro River with aquatic habitat present; no *L. schaffneriana* ssp. *recurva* were found (Titus pers. comm. February 27, 2014b). In 2013, The Nature Conservancy published a Water Budget map (entire) which clearly shows the area 9.7 km (6 mi) to the south of Winkelman has perennial flow. Additional surveys are warranted.

Tucson area – An 1881 herbarium collection from somewhere along the Santa Cruz River in Tucson documents the oldest known occurrence of *L. schaffneriana* ssp. *recurva* (Warren et al. 1991, p. 5). Because the Santa Cruz River in the vicinity of Tucson is now dry, this occurrence is presumed extirpated (Warren et al. 1991, p. 5; Johnson et al. 1992, p. 3).

Mexico:
The distribution of *L. schaffneriana* ssp. *recurva* in Mexico is not well studied or understood. Affolter (1985) reported only two localities from Chihuahua and none from Sonora; Hendrickson et al. (1980, pp. 96-97) reported *Lilaeopsis* sp. from one locality in northeastern Sonora at Rancho Mababi and from La Junta, Chihuahua. Our current understanding of the distribution in Mexico comes from two primary sources: a section-6 funded survey for *L. schaffneriana* ssp. *recurva* from 2004-2005 conducted by Greta Anderson and a 2007 Service study of gartersnakes (*Thamnophus* sp.) by Jim Rorabaugh, in which locations that supported *Lilaeopsis* sp. were documented (Anderson 2006, entire; Rorabaugh 2013, entire). These two studies indicate that *L. schaffneriana* ssp. *recurva* is currently known only from the state of Sonora in Mexico. *Lilaeopsis* species are found in Chihuahua, but they are not known to be *L. schaffneriana* ssp. *recurva.*

Sonora – From these two studies (Anderson 2006, entire; Rorabaugh 2013, entire) we have confirmed observations of *L. schaffneriana* ssp. *recurva* from the following 15 locations in Sonora: (1) Arroyo el Tigre; (2) Arroyo los Fresnos (numerous patches; also noted by Warren et al. 1991, p. 13); (3) cienega near the Casa Grande (abundant); (4) Las Nutrias (one occurrence with sparse small patches); (5) Las Pamitas (one occurrence with small patches); (6) Ojo de Aqua (one occurrence with a very small patch; also noted in Gori et al. 1990, p. 64); (7) Rancho el Aribabi along the Rio Cocospera (occurs sparingly along 6 km (3.7 mi) of river; also recently noted by T. Van Devender in 2009, K. Fehlberg in 2010 [SEINET observations], and J. Rorabaugh in 2014 [Rorabaugh pers. comm. April 9, 2014]); (8) Rancho Los Fresnos including: Arroyo los Alisos (one occurrence with one small patch), (9) Cienega Los Fresnos (uncommon), (10) La Cieneguita (one occurrence with one small patch), and (11) Portrero del Alamo (one occurrence with one small patch); (12) Rio Casa Blanca (one occurrence with frequent patches); (13) Rio San Pedro (patchy occurrence); (14) Rio San Rafael (one occurrence with scattered plants; also noted by Warren et al. 1991, p. 13); and (15) Villa Verde (one occurrence with dense patches).

From other studies in Sonora, there are observations of five additional occurrences (numbered below) of *L. schaffneriana* ssp. *recurve*. Observations were reported by Esther Saucedo

Monarque (1990, pp.48-54) from: (1) Arroyo el Tapiro, (2) La Cienega la Atascosa, and (3) La Sauceda in Sonora. Tom Deecken observed numerous *L. schaffneriana* ssp. *recurva* at (4) Mababi Spring west of Presa Cuquiarichi in Sonora (Deecken 1994, entire). Warren et al. (1991, p. 10) found an occurrence with two small patches along the (5) Rio San Bernardino in Sonora in May of 1988; both were destroyed in an August 1988 flood. Phil Jenkins collected *L. schaffneriana* ssp. *recurva* along the (6) Santa Cruz River south of the town of Santa Cruz in Sonora in 2005 (Jenkins, 2005, entire).

Chihuahua – From the two studies mentioned above (Anderson 2006, entire; Rorabaugh 2013, entire) we have also confirmed observations of *Lilaeopsis* sp. from the following 7 locations in Chihuahua: Arroyo Rincon (two patches); La Junta; Rio Casas Grandes (one occurrence with a few patches); Rio Conchos tributary (moderately abundant); Rio Papogochic (several occurrences); Rio east of Cusarare (moderately abundant); and the Rio Santa Clara (one occurrence with two patches). It is unknown if the *Lilaeopsis* from Chihuahua are *L. schaffneriana* ssp. *recurva* or *L. r*ecurva ssp. *schaffneriana*. No collections were made from these observations, however, photographs were taken. Historically, it was thought that *L. r*ecurva ssp. *recurva* only occurred on the west side of the Continental Divide, and that ssp. *schaffneriana* occurred on the east (64 FR 37441, p. 37442). Due to the work of J. Rorabaugh and others, we are aware of addition small occurrences of *L. schaffneriana* to the south and east of this divide at Rio Casas Grandes, Rio Santa Clara, Rio Papogochic, and Rio Conchos. It is unknown which variety these plants represent and these occurrences were excluded from this analysis. It is currently not believed that hybridization occurs between subspecies.

Introduced and Augmented Occurrences:
In recent decades, a variety of efforts have been initiated in order to determine if planting clumps of *L. schaffneriana* ssp. *recurva* propagated in a greenhouse setting, or transplanted directly, could serve as a viable tool with which to establish new occurrences, restore lost occurrences, and to serve as reserves in which *L. schaffneriana* ssp. *recurva* would be preserved in the event that naturally occurring occurrences were subjected to catastrophic loss.

Audubon Research Ranch – In December 2003, a total of 128 10 x 10 cm (4 x 4 in) *L. schaffneriana* ssp. *recurva* plugs were planted in four spring runs at Finley Tank on the Audubon Research Ranch (Titus and Titus 2008a, p. 314). This area was chosen because it is located in the San Pedro watershed but is hydrologically isolated from extant *L. schaffneriana* ssp. *recurva* sites, thus preventing potential contamination by differing genetic stock. Prior to the transplant, *L. schaffneriana* ssp. *recurva* was propagated in a greenhouse using plugs obtained from the Desert Botanical Garden in Phoenix that had originated from Cottonwood Springs on Sonoita Creek. *Lilaeopsis schaffneriana* ssp. *recurva* established quickly at Finley Tank and, by 2004, many of the plugs had merged and formed contiguous patches in two of the spring runs. These transplants are still flourishing to date, although *L. schaffneriana* ssp. *recurva* no longer appears to be present in drier portions of the site or within two of the spring runs with greater interspecific competition. In 2014, Kennedy (pers. comm. February 3, 2014) noted *L. schaffneriana* ssp. *recurva* was doing well in north Finley Spring, but that the non-native, aggressive invasive, *Rubus discolor* (Himalayan blackberry), was a problem in the south spring and will become a problem in the north spring, unless it is controlled or removed.

Leslie Canyon National Wildlife Refuge – Haas and Frye (1997, p. 7) report two transplanted plugs of *L. schaffneriana* ssp. *recurva* taken from the San Bernardino Black Draw occurrence and placed into Leslie Canyon. One plug was placed above a U.S.G.S. stream gauge along a pool; the second plug was placed near large *Juglans major* (walnut) trees at the end of permanent water in the creek downstream from the weir (Cobble pers. comm., April 14, 2014). The plug near the pool reportedly became very robust, spreading to cover between 9.1 and 12.2 m (30 and 40 ft) of pool edge (Cobble pers. comm., April 14, 2014). The previous Refuge manager, Kevin Cobble, reported that, in 1999, this occurrence was thriving. However, a drought period during 2001 and 2002 eliminated the occurrence near the walnut trees (Radke pers. comm., April 22, 2014). Additionally, a more severe drought beginning in 2009 and extending through 2012 eventually completely dried Leslie Creek and all remaining occurrences disappeared until October, 2013, when individual plants were found scattered upstream from the U.S.G.S. stream gauge during a systematic survey for the taxon, responding to a resumption of flow in Leslie Creek (Radke pers. comm., April 22, 2014). These small patches along Leslie Creek remained healthy through 2014.

In 2003, an estimated 27.11 m^2 (291.8 ft^2) of *L. schaffneriana* ssp. *recurva* occupied Leslie Canyon (Malcom 2004, p. 2), and a formal monitoring program for the taxon was initiated at Leslie Canyon National Wildlife Refuge in 2004. Monitoring of the plant's introduced occurrence along Leslie Creek occurred seven times between 2004 and 2013 (Malcom 2007, entire; Malcom 2008, entire; Lohrengel 2010, entire; Perkins 2011, entire; Terry 2012, entire; Mendoza 2013).

In 2004, 59 m^2 (635 ft^2) of *L. schaffneriana* ssp. *recurva* occupied Leslie Canyon. By 2007, this number had dropped to 45 m^2 (484.4 ft^2) and by 2010 it had dropped to 23.5 m^2 (253 ft^2) (Lohrengel 2010, p. 1). During the annual surveys conducted from 2011 through 2013, *L. schaffneriana* ssp. *recurva* was not found in Leslie Canyon. The decline in *L. schaffneriana* ssp. *recurva* in Leslie Canyon is directly related to insufficient amounts of precipitation and a subsequent lowering of the water table (Terry 2012, entire). Due to extended drought, and with the exception of periodic seasonal flood events, surface water availability in Leslie Creek has been sustained only through a series of disconnected pools and did not exist as a flowing stream between November, 2009, and about November, 2012 (Radke pers. comm., April 22, 2014). The resumption of surface flow in Leslie Creek during 2013 and 2014 may not be sustainable due to continuing drought conditions.

San Bernardino National Wildlife Refuge – In a transplant study at San Bernardino National Wildlife Refuge during 1990-1991, 12.7 x 12.7 cm (5 x 5 in) plugs of *L. schaffneriana* ssp. *recurva* attained from Black Draw exhibited excellent growth and vigor in a pond, newly-created by using flow from Cienega Spring, which was relatively free of competing vegetation (Warren 1991, p. 4). However, at Cienega Spring *L. schaffneriana* ssp. *recurva* was eventually eliminated in one location that exhibited intense competition with spike-rush (*Eleocharis* sp.) and bulrush (*Schoenoplectus* sp.), and it failed to thrive in a second Cienega Spring location that had a moderate amount of competing native and non-native vegetation (Warren 1991, p. 5). At a third transplant site on the north side of the pond, *L. schaffneriana* ssp. *recurva* expanded in size and vigor (Warren 1991, p. 5).

Ongoing efforts to reestablish *L. schaffneriana* ssp. *recurva* in aquatic habitats at San Bernardino National Wildlife Refuge took place during 2005, 2007, 2008, 2010, and 2014 (Radke pers. comm. April 22, 2014). Transplants into pond edges during the July 2005 reintroduction effort were ultimately outcompeted and eliminated by other plants of aquatic habitat (Service 2009a, p. 18). During 2007, additional transplants were made at the Minckley Pond Outflow and the Twin-2 Pond Outflow (Malcom 2008, entire). During 2008, transplants were made at the Twin-2 Pond Outflow, Minckley Pond Outflow, North Pond Outflow, and Hay Hollow Wash Pond Outflow (Malcom 2008, entire). The transplant at Twin-2 Pond Outflow persisted until at least September, 2012, but ultimately did not succeed (Radke pers. comm., April 22, 2014). As of 2013, the transplants at Minckley Pond outflow were 8 m^2 (86.1 ft^2), down from 12.3 m^2 (132.4 ft^2) in 2007 (Lohrengel 2010, p. 1; Mendoza 2013 p. 1). The transplant at Hay Hollow Wash Pond Outflow was thriving during March, 2009, but was negatively impacted by flooding later that summer (Radke pers. comm., April 22, 2014). *Lilaeopsis* could not be found at North Pond Outflow during October 2014.

During 2010, additional transplants were placed in Hay Hollow Wash at the pond outflow. While the *Lilaeopsis* transplants initially responded very well in Hay Hollow Wash, they eventually failed after being covered by tons of sediment following several floods during 2009 and 2010 (Lohrengel 2010, p. 3; Radke pers. Comm., April 22, 2014). Multiple transplants during March 2014 into Snail Spring run on Slaughter Ranch and into Hay Hollow Wash at the pond outflow on San Bernardino National Wildlife Refuge were thriving as of August 2014. Following heavy rain associated with Hurricane Odile, flood flows in Black Draw reached over 25-feet deep in places and over five-feet deep in Hay Hollow Wash during September 2014. The volume of water scoured some areas, widened the stream channels, and transported tons of sediment. After this severe flood, some *Lilaeopsis* patches remained intact at the Minckley Pond Outflow through 2014, but could no longer be located in Hay Hollow Wash (Radke pers. Comm., February 10, 2015). Work to document and evaluate the success of transplanted plugs on San Bernardino National Wildlife Refuge was conducted during 2007, and showed that transplants appeared to be most successful in areas where water saturation levels remained constant, where herbaceous competitors were rare, and where water velocity was low (Radke pers. comm. April 22, 2014).

Las Cienegas National Conservation Area – In June, 2013, representatives of the Bureau of Land Management and the Service, aided by school children, collected 50 plugs from Cienega Creek and planted them directly into a newly dug pond at Cienguita (Rorabaugh pers. comm. June 26, 2013). These plugs were planted at a dry time, but gained hold after monsoon rain came (Simms pers. comm. July 18, 2013). In October, 2014, representatives from the Bureau of Land Management and the Service collected 25 plugs from the pond at Cienguita where *L. schaffneriana* ssp. *recurva* has thrived since its introduction in 2013. These plugs were moved to two additional ponds on Bureau of Land Management Land. In addition, a second pond nearby that introduced into in 2013 also now contains *L. schaffneriana* ssp. *recurva*, presumably due to the movement of water fowl.

The Desert Botanical Garden – The Desert Botanical Gardens maintains a sizable occurrence of *L. schaffneriana* ssp. *recurva* in an artificial pond in the botanical garden that is useful for educational purposes. The Desert Botanical Gardens also maintains living collections in pots in

the greenhouse for use in research and for potential use in reintroduction efforts. The greenhouse material originated from Sonoita Creek, Scotia Canyon, San Pedro River, and Garden Canyon. The collections are labeled and propagated separately in order to retain the genetic integrity of each collection.

The Arizona Sonora Desert Museum – The Arizona Sonora Desert Museum in Tucson maintains 25, 20.3 x 20.3 cm (8 x 8 in) nursery pots of *L. schaffneriana* ssp. *recurva* in a greenhouse on the museum grounds, and two same sized pots on the grounds in a public display (Montgomery 2012, entire). These plants were cultivated using material obtained from the Desert Botanical Garden. The Museum planted some material in a marsh exhibit in the spring of 2012, and periodically includes living specimens in an educational display at the museum entrance that highlights Threatened and Endangered plants. In addition eight potted plants grown at the Desert Botanical Garden were transferred to the Arizona Sonora Desert Museum in 2014.

Sonoita Creek – In 1995, representatives of The Nature Conservancy installed a total of 57 10 x 10 cm (4 x 4 in) diameter *L. schaffneriana* ssp. *recurva* plugs into 4 different habitats in Sonoita Creek, within the Sonoita-Patagonia Preserve, using material collected at Cottonwood Springs, a perennial stretch of Sonoita Creek approximately 16 km (10 mi) upstream from the transplant location (Warren 1996, p. 4). The four habitats consisted of the main Sonoita Creek channel, a sand bar, an unnamed tributary stream, and a spring on the north side of the canyon (Warren 1996, p. 4). Initially, *L. schaffneriana* ssp. *recurva* grew vigorously, but when the sites were revisited in 2002 and 2006, the taxon could not be relocated, and it is presumed extirpated from all four habitats at this location. The two nearest the stream were lost to flood scour, one spring site dried up and the other spring site was anaerobic and did not sustain *L. schaffneriana* ssp. *recurva* (Warren pers. comm. February 6, 2014).

San Pedro Riparian National Conservation Area – Fort Huachuca has implemented two *L. schaffneriana* ssp. *recurva* transplant efforts in recent years. These efforts were undertaken in compliance with the 2007 Biological Opinion for proposed ongoing and future military operations and activities at the Fort (Service 2007, entire). The Biological Opinion stipulated that efforts should include off-post activities including *L. schaffneriana* ssp. *recurva* collection, propagation and planting in suitable habitat along the San Pedro Riparian Natural Conservation Area, and assisting the Bureau of Land Management, the Coronado National Forest, and other land owners/managers responsible for *L. schaffneriana* ssp. *recurva* (Service 2007, p. 65).

In December, 2010, Fort Huachuca representatives in partnership with the Bureau of Land Management transplanted 32, 16, and 16 *L. schaffneriana* ssp. *recurva* plugs respectively, in Murray Spring, Horse Thief Canyon, and Frog Spring within the San Pedro Riparian Natural Conservation Area (Simms pers. comm. October 26, 2011; Vernadero Group 2011b, p. 3). Plugs for the transplant effort were propagated by the Desert Botanical Gardens using material obtained from within the San Pedro Riparian Natural Conservation Area in 2007. In August of 2011, the Bureau of Land Management noted in visits to the Horse Thief Draw site that *L. schaffneriana* ssp. *recurva* was scoured by floods, but was re-sprouting from the root at most locations (Simms pers. comm. October 26, 2011). The most recent monitoring of these plugs, in 2013, revealed that percentage of occupied habitat continues to expand three years post-transplant in both Horse Thief Draw and Murray Springs (Directorate of Public Works 2013, p.

1). The extent of occupied habitat at Frog Spring has decreased in each year since the transplant (Directorate of Public Works 2013, p. 2).

Fort Huachuca – In 2009, Fort Huachuca staff transplanted 64 *L. schaffneriana* ssp. *recurva* plugs (material grown from two plugs each from the Garden Canyon Picnic area and McClure Canyon) into 6 locations within Huachuca Canyon Creek, McClure Canyon, and Cave Spring. The purpose of the transplant was to establish *L. schaffneriana* ssp. *recurva* in suitable habitat outside of known locations in order to increase the number of occurrences and decrease the likelihood of a stochastic event, such as flood or drought, eliminating the currently existing occurrences (Brewer, pers. comm. February 18, 2009). As of the most recent monitoring of these plugs in the spring of 2013, all but one of these locations showed continued expansion of occupied habitat. While one location in Huachuca Canyon Creek has shown a decrease in percentage of occupied habitat since 2012, occupied habitat remains higher than in 2010 (Directorate of Public Works 2013, p. 2).