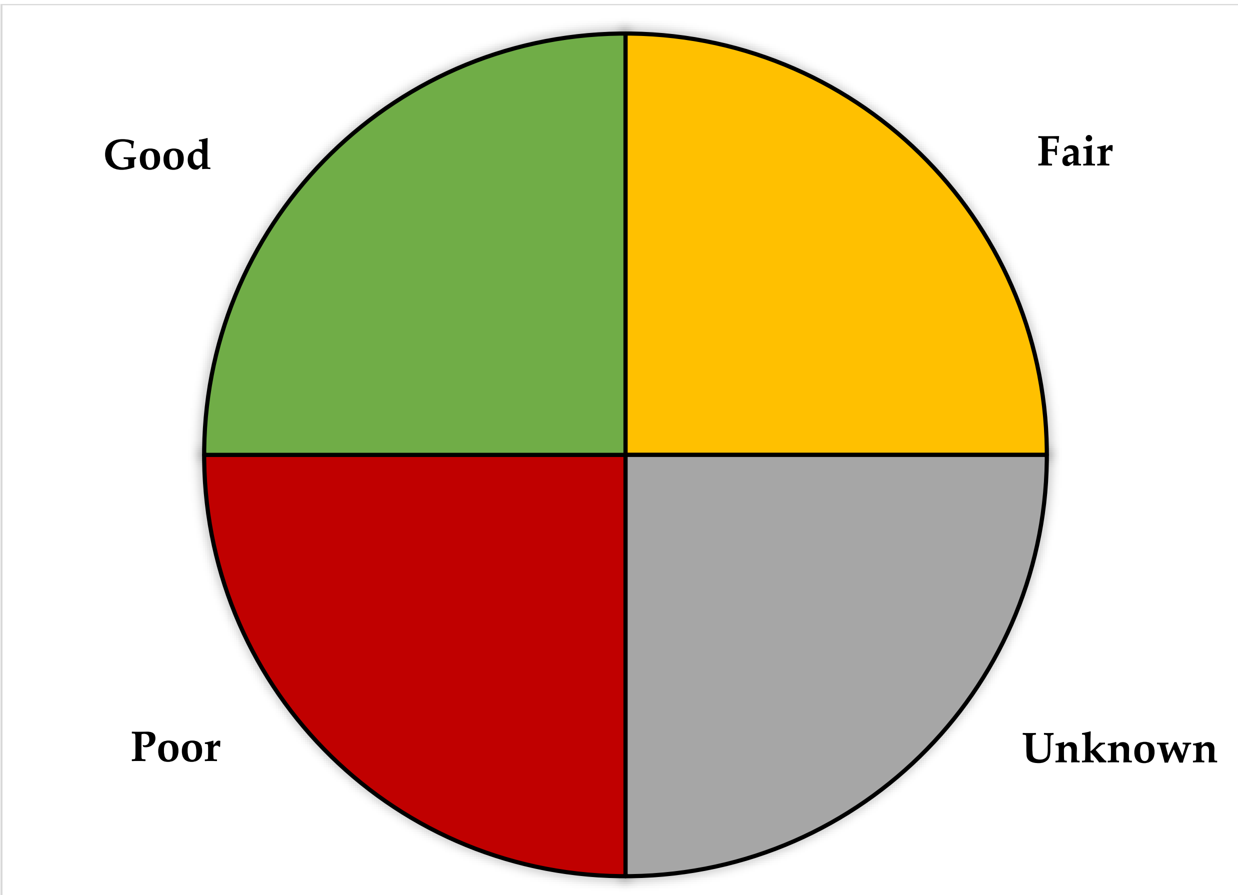
Component 2: Assessment Tool

Site Assessment Tool



Amber Reedy, Erik Martinez, Dannique Aalbu, Devin Rothman

Bren School of Environmental Science & Management
Bren Hall 2400 University of California, Santa Barbara, CA 93117

May 5, 2017

1. Abstract

The Assessment Tool (Tool) is a decision support tool that allows land managers to evaluate potential restoration sites in the Western Mojave Desert, based on the condition of habitat characteristics important to successful restoration for the desert tortoise. The Tool was created in Microsoft Excel, and uses a simple intuitive user interface which will allow a broad range of land managers to use it effectively. Habitat characteristics were chosen based on an extensive literature review to understand what makes good desert tortoise habitat, as well as the expert opinions of researchers and site managers from the Council and DTPC as to what characteristics need be considered for the success of restoration efforts. For each characteristic, conditions that constitute a "Poor", "Fair", or "Good" site assessment are defined and tool users are instructed to assess a potential restoration site based on which category best fits their site. The Tool will then generate graphs which offer visual representations of which aspects of a site are in good condition, and which aspects might need further consideration. This will allow land managers more information to choose whether a site should be selected for restoration efforts, and which aspects of a site might be most in need of attention.

2. Background and Instructions

2.1 What is this Tool?

This Assessment Tool (Tool) is a decision support tool that allows land managers to evaluate potential restoration sites for Agassiz's Desert Tortoise (*Gopherus agassizii*) habitat. This evaluation is based on the condition of habitat characteristics that are important for successful restoration. Habitat characteristics were chosen based on an extensive literature review focused on key features of desert tortoise habitat. Similarly, the expert opinions of researchers and professionals from the Desert Tortoise Council and Desert Tortoise Preserve Committee, Inc. were consulted to determine what characteristics need be considered for successful restoration.

2.2 How does this Tool work?

In the 'Habitat Assessment' tab, conditions that constitute a “Poor”, “Fair”, or “Good” site assessment are defined for 18 habitat characteristics. For each characteristic, users can choose the category (“Poor”, “Fair”, or “Good”) that best describes the present condition at their site, using the drop down list provided (Note: users can also enter the category manually). The "Unknown" category may be chosen if not enough information is available to assess a particular characteristic. Once all characteristics have been assessed, the Tool generates a dashboard in the 'Reports' tab which offer visual representations of present conditions onsite; using this visualization, managers can see which characteristics of a site provide good tortoise habitat and which characteristics might need further consideration. Users can consult the 'Resources' tab for links to useful information on improving habitat characteristics.

2.3 Where should this Tool be used?

This Tool is intended for use in the Western Mojave Recovery Unit as defined in the 2011 Revised Recovery Plan for the Desert Tortoise (USFWS 2011). While some of the habitat considerations in this Tool can be applied more broadly to other areas of desert tortoise habitat, the specific needs of desert tortoise habitat are different in other recovery units and the Tool was not developed to be used in those areas.

2.4 How do I get started?

If you would like to use this Tool for your restoration project, navigate to the 'Habitat Assessment' tab and start by choosing the category (“Poor”, “Fair”, “Good”, or "Unknown") that best describes the present condition at your site for each of the 18 habitat characteristics.

3. Characteristics

3.1 Biological Factors

3.1.1 Vegetation Association

The dominate vegetation associated with desert tortoise habitat in the Western Mojave Desert is the white bursage and creosote bush (*Ambrosia dumosa-Larrea tridentata*) association (Berry et al. 2006, Berry et al. 2014, Abella & Berry 2016). This vegetation matrix is represented by the Ambrosia dumosa-Larrea tridentata Shrubland Alliance, the most widespread and abundant desert alliance in California (Thomas et al. 2004). Characteristic features of this alliance include shrubs that are less than three meters tall and open canopy (Thomas et al. 2004).

3.1.2 Vegetative Cover

Perennial plant species (representing canopy and shrub species) act as an obligatory source of cover for desert tortoises, providing protection from both predators and the harsh desert environment. Studies suggest tortoises avoid areas of very low plant cover (Andersen et al 2000; Drake et al 2015); although, it is difficult to determine how much shrub cover tortoises actually require (Abella & Berry 2016). According to a study conducted by Dr. Berry and colleagues at the National Training Center in the Central Mojave Desert, tortoises may be present in areas with as little as 4.0% plant cover (Berry et al. 2006); though this result is meaningful as it represents the lowest known percent plant cover known to support desert tortoises, the landform is characterized as an alluvial fan, suggesting that there may be scree and other rock features that are used as supplement cover areas. In studies conducted in other areas with similar vegetation, the average density of mature perennial plants (>10 cm tall) were 17 plants per square kilometer for creosote and 5.9 plants per square kilometer for white bursage (Abella & Berry 2016).

3.1.3 Native Forage

Native forbs are a fundamental component of desert tortoise habitat, providing nutritious and suitable forage species for the desert tortoise. Though diet analyses and observations of foraging indicate that desert tortoises eat dozens of plant species, they are known to be selective foragers (Henen 2002; Esque et al. 2014; Jennings and Berry 2015, Abella & Berry 2016). In addition, tortoises of different age have been observed to prefer different species, based on varying sizes and, more specifically, leaf heights (Morafka & Berry 2002; Oftedal et al. 2002). Furthermore, there is extensive evidence in the literature stating the importance of quality forage for the desert tortoise (Drake et al. 2015; Jennings and Berry 2015).

Though forage species may vary by timing and availability, several studies have reported on preferred forage in the Western Mojave Desert. In one study, desert tortoises preferred to consume certain herbaceous perennial forbs, even though annuals were available (Jennings and Berry 2015); in this study, preferred forbs included: wishbone-bush (*Mirabilis laevis*), Layne Locoweed (*Astragalus layneae*), whitemargin sandmat (*Chamaesyce albomarginata*), Mojave lupine (*Lupinus odoratus)*, foothill deervetch (*Acmispon brachycarpus*), dwarf milkvetch (*Astragalus didymocarpus*), lacy phacelia (*Phacelia tanacetifolia*), and desert dandelion (*Malacothrix coulteri*). Other preferred species in the Western Mojave may include: Hairy Lotus (*Lotus humistratus*), Four O'Clock (*Mirabilis laveis*), Rattlesnake Sandmat (*Chamaesyce albomarginata*), Layne Locoweed (*Astragalus layneae*), Egbertia (*Prenanthella exigua*), Two-seeded Milkvetch (*Astragalus didymocarpus*), Booth's Evening Primrose (*Eremothera boothii*), Brittle Spineflower (*Chorizanthe brevicornu*), and Lacy Phacelia (*Phacelia tanacetifolia*) (Jennings 2002). In addition, native perennial grasses are also foraged on by the desert tortoises, but herbaceous perennial forbs are preferred when available (Hazard et al. 2009, 2010).

3.1.4 Invasive Plants

The presence of invasive plant species can negatively affect desert tortoise habitat. The most abundant invasive annual plants found in desert tortoise habitat include: red brome (*Bromus rubens*), cheatgrass (*Bromus tectorum*), Mediterranean grass (*Schismus barbatus*) and filaree

(*Erodium cicutarium*). Invasive plants may act in combination with other threats, such as increasing the proliferation of wildfires and competing with native forage, decreasing both the quantity and quality of forage, which can negatively affect the tortoise's nutritional needs (Oftedal 2002; Hazard et al. 2009, 2010).

3.1.5 Desert Tortoise Density

Historically, population densities in the Western Mojave Desert were quite large. In a survey conducted in the Desert Tortoise Research Natural Area conducted between 1979 and 1982, population densities were 150 tortoises per square kilometer (Berry and Medica 1995; Brown et al. 1999; Keith et al. 2008). However, subsequent studies suggest that the population densities in the area declined by over 90% in the early 1990s (Berry and Medica 1995; Brown et al. 1999; Keith et al. 2008) In the Desert Tortoise Recovery Plan published by the US Fish and Wildlife Service, a density of 3.86 adult tortoises per square kilometer was cited as a minimum density to support genetic viability.

3.1.6 Proximity to Current Desert Tortoise Habitat

The proximity to known desert tortoise habitat is an important consideration for assessing potential habitat, as it serves to promote genetic viability, which is fundamental to recovery efforts. In the Desert Tortoise Recovery Plan published by the US Fish and Wildlife Service, along with a minimum density requirement, a habitat area of 518-1295 km2 was estimated for genetic viability. In addition, past genetic work also suggests that, historically, levels of gene flow among subpopulations were likely high, corresponding to high levels of connectivity among habitat types (Murphy et al. 2007; USFWS 2011). Since desert tortoises possess the capability for long-distance dispersal, are long-lived and can reproduce annually throughout adulthood, they possess a high potential for gene exchange outside of local areas (USFWS 2011). According to tortoise expert Dr. Kristin Berry, large males are known to occupy home ranges of over 0.75 square miles. Translating this to a diagonal distance of travel, male tortoises may travel up to 0.87 miles or approximately 1.4 kilometers within their home range. Therefore, we may safely assume tortoises can travel this distance to other areas of suitable habitat.

3.2 Physical Features

3.2.1 Geologic Substrate

The ability for desert tortoises to burrow is an important consideration for habitat suitability (Germano et al. 1994, Andersen et al. 2000, Abella and Berry 2016). Suitability of a site for burrowing is linked to soil parent material and geologic substrate (Andersen et al. 2000). Due to this linkage and the importance of burrows, suitable tortoise habitat usually contains loamy soils and alluvial fans (Rautenstrauch and O'Farrell 1998, Andersen et al. 2000, Murphy et al. 2011, USFWS 2011).

3.2.2 Soil Composition

Desert tortoises create burrows which provide shelter from predators and help with thermoregulation (Germano et al. 1994, Andersen et al. 2000, Abella and Berry 2016). These burrows are important for the survival of the desert tortoise, and tortoises spend the majority of the year inside burrows in order to escape predation and temperature extremes (Andersen et al. 2000, Mack et al. 2015). The ability for a tortoise to burrow is dependent on a site having friable soil which is easy for a tortoise to move aside when digging burrows, but is not so fine that burrow structures collapse (Andersen et al. 2000, Abella and Berry 2016).

3.2.3 Elevation

Desert tortoises have a wide range of elevations, and are commonly found between elevations of 500 and 1500 meters (Rautenstrauch and O'Farrell 1998, USFWS 2011). Although desert tortoises have been found outside of these ranges (USFWS 2011), it is rare case.

3.2.4 Slope

Desert tortoise thrive in a variety of habitats from flatlands to slopes (Germano et al. 1994), but are not typically found on slopes greater than 45° (Keith et al. 2008).

3.3 Threats

3.3.1 Off Highway Vehicle Access

Off highway vehicle (OHV) use is one of the most detrimental activities to desert tortoise habitat (Lovich and Bainbridge 1999, Berry et al. 2014). OHVs crush important vegetation (Berry et al. 2014), compact soil to levels unsuitable for plant establishment (Lovich and Bainbridge 1999), and directly cause some desert tortoise deaths (Ruby et al. 1994). Since desert habitat recovers slowly from these sorts of disturbances, limiting these disturbances in the first place is critical to the health of a site (Brooks 1995, Lovich and Bainbridge 1999, Abella 2010,).

The effects of further OHV use is largely dependent on the ability of OHV users to have continued access to a site (Berry et al. 2014). Fencing is the most important method for limiting OHV access to a site (Ruby et al. 1994, Berry et al. 2014). Sites which are fully fenced show decreased impacts of OHV use than unfenced sites (Brooks 1995, Berry et al. 2014). The ability to limit access to a site is also dependent on proximity to access roads (Lovich and Bainbridge 1999, Brooks and Berry 2006). Roadways serve as the main arteries for OHV users to access desert habitat, and sites nearer to these roads may have continued OHV issues even if fully fenced.

3.3.2 Grazing

Grazing is one of the most detrimental activities to desert tortoise habitat (Lovich and Bainbridge 1999, Berry et al. 2014). Grazing animals selectively browse important forage plants (Abella 2008, Berry et al. 2014), compact soils (Lovich and Bainbridge 1999), and are correlated with an increase in invasive plant abundance (Brooks and Berry 2006). Since desert habitat recovers slowly from these sorts of disturbances, limiting these disturbances in the first place is critical to the health of a site (Brooks 1995, Lovich and Bainbridge 1999, Abella 2010). Fencing is the most important method for limiting grazing access to a site (Ruby et al. 1994, Berry et al. 2014).

3.3.3 Raven Predation

Ravens are known predators of the desert tortoise (e.g. Boarman 1995), and due to the resource subsidies of human dominated areas have undergone population booms which make them difficult to manage for apart from site selection. Ravens are opportunistic and often congregate around landfills which provide consistent food and water resources (Boarman et al. 2006) and utility corridors which provide structures for building nests (Boarman 2003). While raven populations have wide ranges, individuals are unlikely to be found more than 2000 meters from their home sites in open ecosystems (Coates et al. 2014). Ravens are most likely to prey on desert tortoise in order to feed young, but are also likely to stay within 500 meters of nesting sites when they have fledglings (Kristan and Boarman 2003).

3.3.4 Proximity to Roads

Roadways have detrimental effects on both desert tortoise habitat and desert tortoises themselves (Boarman and Sazaki 2006). The ability for invasive plants and off highway vehicles to traverse down roadways contributes to habitat degradation (Abella and Berry 2016), and vehicles along roadways also often directly kill tortoises (Boarman and Sazaki 2006, Nafus et al. 2013). The effects of off highway vehicles and invasive plants are important but can be managed (see “Off Highway Vehicles” and “Invasive Plants”), whereas tortoises killed by vehicles is correlated with proximity to roads (Boarman and Sazaki 2006) and is largely difficult to manage for outside of site selection.

The effect of roads on substantial reduce tortoise density somewhere between 400 and 800 meters from the roadway (Boarman and Sazaki 2006, Nafus et al. 2013). The amount of traffic on a roadway can also play a role in detrimental effects on the desert tortoise (Nafus et al. 2013). Low traffic volume roads (<30 vehicles traveled per day) have less detrimental effects on desert tortoise populations than intermediate or high volume roads (Nafus et al. 2013). Roads with high traffic volume (>300 vehicles per day) can contribute to population declines (Nafus et al. 2013), and decline may be seen at traffic volumes as low as 100 vehicles per lane per day (Gibbs and Shriver 2002).

3.4 Disturbance History

3.4.1 Trash

Both toxic and non-toxic waste materials can affect the health of the desert tortoise (Abella and Berry 2016). Toxic contaminants from illegal dumping or historic mining activities can be ingested by tortoises either directly or through vegetation which has absorbed harmful chemicals in the soil (Abella and Berry 2016, Chaffee and Berry 2006). These contaminants are difficult to manage for outside of detection in site selection. Non-toxic contaminants also are detrimental to tortoises who sometimes eat litter, leading to illness or death (Walde et al. 2007). These non-toxic contaminants are possible to remove however, and can be managed for if present on a selected restoration site.

3.4.2 Off Highway Vehicles

The detrimental effects of OHVs on the condition of tortoise habitat are severe and long lasting (Lovich and Bainbridge 1999, Berry et al. 2014). Since soil condition and plant community composition can take large amounts of time to recover from severe disturbance (Lovich and Bainbridge 1999), sites with heavy and recent OHV use may take an especially large amount of effort to make suitable for desert tortoise habitat, and potentially have a higher chance to suffer restoration failure (Brooks 1995, Abella 2010).

3.4.3 Grazing

The effects of grazing activity on a site can be severe and long lasting (Lovich and Bainbridge 1999, Berry et al. 2014). Grazing can drastically alter the plant community composition of a site by removing native forage (Abella 2008, Berry et al. 2014), and increasing the abundance of invasive plants (Brooks and Berry 2006). Grazing animals can also compact soil, altering the ability for plants to establish (Brooks et al. 2006). Since soil condition and plant community composition can take large amounts of time to recover from severe disturbance (Lovich and Bainbridge 1999), sites with heavy and recent grazing history may take a large amount of effort to make suitable for desert tortoise habitat (Brooks 1995, Abella 2010).

3.4.4 Fire History

Fire is tightly coupled with the invasion of invasive grasses in arid ecosystems (D’Antonio and Vitousek 1992). The ability for invasive grasses to recover rapidly after fire allows them to outcompete native cover and forage. Desert tortoises have been shown to recolonize areas that have recently undergone a single fire (Drake et al. 2015), but plant communities can take decades to recover from burns (Abella 2009, Engel and Abella 2011). Due to the heightened ability of invasive grasses to recolonize quickly after fire, multiple fires can change the plant composition of a site drastically enough that it cannot be suitable for desert tortoise habitat without large amounts of restoration effort (D’Antonio and Vitousek 1992, Abella 2009).

4. Interpreting Results

Results produced by the Assessment Tool (Tool) are meant to help land managers prioritize restoration efforts. As the Tool is intended to be used in areas in need of restoration, potential sites are expected to contain features assessed as being in “fair” or “poor” condition; otherwise, there would be no need for restoration. When the tool is used to assess a potential restoration site, a land manger can visualize the features in need of restoration and subsequently decide whether an improvement of current conditions is feasible given present constraints. In addition, a land manager may also use the Tool to visualize conditions at a number of potential sites, as a means of comparison. The Tool itself does not prioritize one site over another, but can assist a land manager in choosing a best-suited site based on their current situation and set of constraints. It is recognized that constraints may vary widely based on funding, stakeholders, time, etc. As the purpose of the tool is to provide decision support as opposed to a means of prioritization, it is important that users are knowledgeable about the desert tortoise and its habitat needs. It is also worth noting that certain conditions, like for example, proximity to a road, may be unchangeable; in this case, the present condition of the feature is taken with face value as something that restoration will have to address indirectly or work around. In the case of a road: if site contains an active road, the road may not be subject to removal, but the area adjacent to the road may be fenced for added protection for the tortoise. This would be considered an indirect way of addressing the condition. By creating a tool to assess and visualize the conditions present at potential restoration sites, land managers can quickly and efficiently prioritize restoration efforts.

5. References

Abella, S.R. 2008. A systematic review of wild burro grazing effect on Mojave Desert vegetation, USA. *Environmental Management* 41: 809-819.

Abella, S.R. 2009. Post-fire plant recovery in the Mojave and Sonoran Deserts of western North America. *Journal of Arid Environments* 73:699-707.

Abella, S.R. and K.H. Berry. 2016. Enhancing and restoring habitat for the desert tortoise. *Journal of Fish and Wildlife Management* 7: 255-279

Andersen, M.C., Watts, J.M.Freilich, J.E., Yool, S.R., Wakefield, G.I., MacCauley, J.F., and P.B. Fahnestock. 2000. Regression-tree modeling of desert tortoise habitat in the central Mojave Desert. *Ecological Applications* 10: 890-900

Berry, K.H., Bailey, T.Y., and K.M. Anderson. 2006. Attributes of desert tortoise populations at the National Training Center, Central Mojave Desert, California, USA. *Journal of Arid Environments* 67: 165-191

Berry, K.H., and P. Medica. 1995. Desert tortoises in the Mojave and Colorado deserts. Pages 135-137 *in*: E.T. LaRoe, G. S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, editors. Our Living Resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Dept. of the Interior, National Biological Service, Washington, D.C. USA.

Berry, K.H., Yee, J.L., Coble, A.A., Perry, W.M., and T.A. Shields. 2013. Multiple factors affect a population of Agassiz's desert tortoise (*Gopherus agassizii*) in the northwestern Mojave Desert. *Herpetological Monographs* 27: 87–109

Berry, K.H., Lyren, L.M., Yee, J.L., and T.Y. Bailey. 2014. Protection benefits desert tortoise (*Gopherus agassizii*) abundance: the influence of three management strategies on a threatened species. *Herpetological Monographs* 28: 66-92

Brooks, M.L. 1995. Benefits of protective fencing to plant and rodent communities of the western Mojave Desert, California. *Environmental Management* 19: 65–74
Brooks, M.L., and K.H. Berry. 2006. Dominance and environmental correlates of alien annual plants in the Mojave Desert, USA. *Journal of Arid Environments* 67: 100–124
Brooks, M.L., Matchett, J.R., and K.H. Berry. 2006. Effects of livestock watering sites on alien and native plants in the Mojave Desert, USA. *Journal of Arid Environments* 67:125-147.
Boarman, W.I. 2002. Threats to desert tortoise populations: a critical review of the literature. Report for West Mojave Planning Team, Bureau of Land Management, Sacramento, California, USA
Boarman, W.I., Camp R.J., Hagan, M., and W. Deal. 1995. Raven abundance at anthropogenic resources in the western Mojave Desert, California. Report to Edwards Air Force Base, California
Boarman, W.I. 2003. Managing a subsidized predator population—Reducing common raven predation on desert tortoises. *Environmental Management* 32: 205–217
Boarman, W.I., Patten, M.A., Camp, R.J., and S.J. Collis. 2006. Ecology of a population of subsidized predators: common ravens in the central Mojave Desert, California. *Journal of Arid Environments* 67: 248–261
Boarman, W.I., and M. Sazaki. 2006. A highway's road-effect zone for desert tortoises (*Gopherus agassizii*). *Journal of Arid Environments* 65: 94–101
Brown, M.B., K.H. Berry, I. M. Schumacher, K.A. Nagy, M.M. Christopher, and P.A. Klein. 1999. Seroepidemiology of upper respiratory tract disease in the desert tortoise in the western Mojave Desert of California. Journal of Wildlife Diseases 35:716-727.
Bury, R.B., and R.A. Luckenbach. 2002. Comparison of desert tortoise (*Gopherus agassizii*) populations in an unused and off-road vehicle area in the Mojave Desert. *Chelonian Conservation and Biology* 4: 457–463
Coates, P.S., Howe, K.B., Casazza, M.L., and D.J. Delehanty. 2014. Common raven occurrence in relation to energy transmission line corridors transiting human-altered sagebrush steppe. *Journal of Arid Environments* 111: 68-78
D'Antonio, C.M., and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass-fire cycle, and global change. *Annual Review of Ecology and Systematics* 23: 63–87
Drake, K.K., T.C. Esque, K.E. Nussear, L.A. DeFalco, S.J. Scoles-Sciulla, A.T. Modlin, and P.A. Medica. 2015. Desert tortoise use of burned habitat in the Eastern Mojave Desert. *The Journal of Wildlife Management 79*: 618-629
Engell, E.C., and S.R. Abella. 2011. Vegetation recovery in a desert landscape after wildfires: influences of community type, time since fire and contingency effects. *Journal of Applied Ecology* 48: 1401-1410
Esque, T.C., C.R. Schwalbe, L.A. DeFalco, R.B. Duncan, and T.J. Hughes. 2003. Effects of desert wildfires on desert tortoise (*Gopherus agassizii*) and other small vertebrates. *Southwestern Naturalist* 48: 103-110
Gibbs, J.P. and W.G. Shriver. 2002. Estimating the effects of road mortality on turtle populations. *Conservation Biology* 16:1647-1652
Hazard, L.C., Shemanski, D.R., and Nagy, K.A., 2009, Nutritional quality of natural foods of juvenile desert tortoise (Gopherus agassizii)—Energy, nitrogen, and fiber digestibility: Journal of Herpetology, v. 43, p.38–48
Hazard, L.C., Shemanski, D.R., and Nagy, K.A., 2010, Nutritional quality of natural foods of

juvenile and adult desert tortoises (Gopherus agassizii)—Calcium, phosphorus, and magnesium digestibility: Journal of Herpetology, v. 44, p. 135–147

Henen, B.T., Peterson, C.C., Wallis, I.R., Berry, K.H., and K.A. Nagy. 1998. Effects of climatic variation on field metabolism and water relations of desert tortoises. *Oecologia* 117: 365–373

Hughson, D.L., and N. Darby. 2013. Desert tortoise road mortality in Mojave National Preserve, California. *California Fish and Game* 99: 222–232

Jennings, W.B. 2002. Diet selection by the desert tortoise in relation to the flowering phenology of ephemeral plants. *Chelonian Conservation and Biology* 4: 353–358

Jennings, W.B., and K.H. Berry. 2015. Desert tortoises (*Gopherus agassizii*) are selective herbivores that track the flowering phenology of their preferred food plants. *PLOS One* 10: 1–32

Keith, K., Berry, K.H., and J.F. Weigand. 2008. When desert tortoises are rare—Testing a new protocol for assessing status. *California Fish and Game* 94: 75–97

Kristan, W.B., and W.I. Boarman. 2003. Spatial pattern risk of common raven predation on desert tortoises. *Ecology* 84:2432-2443

Lovich, J.E., and D. Bainbridge. 1999. Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration. *Environmental Management.* 24: 309–326

Mack, J.S., Berry K.H., Miller, D.M., and A.S. Carlson. 2015. Factors affecting the thermal environment of Agassiz's desert tortoise (*Gopherus agassizii)* cover sites in the central Mojave Desert during periods of temperature extremes. *Journal of Herpetology* 49:405-414

Murphy, R.W., Berry, K.H., Edwards, T., Leviton, A.E., Lathrop, A., and J.D. Riedle. 2011. The dazed and confused identity of Agassiz's land tortoise, *Gopherus agassizii* (Testudines, Testudinidae) with the description of a new species, and its consequences for conservation. *ZooKeys* 113: 39–71

Murphy, R.W., Berry, K.H., Edwards, T., and McLuckie, A.M., 2007, A genetic assessment of the recovery units for the Mojave population of the desert tortoise, Gopherus agassizii: Chelonian Conservation and Biology, v. 6, p. 229–251.

Morafka, D.J., and K.H. Berry. 2002. Is Gopherus agassizii a desert-adapted tortoise, or an exaptive opportunist? Implications for tortoise conservation. Chelonian Conservation and Biology 4:263-287

Nafus, M.G., Tuberville, T.D., Buhlmann, K.A., and B.D. Todd. 2013. Relative abundance and demographic structure of Agassiz's desert tortoise (*Gopherus agassizii*) along roads of varying size and traffic volume. *Biological Conservation* 162: 100–106

Oftedal, O.T., S. Hillard, and D.J. Morafka. 2002. Selective spring foraging by juvenile desert tortoises (Gopherus agassizii) in the Mojave Desert: evidence of an adaptive nutritional strategy. Chelonian Conservation and Biology 4:341-352

Rautenstrauch, K.R., and T.P. O'Farrell. 1998. Relative abundance of desert tortoises on the Nevada test site. *Southwestern Naturalist* 43: 407–411

Thomas, K., T. Keeler-Wolf, J. Franklin, and P. Stine. 2004. Mojave Desert Ecosystem Program:

Central Mojave Vegetation Database. Final Report. Sacramento, California. US Geological Survey. Western Ecological Research Center & Southwest Biological Science Center.

USFWS. U.S. Fish and Wildlife Service. 2010. Mojave population of the desert tortoise (*Gopherus agassizii*) 5-year review: summary and evaluation. Report for the U.S. Fish and Wildlife Service Desert Tortoise Recovery Office, Reno, Nevada, USA

USFWS. U.S. Fish and Wildlife Service. 2011. Revised recovery plan for the Mojave population of the desert tortoise (*Gopherus agassizii*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California.

Walde, A.D., Harless, M.L., Delaney, D.K., and L.L. Pater. 2007. Anthropogenic threat to the desert tortoise (*Gopherus agassizii*): litter in the Mojave Desert. *Western North American Naturalist* 67: 147–149

Appendix A - Assessment Tool Graphics

Feature	Poor Site	Fair Site	Good Site	Assessment	Notes
		Biological Factors			
Vegetation Association*	Site contains little to no white bursage (*Ambrosia dumosa*)/creosote bush (*Larrea tridentata*) vegetation.	Site may contain some white bursage/creosote bush vegetation, but it is not the dominant asosciation (<50% of site).	Site is dominated by white bursage/creosote bush vegetation. Site may additionally contain Box-thorn, Indigo bush, Nevada ephedra and emergent Joshua trees.	Fair	
Vegetative Cover	Site is highly denuded; has less than 4% density of creosote, white bursage and/or other cover flora; most of the area is bare earth.	Site is partially denuded; has low density of creosote, white bursage and/or other cover flora; there are some patches of bare earth, but they do not dominate the site.	Site has high density (>17 plants/km^2) of creosote, white bursage (> 6 plants/km^2) and/or other cover flora; there are limited patches of bare earth.	Fa	
Native Forage	Site contains very few or no native perennial plant species.	Site contains small amounts of (Chylismia claviformis) and desert plantain (Plantago Ovata) and a low diversity of native forage.	Site contains a large abundance of native perennial plant species. Broweyes (Chylismia claviformis) and desert plantain (Plantago Ovata) are present onsite.	Poor	
Invasive Plants	Site contains a high abundance of invasive grasses and mustards such as red brome (*Bromus rubens*), cheatgrass (*Bromus tectorum*), Mediterranean grass (*Schismus barbatus*) and filaree (*Erodium cicutarium*). These species are visibly present over the majority of the site.	Site contains an appreciable amount of invasive species, such as red brome , cheatgrass, Mediterranean grass and filaree.	Site contains no or very little invasive species, such as red brome, cheatgrass , Mediterranean grass, and filaree.	Fair	
Tortoise Density	No tortoise sign is present onsite.	Tortoise sign is present onsite, but may be minimal.	Tortoise sign indicates densities of at least 3.86 tortoises/km^2	Unknown	
Proximity to Current Tortoise Habitat	Site is not within 1.4 km of current tortoise habitat or protected lands	Site is within 1.4 km of potential tortoise habitat or protected lands with suitable habitat features	Site is within 1.4 km of current tortoise habitat	Good	

Assess your site:
Choose which category of Poor, Fair, or Good best matches your site. Choose Unknown if there is not enough information.

		Physical Features			
Geologic Substrate*	Site lacks loamy soils, fine grained alluvial fan deposits	Site contains some loamy soils, fine grained alluvial fan deposits, but this substrate is not dominant at the site	Site contains a high proportion of loamy soils and fine grained alluvial fan deposits	**Good**	
Soil Composition*	Site lacks sand and fine gravel	Site contains minimal or patchy patchy areas of friable soil: sand and fine gravel	Site contains a high proportion of friable soil: sand and fine gravel.	**Fa**	
Elevation*	The majority of the site (>50%) is above 1500m or below 500m.	Some of the site is located above 1500m or below 500m, but the majority (>50%) is below 1500m.	100% of the site is contained in the expected elevation range of 500-1500 meters above sea level.	**Good**	
Slope*	Site is entirely located on slope greater than 45°	The majority (>50%) of the site is located on slopes greater than 45°	100% of the site is located on slope less than 45°	**Good**	
		Threats			
Off Highway Vehicles Access	Site is not fenced. Site is near major access roads. Site has signs of recent OHV and dirt bike use.	Site is fully fenced. Site is near major access roads and has signs of recent OHV and dirt bike use.	Site is fully fenced, and has no active OHV or dirt bike trails.	**Fair**	
Grazing Access	Site is not fenced and contains scat or other signs of active grazing.	Site is not fully fenced but contains no scat or other signs of active grazing.	Site is fully fenced and has no scat or other signs of active grazing.	**Good**	
Raven Predation	Site is within 500m of a utility corridor or a landfill. Ravens are common at site.	Site is between 500 and 2000m from any utility corridors or landfills. Ravens are not common at the site.	Site is at least 2000m away from any utility corridors or landfills.	**Fair**	
Proximity to Roads	Site is within 400m of roadways with high traffic volume (>100 vehicles per day).	Site is 400 - 800m from roadways. Roadways near site have intermediate traffic volume (30-100 vehicles per day).	Site is at least 800m from roadways. Roadways near site have low traffic volume (<30 vehicles per day).	**Poor**	

Assess your site:
Choose which category of Poor, Fair, or Good best matches your site. Choose Unknown if there is not enough information.

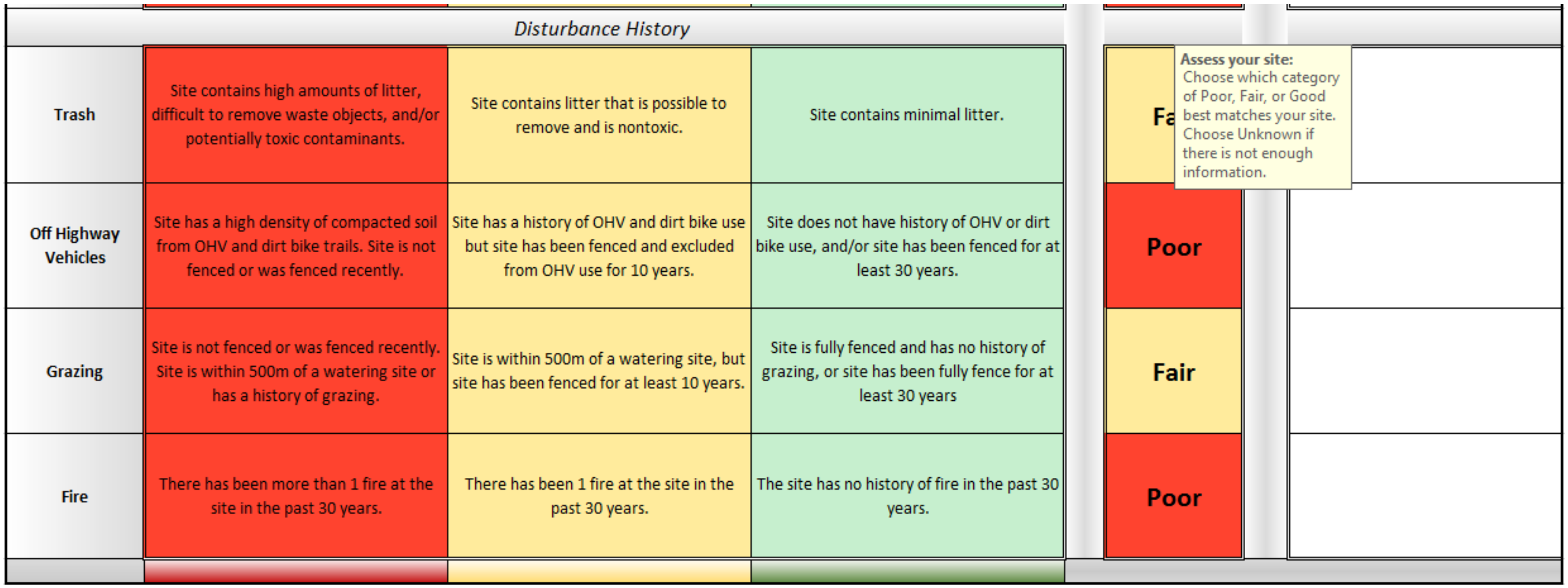


Figure 1. User interface of Assessment Tool

Figure 2. Graphical Outputs of Assessment Tool