Results of 2016 Mazama Pocket Gopher Screening in Thurston County

Prepared by
Washington Fish and Wildlife Office
U.S. Fish and Wildlife Service
Lacey, Washington

January 27, 2017

TABLE OF CONTENTS PAGE

We acknowledge the following individuals for their contributions in making the 2016 screening season and this report possible.

U.S. Fish and Wildlife Service:
Marty Acker, Paul Bakke, Shirley Burgdorf, Christina Capelli, Michael Carlson, Carrie Cook-Tabor, Lee Corum, Katherine Fitzgerald, Kim Flotlin, Jamie Hanson, Russ MacRae, Ryan McReynolds, Carol Mitchell, Ginger Phalen, Karen Reagan, Paco Rodriguez, Tim Romanski, Joanne Stellini, Teal Waterstrat, Lindsy Wright

Thurston County:
Maya Buehler, Andrew Deffobis, Marisa Whisman

EXECUTIVE SUMMARY

In April 2014, the U.S. Fish and Wildlife Service (USFWS) listed four subspecies of Mazama pocket gopher (MPG) as threatened species requiring protection under the federal Endangered Species Act of 1973, as amended (ESA). Three of those subspecies are present in, and endemic to, Thurston County, Washington (*Thomomys mazama pugetensis, T. m. tumuli,* and *T. m. yelmensis*).

In February 2016, the USFWS recommended that Thurston County (County) government implement field screening in advance of issuing County building permits, using a multiple visit protocol (dependent on MPG soil types) to detect the presence of MPGs. The Thurston County Board of Commissioners voted to adopt and implement the proposed screening process. Based on field screening results using this protocol, USFWS then determined if: 1) projects were unlikely to take[1] MPGs, and provided this information to the County to inform the County's permit process; or 2) MPGs were present, and recommended to the County that their permit issuance would place the County at risk of take (that is, at risk of section 9 ESA violations due to the lack of a federal permit allowing incidental take). This field screening was conducted as an interim approach to avoid take liability until the County implements a USFWS-approved Habitat Conservation Plan (HCP).

Field screening for MPG mounds was conducted from June 1, 2016 through October 31, 2016. A total of 221 sites were visited two to three times typically, depending on soil type, to screen for MPG mounds.

MPG mounds were not detected on 182 sites (82 percent of all screened sites), and the USFWS determined that actions on these sites would be unlikely to result in take of MPGs. MPG mounds were detected on 39 sites (18 percent of all screened sites). Landowners and the County were notified by the USFWS that future actions on properties with MPG mounds could result in prohibited take.

This report presents results of the 2016 MPG screening season. It is expected that this information will inform future screening for MPG, development of the Thurston County Prairie HCP, the siting of mitigation, recovery planning, and MPG conservation efforts.

[1] NOTE: Section 9 of the ESA, and federal regulations pursuant to section 4(d) of the ESA, prohibit the take of endangered and threatened species, respectively, without specific exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Harm is defined by the USFWS as an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Harass is defined by the USFWS as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3).

INTRODUCTION

This document describes and summarizes information collected during the 2016 MPG screening season conducted in Thurston County, Washington. USFWS recommended to Thurston County that their pending building permit applications be field-screened using a protocol (Appendix 1) developed by USFWS to assess the likelihood for take of MPG occurring from permit issuance. The field screening protocol entailed looking for MPG mounds at a given site multiple times, depending on soil type.

Results from the MPG screening are presented in this document. Some analysis and interpretation of these results is also presented, and could be used to inform future screenings or surveys, development of the County Prairie HCP, and MPG conservation.

County staff collected information about prairie and oak habitat prior to or concurrent with MPG screening, and prepared results of that work. Those results are also presented and analyzed in this report.

APPROACH

Mazama Pocket Gopher Mounds

The USFWS, in partnership with the County and Washington Department of Fish and Wildlife, assembled a field screening team (Screen Team) to look for MPG mounds on properties with pending County permit applications, and on properties where landowners requested screening for informational or other purposes (i.e., no pending permit application).

Consistent with County review of permit applications, sites subject to screening were located on or within 300 feet of MPG soils (to account for soil mapping error), or were within 600 feet of a previously-confirmed MPG location (to comply with the County's Critical Area Ordinance (CAO) for important habitats and species).

Field screenings were conducted according to the protocol recommended for use in 2016 by the USFWS to the County (Appendix 1), and adopted by the Thurston County Board of Commissioners. The 2016 protocol recommended screening each site two or three times, depending on soil type and MPG preference for that soil type. Two or three screenings were conducted at each site, from June 1 through October 31, 2016, with consecutive site visits at least 30 days apart to account for variation in environmental and biological factors. However, once mounds with MPG characteristics were detected, no further site visits were required by the protocol, so some sites with MPG mounds were only visited once. Mounds with MPG characteristics are an indicator of occupancy, but season, weather, and other environmental and biological factors influence mounding. Identifiable mounds are not always present or observable on occupied MPG habitat.

The County notified landowners by telephone that screening would be conducted on their property, generally within one week of the site visit. Screenings were typically conducted Tuesday through Thursday between approximately 8:00 am and 5:00 pm by an interagency,

interdisciplinary team of three to four staff. MPG mound identification was conducted by personnel with training and experience in MPG mound identification. The protocol called for the entire property (ownership) to be screened, regardless of the nature of the pending permit, project, or activity; this was achieved at most sites.

Screening was conducted once the Screen Team arrived at a site, assessed site conditions, and determined a route for walking through the site. Generally, a transect approach was taken where members of the team would align and space themselves to be able to detect mounds between them, traverse the entire site, confer on proper identification of any mounds, and record mound data on field forms and a Trimble *Geo7x* geographic positioning system (GPS) unit. The survey path or transect walked was recorded with a Garmin *64st* unit, or recorded by hand on a diagram or aerial photograph of the site. The Trimble GPS points were differentially corrected to increase accuracy. The digital data were downloaded at least weekly, checked for accuracy against field forms and with field staff, and transmitted to the County and Washington Department of Fish and Wildlife every two weeks for incorporation into their databases.

Once the required number of screenings for MPG mounds was completed at a site and no MPG mounds were detected, the USFWS determined that the project was unlikely to take MPGs and provided this information to the County to inform the County's permitting process. If, however, MPG mounds were detected at a site, typically no further site visits were conducted and USFWS recommended to the County that permit issuance would place the County at risk of section 9 ESA violations.

Letters were sent by USFWS to the County when it was determined that a project was unlikely to take MPGs (no mounds with MPG characteristics were detected). Letters were sent by USFWS to both the County and to the landowners of those properties where take of MPG could occur (mounds with MPG characteristics were detected). In a few instances, USFWS was able to work with landowners to avoid take by adjusting the proposed project.

Soils

The USFWS sought to evaluate soils at all sites with MPG mound detections to verify soil type against those mapped for the site (2006 USDA Soil Survey Geographic Database). Evaluating soils was conducted to help inform our understanding of MPG use relative to soil type. Thus, it should be noted that the term "gopher soils" refers to certain soil types MPG have been known to use. In 2015 and 2016, those soil types were placed in high, medium, and low preference categories by USFWS, based on the relative occurrence of MPG in those soil types, compared to the abundance of those soils in Thurston County (Appendix 1).

Verifying soils entailed observing the whole site and how it was situated relative to mapped soil types. Landscape features such as landform, slope, hydrology, and vegetation were noted and compared to surrounding areas. Topography was considered around the sampling point. Observations of vegetation and changes in vegetation type and growth form were also considered. If there were obvious indications at a site that soils had been previously graded, filled, or otherwise substantially disturbed, an attempt was made to identify and evaluate soils at one of the least disturbed portions of the site.

Soils were observed to a depth of at least 12 inches and examined for texture, color, and other characteristics typical of the soil series (such as amount of rock fragments, cemented layers, layers of silt or substantial clay content, or strongly contrasting soil textures). Soil test pits were dug or soils were checked in already-exposed soil profiles, such as in fresh slope cuts or septic test pits. Soil test pits were filled back in after soil evaluation.

Prairie/Oak Habitat

The County conducted prairie habitat screening to assess sites for the presence of prairie plants (Appendix 2) consistent with their CAO prairie protocol. Plant species listed in the CAO as indicators of prairie habitat are referred to here as "target" prairie plants, while vegetation not listed as prairie indicators are referred to as "non-target" plants. Prairie habitat screening was generally conducted in conjunction with MPG screening during the first site visit. The primary focus of prairie habitat screening was within the proposed project area: the footprint, or immediate area where a structure or facility would be placed which could result in ground disturbance, including a 150-foot buffer surrounding the footprint. Prairie habitat screening took place beyond the project area, preferably on the entire parcel, as time allowed or if the landowner had requested a "gopher/prairie review" of the parcel (that is, not specific to a proposed project).

Under current County prairie screening guidelines, the presence of three target prairie plants, numbering a total of 25 individual plants per species, is required in order to meet prairie habitat criteria. Plant species known to serve as a nectar source and/or host plant for any of the butterflies proposed to be covered in Thurston County's HCP in addition to the Taylor's checkerspot butterfly (*Euphydryas editha taylori*) need not add up to 25 individual plants -- onsite presence is enough (see Appendix 2). The same rule applies to plants listed as Washington Natural Heritage Program (WHNP) rare plants, such as white-topped aster (*Sericocarpus rigidus*).

Transects were used to screen for prairie vegetation, with transects generally 5 meters apart depending on visibility. In addition to prairie vegetation, non-target plant species were recorded on a separate datasheet for site characterization. Prairie habitat detected at greater than 46 meters (150 feet) from a project area did not affect the building/permitting process (i.e., require moving the footprint or mitigation), but landowners were informed verbally that prairie habitat exists on their property, for educational purposes. In instances where prairie habitat was detected within a project area, landowners were presented with the following options, per CAO mitigation sequencing: 1) move the building footprint to avoid impacts to prairie habitat, if possible; or 2) hire a consultant to develop a critical areas report and delineate portions of the property where prairie habitat is present, to determine whether avoidance is possible; and/or develop a mitigation plan, which includes planting or seeding of native prairie species, if avoidance is not determined to be feasible.

Additional habitat features included in the prairie screening process included the presence of Mima mounds, which are classified as prairie habitat in the CAO, and the presence of Oregon white oak (*Quercus garryana*). Mima mounds are protected both as prairie habitat and as a unique geologic feature in the CAO; a minimum standard buffer of 50 feet must be afforded to

protect these mounds from soil disturbance. Oregon white oak trees are also protected in the CAO. A minimum buffer of 5 feet beyond the canopy dripline is required to protect these trees from root damage. If oak trees are damaged or removed, mitigation efforts require the planting of three oak saplings for each tree affected.

RESULTS

Environmental Conditions

This section reports results of the 2016 MPG screening season. It is important to consider these results with an understanding that screening was conducted during, and results could have been influenced by, environmental conditions affecting the behavior and survival of MPGs.

Last year, low precipitation and high temperatures during the 2015 screening season -- especially during the first half of the year -- resulted in very low soil moisture conditions and early senescence of vegetation eaten by MPG. We noted that such environmental conditions may have influenced 2015 MPG mound detection results (USFWS 2016, *Results of 2015 Mazama Pocket Gopher Screening in Thurston County*).

This year, precipitation during the screening season was not only higher than in 2015 (390.14 mm in 2016, 255.02 mm in 2015), but also much greater than the 20th century average for the same period. This is indicated by Washington State Climate Division 3 precipitation information, which contains the majority of areas screened in Thurston County[2].

Lower temperatures occurred in 2016 during the screening season relative to 2015, though some higher temperatures occurred earlier in the year and prior to screening. Monthly temperature and precipitation data collected from 2010-2016 at the Olympia Airport in Thurston County[3] is shown in Figures 1 and 2.

[2] NOAA National Centers for Environmental Information, Climatological Rankings, published online December 2016, retrieved on December 9, 2016 from www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/index.php?periods%5B%5D=4&parameter=pcp&state=45&div=3&month=10&year=2016

[3] NOAA National Centers for Environmental Information, Data Tools, published online December of 2015 and 2016, retrieved on December 8, 2015 and December 9, 2016 from https://www.ncdc.noaa.gov/cdo-web/datatools.

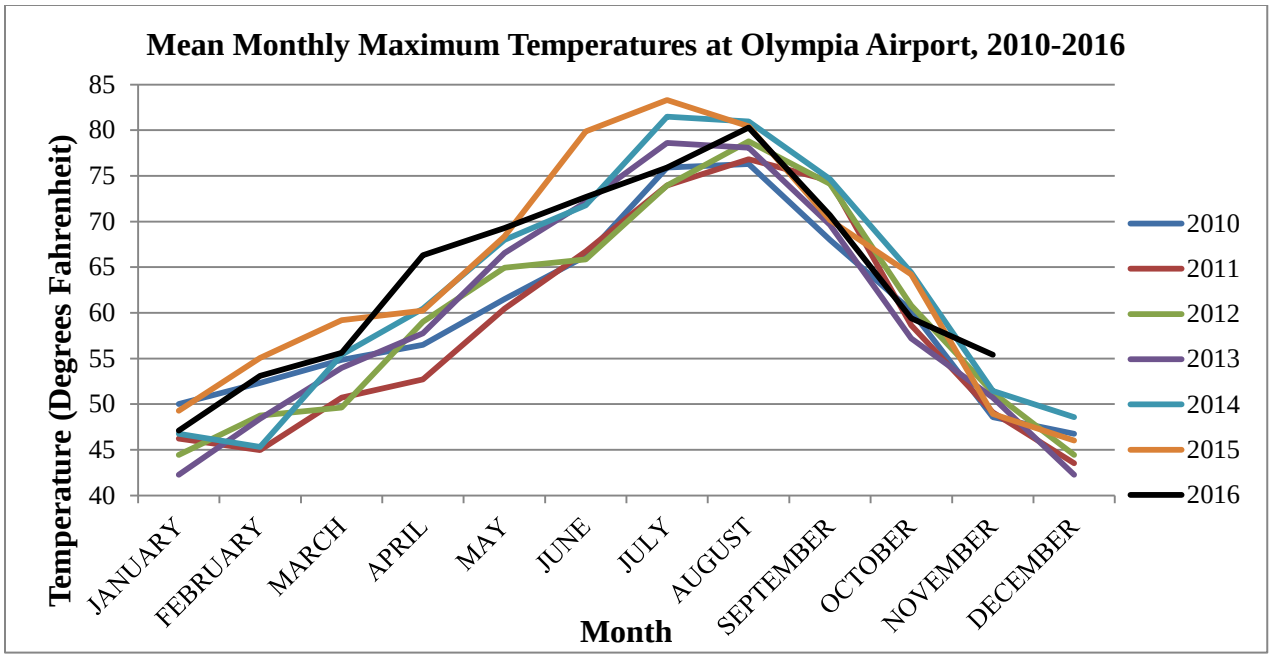


Figure 1. Mean monthly maximum temperatures as recorded by the Olympia Municipal Airport weather station in Thurston County, WA relevant to the MPG screening area from 2010 to 2016.

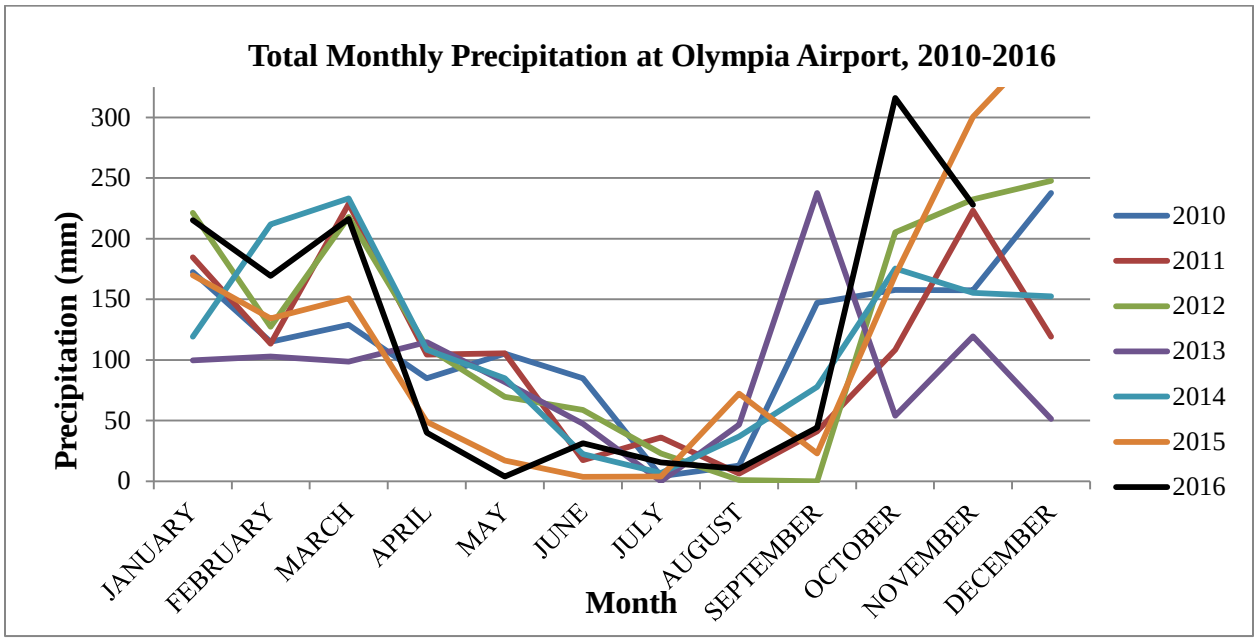


Figure 2. Total monthly precipitation as recorded by the Olympia Municipal Airport weather station in Thurston County, WA relevant to the MPG screening area from 2010 to 2016.

Field Results

Thurston County received over 4000 land use applications since the end of the 2015 MPG screening season (October 31, 2015). A small subset of those applications was subject to MPG screening. As a first step, the County conducted preliminary, in-office assessment of applications that were flagged for prairie or MPG review. The County then conducted field assessments for those applications that could potentially not be subject to MPG screening due to certain factors. As a result, about 150 applications were determined not to be subject to MPG screening due to a variety of factors. These factors included: location, distance from gopher soils and occupied sites, total woody vegetation cover, wetland conditions, existing impervious substrates, removal of underground storage tanks, and proposed work confined to building interiors or to hardened/graveled portions of a property.

Just over 200 applications were then scheduled for MPG field screening, based on USFWS-County screening capacity for 2016. A total of 490 site visits were conducted during the 2016 MPG screening season to meet the multiple-visit protocol, in addition to the approximately 150 County-only site visits performed to assess prairie habitat or to pre-screen for MPG concerns.

Mazama Pocket Gophers

A total of 221 individual sites were screened, encompassing 261 legal tax parcels associated with approximately 2,918 acres. Twelve of the 221 sites were not screened to protocol for various reasons including: the inability to complete all required site visits within the screening season; the County making a decision to release the site from further visits upon internal review; and the land changing ownership. However, these 12 sites received at least one screening and were thus counted in the overall total and included as sites where no MPG mounds were detected.

Table 1 shows the number of sites screened (column A), by MPG soil preference (column B), and the number of sites on which MPG mounds were detected (column C) and not detected (column D). Sites with more than one mapped MPG soil preference were accounted for only once and by whichever soil type was of greater preference. Percents shown in parentheses are relative to the total values per column; rounding up accounts for any totals over 100.

Table 1. Summary of all sites screened for Mazama pocket gophers in 2016, in Thurston County, WA.

A	B	C	D
Sites Screened	MPG Preference (based on soil type)	Sites with MPG Mounds Detected	Sites with No MPG Mounds Detected
61 (28%)	High	12 (31%)	49 (27%)
82 (37%)	Medium	21 (54%)	61 (34%)
78 (35%)	Low	6 (15%)	72 (40%)
221	---	**39**	**182**

MPG mounds were detected on 39 of the 221 sites screened (18 percent), and were not detected on 182 sites (82 percent). Of the 39 sites where MPG mounds were detected, 17 were within 600 feet of a known MPG location (44 percent), and 22 were not (56 percent). Of the 182 sites where MPG mounds were not detected, 17 were within 600 feet of a known MPG location (9 percent), and 165 were not (91 percent). Figure 3 on the following page shows the approximate locations of sites screened in 2016 relative to MPG preference based on soil type.

Moles

Collection of mole mound data was reduced this year to save field effort and time; no GPS data for mole mound locations was collected. However, mole mound presence and an estimate of mole mound numbers were recorded on field forms. Our data show that presence of mole mounds co-occurred on properties with MPG mounds at 28 of the 39 sites (72 percent) where MPG mounds were detected.

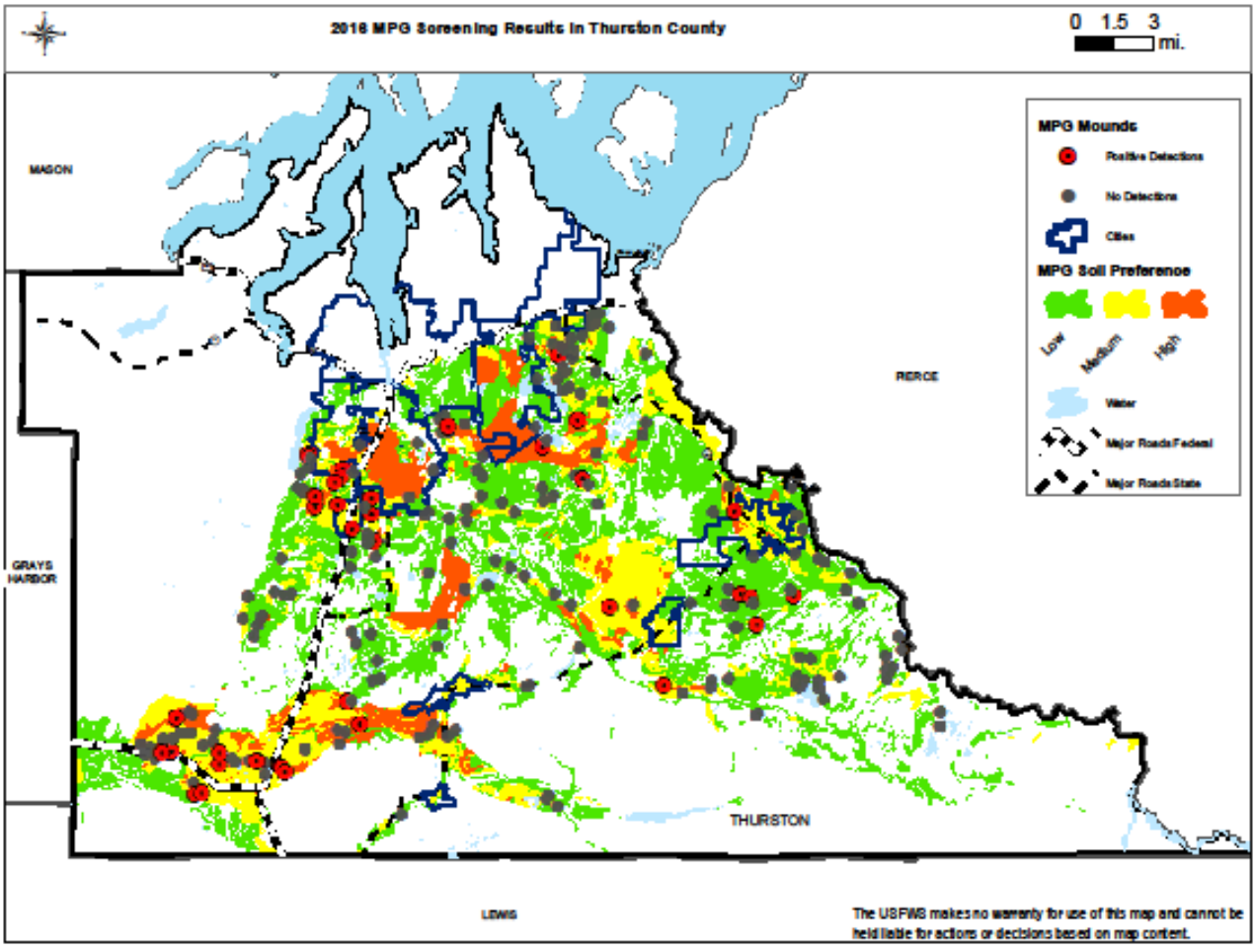


Figure 3. Sites screened for Mazama pocket gophers relative to their soil type preference.

Soils

Soils on sites where MPG mounds were detected were physically evaluated in the field to determine if soils onsite matched mapped soils. Soils were not evaluated on sites where MPG mounds were not detected.

Soils were evaluated at 35 (90 percent) of the 39 sites where MPG mounds were detected, and were not evaluated at 4 sites (10 percent) due to a lack of time. Soil types were evaluated at 41 locations across the 35 sites (some sites had more than one mapped soil type), with soil types verified to soil series 28 times (68 percent), and not verified 13 times (32 percent). However, all soils mapped as MPG soils were verified to be MPG soils, even if they were different than what was mapped. The results are summarized below.

MPG mounds were detected at 12 sites with soils mapped as high MPG preference. Soil series were verified at all 12 of these sites (100 percent). In addition, 3 of the 4 sites where soils were not evaluated but where MPG were detected, were mapped as high MPG preference.

MPG mounds were detected at 23 sites with soils mapped as medium MPG preference. These soil types were verified 13 times (57 percent). Soil types were not verified 10 times (43 percent): soil types at 2 sites appeared to be low preference rather than medium preference soil types; and soil types at 8 sites appeared to be high preference rather than medium preference soil types. In addition, 1 of the 4 sites where soils were not evaluated but where MPG were detected, was mapped as medium preference soil.

MPG mounds were detected at 6 sites with soils mapped as low MPG preference. Soil series were verified at 3 sites (50 percent). Soil series were not verified at 3 other sites: 1 soil series was not verified and appeared to be a medium preference soil; and 2 sites remained in low MPG preference soil but appeared to be in different soil series than what was mapped.

Prairie and Oak Habitat

The majority of prairie habitat screening took place between June 1 and October 31, 2016. Screenings for prairie and oak habitat began as early as mid-April 2016 on sites that contained prairie soils but not gopher soils; on vested properties (not subject to further CAO review); or for projects and sites that were determined after internal review by Thurston County to be exempt from full gopher review during the official review season. A total of 285 sites were screened for prairie habitat: 198 sites were screened concurrent with MPG screening visits (23 properties subject to MPG screening had no prairie soils); 87 sites were screened separately by the County (24 for prairie habitat only and 63 for projects potentially exempt from MPG review).

Prairie habitat was present on a total of 11 sites, or 4 percent of all sites screened. Of these sites, 2 had prairie habitat within the project area (1 percent of sites screened for prairie). In most cases, prairie vegetation was detected in locations separate from the proposed project areas. Additionally, 85 (30 percent) sites screened for prairie habitat had some target plant species onsite but did not meet County prairie habitat criteria; 31 sites (11 percent) contained target plants within the project area.

Mima mounds were present at 4 sites (1 percent). Oregon white oak trees, woodlands, or seedlings were present in 63 sites (22 percent), with 11 instances in which oak were present within proposed project areas (4 percent).

Prairie habitat, as defined by the County, coincided with MPG mound detection at 5 sites (2 percent of total sites). Sites containing some target prairie plants but not meeting the prairie habitat criteria coincided with MPG mound detection at 14 sites (5 percent of total sites). Table 2 presents these prairie and oak results.

Table 2. Prairie and oak field data for 2016.

2016 Thurston County Prairie Data			
	# Sites	Percent of Total Sites*	Comments
Total prairie screenings	285	100%	Prairie screening conducted on first MPG visit or County only
Prairie screenings with MPG Screen Team	198	69%	Prairie screening conducted concurrent with MPG screening
County site visits	87	31%	Sites with prairie soils in addition to gopher soils; 24 prairie only
Prairie habitat identified on parcel	11	4%	
Prairie habitat identified within proposed project area	2	1%	
Target plants present on parcel	85	30%	
Target plants present within project area	31	11%	
Prairie habitat and MPG mounds present on parcel	5	2%	
Target plants and MPG mounds present on parcel	14	5%	
Oregon white oak present on parcel	63	22%	Trees, woodlands, seedlings
Oregon white oak present within proposed project area	11	4%	CAO requires 5 feet of buffer beyond canopy dripline
Mima mounds present on parcel	4	1%	CAO requires 50 feet of buffer

**Total Sites* pertains to the 285 properties screened for prairie and oak habitat.

During the 2016 season, a total of 23 target prairie species were detected during prairie habitat screenings (Figure 4). The five species most frequently encountered were common camas (*Camassia quamash*), Virginia strawberry (*Fragaria Virginia*), sickle-keel lupine (*Lupinus*

albicaulis), long-stolon sedge (*Carex inops*), and Missouri goldenrod (*Solidago missouriensis*). See Figure 4 for percent abundance of all target species encountered. Percents are based on the 96 sites on which CAO-listed prairie plants were detected.

The following percentages of prairie plants, known to serve as nectar or host plants for butterflies proposed by the County for HCP coverage, including Taylor's checkerspot, were detected in 2016 prairie screenings: common camas at 35 percent of sites screened; graceful cinquefoil at 7 percent of sites; common lomatium at 4 percent of sites; and western buttercup at 3 percent of sites. Prairie plants known to serve as nectar sources or hosts for *either* the Taylor's checkerspot or the other butterflies proposed for HCP coverage were detected in the following abundances: Virginia strawberry at 22 percent of sites screened; sickle-keel lupine at 20 percent of sites; long-stolon sedge at 17 percent of sites; prairie lupine at 14 percent of sites; Oregon sunshine (*Eriophyllum lanatum*) at 8 percent of sites; early blue violet (*Viola adunca*) at 8 percent of sites; Roemer's fescue (*Festuca idahoensis v. roemeri*) at 7 percent of sites; California oatgrass (*Danthonia californica*), at 6 percent of sites; showy fleabane, at 5 percent of sites; white-top aster (*Sericocarpus rigidus*), also classified as a WHNP rare plant, at less than 1 percent of sites; and blue-eyed grass (*Sisyrinchium idahoensis*), at less than 1 percent of sites.

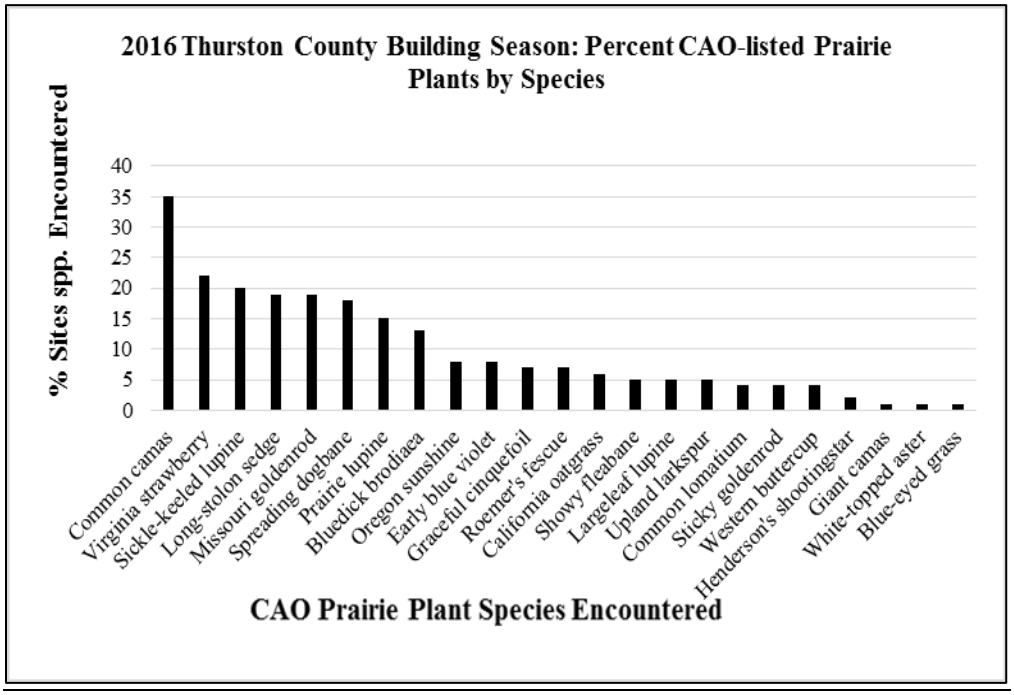


Figure 4. Target prairie plants encountered during 2016 building season reviews.

Expenditures

Implementation of the 2016 MPG screening protocol required significant time and funding. USFWS hired one individual to assist with screening and provided funding to Thurston County to enable the County to contract with one individual for screening assistance. Other USFWS and

County staff were assigned to screening from other work or in addition to other work. The 2016 screening effort resulted in the following approximate expenditures of personnel:

- Field work for 64 days, with 1 to 3 USFWS staff and 1 Thurston County staff, totaling 1328 person hours for USFWS staff, and 474 person hours for Thurston County (duties included field gear pick-up, site visits, data collection, interacting with landowners or project proponents, field data form completion).

- Office support for 110 days, totaling 1039 person hours for USFWS staff, and approximately 1018 person hours for Thurston County (duties included planning, coordination, equipment preparation, data download, field form review, preparation of determination forms, database maintenance, mapping).

APPLICATION OF RESULTS

Areas North of Interstate 5

None of the sites screened this year were located north of Interstate 5 (I-5). USFWS had previously recommended that Thurston County only screen sites on medium MPG preference soils in this area of land located in the northeastern portion of Thurston County (refer back to Figure 3). This is because no high MPG preference soils occur on this peninsula, and because screening low preference soils in this area is not needed, based on a 2015 USFWS determination. However, since no such sites were screened for this area, no additional data were obtained and no further analysis could be conducted. Thus, until additional screening occurs that may inform whether screening is needed or not, screening for MPG on medium soils north of I-5 is still appropriate, if screening occurs.

Mound Proximity to Structures

Based on discussion with current Thurston County Commissioners, we used three years of screening data (2014 – 2016) from sites where MPG mounds were detected and analyzed each parcel's MPG mound locations relative to existing structures on the parcel. The distance tool in GIS software was used to measure and determine the shortest distance between plotted mound locations and the nearest built structure visible on aerial photography. Structures included in the analysis were homes, garages, barns, and outbuildings.

Table 3 displays the number of sites within a given range of distance measured between MPG mounds and the nearest structure, the percent of sites within each range, and the cumulative percent of sites within each range.

Table 3. Distance between Mazama pocket gopher mounds and existing structures at 97 sites in Thurston County, WA.

Sites	Distance between MPG Mounds and Structures (ft)	Percent of Sites	Cumulative Percent of Sites
17	0 - 25	17.5%	17.5%
14	26 - 50	14.4%	32.0%
9	51 - 75	9.3%	41.2%
14	76 - 100	14.4%	55.7%
12	101 - 125	12.4%	68.0%
5	126 - 150	5.2%	73.2%
6	151 - 175	6.2%	79.4%
6	176 - 200	6.2%	85.6%
0	201 - 225	-	-
2	226 - 250	2.1%	87.6%
1	251 - 275	1.0%	88.7%
0	276 - 300	-	-
11	301 or more	11.3%	100.0%

Analysis of 97 sites indicates that more than half of the sites (55.7 percent) had mound detections within 100 feet of existing structures (Table 3). That is, on sites where MPG mounds were detected, mounds were predominantly located in close proximity to existing structures. However, 11 percent of sites had mound detections that occurred beyond 300 feet from any structure.

When reviewing the results above, it should be noted that the presence of MPG mounds is an indication of MPG occupancy at a site, and not a definitive indication of all areas of use by MPG on a site. That is, on sites where MPG mounds are detected, MPG use may occur in areas where mounding is not detected, providing MPG soils are present and there are no barriers to MPG movement. Hence, MPG may be using areas between buildings and mound locations, or beyond mound locations.

Soils

Soil information from the 39 sites where MPG were detected during 2016 MPG screening was used to extend our prior analysis of MPG soil preferences in Thurston County. The results of this updated analysis are presented in Appendix 3.

Based on the values obtained and the limitations of the data, it appears that there is less reason to separate MPG soils into high, medium, and low categories as previously done. The main distinction appears to occur between soils that are more preferred (what we have previously called high and medium preference soils) and soils that are less preferred (what we have previously called low preference soils).

Soils that are more preferred by MPG, tend to be occupied by MPG proportionately more than less preferred soils, relative to the occurrence of that soil type in Thurston County (that is, across the landscape in which three listed subspecies of MPG are found).

For that reason, we now recognize two groups of MPG soils: "more preferred" and "less preferred" for all soils known to be used by MPG. This better characterizes the relative importance of these soil groups to MPG, though both groups are used by MPG and will collectively be necessary for MPG recovery, based on information available at this time.

Timing and Frequency of MPG Screening

In 2014, MPG screening was conducted as a one-time only site visit and provides limited data for analysis. MPG screening in 2015 and 2016 required multiple site visits based on soil type and MPG preference for those soil types. This was done both to expand on information that existed about the timing and frequency of screening needed to confidently detect MPG presence at a site if it occurred, and to improve the chances of correctly determining MPG presence at a site if it occurred. Accurate determination of MPG presence is important in reducing the liability associated with unauthorized take and violation of the ESA.

We have examined the most recent two years of screening results including: positive MPG mound detections, when MPG mounds were detected relative to season and the number of site visits performed, and what mounding was observed in the field and documented. Our analysis of this data indicates that when we conduct only one site visit to screen for MPG mounds, we are likely to miss about 10 percent of the sites that are occupied by MPG. If we conduct two site visits to screen for MPG mounds, we are likely to miss about 4 percent of the sites that are occupied by MPG, and if we conduct three sites visits, we are likely to miss less than 2 percent.

If we only screen once on sites where MPG occur, a variety of factors likely influence whether MPG mounds are detected on that one visit. These factors appear to include when screening occurs within the screening season (June-October) and what the environmental conditions (temperature, precipitation) are; and likely include land management on or near a site, and MPG abundance at a site. The same factors affect detection even when multiple visits are conducted, but multiple visits reduce the error rate or the likelihood of not detecting MPG mounds when MPGs do occupy a site. Simply stated, more site visits increase the chances of detecting MPGs when MPGs are present on a site.

Our data also indicate that additional site visits are important for detecting MPG mounds on sites where indeterminate mounds occur. Indeterminate mounds are those mounds that lack enough characteristics to be associated with a particular animal, but have attributes that suggest a ground-dwelling animal could have created the mound. Identification of indeterminate mounds is subjective, however, and affected by the experience and expertise of individuals conducting screening. This year's protocol called for an additional site visit (beyond the number required per soil type) to be conducted if indeterminate mounds (and no MPG mounds) were identified.

On sites that ultimately had positive identification of MPG mounds, data show that if any indeterminate mounds were identified (and no MPG mounds were positively identified during the same site visit), an additional visit (beyond the number per protocol) always resulted in detecting MPG mounds. This was true where indeterminate mounds were identified at each successive site visit. It is unclear what the result would be if additional visits occurred whenever indeterminate mounds are identified, even if subsequent site visits do not identify MPG mounds or indeterminate mounds, as this was not the protocol and such sites were released from further screening. Thus, it appears that an additional site visit helped span a longer period of time over which a site was screened and thus increased the opportunity for MPG mound detection, particularly where there was cause (indeterminate mounds) to indicate MPG could be present at the site.

In summary, if the objective of MPG screening is primarily to avoid direct take to individual MPGs, then conducting three site visits spaced over the June-October time period, 30 days apart, with an additional visit(s) if indeterminate mounds are observed, is appropriate. This approach reduces the risk of missing MPG mound detection at a site where MPGs occur (thereby decreases the potential of a false negative result or Type II error). This would apply to all soil types known to be used by MPG, as we have no data to suggest otherwise.

Screening Utility

Given the last three years of MPG screening by USFWS and Thurston County, MPG mounds are encountered about 10-18 percent of the time. However, while screening allows direct take of individual MPGs to be avoided, it does not result in addressing the underlying causes of the subspecies decline: the loss, degradation, and fragmentation of suitable habitat.

In fact, screening further exacerbates those factors identified by USFWS as factors responsible for the listing of the MPG subspecies. That is, each time an individual property is identified as not having MPG mounds, the proposed project is generally allowed to proceed (although other County requirements are considered). There is no County procedure or process in place to evaluate, account for, or offset the loss, degradation, or fragmentation of MPG habitat. Thus, impacts to the parcel's habitat, adjacent habitat, and habitat at the landscape level is not addressed by County permitting, exacerbating threats to MPG subspecies, and likely impeding the potential for recovery of those subspecies.

Critical Area Ordinance

Under the current County CAO, projects within 600 feet of known MPG locations are screened. However, this tool for identifying sites for screening has its limitations. Specifically, this year's screening showed that more than half (56 percent) of the sites where MPG mounds were found, were not within 600 feet of a known/mapped MPG location. During 2015 MPG screening, 36 percent were not.

It appears that this year's new detections were found in areas of the County where MPG have not been looked for and thus not documented; this was likely the main cause of this year's high percentage of sites not being close to known gopher locations. Each year that screening is

performed, however, helps to further identify the location of MPGs, and could make the distance of 600 feet more relevant, and thus more useful for conserving MPG. However, this is dependent on what land use applications are submitted and which parcels they involve.

Prairie Habitat Screening

Results from prairie screening reveal little overlap between where MPG mounds occur and where prairie habitat --as identified using the County prairie habitat definition-- occurs. Specifically, at the 39 sites where MPG mounds were detected in 2016, prairie habitat was identified only 5 times or 13 percent of the time. Prairie plants were identified at 14 of the 39 sites (36 percent) with MPG mounds.

This year's results are similar to the 2015 results (both with low percentages of co-occurrence), when, at the 33 sites where MPG mounds were detected, prairie habitat was identified only 5 times or 15 percent of the time, and prairie plants were identified at 17 of the 33 sites (52 percent) with MPG mounds.

This data suggests that the County's prairie habitat definition cannot be considered a reliable tool for identifying MPG habitat or MPG use. The County's protocol may effectively identify high quality prairie habitat, but not lower quality or restorable prairie habitat.

While not all prairie habitat overlaps MPG soils and thus potential MPG habitat, it appears that continuing to use the current CAO for prairie protection will not stem the loss of either prairie soils or MPG soils, that are foundational for prairie habitat and MPG habitat, respectively.

If the County determines that additional measures are needed to protect prairie habitat under the HCP, prairie habitat criteria under the prairie screening protocol or CAO may be modified by some or all of the following means:

1) Omit the maximum 5 meter distance between the minimum three target prairie plants which must be detected on a property, currently on the County prairie screening protocol; a determination of three different target species per acre, based on the current minimum number based on species, may suffice.

2) Add additional plants as target species in the CAO, based on their use by butterflies covered under the HCP or commonality in South Puget Sound prairies. Several examples are: kinnikinnick (*Arctostaphylos uva-ursi*), utilized as the sole host plant and one of only a few nectar sources for the Hoary Elfin (*Callophrys polios*); bluebell-of-Scotland (*Campanula rotundifolia*), common in South Puget Sound prairies and known to persist among invasive plants; and pearly everlasting (*Anaphalis margaritacea*), common in South Puget Sound prairies and a nectar source for the Oregon branded skipper (*Hesperia Colorado oregonia*).

3) Modify the prairie criteria such that, if three target species are detected that do not individually add up to the required number of plants, the detection of four or more species would still meet the prairie habitat criteria due to greater potential availability of nectar sources for butterflies covered under the HCP.

Additionally, further specificities for Oregon white oak protection in the CAO, such as minimum diameter at breast height (dbh) for individual trees to meet important oak habitat criteria, may further protect oak woodland and savanna habitat. Greater distinction of protective buffers for oak trees and protection of native understory vegetation associated with oak woodlands would also be beneficial if clarified in the CAO and applied to the HCP.

CONCLUSIONS

The MPG mound screening conducted in 2016 provides results that will be useful for informing efforts to detect MPG use, recovery planning, local land use planning, and HCP development.

MPG mound detection results once again indicate that MPG subspecies are rare and not well-distributed either in the County or in MPG soils. MPG mound screening, when conducted repeatedly and over time, is effective in detecting MPG mounds, which provide an indication of MPG occupancy.

Prairie screening results indicate that remnants of higher quality prairie patches are rare in the County on private land and do not necessarily coincide with MPG occurrences. Together, these results indicate that County implementation of the prairie protocol under the CAO provides little to no protection for MPG.

APPENDIX 1
2016 MPG Screening Protocol

Summary Table of Site Visits by Soil Type Needed for the 2016 Mazama Pocket Gopher Review Process for Permit Applications in Thurston County. Additional Conditions Apply.

Mazama Pocket Gopher Preference	Soil Type	Site Visits & Timing*
High	Nisqually loamy fine sand, 0 to 3 percent slopes Nisqually loamy fine sand, 3 to 15 percent slopes Spanaway-Nisqually complex, 2 to 10 percent slopes	• 3 site visits at least 30 days apart At least 1 visit must occur in September or October • To meet the above, 1st visit must occur no later than the last week in August
Medium	Cagey loamy sand Indianola loamy sand, 0 to 3 percent slopes Spanaway gravelly sandy loam, 0 to 3 percent slopes Spanaway gravelly sandy loam, 3 to 15 percent slopes	
Low	Alderwood gravelly sandy loam, 0 to 3 percent slopes Alderwood gravelly sandy loam, 3 to 15 percent slopes Everett very gravelly sandy loam, 0 to 3 percent slopes Everett very gravelly sandy loam, 3 to 15 percent slopes Indianola loamy sand, 3 to 15 percent slopes Kapowsin silt loam, 3 to 15 percent slopes McKenna gravelly silt loam, 0 to 5 percent slopes Norma fine sandy loam Norma silt loam Spana gravelly loam Spanaway stony sandy loam, 0 to 3 percent slopes Spanaway stony sandy loam, 3 to 15 percent slopes Yelm fine sandy loam, 0 to 3 percent slopes Yelm fine sandy loam, 3 to 15 percent slopes	For property more than 600 feet from a gopher occurrence: • 2 site visits at least 30 days apart • To meet the above, 1st visit must occur by September 30 For property within 600 feet of a gopher occurrence: • 3 site visits at least 30 days apart • To meet the above, 1st visit must occur no later than the last week in August

*Sites that are mowed by March 15, 2016 will be prioritized for site visits. All site visits will be conducted by U.S. Fish and Wildlife Service no later than October 31, 2016.

This document updated: January 27, 2016.

APPENDIX 2

Target prairie plants listed in the CAO prairie definition (Tables 24.25-7 and 24.25-8, Appendix 24.25-1 in Chapter 24.25 TCC)

Columns 5 and 6 in both tables indicate use of plants as host or nectar sources by the Taylor's Checkerspot (TC) and Butterflies of Conservation Concern (CC) or Species of Greatest Conservation Need (SGCN). If any plants utilized by the TC and any CC or SGCN butterflies, as indicated on the tables below, are present on site, the number of individual plants on site need not total 25 in the prairie habitat screening process; presence is enough to count as one of three species. This is also true of WHNP plant species, indicated in bold print.

Diagnostic Wet Prairie Plants and Flowering Periods

Scientific Name **Bold font = rare plant**	**Common Name**	**Most Identifiable (lf. morphology, flowering, fruiting)**	**Flowering Period**	**TCB Nectar/ Host**	**CC/ SGCN Nectar/ Host**
Camassia leichtlinii	giant camas		April – May		
Camassia quamash	common camas	Mid-Mar to mid-Jul	April - June	N	N
Carex densa	**dense sedge***	Mid-May to mid-Aug	April - June		
Carex feta	green-sheath sedge	Mid-Apr to mid-Jul	May - July		
Carex tumulicola	foot-hill sedge	Mid-Apr to mid-Jul	April - May		
Carex unilateralis	one-sided sedge	Mid-Apr to mid-Jul	May - July		
Deschampsia cespitosa	tufted hairgrass	Mid-May to mid-sept	June - September		
Deschampsia danthonioides	annual hairgrass	Mid-Apr to mid-Jul	April - May		
Downingia yina	Cascade downingia	Mid-May to mid-Jul	April - August		
Eryngium petiolatum	**Oregon coyote thistle***	Mid-May to mid-Aug	June - August		
Lomatium bradshawii	**Bradshaw's lomatium* Federally Endangered Species**	Mid-Mar to mid- May	May		
Lotus pinnatus	**bog bird's-foot-trefoil***	Mid-May to mid-Jul	May - July		
Lupinus polyphyllus	large-leaf lupine	Mid-May to mid-Jul	June - September		
Perideridia gairdneri	Gairdner's yampah	Mid-May to late Sept	July - August		
Plagiobothrys figuratus	fragrant popcorn flower	Mid-Apr to mid-Jul	May - July		N
Polemonium carneum	**great polemonium***	Mid-May to mid-Aug	May - July		
Polygonum bistortoides	**American bistort***	Mid-May to mid-Aug	May - August		
Potentilla gracilis	graceful (fanleaf) cinquefoil	Mid-May to mid-Aug	July - August	N	N
Ranunculus alismifolius	plantain-leaf buttercup	Mid-May to mid-Jul	May - July		
Ranunculus orthorhynchus	bird's-food buttercup	Mid-Apr to mid-Jul	April - August		
Saxifraga integrifolia	northwestern saxifrage	Mid-Mar to mid-Jul	March - July	N	N
Saxifraga oregana	bog saxifrage	Mid-Mar to mid-Jul	April - July		
Sidalcea malviflora var. virgata	**rose checkermallow***	Mid-Apr to mid-Jul	May - June		

Sisyrinchium idahoense	Idaho blue-eyed-grass	Mid-May to mid-Jul	April - June		N
Veratrum californicum	California false hellebore	Mid-May to mid-Aug	June - August		
Veratrum viride	**American false hellebore***	Mid-May to mid-Sept	June - September		
* Rare Wet Prairie Species					

Diagnostic Dry Prairie Plants (Common and Rare) and Flowering Periods

Scientific Name **Bold font = rare plant**	**Common Name**	**Most identifiable (lf. morphology, flowering, fruiting)**	**Flowering Period**	**TCB Nectar/ Host**	**SCC/ SGCN Nectar/ Host**
Apocynum androsaemifolium	spreading dogbane		June – Sept. (mid June - Jul)*		
Balsamorhiza deltoidea	**deltoid balsamroot**	Mid-Apr to mid-Jul	March - July	N	
Brodiaea coronaria ssp. coronaria	harvest firecracker-flower		May - June		
Camassia quamash	common camas	Mid-Mar to mid-Jul	April - June	N	N
Carex inops ssp. inops	long-stolon sedge		April – July		H
Castilleja levisecta	**golden Indian paintbrush Federal Threatened Species**	Mid-Apr to mid-Jul	April – Sept. (usually only through June);	H	
Castilleja hispida	harsh Indian paintbrush		April – August	H	
Danthonia californica	California oatgrass	Mid-May to mid-Jul	Late May – early July		H
Delphinium menziesii	Puget Sound larkspur	Mid-Apr to mid-Jul	April - July		
Delphinium nuttallii	upland larkspur	Mid-May to mid-Jul	May - June		
Dodecatheon hendersonii	Henderson's shootingstar	Mid-Mar to mid-Jul	March - June		
Erigeron speciosus	showy fleabane (aspen fleabane)	Mid-May to mid-Jul	June - August		N
Eriophyllum lanatum var. lanatum	common woolly sunflower	Mid-Apr to mid-Aug	May - August	N	
Festuca idahoensis v. roemeri	Roemer's fescue	Mid-May to mid-Jul	May - July		H
Fragaria virginiana	Virginia strawberry		May - August	N	
Fritillaria affinis	chocolate lily	Mid-Apr to mid-Jul	April - June		
Hieracium scouleri	hound's-tongue hawkweed	Mid-May to mid-Jul	June - August		
Koeleria macrantha (cristata)	prairie Junegrass	Mid-May to mid-Jul	May - July (primarily June)*		
Linanthus bicolor	bicolored desert-gold	Mid-Apr to mid-Jul	April - June		
Lomatium triternatum	ternate desert-parsley	Mid-Apr to mid-Jul	April - July (late May - mid June)*	N	
Lomatium utriculatum	foothills desert-parsley	Mar to mid-Jul	April - June	N	N
Lomatium nudicaule	barestem biscuitroot		April - June		
Lupinus albicaulis	sickle-keel lupine	Mid-May to mid-Jul	May – July (primarily June)*		N/H

Lupinus lepidus var. lepidus	prairie lupine	Mid-May to mid-Jul	June - August		N
Microseris laciniata	**cut-leaf silverpuffs**	Mid-May to mid-Jul	May – July (primarily June)*		
Plectritis congesta	shortspur seablush	Mid-Apr to mid-Jul	April – June	N/H	N
Potentilla gracillis	fanleaf cinquefoil	Mid-May to mid-Aug	Late May – July	N	N
Ranunculus occidentalis var. occidentalis	western buttercup	Mid-Mar to mid-Jul	April - June	N	N
Saxifraga integrifolia	northwestern saxifrage	Mid-Mar to mid-Jul	March - July	N	N
Sericocarpus rigidus	**aster Curtus (white topped aster)**	Mid-May to mid-Aug	July - August		N
Silene scouleri	**Scouler's catchfly**		June - August		
Sisyrinchium idahoense	Idaho blue-eyed-grass	Mid-May to mid-Jul	April - July		N
Solidago missouriensis	Missouri goldenrod	Mid-May through Sept	Late June - October		
Solidago simplex var. simplex (S. Spathulata)	sticky goldenrod	Mid-Apr to mid-Jul	June – Sept.		
Solidago spathulata	spikelike goldenrod	Mid-Apr to mid-Jul	June – Sept.		
Trifolium willdenowii (T. tridentatum)	springbank clover	Mid-Mar to mid-Aug	April - July		
Triteleia grandiflora	Howell's triteleia	Mid-Apr to mid-Jul	May - June		
Triteleia hyacinthina	white triteleia	Mid-Apr to mid-Jul	May - August		
Viola adunca	early blue violet (sand violet)	Mid-Apr to mid-Jul	April - August		N/H
Viola praemorsa var. nuttallii	upland yellow violet	Mid-Mar to mid-Jul	April - July		
Zigadenus venenosus var. venenosus	meadow death-camas	Mid-Apr to mid-Jul	May - July		

APPENDIX 3

TABLE 1. MPG SOIL PREFERENCE* ANALYSIS	A	B	C	D	E	F	G	H	I
		MPG Soils in County			Occupied Soils in County		Preference Indices		
All Thurston County Soils With Confirmed Gopher Occupancy[1]		Total Thurston[2] MPG Soils Acres	Total Pervious[3] Thurston County MPG Soils Acres	Percent[4] Pervious MPG Soils in the County (n_i)	MPG Acres[5] Pervious	Percent Pervious MPG Soils Used[6] (r_i)	MPG Pervious Index[7] r_i/n_i	Manly's Alpha -- MPG Soil Preference Index[8]	$1/m$ - Manly's Alpha[9]
Nisqually loamy fine sand, 0 to 3 percent slopes		9,308	4,239	3.6%	1,098.2	14.5%	4.07	0.200	0.152
Spanaway-Nisqually complex, 2 to 10 percent slopes		6,959	6,424	5.4%	1,397.4	18.5%	3.42	0.168	0.120
Nisqually loamy fine sand, 3 to 15 percent slopes		3,711	2,813	2.4%	555.4	7.3%	3.10	0.152	0.104
Cagey loamy sand		5,344	4,229	3.6%	611.2	8.1%	2.27	0.111	0.064
Spanaway gravelly sandy loam, 0 to 3 percent slopes		27,975	21,613	18.2%	2,298.8	30.4%	1.67	0.082	0.034
Indianola loamy sand, 0 to 3 percent slopes		5,628	4,189	3.5%	362.5	4.8%	1.36	0.067	0.019
Spanaway gravelly sandy loam, 3 to 15 percent slopes		4,596	4,224	3.5%	295.5	3.9%	1.10	0.054	0.006
Norma silt loam		6,805	6,415	5.4%	199.4	2.6%	0.49	0.024	-0.024
Spana gravelly loam		1,364	897	0.8%	27.7	0.4%	0.49	0.024	-0.024
Spanaway stony sandy loam, 3 to 15 percent slopes		1,093	902	0.8%	24.6	0.3%	0.43	0.021	-0.027
Everett very gravelly sandy loam, 0 to 3 percent slopes		10,772	9,435	7.9%	218.4	2.9%	0.36	0.018	-0.030
McKenna gravelly silt loam, 0 to 5 percent slopes		3,361	3,135	2.6%	52.5	0.7%	0.26	0.013	-0.035
Spanaway stony sandy loam, 0 to 3 percent slopes		1,926	1,456	1.2%	22.2	0.3%	0.24	0.012	-0.036
Yelm fine sandy loam, 0 to 3 percent slopes		7,342	4,904	4.1%	69.0	0.9%	0.22	0.011	-0.037
Yelm fine sandy loam, 3 to 15 percent slopes		4,388	2,728	2.3%	33.6	0.4%	0.19	0.009	-0.038
Indianola loamy sand, 3 to 15 percent slopes		4,839	4,031	3.4%	44.6	0.6%	0.17	0.009	-0.039
Alderwood gravelly sandy loam, 0 to 3 percent slopes		3,010	2,061	1.7%	21.4	0.3%	0.16	0.008	-0.040
Everett very gravelly sandy loam, 3 to 15 percent slopes		17,916	14,671	12.3%	134.9	1.8%	0.14	0.007	-0.041
Norma fine sandy loam		2,341	2,260	1.9%	18.1	0.2%	0.13	0.006	-0.041
Alderwood gravelly sandy loam, 3 to 15 percent slopes		16,106	13,588	11.4%	78.2	1.0%	0.09	0.004	-0.043
Kapowsin silt loam, 3 to 15 percent slopes		5,151	4,775	4.0%	7.6	0.1%	0.02	0.001	-0.046
	Totals	**149,935**	**118,990**		**7,571**		**20.4**		

[1] **Column A:** Soil types in which MPG are known to occur within Thurston County, Washington, east of the Black River.

[2] **Column B:** Total acres of each soil type within Thurston County, Washington, east of the Black River.

[3] **Column C:** Pervious soils are 0-80% pervious; soils acres that are >80% impervious have been removed from Column B to create the values in this column. The layer for this is imperfect: it overestimates the amount of impervious surface on the landscape in some locations, but underestimates it in others.

[4] **Column D:** Pervious acres of each soil type in Column C are divided by the Total at the bottom of Column C to yield the percents (%) in this column. In other words, of all the pervious soils in the County, east of the Black River, what percent is THIS soil type?

[5] **Column E:** Points and polygons of MPG occupancy were used to populate this column. Points are buffered by 200 m, but polygons are unbuffered. Where points and polygons intersect, their boundaries are dissolved. Occupancy data were obtained from WDFW PHS database and USFWS 2014, 2015, 2016 screening results.

[6] **Column F:** Occupied pervious acres of each soil type in Column E are divided by the Total at the bottom of Column E to yield the percents in this column. This is a measure of the percent (%) of each soil type in the County, east of the Black River, that was found to be occupied by MPGs.

[7] **Column G:** Percents from Column F are divided by percents (%) in Column D to yield the values in this column. This is an intermediate step to calculate Manly's Alpha.

[8] **Column H:** Manly's Alpha Index: Values for each soil type in Column G are divided by the Total for Column G to yield the number in this column. If this index value is >1/21 (0.0476), then the soil type is more preferred, whereas if it is <1/21, the soil type is less preferred. This is a measure of soil use by MPGs compared to soil availability in the County, east of the Black River, and assumes all soils are equally accessible by MPGs. See Figure 1.

[9] **Column I:** (1/*m* - Manly's Alpha) Using Manly's alpha index of preference (Manly 1974), we calculated MPG preference for each soil type. If the index value in each row is greater than 0, it indicates this soil type is more preferred by MPGs. See Figure 2.

**Preference* is a term used to describe the amount of use by MPG of habitat - in this case, soils - relative to the availability of that habitat type.
"More Preferred" indicates that MPG use such soils relatively more than those that are "Less Preferred", when considering how many acres of each soil exist in the County.

More Preferred Soils
Less Preferred Soils

Figure 1.

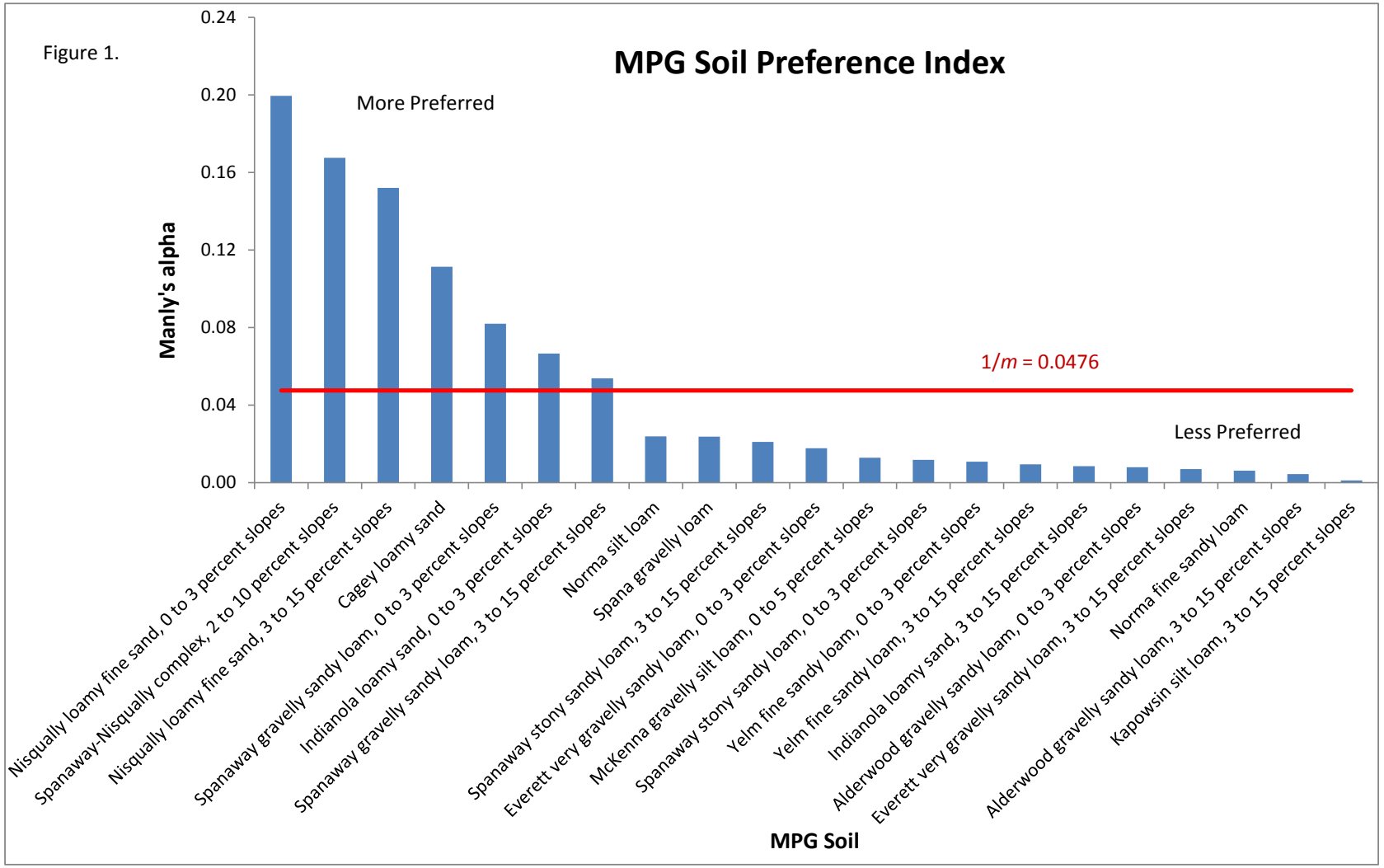
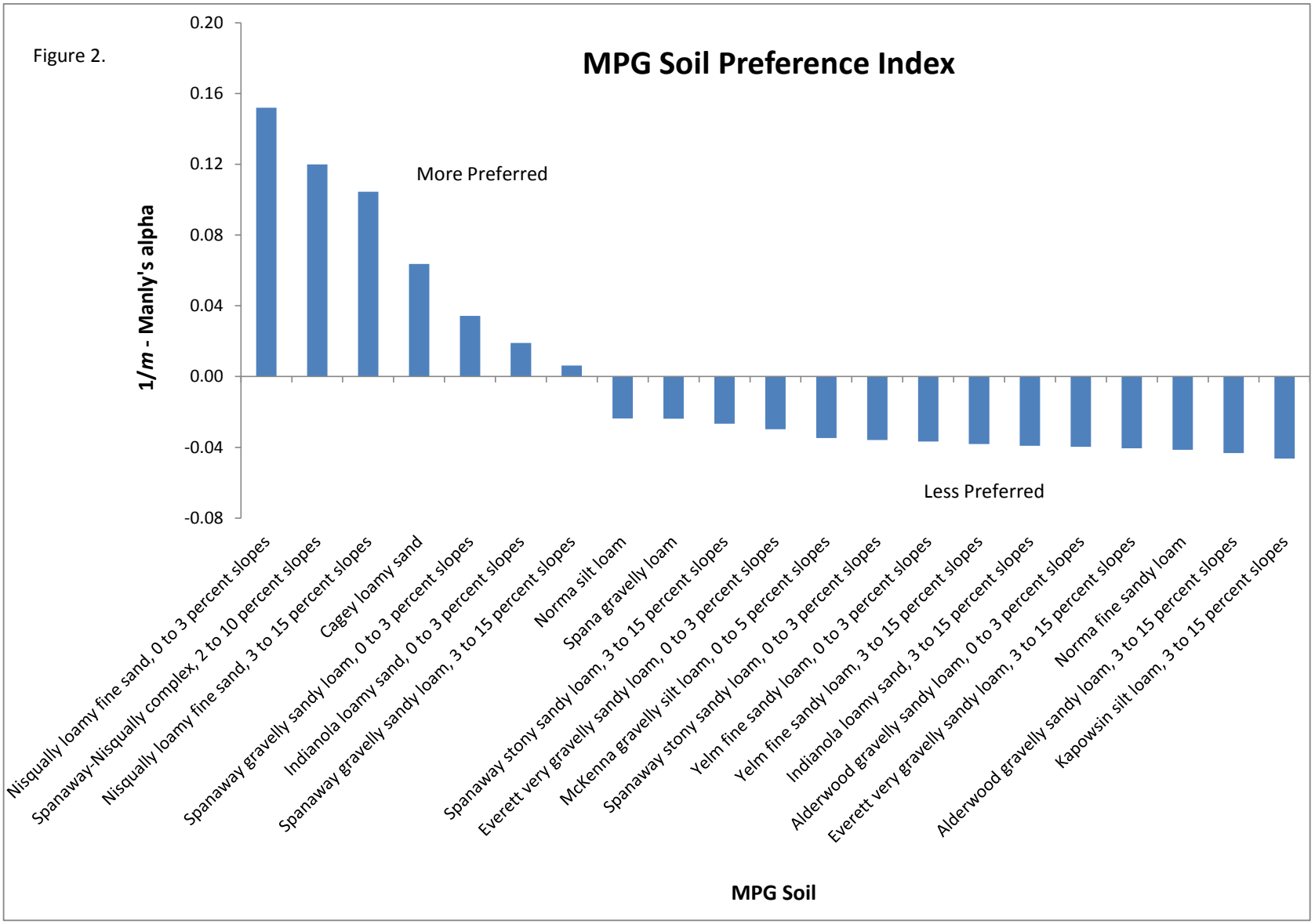

MPG Soil Preference Index
More Preferred
Less Preferred
1/m = 0.0476
Manly's alpha
0.24
0.20
0.16
0.12
0.08
0.04
0.00
MPG Soil
Nisqually loamy fine sand, 0 to 3 percent slopes
Spanaway-Nisqually complex, 2 to 10 percent slopes
Nisqually loamy fine sand, 3 to 15 percent slopes
Cagey loamy sand
Spanaway gravelly sandy loam, 0 to 3 percent slopes
Indianola loamy sand, 0 to 3 percent slopes
Spanaway gravelly sandy loam, 3 to 15 percent slopes
Norma silt loam
Spana gravelly loam
Spanaway stony sandy loam, 3 to 15 percent slopes
Everett very gravelly sandy loam, 0 to 3 percent slopes
McKenna gravelly silt loam, 0 to 5 percent slopes
Spanaway stony sandy loam, 0 to 3 percent slopes
Yelm fine sandy loam, 0 to 3 percent slopes
Yelm fine sandy loam, 3 to 15 percent slopes
Indianola loamy sand, 3 to 15 percent slopes
Alderwood gravelly sandy loam, 0 to 3 percent slopes
Everett very gravelly sandy loam, 3 to 15 percent slopes
Norma fine sandy loam
Alderwood gravelly sandy loam, 3 to 15 percent slopes
Kapowsin silt loam, 3 to 15 percent slopes

Figure 2.


MPG Soil Preference Index
1/m - Manly's alpha
0.20
0.16
0.12
0.08
0.04
0.00
-0.04
-0.08
More Preferred
Less Preferred
Nisqually loamy fine sand, 0 to 3 percent slopes
Spanaway-Nisqually complex, 2 to 10 percent slopes
Nisqually loamy fine sand, 3 to 15 percent slopes
Cagey loamy sand
Spanaway gravelly sandy loam, 0 to 3 percent slopes
Indianola loamy sand, 0 to 3 percent slopes
Spanaway gravelly sandy loam, 3 to 15 percent slopes
Norma silt loam
Spana gravelly loam
Spanaway stony sandy loam, 3 to 15 percent slopes
Everett very gravelly sandy loam, 0 to 3 percent slopes
McKenna gravelly silt loam, 0 to 5 percent slopes
Spanaway stony sandy loam, 0 to 3 percent slopes
Yelm fine sandy loam, 0 to 3 percent slopes
Yelm fine sandy loam, 3 to 15 percent slopes
Indianola loamy sand, 3 to 15 percent slopes
Alderwood gravelly sandy loam, 0 to 3 percent slopes
Everett very gravelly sandy loam, 3 to 15 percent slopes
Norma fine sandy loam
Alderwood gravelly sandy loam, 3 to 15 percent slopes
Kapowsin silt loam, 3 to 15 percent slopes
MPG Soil