SITE MANAGEMENT PLAN FOR THE SIUSLAW HAIRY-NECKED TIGER BEETLE (*CICINDELA HIRTICOLLIS SIUSLAWENSIS* GRAVES, KREJCI, AND GRAVES, 1988) ON NEW RIVER ACEC, COOS BAY BLM, OREGON

Photo by Candace Fallon / The Xerces Society.

Developed by Candace Fallon and Sarina Jepsen of
The Xerces Society for Invertebrate Conservation

SEPTEMBER 2015

U.S.D.A. FOREST SERVICE REGION 6 AND U.S.D.I. BUREAU OF LAND MANAGEMENT
INTERAGENCY SPECIAL STATUS AND SENSITIVE SPECIES PROGRAM

CONTENTS

Goal of the Management Plan 4

Section I: Status and Threats 4

Conservation Status 4

Taxonomy 4

Species Range, Distribution, Abundance, and Trends 4

Species Life History 7

New River ACEC Site Description 7

Croft Lake (Breach 1) 10

New Lake (Breach 2) 12

Hammond (Breach 3) 14

Bono Clay Island (Breach 4) 16

Management History 18

Grazing 18

Breaching 18

Snowy Plover Management 19

Recreation 19

Threats 19

General Threats 19

Site Specific Threats 20

Section II: General Management Considerations 22

Section III: Specific Management Actions 23

Goal 1: Maintain Open Habitat Free of Invasive Vegetation 23

Goal 2: Restore Native Dune Habitat 24

Goal 3: Limit Vehicle and Pedestrian Access 24

Section IV: Additional Research 25

Population Monitoring 25

Overwintering Behavior 25

Invasive Plant Management 26

Habitat Needs and Foraging Preferences 26

Population Dynamics 27

Survey Techniques 27

Acknowledgements 28

References Cited 28

Personal Communication 31

FIGURES

Figure 1: Croft Lake tiger beetle habitat. 10

Figure 2: New Lake tiger beetle habitat 12

Figure 3: Hammond tiger beetle habitat. 14

Figure 4: Bono Clay Island tiger beetle habitat. 16

Figure 5: Invasive European beachgrass at the New Lake tiger beetle site. 21

MAPS

Map 1: Current and historic distribution of the Siuslaw hairy-necked tiger beetle in Washington, Oregon, and California 6

Map 2: New River ACEC depicting core Siuslaw hairy-necked tiger beetle locations and the snowy plover Habitat Resource Area. 9

Map 3: Croft Lake occupied habitat and adjacent snowy plover nest 11

Map 4: New Lake occupied habitat 13

Map 5: Hammond Breach occupied habitat 15

Map 6: Bono Clay Island occupied habitat 17

TABLES

Table 1: Locations of extant *C. h. siuslawensis* populations in OR and WA. 5

Table 2: Siuslaw hairy-necked tiger beetle counts at core sites on New River ACEC 8

Table 3: Prioritization of Research and Monitoring Goals 25

GOAL OF THE MANAGEMENT PLAN

The goal of this Site Management Plan is to provide site specific management guidance to maintain and increase Siuslaw hairy-necked tiger beetle (*Cicindela hirticollis siuslawensis*) populations and available habitat in the New River ACEC managed by the Coos Bay BLM. This document also provides information on the conservation status of and threats to this tiger beetle and general management considerations for any Siuslaw hairy-necked tiger beetle populations on public land. In addition, we outline data gaps and further research needed to better understand and manage for this species both at New River and across its range.

SECTION I: STATUS AND THREATS

CONSERVATION STATUS

The Siuslaw hairy-necked tiger beetle, *Cicindela hirticollis siuslawensis*, is a rare beetle most often associated with river mouths along Pacific Coast beaches from central Washington to Eureka, CA (Graves et al. 1988, Pearson et al. 2015). This tiger beetle has a state Heritage rank of S1 in Washington (WNHP 2014) and S1S2 in Oregon (ORBIC 2013), a U.S. national status of N1N2 (NatureServe 2015), and a global conservation rank of G5T1T2 (rounded to T1) (NatureServe 2015). The species is considered to be Critically Imperiled because it "currently exists at only a few of its known historic sites and may be even more at risk than [*C. hirticollis*] *gravida*" (NatureServe 2015). It is classified as a Forest Service Region 6 and OR/WA BLM Sensitive Species. Surveys in recent years confirm that this beetle has disappeared from most Oregon sites (Pearson et al. 2015, Mazzacano et al. 2009, NatureServe 2015), primarily due to habitat loss and degradation. Pearson et al. (2006) estimate that at least 33 (15%) of the 223 named species and subspecies of tiger beetles in the U.S. and Canada, including the Siuslaw hairy-necked tiger beetle, may be declining at a rate that justifies their listing as a threatened or endangered species.

TAXONOMY

Siuslaw hairy-necked tiger beetles belong to the tiger beetle genus *Cicindela*, which includes nearly 900 of the 2,700 known species of tiger beetles worldwide (Pearson et al. 2015). The species *Cicindela hirticollis* is widespread across North America but rarely found far from the sandy edges of water bodies. There are 11 known subspecies, seven of which are found in the western United States (Pearson et al. 2015). Pearson et al. (2015) note that a recent study of *C. hirticollis* mitochondrial DNA from across North America did not strongly support the validity of currently named subspecies; however, western populations did show some genetic differentiation, and further research is needed. The Siuslaw subspecies was first described in 1988 by Robert C. Graves, Mark E. Krejci, and Anne C. F. Graves from specimens collected along the Washington, Oregon, and northern California coasts between Moclips, WA and Eureka, CA.

SPECIES RANGE, DISTRIBUTION, ABUNDANCE, AND TRENDS

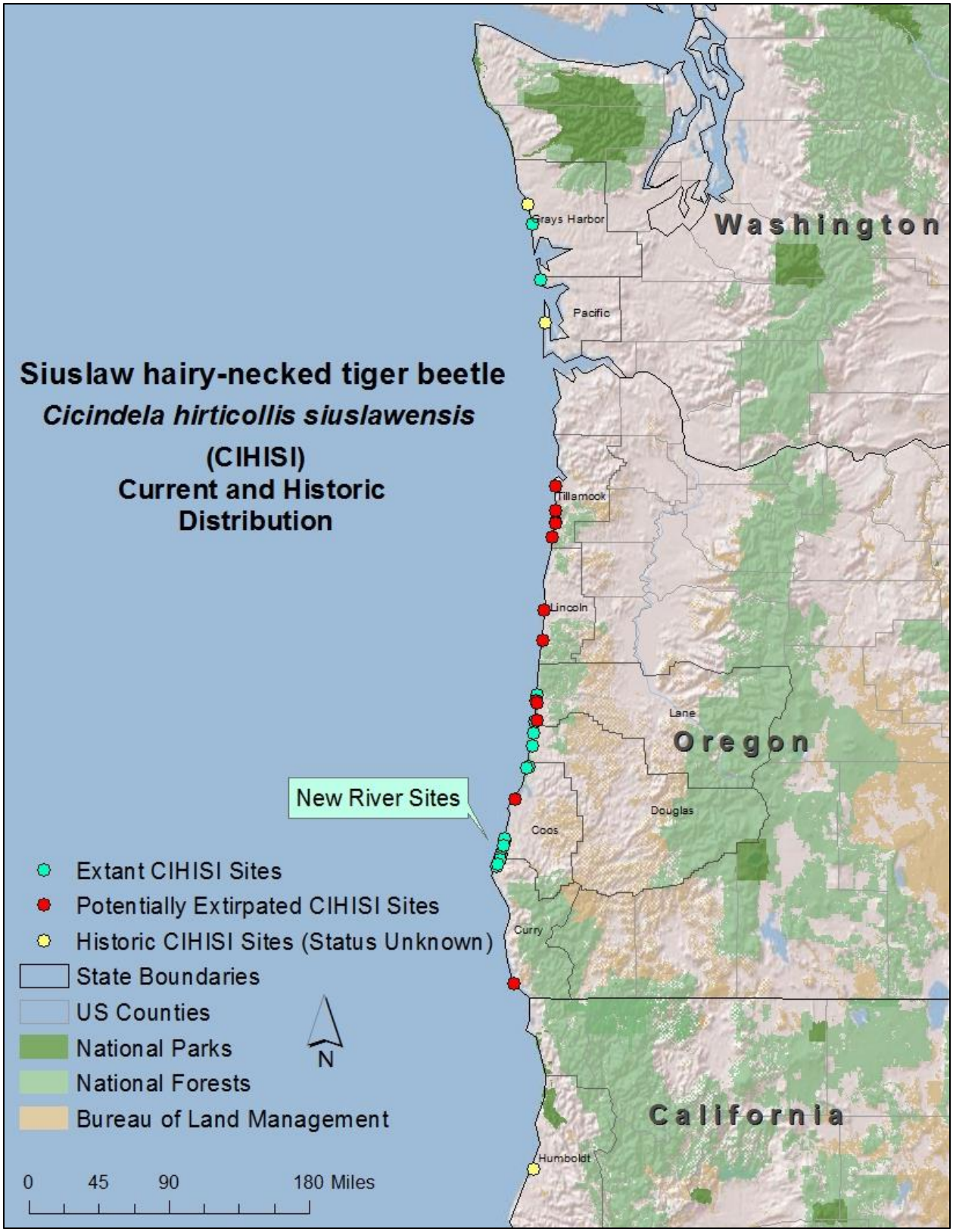
The Siuslaw hairy-necked tiger beetle is believed to have been present historically from river mouths along the Pacific Ocean from Grays Harbor, WA, to Eureka, CA (Graves et al. 1988, Pearson et al. 2015). Prior to 1979, specimens collected in Oregon were from Lincoln County (Waldport and Yaquina Bay, Newport sites), Tillamook County (Neskowin, Sand Lake, Twin Rocks, and Woods sites), Lane County (Siltcoos outlet, Westlake, and Florence sites), and Coos County (Hauser sites) (Knisley et al. 2014). Historic records in Washington include Grays Harbor (Moclips) and Pacific counties (Ocean Park) (Leffler 1979).

Unpublished reports from informal surveys conducted within the last ten years found *C. h. siuslawensis* only in the Bandon/New River area in Oregon (Lyons 2008, pers. comm.) and a few sites in Washington (Steffens 2009, pers. comm.; Paulson 2012). The status of this beetle in California is unknown. Systematic surveys of historic and potential habitat along the Oregon coast (from Astoria to Brookings) were conducted by the Xerces Society in 2009 (see Mazzacano et al. 2009). These surveys confirm that this beetle is currently restricted to habitat within an 82 mile long stretch in Curry, Coos, Douglas, and Lane Counties; it appears to be absent from historic sites in Lane, Lincoln, and Tillamook Counties (Mazzacano et al. 2009). Extant populations were found primarily in areas with an absence of vehicular traffic and low levels of foot traffic, (Mazzacano et al. 2009). Most occupied *C. h. siuslawensis* habitat appears to be closely tied to protected snowy plover habitat, which is closed to recreation and human disturbance for six months out of every year.

C. h. siuslawensis is now known to occur at 17 locations in Oregon and 2 locations in Washington (see Table 1), and is absent from 5 of 6 surveyed historic locations in Oregon (Mazzacano et al. 2009). Seven of the extant sites occur on BLM-owned land, and are concentrated along a single river: New River and the associated Floras Lake. Six of the sites are on USFS-owned land: Sutton Creek, Siltcoos River, Tahkenitch Creek, Umpqua Spit, and Tenmile Creek (in two locations), though it is important to note that much smaller populations occur at sites on USFS-owned land than the populations that occur along New River. The remaining sites are managed by Oregon State Parks and Washington State Parks, with the exception of two sites that appear to be on private land. No occupied sites are currently known from BLM or Forest Service lands in Washington. In Oregon, all currently confirmed populations occur within one mile of the coast along sandy freshwater outlets to the Pacific Ocean in an area that is approximately 132 km (82 miles) long and a few hundred meters wide (see Map 1).

Table 1: Locations of extant *C. h. siuslawensis* populations in OR and WA (listed from north to south). The Year column indicates the last year the population was confirmed to be extant (based on Steffens 2008, pers. comm.; Mazzacano et al.. 2010; Paulson 2012; Burns 2014, pers. comm.).

Site Name	County	State	Land Manager	Year
Griffiths Priday State Park	Grays Harbor	WA	Washington State Parks	2008
Midway Beach	Pacific	WA	Washington State Parks	2011
Sutton Creek	Lane	OR	Siuslaw National Forest	2009
Siltcoos River outlet	Lane	OR	Siuslaw National Forest	2009
Tahkenitch Creek	Douglas	OR	Siuslaw National Forest	2009
Umpqua Spit	Douglas	OR	Siuslaw National Forest	2014
Tenmile Creek (~1 mi u/s of outflow)	Coos	OR	Siuslaw National Forest	2009
Tenmile Creek (outflow)	Coos	OR	Siuslaw National Forest	2009
Johnson Creek	Coos	OR	Oregon Parks and Rec	2009
Devil's Kitchen (Crooked Creek)	Coos	OR	Oregon Parks and Rec	2009
China Creek	Coos	OR	Oregon Parks and Rec	2009
New River (from Lost Lake trail)	Coos	OR	Private	2009
Twomile Creek	Coos	OR	Oregon Parks and Rec	2009
New River breach 1 (Croft Lake)	Coos	OR	Coos Bay BLM	2014
New River breach 2 (New Lake)	Coos	OR	Coos Bay BLM	2014
New River breach 3 (Hammond)	Coos	OR	Coos Bay BLM	2014
New River breach 4 (Bono/Clay Island)	Curry	OR	Coos Bay BLM	2014
New River breach 5 (Historic Breach)	Curry	OR	Private	2009
Floras Lake	Curry	OR	Coos Bay BLM, OPRD	2009



Map 1: Current and historic distribution of the Siuslaw hairy-necked tiger beetle in Washington, Oregon, and California

SPECIES LIFE HISTORY

Hairy-necked tiger beetles (*C. hirticollis*) inhabit sandy areas around freshwater outflows onto the Pacific coast. They go through complete metamorphosis with four life stages: egg, larva, pupa, and adult. Both adults and larvae live in burrows in the sand. Females dig shallow holes in moist sand and deposit eggs singly. After they hatch, the grub-like larvae dig small burrows in the sand and live there while they develop. They are sit-and-wait predators, catching invertebrate prey as it wanders past the burrow mouth. Larval development can take one to three years (Pearson et al. 2006). Females select oviposition sites that are moist enough to keep eggs and larvae from desiccating, and may also select sites that are not prone to extended inundation. In laboratory experiments, Cornelisse and Hafernik (2009) found that *C. hirticollis* females had a narrow preference for 20 percent sand moisture. While female nest choice can be critical to larval tiger beetle survival, hairy-necked tiger beetle larvae are unusual among tiger beetles in that they can be found crawling along the surface to relocate their burrows in response to changing soil moisture levels (Pearson et al. 2015).

Adult abundance peaks from April to late June and from early August to September (Pearson et al. 2015). Adults typically live for about 10 months from late fall to late summer of the following year, with a large portion of that time spent overwintering. Both adults and larvae overwinter (Pearson et al. 2015). Adults are extremely fast visual hunters, racing across the sand in quick bursts or moving in short hopping flights. Prey is caught and eaten with long, sharp, sickle-shaped mandibles. Foraging for food and mating takes place in open areas with little to no vegetation (Pearson et al. 2006). Little is known about the mating habits of hairy-necked tiger beetles, but in general tiger beetle mating takes place in the spring after adults emerge from hibernation. Males have been known to guard their mates against other males, even when mating is over (Pearson et al. 2006).

The Siuslaw hairy-necked tiger beetle in particular depends on freshwater outflows to the Pacific Ocean in areas with wet, firm sand and drier upland areas (such as sand dunes) (Mazzacano et al. 2009). Utilized habitat is characterized by a lack of compaction in larval burrow areas by human foot or ATV traffic. Adults do not appear to range very far from the moist, firmly packed sand on the edges of freshwater outflows (Mazzacano et al. 2009). Detailed habitat utilization surveys in 2009 found that core habitat for adult Siuslaw hairy-necked tiger beetles in Oregon consisted of “firm, flat, moist sand at and near the water’s edge, close to the outflow but also upstream; and the sloping edges of dunes where the sand is dryer, just above the high water mark” (Mazzacano et al. 2010). Within these habitats, the beetles showed a preference for dark sand flats in backwater or slackwater areas characterized by a light coating of algae and very dark, almost reddish sand (Mazzacano et al. 2010). Larval burrows were concentrated more densely in these areas, but were also scattered across a wider area of floodplain. At sites where *C. h. siuslawensis* co-occurred with other tiger beetle species, the other species were not observed on these marshier flats, suggesting each species occupies its own narrow niche within the habitat.

NEW RIVER ACEC SITE DESCRIPTION

The New River site complex was first reported by Ron Lyons in 2008 (Lyons 2008, pers. comm.) and is now known to host one of the largest and most abundant breeding populations of this subspecies. The site complex is within the New River Area of Critical Environmental Concern (ACEC), managed by the Bureau of Land Management. This is the only BLM-owned site complex where *C. h. siuslawensis* persists; it represents the southernmost extent of known *C. h. siuslawensis* populations in the state.

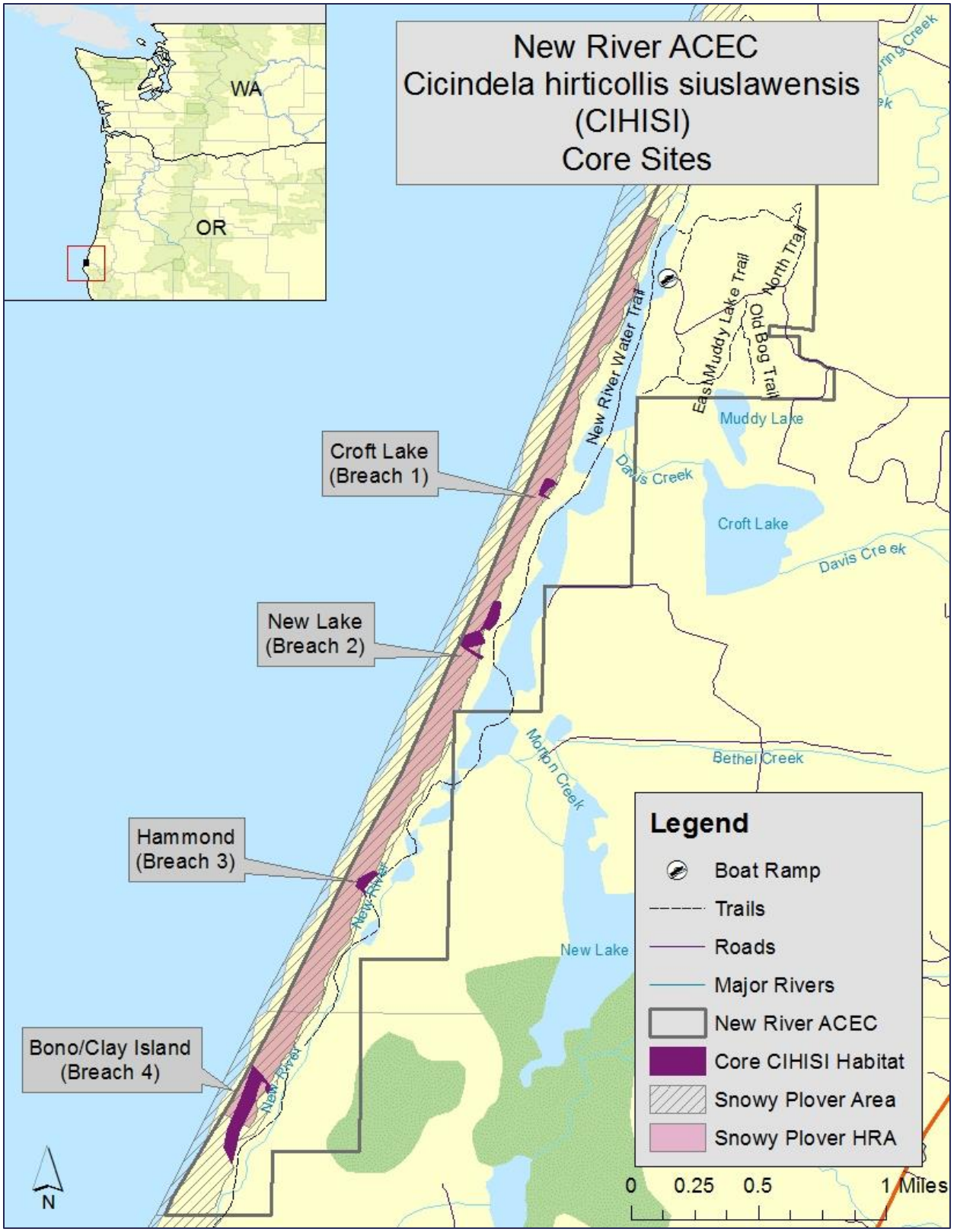
The New River ACEC is located on the western edge of Coos County, Oregon, on the Coos Bay BLM District, encompassing 1,136 acres of coastal dune and forest habitats. New River itself is approximately ten miles long and

growing, with an extensive dune system on the west side of the river. The natural river mouth has been steadily moving north in response to European beachgrass (*Ammophila arenaria*) invasion and subsequent dune build-up. This grass was introduced to the area in the 1930s and has since come to dominate the dune system at New River, altering stream flow and leading to succession of the dunes to coastal forest. Before the introduction of the beachgrass, the river had multiple stream mouths with outlets for creeks and other water bodies, including New Lake and Croft Lake (BLM 1995). These outlets closed prior to the mid-2000s, when the BLM and local ranchers created several breaches along the river to allow greater river-ocean connectivity and encourage salmonids to use the river. These breaches are the primary areas where the Siuslaw hairy-necked tiger beetle persists at New River.

New River ACEC is home to four core Siuslaw hairy-necked tiger beetle populations, which may form a metapopulation (see Table 2 and Map 2). Two other species of tiger beetles, *C. bellissima* and *C. oregona*, also occur at these sites, but appear to use slightly different microhabitats (see Mazzacano et al. 2010). Areas of suitable habitat along New River are limited and because of this tiger beetle distribution is patchy. However, the sites that do persist are relatively protected from human impact due to their difficult access and the fact that beaches along the spit are closed for several months each year to protect nesting snowy plovers (see snowy plover areas outlined in Map 2). In other areas of the state without this protection, Siuslaw hairy-necked tiger beetle populations have been lost, and pedestrian and Off Highway Vehicle activity are suspected to have played a role in these local extirpation events.

Table 2: Siuslaw hairy-necked tiger beetle counts at core sites on New River ACEC. (Note that three species of tiger beetles co-occur at these sites, and larval burrows cannot be identified to species.)

	2009 (presence/absence)		2010 (habitat utilization & population counts)		2014 (population counts)	
Site Name (breach)	**Adults**	**Larval Burrows**	**Adults**	**Larval Burrows**	**Adults**	**Larval Burrows**
Croft Lake (1)	6	N/A	45	7	30	740
New Lake (2)	4	N/A	97	521	57	80
Hammond (3)	2	N/A	3	907	14	32
Bono Clay Island (4)	19	N/A	56	168	29	6

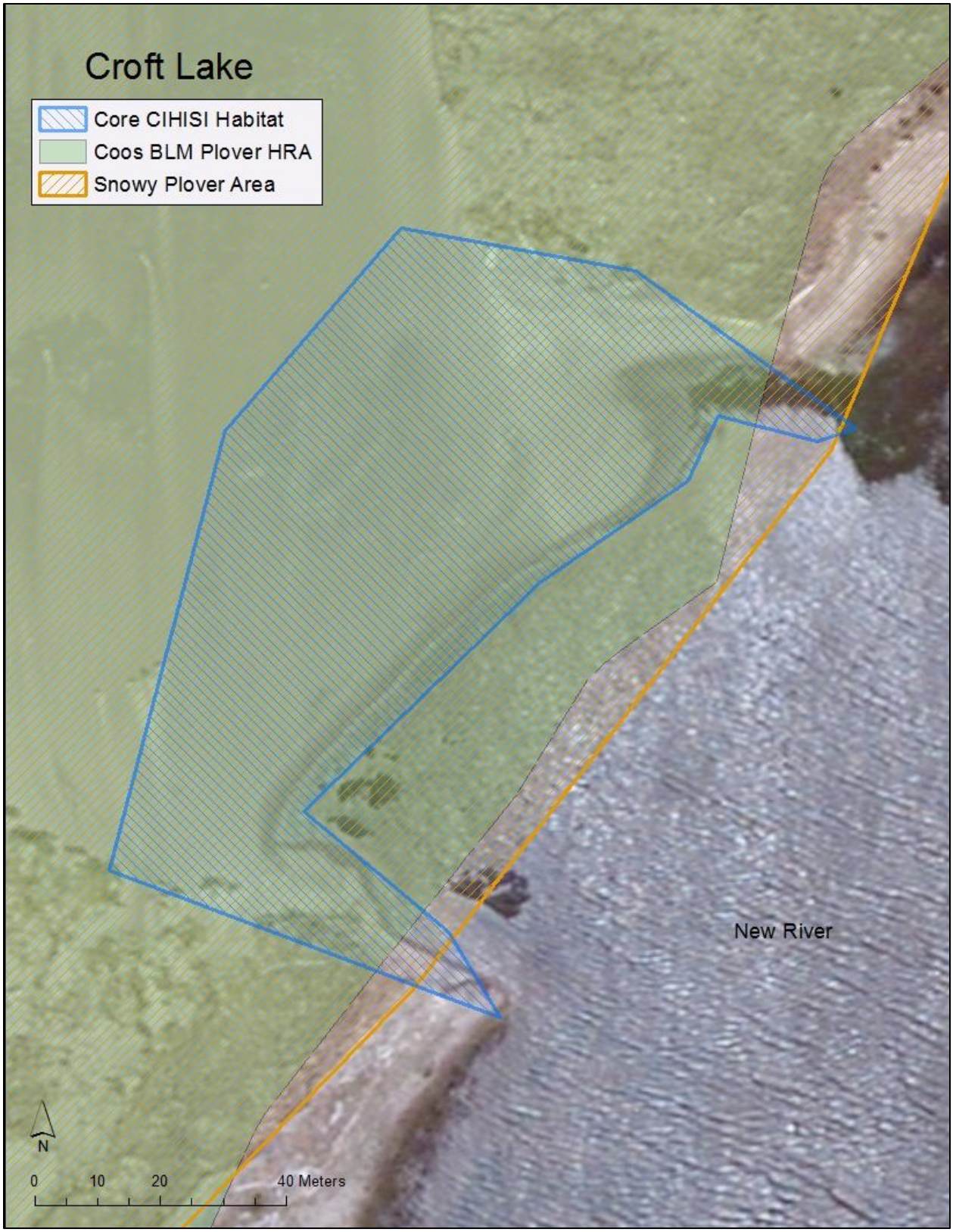


Map 2: New River ACEC depicting core Siuslaw hairy-necked tiger beetle locations and the snowy plover Habitat Resource Area.

CROFT LAKE (BREACH 1)

Figure 1: Croft Lake tiger beetle habitat.

Croft Lake is the northernmost breach at New River and was last breached in 2006. This site is composed of fine sands with ample adult and larval burrows found throughout the survey area (see Figure 2). Adults appear to utilize all sections of beach surveyed. Larval burrows are most abundant in hard packed, fine-grained sand. Both *C. oregona* and *C. bellissima* have been observed at this site. During summer 2014 surveys, burrows appeared to be generally larger in diameter at this site than at other breaches surveyed, which may indicate older instars. The core occupied habitat at this site falls almost entirely within the Coos Bay BLM snowy plover Habitat Restoration Area (see Map 3) and is subject to excavation and breaching activities related to plover management.



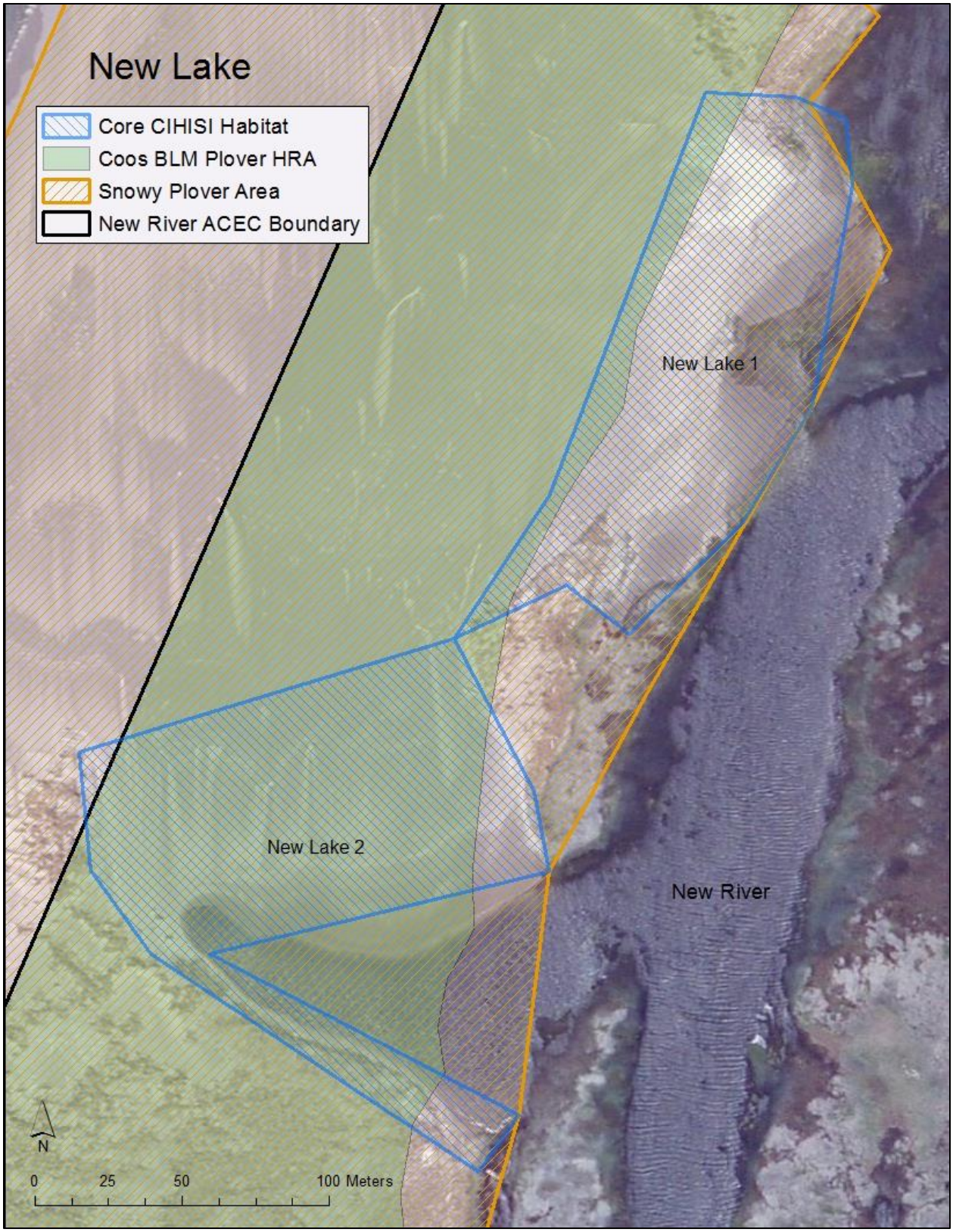
Map 3: Croft Lake occupied habitat and adjacent snowy plover nest. The full extent of this map falls within New River ACEC. CIHISI refers to *Cicindela hirticollis siuslawensis*.

NEW LAKE (BREACH 2)

Figure 2: New Lake tiger beetle habitat. The photo on the left depicts New Lake 1 (the river-carved opening), while the photo on the right shows the actual breach at New Lake 2.

The New Lake breach was created in 2005. Since then, the river has carved out open sand north of the actual breach (labeled New Lake 1 on Map 4), and the ocean has also washed over the open sand area to keep the breach open. Because of this, there are two open sand areas, both of which are occupied by the Siuslaw hairy-necked tiger beetle. These areas are located within the snowy plover closure area and are in snowy plover critical habitat (USFWS 2012). The close proximity of the two sites means the actual breach area may be easily recolonized by Siuslaw hairy-necked tiger beetles from the north. There are currently no plans to breach New Lake 2, the BLM may re-breach New Lake 1 in the future if the necessary trigger points identified in the breach permit are met (Wright 2015, pers. comm.).

Both *C. oregona* and *C. bellissima* co-occur with the Siuslaw hairy-necked tiger beetle at this site. During 2014 surveys, we observed one mating pair of *C. h. siuslawensis* at the New Lake 1 site and six mating pairs at the New Lake 2 site (identified on map). Many adult burrows were also observed in upland areas of New Lake 2. Tiger beetles were most common in hard packed sand area adjacent to New River, extending westward approximately 50 feet.

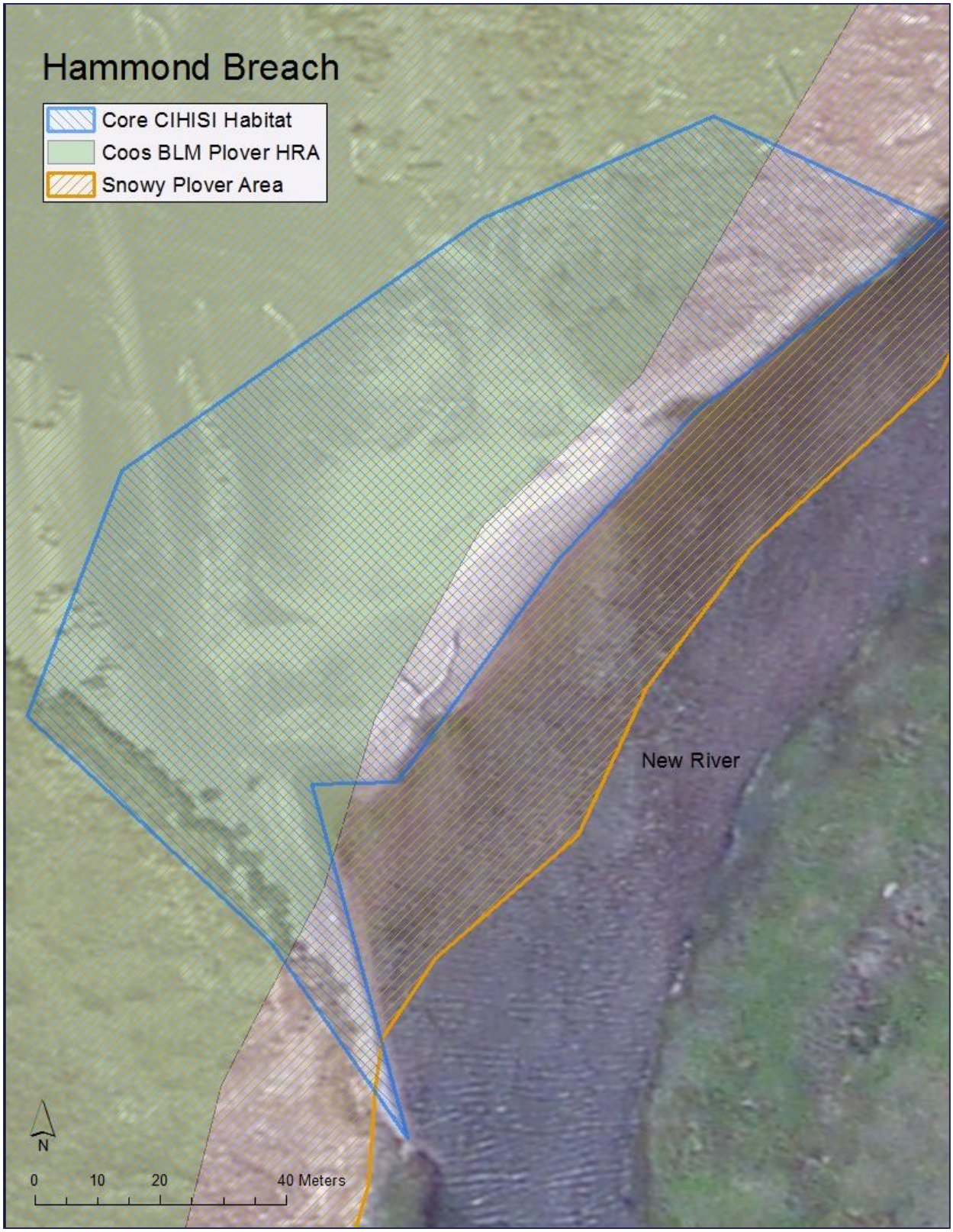


Map 4: New Lake occupied habitat. The New River ACEC lands stretch east from the boundary line seen on this map. CIHISI refers to *Cicindela hirticollis siuslawensis*.

HAMMOND (BREACH 3)

Figure 3: Hammond tiger beetle habitat, prior to winter 2014/2015 breaching.

Hammond Breach was created in the winter of 2002-2003 and is the most recently breached site, having been excavated during December 2014 (note that the photo in Figure 4 was taken prior to breaching). This breaching resulted in a wider breach and a lowering of the foredune which will allow for general ocean overwash (Wright 2015, pers. comm.). Both *C. oregona* and *C. bellissima* have been observed at this site. At the time of our summer 2014 surveys, most adult beetles were confined to 10-15 feet from the water's edge. The sand at this site was hard packed and algae coated. Many potential adult burrows were observed along the grass and sedge line. Digger wasps (*Bembix* sp.) use crescent shaped burrows that look similar to adult tiger beetle burrows at this site, making positive identification difficult.



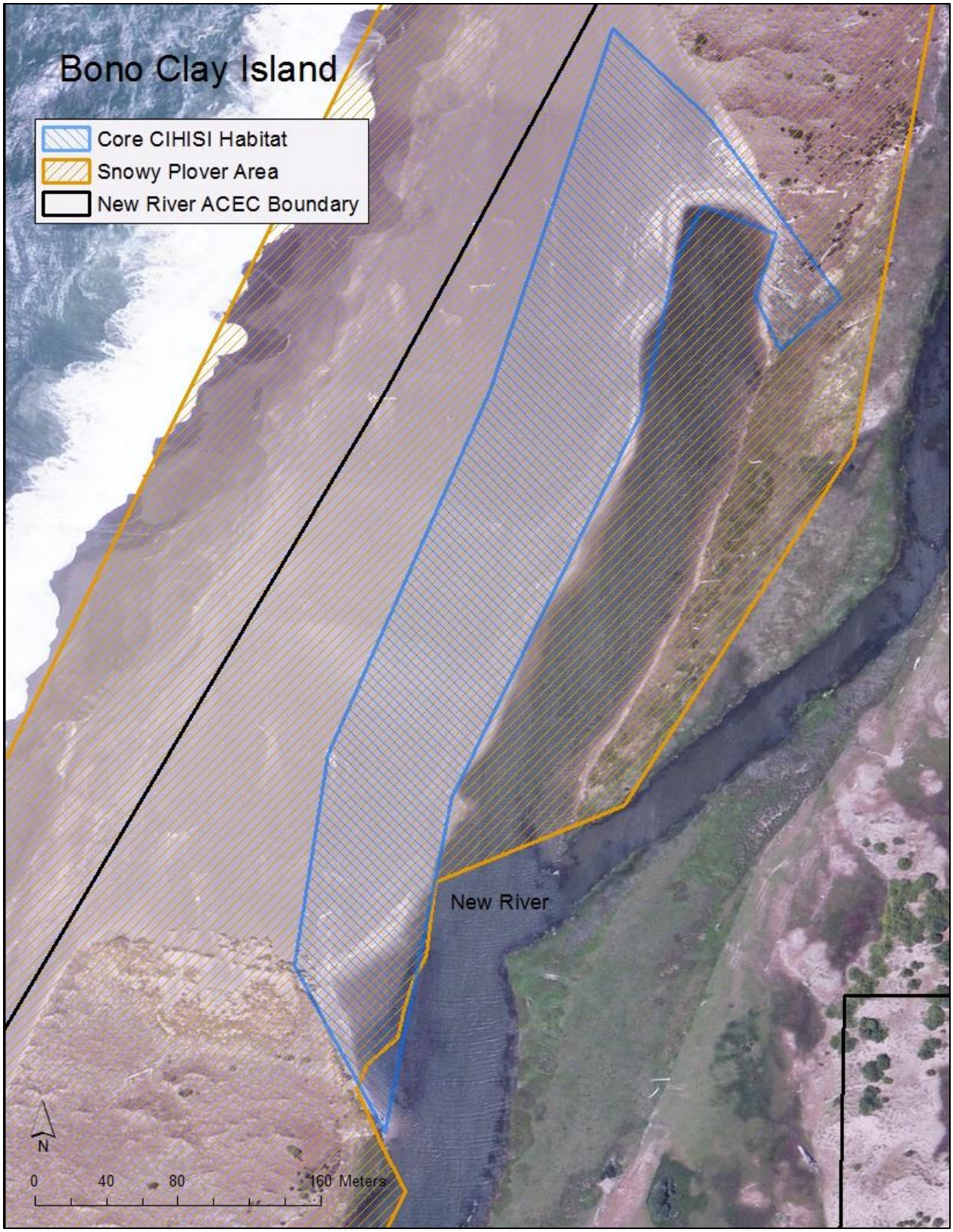
Map 5: Hammond Breach occupied habitat. The full extent of this map falls within New River ACEC. CIHISI refers to *Cicindela hirticollis siuslawensis*.

BONO CLAY ISLAND (BREACH 4)

Figure 4: Bono Clay Island tiger beetle habitat.

The Bono Clay Island breach was created in 2006 or 2007. The site is now continually carved out by the river, and there are no current plans to re-breach this site (Wright 2014, pers. comm.). Clay Island is technically outside of the Habitat Restoration Area; however, breaching has restored this site to suitable plover nesting habitat and it has been occupied by the plovers in recent years (Wright 2015, pers. comm.). Although the BLM is not obligated to maintain the area as habitat for plovers under USFWS regulations, it is still considered critical plover habitat (Wright 2015, pers. comm.). About 50 years ago, the dunes along New River were all shallow, similar to the habitat found at this breach. Recreation near this site includes late fall fishing access for Chinook, coho, and steelhead salmon. Occasionally, beach walkers from the Oregon State Beach Trail also venture to this site.

Surveys in 2014 took place under less than ideal conditions, with high winds and frequent gusts that caused the sand to skim along the beach surface. Most *Cicindela* observed at this site were found in an area sheltered from the heavy winds. This site had finer grain sands than other areas, and this combined with the wind may have caused larval and adult burrows to become covered up, which may be the reason so few burrows were counted in 2014 (see Table 2). Digger wasps (*Bembix* sp.) were observed digging burrows in upland sand areas that looked very similar to adult tiger beetle burrows. *C. bellissima* and *C. oregona* also occur at this site.



Map 6: Bono Clay Island occupied habitat. Note that this site is outside of the western snowy plover Habitat Restoration Area, which ends at Hammond Breach. CIHISI refers to *Cicindela hirticollis siuslawensis*.

MANAGEMENT HISTORY

As an ACEC, New River is specially managed to "protect and prevent irreparable damage to important, unique, and significant historic, cultural, and scenic values; fish or wildlife resources; and natural systems or processes; or to protect life and safety from natural hazards" (Bureau of Land Management [BLM] Manual 1613 - .02). A thorough review of New River's site management history is available in the New River ACEC Final Management Plan (BLM 2004). This plan is currently being revised and is expected to be finalized over the next few years (Wright 2015, pers. comm.). Past site management activities at New River include grazing, prescribed fire, weed removal, predator control for western snowy plover conservation, and breaching. Below, we touch upon the site management history most pertinent to the Siuslaw hairy-necked tiger beetle.

GRAZING

Both the BLM and private ranchers own land along New River. Prior to 2001, private ranchers grazed livestock regularly along the riparian zone of New River and along the Floras Lake outlet (BLM 2004), although grazing on the west side of the river was phased out in the late 1990s (Wright 2015, pers. comm.). In 2001, these existing grazing permits within the ACEC were analyzed in an environmental assessment; it was determined that grazing actions needed to change in order to better protect habitats for imperiled species along New River, such as coho salmon and western snowy plover. Grazing permits were converted to Cooperative Management Areas, which allow livestock to graze in designated portions of the ACEC located outside of the New River riparian corridor (BLM 2004). All grazing in the corridor was phased out by 2003 (Wright 2015, pers. comm.).

BREACHING

New River has a long history of breaching, which has occurred both naturally (during periods of high rain and flooding) and mechanically (originally with shovels and dynamite for gill netting, and later with large earthmovers) since at least 1919 (Wright 2014, pers. comm.). Mechanical breaching is used to alleviate flooding to nearby ranch lands, flush sediment out of the river channel (important for salmon smolts), and improve general river health. Mechanical breaching may also improve river channel depth to maintain continuous summer flows and lower high summer stream temperatures. Temporary mechanical breaches were conducted within the ACEC during the 2002-2003 and 2003-2004 winters, which were effective at deepening the channel and providing flood alleviation of adjacent ranch lands. More permanent breaches were constructed from 2003 to 2007 (Wright 2015, pers. comm.).

More permanent breaching activities help maintain open sand habitat for the plover, but the timing of these practices is limited based on when coho salmon are smolting, as managers do not want to flush the smolt from the river into the ocean at this young stage. They are further constrained by the need for the river to be 15.5 feet high before February 15, after which snowy plover restrictions fall into place and juvenile coho salmon are in New River. This leaves a narrow window of opportunity to breach the spit. In recent years rainfall has occurred later than expected (significant rain has come in the spring rather than the winter), so the river does not rise high enough during the appropriate time period to conduct the breaching (Wright 2014, pers. comm.). However, when conditions are right, breaches are excavated with large earthmovers that are brought along the beach side of the spit from the north. Some of the dune is carved out with the earthmovers, leaving behind a small 'plug.' When the river reaches at least 15.5 feet, the 'plug' is bulldozed, allowing New River to rush through to the ocean. Breaching done in the winter of 2014-2015 at Hammond Breach was the first successful breaching conducted by the BLM since 2009 (Wright 2015, pers. comm.).

SNOWY PLOVER MANAGEMENT

An important management concern is providing breeding and overwintering habitat for the federally threatened western snowy plover. The BLM maintains approximately 100 acres of Habitat Restoration Areas for the western snowy plover within the ACEC, primarily by excavating sand (and European beachgrass) with large earthmovers. Since 1998, the BLM has implemented an annual habitat restoration project on the New River foredune designed to provide breeding and wintering habitat for the western snowy plover (BLM 2004; Wright 2014, pers. comm.). This foredune has been treated with bulldozers and prescribed fire to remove invasive European beachgrass and provide open sand habitat for the plovers. This project has also been integrated with the mechanical breaching described above. Each site is generally excavated every two to three years to flatten dunes and push material against the back dune to prevent ocean overwash (Wright 2014, pers. comm.). With the exception of the temporary breach locations, a 50-foot buffer of European beachgrass is left along the east side of the dune to ensure that sand is not deposited into New River, which would degrade habitat for coho salmon smolts. Back dunes are maintained for coho salmon and are not part of snowy plover management.

As part of their snowy plover management activities, the BLM places signs along the beach to mark restricted areas for plover breeding. These are monitored and maintained several times every week from March through September. In addition, predator management activities and bird banding take place each season. Fencing and sign placement, monitoring, predator control, and maintenance are all facilitated by ATV use. With the exception of these activities and the use of ATVs for administrative access and other specially permitted scientific research, monitoring, resource protection, and restoration projects, ATVs are not permitted on lands with the ACEC.

RECREATION

New River ACEC is also managed for recreational use, including hiking, boating, fishing, horseback riding, and waterfowl hunting. Hikers can access the west side of New River via a footbridge and trail leading from Floras Lake. This footbridge has a permanent post to restrict vehicle access to the beach; however, this post is removable for authorized access for maintenance or emergency purposes. Beach camping is allowed only under special circumstances for long-distance backpackers hiking the Oregon Coast Trail and requires a special use permit issued by the BLM. Camp stoves are allowed but open fires are not permitted without special permit. Boating and sport fishing are both allowed throughout New River. Waterfowl hunting is allowed south of Croft Lake.

THREATS

GENERAL THREATS

NatureServe (2015) classifies the overall threat impact to Siuslaw hairy-necked tiger beetles as “very high to medium” with a long-term population trend decline of greater than 70 percent. Habitat loss, degradation, and fragmentation have likely destroyed much of the Siuslaw hairy-necked tiger beetle’s historic range, and they now appear to be absent from the northern and southern extents of their range in Oregon (Mazzacano et al.. 2009, Knisley et al.. 2014). They are highly vulnerable to anthropogenic disturbances such as trampling and compaction from recreation (pedestrian foot traffic, public beach use) and vehicle use (Knisley and Hill 1992a; Cornelisse and Hafernik 2009); habitat succession and invasive plants can also negatively impact hairy-necked tiger beetle populations. In Oregon, *C. h. siuslawensis* is threatened by vehicular and pedestrian traffic, coastal development, livestock grazing, soil movement and deposition, and invasive plants (Mazzacano et al. 2009, Knisley 2011, Knisley et al. 2014). Knisley et al. (2014) assigned *C. h. siuslawensis* in Oregon and Washington a rarity grade of imperiled

after finding that populations were most threatened by recreational beach activity. Surveys of *C. h. siuslawensis* throughout Oregon have indicated an overall pattern of absence from beaches with moderate to heavy OHV and recreational use (including beach activities such as pedestrian foot traffic, bonfires, sandcastle building, etc.) (Mazzacano et al. 2009, 2010).

At the landscape scale, the small and isolated nature of extant populations, coupled with relatively small patches of habitat, leave the Siuslaw hairy-necked tiger beetle inherently vulnerable to extinction. Small and fragmented populations are generally at greater risk of extinction from normal population fluctuations due to predation, disease, and changing food supply; in addition, they are also threatened with extinction from a loss of genetic variability and reduced fitness due to inbreeding that can occur in such small populations (*reviewed in* Shaffer 1981). Climate change may also alter the seasonality and range of moisture and temperatures experienced by this species; however, more research is needed to determine the effects of climate change on existing populations.

SITE SPECIFIC THREATS

At New River ACEC, the largest threats to the Siuslaw hairy-necked tiger beetle include invasive plants and dune succession, soil movement and compaction, and, to a lesser extent, recreation and predator control activities relating to western snowy plover management. Local extinctions can occur as a result of habitat deterioration and stochastic weather events. Potential events of greatest concern may include: 1) heavy rain storms and severe flooding which drown and scour larvae away and result in sediment deposition, and 2) outright removal or destruction of tiger beetle habitat as a result of breaching and invasive grass removal for western snowy plover management. Interestingly, the New River ACEC site, which hosts the largest known population of *C. h. siuslawensis*, is relatively inaccessible and has been protected from visitor and vehicle use due to its location and annual beach closures to protect western snowy plover breeding habitat. However, while the protection of beaches for western snowy plover from human activity for six months out of every year has likely benefited *C. h. siuslawensis*, certain plover management activities – such as breaching – have the potential to negatively impact *C. h. siuslawensis* populations.

INVASIVE PLANTS

Invasive vegetation is increasingly becoming a serious threat to tiger beetle habitats across the country. Knisley and Hill (1992a) described the extirpation of two tiger beetle species as a result of increasing vegetation with natural succession. In addition, several populations of the endangered Ohlone tiger beetle have been lost due to invasive vegetation eliminating open patches in their coastal California grasslands (Knisley and Arnold 2004, 2013; Cornelisse 2015, pers. comm.). Invasive vegetation has also been documented as a primary threat to populations of *C. puritana* in New England and Maryland (Knisley and Fenster 2009) and *C. waynei* in Idaho (Winton 2015, pers. comm.). Mechanical and manual removal of invasive plants in addition to prescribed fire have often been used to control these species; however, land managers are increasingly turning to herbicides to control these invasive plants across large parcels of land.

Dune stabilization and subsequent ecological succession, caused in part by invasive European beachgrass (*Ammophila arenaria*), are reducing the amount of open sand habitat and may be the greatest threat to the Siuslaw hairy-necked tiger beetle at the New River ACEC. European beachgrass is the primary invasive plant at the tiger beetle occupied sites, and poses a number of management challenges for both the tiger beetle and other sensitive species such as western snowy plover. European beachgrass was originally planted along west coast rivers and roadways in the early 1900s to stabilize shifting sands and protect homes and businesses; unfortunately,

it has proven very effective at stabilizing the dunes and allowing coastal forests to take hold behind the foredunes. This species spreads via an extensive underground rhizome system and has proven to be incredibly difficult to eradicate. European beachgrass now out-competes native species and builds unnaturally high sand dunes at the front of the beach by capturing sand grains at the base of its leaves. Beachgrass also eliminates the open sandy habitat needed by tiger beetles to forage and oviposit by shading available habitat and filling open spaces, hence creating unsuitable and often densely vegetated habitat (see Figure 1). Cornelisse and Hafernik (2009) found that larval tiger beetle burrows (including those of *C. hirticollis*) were often located near sparse low-lying vegetation (such as occurred on Oregon beaches prior to the invasion of European beachgrass) but never under the dominant and invasive European beachgrass. For adult beetles, bare ground open to sunlight is critical for behavioral thermoregulation and the maintenance of the high body temperature necessary for prey capturing (Dreisig 1980, Dreisig 1981, Knisley et al.. 1990, Knisley and Hill 1992b).

Yellow flag iris (*Iris pseudacorus*) has recently become a major invader at New River, where it outcompetes native riparian vegetation and takes over sites that Siuslaw hairy-necked tiger beetle adults and larvae use at the water's edge (Wright 2015, pers. comm.). This perennial species can spread by seed or underground rhizomes and poses many of the same threats to tiger beetle populations as outlined for European beachgrass above. Invasive Scotch broom (*Cytisus scoparius*) and gorse (*Ulex europaeus*) also pose threats to Siuslaw hairy-necked tiger beetle habitat, but to a lesser degree than European beachgrass and yellow-flag iris. More recently, American beachgrass (*Ammophila breviligulata* - native to the East Coast and Great Lakes region but introduced in the west) has become established at a number of locations along the Oregon coast and seems to be out-competing the European beachgrass; however, this species is not currently present in New River ACEC (Wright 2015, pers. comm.).

Figure 5: Invasive European beachgrass at the New Lake tiger beetle site.

SOIL MOVEMENT

While creation of bare ground has been shown to increase tiger beetle habitat (Cornelisse et al.. 2013), the use of earthmovers to entirely remove dunes and periodically breach the New River spit may drastically affect tiger beetle populations by destroying larval burrows and killing adults. Of particular concern are the depth of breaching activities, timing of these activities, and speed of driving by earth moving equipment (Cornelisse 2015, pers. comm.). Breaching occurs every few years, while bulldozing to remove beachgrass can occur annually if funds are available (Wright 2015, pers. comm.). Bulldozing activities generally occur within vegetated buffers and likely do not have large impacts on tiger beetles. Breaching, on the other hand, can physically remove, crush, or bury tiger beetle adults and larvae, depending on the speed of the equipment, the moisture of the sand, the depth of the bulldozer, and the amount and location of deposited sand. Sand movement and deposition may also have indirect negative effects on prey availability by removing or burying prey populations and their habitats.

SOIL COMPACTION

In addition to the potential for physically crushing larvae, soil compaction from trampling and vehicle use can reduce soil pore space and moisture, which may have significant effects on larval tiger beetle survivability (Cornelisse and Hafernik 2009). At New River ACEC, soil compaction can occur through western snowy plover management activities described above and from ATV use for predator control, rope and sign installation and removal (Wright 2015, pers. comm.). These vehicles can compact soil and negatively impact tiger beetle populations if used in areas with larval burrows. They can also directly kill tiger beetle adults. Recreational use of the site, including hiker and day-use pedestrian traffic, can also lead to soil compaction, although these activities at New River are minimal and probably pose less of a threat.

RECREATION

The primary recreational uses at the New River ACEC include late fall fishing access for Chinook, coho, and steelhead; waterfowl hunting; beachcombing; wildlife viewing; canoeing and kayaking; picnicking; hiking; and camping (BLM 2004; Wright 2014, pers. comm.); however, due to the somewhat isolated nature of the spit, these pressures are fairly limited compared to nearby sites on the Oregon coast. Within the ACEC, the entire beach west of New River is closed to OHVs year-round, with the exception of predator control vehicles (ATVs) used for snowy plover management and other special allowances for resource protection and restoration (BLM 2004; Wright 2014, pers. comm.). Hiking occurs along a ten mile stretch of the Oregon Coast Trail, which runs along the New River ACEC. This portion of the trail is unmaintained and consists entirely of the beach below the high tide line. Most backpackers hike this trail in the summer, when river levels are lower and crossings are easier (BLM 2004). Backcountry camping is permitted with a special permit, and is only allowed at a remote campsite which is located in the dunes outside of known tiger beetle habitat.

SECTION II: GENERAL MANAGEMENT CONSIDERATIONS

Habitat and conservation needs of the Siuslaw hairy-necked tiger beetle should be taken into consideration in management guidelines for the threatened western snowy plover, with which it co-occurs at New River and several other sites in Oregon and Washington. At New River ACEC, the Siuslaw hairy-necked tiger beetle would benefit from the removal of invasive plants, protection of suitable microhabitat, limitation of vehicular and pedestrian traffic on beaches, and restoration of potential nearby habitat. Extant populations of the Siuslaw hairy-necked tiger beetle in Oregon are found primarily in areas where human presence is highly restricted either for

protection of snowy plover nests, or from lack of easy access. Overlap with snowy plover habitat likely provides some level of protection for this species, although *C. h. siuslawensis* is more frequently observed on the wet sand adjacent to outflows, whereas snowy plover habitat usually consists of nesting sites in the drier sand areas and foraging areas at the tideline.

Both *C. h. siuslawensis* and western snowy plovers require open sand habitat for survival, yet activities conducted in the winter to combat invasive non-native beachgrasses and maintain open beaches for snowy plover nesting could have dramatic negative impacts on the relatively small, scattered populations of *C. h. siuslawensis* that still survive in Oregon. With detailed knowledge of *C. h. siuslawensis* habitat utilization, it is possible for machinery and equipment needed for beach maintenance activities to avoid important habitat regions. In places where this is not feasible, different patches of core habitat could be protected from year to year, to maintain stable beetle populations that could re-colonize restored areas of habitat at New River. Breaching activities could also be timed for periods of low larval activity, to help reduce impact to sensitive life stages (Cornelisse 2015, pers. comm.); however these periods are not well understood for the Siuslaw hairy-necked tiger beetle at New River, and additional research is needed.

Once implemented, these management actions should be accompanied by regular surveys to assess their success in conserving *C. h. siuslawensis* populations at the site, and to allow for adaptive management if new or different conservation practices are needed.

SECTION III: SPECIFIC MANAGEMENT ACTIONS

GOAL 1: MAINTAIN OPEN HABITAT FREE OF INVASIVE VEGETATION

Maintenance of bare ground may be critical to sustaining Siuslaw hairy-necked tiger beetle populations at New River, as this species apparently needs open, sandy areas with little or no vegetative cover (Mazzacano et al. 2010). In order to maintain this type of habitat, these locations need regular, moderate disturbance to impede the growth of vegetation (Stanton and Kurczewski 1999). Mechanical removal of vegetation can help to keep areas open by delaying succession. Herbicides (containing imazapic and glyphosate) have been used with some success in reducing vegetation, but herbicide effects on *C. h. siuslawensis* are mostly unknown and need further study. Creation of bare soil and sand by removal or relocation may be beneficial to tiger beetle survival by providing flat, open surfaces for them to colonize. Staines (2005) found that a large population of *C. hirticollis* and smaller populations of four other species colonized newly deposited sand along a beach in the Upper Chesapeake Bay. Cornelisse et al. (2013) found that scraping of vegetation from ground surfaces successfully augmented egg-laying habitat for the endangered *C. ohlone*. To augment bare sand habitat for adults, we recommend hand removal of invasive grasses at occupied sites and restoration of natural dune ecosystems with sparse native vegetation. In addition, land managers could consider altering the current practice of leaving a 50 foot vegetation buffer along New River, which is likely not beneficial to the Siuslaw hairy-necked tiger beetle. If at all possible, removal of non-native vegetation along the river edge, particularly between breaches, would expand potential habitat.

Specific Management Actions:

1. Conduct hand removal of invasive vegetation within core tiger beetle habitat (see Map 2 and individual breach maps under New River ACEC Site Description) to minimize impacts associated with more intensive control methods. Avoid trampling burrows during this process.

2. Control invasive vegetation near occupied tiger beetle sites and do not allow it to encroach into core habitat. If herbicides are necessary, protect non-target (native) vegetation and use the least toxic, lowest amount necessary to achieve desired results.
3. Identify periods of adult inactivity and decreased larval sensitivity and conduct vegetation management practices during this time. This may be when larvae are in their latest instar, when they are able to crawl out and relocate to new burrows following disturbance.

GOAL 2: RESTORE NATIVE DUNE HABITAT

At New River ACEC, the Siuslaw hairy-necked tiger beetle is known primarily from open man-made breaches along the west side of New River. Removal of non-native plants and restoration of the native dune community along additional stretches of New River, particularly between populated breaches, could be beneficial to this subspecies by opening up corridors for dispersal and providing additional breeding and feeding habitat.

Specific Management Actions:

1. Restore native dune vegetation with species that are compatible with tiger beetle habitat needs and the needs of other species on the ACEC, including the western snowy plover.
2. Maintain adjacent vegetative composition and structural characteristics of native coastal habitat preferred by hairy-necked tiger beetles, including:
    a. Low total vegetative cover
    b. Low to no relative cover of non-native grasses and shrubs
    c. High relative cover of native grasses and other herbaceous species
    d. High proportion of un-vegetated bare ground
3. Avoid excessive foot traffic and the use of heavy equipment or other vehicles in occupied areas to prevent killing individual adults and sensitive larval burrows.

GOAL 3: LIMIT VEHICLE AND PEDESTRIAN ACCESS

Vehicle and pedestrian access should be limited to reduce the threats associated with trampling and off-road vehicle use (see Cornelisse and Hafernik 2009). Measures taken to reduce these impacts may involve posted signage and limited seasonal access, some of which already occurs at New River. In the past, predator control vehicles (ATVs) have been observed driving on the wet sand along New River in order to avoid snowy plover nests; unfortunately, this is the same area where *C. h. siuslawensis* larval burrows occur (Mazzacano et al.. 2009). A focused effort should be made to avoid areas of moist, firm sand adjacent to New River. Predator control employees could also be trained to identify adult tiger beetles and larval burrows, so that the impacts from ATVs can be minimized.

Specific Management Actions:

1. Avoid driving through known occupied tiger beetle habitat with ATVs, earth moving equipment, or any other vehicles. If vehicles absolutely must go through occupied habitat, avoid areas of moist, firm sand directly adjacent to New River. Vehicles could be equipped with wide, smooth-surfaced tires during the wet season to avoid rutting tiger beetle habitat.
2. Train predator control employees, contractors, and BLM staff in identifying adult tiger beetles and larval burrows, so that impacts from ATVs and earth moving equipment can be minimized.

3. Discourage camping by through-hikers and banking of boats in breach areas or other occupied habitat by expanding western snowy plover restricted areas to include tiger beetle core habitat.
4. Include educational material on signs at the New River Nature Center and other trailheads to inform the public about sensitive habitats.

SECTION IV: ADDITIONAL RESEARCH

Although some facets of the Siuslaw hairy-necked tiger beetle's life and behavior are relatively well-known, considerable information gaps remain that make it difficult to adequately assess the conservation status and management needs of this species. Additional research is needed to better understand this beetle's life history and to inform and refine management techniques for this species at New River. See Table 3 for a summary of these research needs and their priority levels at New River ACEC.

Table 3: Prioritization of research and monitoring goals at New River.

Specific Research or Monitoring Goal	Priority
Determine the effects of various methods of invasive vegetation removal on beetle abundance and distribution and implement the methods that are most beneficial to maintaining and increasing habitat for the beetle.	1
Document overwintering behavior and determine what areas the beetles use in the winter.	2
Establish better survey methods for determining true population size at New River and continue to monitor beetle populations annually to understand population trends over time.	3
Investigate population dynamics within the ACEC to shed light upon dispersal capabilities, recolonization potential, movement patterns, etc.	4
Document habitat associations (including diet and foraging needs) of adult and larval beetles to better inform restoration and management activities.	5

POPULATION MONITORING

Long-term monitoring of the tiger beetle populations at New River is vital for understanding the status of these rare insects. In addition to monitoring presence at known sites and searching for new sites, we recommend monitoring the abundance of *C. h. siuslawensis* annually at New River. To do this effectively, a more robust survey effort is needed than has been employed in the past (see survey techniques section, below). In particular, long term monitoring of disturbance regimes (i.e., breaching and bulldozing) in occupied habitats will provide insight into microhabitat requirements and limits. Do populations stabilize, decline, or grow? Surveyors should focus on moist areas with fine grain sands and should continue to inventory currently unoccupied but appropriate habitat to determine if beetles are present. Tiger beetles depend on areas that are inherently temporary, as shifting sands and fluctuating water levels dictate appropriate habitat. Because of this, individual populations can fluctuate from year to year. It may be best to consider metapopulations in an area, and calculate the population size and health as an entire metapopulation.

OVERWINTERING BEHAVIOR

Riparian tiger beetles occupy dynamic habitats that are constantly changing in response to fluctuating moisture regimes, and as a result some species may be specially adapted to survive long periods of inundation and flooding (Wilson 1974, Pearson 1988, Brust et al. 2005, Brust and Hoback 2009). Brust et al. (2005) found that *C. hirticollis* larvae from riverine and seashore habitats survived 1-5 days of immersion under laboratory conditions. Larvae of

the salt flat-associated tiger beetle *C. togata* survived up to six days of immersion by entering a quiescent state (Hoback et al. 2009). It has been proposed that some tiger beetle adults can also survive immersion by trapping air bubbles beneath the elytra (Adis and Messner 1997, Brust et al. 2005), a behavior that Brust et al. (2005) suggest may apply to *C. hirticollis.*

C. hirticollis individuals are known to overwinter as both larvae and adults (Pearson et al. 2015), so it is likely that *C. h. siuslawensis* is present year-round in both life stages at the New River ACEC. While adults are more mobile and can likely escape to higher ground during floods and other winter submergence events, it is unknown how long larvae of this subspecies can persist in their burrows. Interestingly, although larval burrow locations are initially determined by ovipositing females, *C. hirticollis* larvae can relocate their burrows in response to changes in moisture (Brust et al. 2006).

Mazzacano et al. (2010) suggest that *C. h. siuslawensis* is adapted to tolerate periods of inundations as the tide comes in, and does not generally relocate in response to normal tidal activity. However, Wright (2014, pers. comm.) notes that the winter high water line can reach the plover fence line, completely inundating the summer-occupied New River larval burrow sites, sometimes for several weeks at a time. It seems unlikely that larvae could withstand such long periods of inundation. Additional studies could investigate larval and adult responses to flooding at New River, and the ability of *C. h. siuslawensis* to relocate larval burrows or survive long periods of immersion. What specific behavioral or physiological responses are employed? And how much do winter storms and flooding contribute to larval mortality? Mapping of larval burrows during the winter season is needed to determine if larvae remain in their burrows or relocate further up the beach. For example, *C. dorsalis dorsalis* larvae on Martha's Vineyard have been observed moving 20-50 meters up the beach to overwinter on higher ground, apparently as an adaptive behavior to avoid being washed out into the ocean (Nothnagle and Simmons 1990, cited in USFWS 1994). It is possible *C. h. siuslawensis* has evolved similar behavioral adaptations to survive winter flooding of summer larval burrows.

INVASIVE PLANT MANAGEMENT

Invasive plants represent one of the greatest management concerns at the New River tiger beetle sites. Historically, these plants have been treated with a combination of mechanical, manual, and chemical means. European beachgrass is particularly difficult to eliminate from the coastal dune landscape, and alternate chemical means of control are currently being considered. Additional research is needed to determine the best timing, rate, and class of herbicide applications at the New River tiger beetle sites. Although some herbicides appear to have little to no negative effects on tiger beetle larvae (Knisley and Fenster 2009; Knisley 2015, pers. comm.), adults may be more sensitive to treatments. Application of herbicides during periods when adults are less active may provide an additional safeguard. A study comparing the effects of various forms of beachgrass removal (i.e., herbicides, mechanical removal, manual removal, etc.) on *C. h. siuslawensis* abundance would be beneficial.

HABITAT NEEDS AND FORAGING PREFERENCES

Species-specific preferences for particular salt and soil moisture regimes have been documented for multiple tiger beetle species and may be important for habitat partitioning and reduction in competition between species. *C. h. siuslawensis* co-occurs with two other tiger beetle species (*C. oregana and C. belissima*) and each species appears to occupy its own habitat niche within the site, although detailed studies have not been conducted to determine which factors are most important to each species. This knowledge, coupled with additional research to evaluate microhabitat characteristics of larval habitat including salinity and hydrology, will be critical to restoration efforts.

Soil mapping of known *C. h. siuslawensis* sites could also be conducted to determine if known sites share the same soil type. Restoration practices should be evaluated to determine their effectiveness and impact on Siuslaw hairy-necked tiger beetle populations.

Little is known about the diet and foraging preferences of *C. h. siuslawensis*. Basic life history research could address questions regarding how and where adult beetles forage and what they are foraging for. Knowledge of foraging habits and needs can directly guide management and restoration practices. For example, do adults only hunt on bare ground? Is bare ground under the vegetation canopy adequate or does bare ground need to be free of overhanging vegetation? What is the bare ground threshold for this subspecies? Is there a threshold below which the site is not suitable habitat? What do adults and larvae typically eat? Is prey availability limited by surrounding vegetation and other microhabitat factors? Additional research that would help inform management of this species includes habitat factors that affect larval distribution and the importance of competition with sympatric species.

POPULATION DYNAMICS

Tiger beetles are strong fliers and some species have evolved as long-distance dispersers (Pearson & Vogler 2001); however, it is unknown if *C. h. siuslawensis* is one of these. *C. h. siuslawensis* populations are patchily distributed along New River, and it is possible these populations may function as a metapopulation. Research on dispersal ability and rates (such as through mark-recapture studies) would be useful for determining movement patterns within the ACEC. Dispersal rates and distances could also help land managers determine whether potential or extirpated habitat should be targeted for restoration. In addition, it would be useful to know if and how *C. h. siuslawensis* can disperse from nearby populations, particularly in light of the fact that entire tiger beetle populations are likely destroyed during breaching activities. Studies could be conducted to determine the minimum sustainable population size for the Siuslaw hairy-necked tiger beetle and the amount and distribution of habitat necessary to preserve a population of this size. Research is needed to determine how long it takes to recolonize a newly created breach, and if recolonization is actually happening. Mazzacano et al. (2010) found occupied habitat at a number of “gap” areas between breaches that may support recolonization of core habitat areas and dispersal between sites. While these gap sites are located outside of the ACEC boundary, it is possible they contribute to the core breach populations. For example, the open beach between Bono Clay Island (breach 4) and the historic breach (breach 5) was found to host 13 *C. h. siuslawensis* adults during 2010 surveys (Mazzacano et al. 2010). Research questions could address variability of population size over time, dispersal capabilities, and recolonization. Do all sites support breeding, or are some sites merely temporary refuges for adults that have dispersed from other sites? Do males and females disperse at different rates?

SURVEY TECHNIQUES

To complement long-term monitoring efforts, methods for better determining the population size at New River could be developed. These methods need to account for imperfect detection and the possibility of multiple detections of single individuals. Detectability will vary with each site and each surveyor. Hairy-necked tiger beetles are cryptically colored to blend in with the large sand grains found at the New River sites, and unless they are moving can be difficult to detect. Once they move, they are difficult to count, especially when many are moving at the same time. Two potential methods for better capturing population size at the New River site complex include mark-release-recapture and distance sampling.

The standard survey techniques for assessing adult presence and counting individuals is to set up transects through appropriate habitat and slowly move through the site, counting all beetles observed. However, this method causes adults to flush ahead of the surveyor. Future surveyors may want to investigate ways to improve surveys to better account for tiger beetles and know whether or not the same individuals are being recounted. In addition, larval burrows are often counted in the same manner, but early instar individuals are very small and can be easily overlooked. The New River tiger beetle sites are also home to a species of sand wasp (*Bembix* sp.), which make burrows that look very similar to adult burrows. Surveyors should familiarize themselves with these burrow shapes and characteristics to better differentiate them in the field.

ACKNOWLEDGEMENTS

This management plan and the habitat utilization and occupation surveys upon which it is based were funded by the USDA Forest Service and USDI Bureau of Land Management Interagency Special Status Species Program (ISSSP). Special thanks go to Kip Wright (Coos Bay BLM) for coordinating with us to access our field sites and conduct the surveys. We are grateful to the New River Nature Center for allowing us to stay in their bunkhouse. We had the good fortune of working with Ed Jahn and Todd Sonflieth from Oregon Field Guide to film a story about the New River ACEC and the creative management needed to protect a trio of rare or threatened species at this site, including the hairy-necked tiger beetle, the western snowy plover, and Coho salmon. In addition, we are thankful to Dr. Barry Knisley, Ross Winton, Dr. Tara Cornelisse, and Kip Wright for discussing tiger beetle management strategies with us and providing valuable feedback and insights on this management plan. Scott Hoffman Black, Kip Wright, and Rob Huff provided critical review of the document, which greatly improved the final management plan.

REFERENCES CITED

[BLM] Bureau of Land Management, Department of the Interior. 1995. Coos Bay District Record of Decision and Resource Management Plan and associated Environmental Impact Statement, Volumes I, II, and III. As found in Komar et al., 1999.

[BLM] Bureau of Land Management, Department of the Interior. 2004. New River Area of Critical Environmental Concern management plan. Available online at http://www.blm.gov/or/districts/coosbay/plans/files/Final_New_River_Plan_Update.pdf (last accessed 14 Apr 2015).

[BLM] Bureau of Land Management, Department of the Interior. 2010. Attachment B – Conservation Measures for Special Status Species. Available at http://www.blm.gov/or/plans/vegtreatmentseis/files/Veg_Treatments_ROD_Oct2010_AttachB.pdf (last accessed 5 May 2015).

Brust, M. L. 1990. Direct and indirect effects of four herbicides on the activity of carabid beetles (Coleoptera: Carabidae). Pesticide Science 30: 309-320.

Brust M. L. W. W. Hoback, K. M. Skinner and C. B. Knisley. 2005. Differential immersion survival by populations of *Cicindela hirticollis* Say (Coleoptera: Cicindelidae). Annual Review of the Entomological Society of America 98: 973-979.

Brust M. L., W. W. Hoback, K. F. Skinner and C. B. Knisley. 2006. Movement of *Cicindela hirticollis* Say larvae in response to moisture and flooding. Journal of Insect Behavior 19(2): 251-263.

Cornelisse T. M. and J. E. Hafernik. 2009. Effects of soil characteristics and human disturbance on tiger beetle oviposition. Ecological Entomology 34: 495-503.

Cornelisse, T. M., M. C. Vasey, K. D. Holl, and D. K. Letourneau. 2013. Artificial bare patches increase habitat for the endangered Ohlone tiger beetle (*Cicindela ohlone*). Journal of Insect Conservation 17(1): 17-22.

Cornelisse, T. M., M. K. Bennett, and D. K. Letourneau. 2013. The implications of habitat management on the population viability of the endangered Ohlone tiger beetle (*Cicindela ohlone*) metapopulation. PlosOne 8(8):1-8.

Dreisig, H. 1980. Daily activity, thermoregulation and water loss in the tiger beetle *Cicindela hybrida*. Oecologia 44: 376-389.

Dreisig, H. 1981. The rate of predation and its temperature dependence in a tiger beetle, *Cicindela hybrida*. Oikos 36: 196-202.

Graves, R.C., M.E. Krejci, and A.C.F. Graves. 1988. Geographic variation in the North American tiger beetle, *Cicindela hirticollis* Say, with a description of five new subspecies (Coleoptera, Cicindelidae). Canadian Entomologist, 120(7): 647-678.

Hoback, W. W., D. W. Stanley, L. G. Higley, and M. C. Barnhart. 1998. Survival of immersion and anoxia by larval tiger beetles, Cicindela togata. American Midland Naturalist 140: 27-33.

Knisley, C. B. and J. M. Hill. 1992a. Effects of habitat change from ecological succession and human impact on tiger beetles. Virginia Journal of Science 43(1B): 133-142.

Knisley, C. B. and J. M. Hill. 1992b. Status survey of the rare Florida scrub tiger beetle, *Cicindela highlandensis*. Manuscript report prepared for U.S. Fish and Wildlife Service, Jacksonville, FL.

Knisley, C. B. and M. S. Fenster. 2009. Studies of the Puritan tiger beetle (*Cicindela puritan*) and its habitat: implications for management. Final report to U.S. Fish and Wildlife Service, Annapolis, MD.

Knisley, C. B. and R. Arnold. 2004. Biology and conservation of the Ohlone tiger beetle. Final report to U.S. Fish and Wildlife Service, Ventura, CA.

Knisley, C. B. and R. A. Arnold. 2013. Biology and conservation of *Cicindela ohlone* Freitag and Kavanaugh, the endangered Ohlone tiger beetle (Coleoptera: Carabidae: Cicindelinae). I. Distribution and Natural History. The Coleopterists Bulletin 67(4): 569-580.

Knisley, C. B., Mike Kippenhan, and David Brzoska. 2014. Conservation status of United States tiger beetles. Terrestrial Arthropod Reviews 7: 93-145.

Knisley, C. B., T. D. Schultz, and T. H. Haseinkel. 1990. Seasonal activity and thermoregulatory behavior of *Cicindela patruela* (Coleoptera: Cicindelidae). Annals of the Entomological Society of America 83: 911-915.

Komar, P. D., J. J. Marra, and G. Diaz-Menez. 1999. A study of the New River Spit, Oregon, to acquire information relevant to an adjustment of the statutory vegetation line. Report to the Oregon Parks & Recreation Department, Salem, Oregon, 44 p. Report published as: Komar, P. D., J. J. Marra, and G. Diaz-Menez. 2001. Stability of the New River Spit, and the position of Oregon's beach-zone line. Journal of Coastal Research 17(3): 625-635.

Leffler, S. 1979. Tiger beetles of the Pacific Northwest (Coleoptera, Cicindelidae). Unpublished dissertation. University of Washington, Seattle, WA.

Mazzacano, C., S. Jepsen, and S. H. Black. 2009. Project Completion Report: Surveys to determine the status of two rare insect species on the Oregon coast: the Siuslaw hairy-necked tiger beetle (Coleoptera: Cicindelidae: *Cicindela hirticollis siuslawensis* Graves, Krejci, and Graves, 1988*)* and the Oregon plant bug (Hemiptera: Miridae: *Lygus*

oregonae Knight, 1944). Submitted to Interagency Special Status/Sensitive Species Program (ISSSSP) U.S. Fish and Wildlife Service, Section 6 and The Oregon Zoo. The Xerces Society for Invertebrate Conservation. 39 pp.

Mazzacano, C., S. Jepsen, and S. H. Black. 2010. Project Completion Report: Surveys to determine habitat utilization by the rare Siuslaw hairy-necked tiger beetle (Coleoptera: Cicindelidae: *Cicindela hirticollis siuslawensis* Graves, Krejci, and Graves, 1988) at extant sites on BLM and FS lands on the Oregon Coast. Submitted to the Interagency Interagency Special Status/Sensitive Species Program (ISSSSP). The Xerces Society for Conservation. 37 pp.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 29, 2015).

Nothnagle, P. and T. Simmons. 1990. Ecology of the northeastern beach tiger beetle, *Cicindela dorsalis* in southeastern Massachusetts. Final report to the Massachusetts Natural Heritage Program.

[ORBIC] Oregon Biodiversity Information Center. 2013. Rare, threatened, and endangered species of Oregon. Institute for Natural Resources, Portland State University, Portland, Oregon. 111 pp. Available online at http://orbic.pdx.edu/documents/2013-rte-book.pdf (last accessed 24 September 2015).

Paulson, D. 2012. Discovery of a population of *Cicindela hirticollis siuslawensis* in Washington. Cicindela 44:44-48.

Pearson, D. L. and A. P. Vogler. 2001. Tiger beetles: the evolution, ecology and diversity of the Cicindelids. Cornell University Press, Ithaca, NY.

Pearson, D. L., C. B. Knisley, and C. J. Kazilek. 2006. *A Field Guide to the Tiger Beetles of the United States and Canada. Identification, Natural History, and Distribution of the Cicindelidae*. Oxford University Press, New York, NY. 227 pp.

Pearson, D. L., C. B. Knisley, D. P. Duran, and C. J. Kazilek. 2015. *A Field Guide to the Tiger Beetles of the United States and Canada. Identification, Natural History, and Distribution of the Cicindelinae*. 2nd edition. Oxford University Press, New York, NY. 251 pp.

Staines, C. L. 2005. *Cicindela hirticollis* Say (Coleoptera: Cicindelidae) naturally colonizing a restored beach in the Chesapeake Bay, Maryland. Cicindela 37: 79-80.

[USFWS] U. S. Fish and Wildlife Service. 1994. Northeastern beach tiger beetle (*Cicindela dorsalis dorsalis* Say) recovery plan. Hadley, Massachusetts. 60 pp. Available online at http://pbadupws.nrc.gov/docs/ML0719/ML071970332.pdf (last accessed 6 July 2015).

[USFWS]. U. S. Fish and Wildlife Service. 2012. Revised designation of critical habitat for the Pacific Coast population of the western snowy plover: final rule. Federal Register 77 (118): 36727-36869.

Wilson, D. A. 1974. Survival of cicindelid larvae after flooding. Cicindela 6: 79-82.

[WNHP] Washington Natural Heritage Program. 2014. Animal Species with Ranks. Available online at http://www1.dnr.wa.gov/nhp/refdesk/lists/animal_ranks.html (last accessed 24 September 2015).

PERSONAL COMMUNICATION

Burns, C. 2014. Wildlife Biologist, Siuslaw National Forest. Personal communication with Sarina Jepsen, the Xerces Society.

Cornelisse, T. M. 2015. Science Editorial Postdoctoral Fellow, American Museum of Natural History. Personal communication with Candace Fallon, the Xerces Society, on 19 May 2015.

Knisley, C. B. 2015. Professor Emeritus, Department of Biology, Randolph-Macon College. Personal communication with Candace Fallon, the Xerces Society.

Lyons, R. 2008. Personal communication with Sarina Jepsen, the Xerces Society.

Steffens, W. 2009. Steffens Consulting. Personal communication with Sarina Jepsen, the Xerces Society.

Winton, R. 2015. Regional Wildlife Biologist, Idaho Department of Fish and Game. Personal communication with Candace Fallon (the Xerces Society) on 30 April 2015.

Wright, K. 2014. Coos Bay Bureau of Land Management. Personal communication with Candace Fallon and Sarina Jepsen, the Xerces Society.

Wright, K. 2015. Coos Bay Bureau of Land Management. Personal communication with Candace Fallon, the Xerces Society.