Predicting the potential habitat of Russian-Olive (*Elaeagnus angustifolia*) in urban landscapes

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Abstract. Russian-olive (*Elaeagnus angustifolia*) is a species native to southern Europe and central and eastern Asia. This species plays an important role in urban landscape design because of its rapid growth, resistance in harsh climates and tolerance to human-caused pressure. Understanding its potential dispersal and restricting parameters are the first steps toward the sustainable use of this species. Here, we used Species Distribution Models to predict the potential distribution of Russian-olive in Iran climate and estimate the possible limiting factors for its spread. Our results highlighted the importance of environmental variables including climatic factors, soil, and lithology in the distribution of this species throughout the country. According to these results, suitable habitats for Russian-olive are located in the north of Iran along the Alborz and Koppeh-Dagh mountain ranges. Therefore, the suitable habitats for this species are limited to only nine percent of the country. A habitat suitability map can be used to evaluate future developments in urban areas and predict the dispersal range of Russian-olive in Iran. Our results show that Russian-olive can be used to create new green spaces in urban climates in the northern regions of Iran.

Keywords: climate, green space, ornamental tree, SDM, urban areas.

INTRODUCTION

The Middle East and North Africa are home to five percent of Earth’s human population. However, only one percent of the global freshwater resources is located in Middle Eastern and North African countries (Djuma et al. 2016). As a result, water scarcity looms large across the region (Al-Ansari and Knutsson 2011; Al-Ansari et al. 2014; Abbas et al. 2018). To complicate the problem even further, population growth and political tensions threaten the sustainability of existing water resources in the Middle East and North Africa (Djuma et al. 2016).

Consequently, making use of different water sources and enhancing the resilience of water supply is crucial to meet the needs of the increasing urban population (Bichai et al. 2015). The environmental damage associated with urban devel-
Development has drawn attention to the need for green spaces in cities, which will lead to increased water use (Zhang et al. 2017). Green spaces are among the indicators of sustainable urban development. When planning for urban green spaces, numerous elements, such as economic, political, social, and cultural factors, along with management and planning considerations need to be taken into account (Haq 2011). Conservation of biological resources and maintaining soil and water quality are among the services provided by urban green spaces (Haq 2011, 2015). Many studies indicate that plant particularly trees can improve the urban micro-climate and influence thermal comfort in various ways including shading, controlling the humidity, wind break, pollutant absorption and produce oxygen (Abreu-Harbich et al. 2015; Thoma et al. 2016; Afshar et al., 2018).

In arid regions such as the Middle East, design of urban green spaces is one of the main challenges facing city planners and urban architects. One solution to address this challenge is the use of native plant species which are adapted to the dry conditions of the region (Katz and Shafroth 2003; Kiseleva and Chindyavea 2011).

The first step in utilizing native species is identification of their habitat requirements. Species distribution models (SDMs) trace their origin to the 1970s and have remained a common tool for ecologists throughout the following decades (e.g., Guisan and Zimmermann 2000; Guisan and Thuiller 2005; Rooper et al. 2016). In the time since their conception, several SDM algorithms have been developed, as discussed by Elith and Leathwick (2009) and Farashi and Alizadeh-Noughani (2018). These algorithms distinguish the major variables that determine a species’ suitable habitat and show how predictor variables impact response variables. Furthermore, SDM algorithms enable researchers to see species’ potential distribution (Liang and Stohlgren, 2011; Liang et al. 2017). Through modifications, these algorithms have been optimized for use in fields such as biogeography, ecology, evolution, and species conservation and management (Mikolajczak et al., 2015; Hannah et al., 2015). SDMs have also been used to assess the potential distribution of plant species (e.g., Kumar and Stohlgren 2009; Hemsing and Bryn 2012; Zhang et al., 2013; Guida et al. 2014; Hu et al. 2018). In the present study, we have used SDMs to predict the spatial distribution of Russian-olive (*Elaeagnus angustifolia*), a native plant species in Iran. Iran is a Middle Eastern country located on Earth’s arid belt with upwards 60% of the country’s area having an arid or semi-arid climate. In areas that receive little precipitation and experience severe fluctuations from year to year, agriculture is often limited by water availability (Modarres and da Silva 2007).

Russian-olive is native to Eurasia that occurs on coasts, in riparian areas, along watercourses, in other relatively moist habitats and also in many arid and semiarid regions of the world (Klich, 2000; Peterson et al., 2003). Soil salinity (low to medium concentrations), pH and water supply and moisture (low) are important environmental factors in Russian-olive habitat (Carman, 1982; Zitzer and Dawson, 1992; Reynolds and Cooper, 2010; Dubovyk et al., 2016). Russian-olive is resistant to drought (+46 °C) and frost (-46 °C) (Stratu et al., 2016; Akbolat et al., 2008). This tree is an ecologically valuable plant that are adapted to a variety of harsh conditions such as cold, drought, and salinity or alkalinity of soil (Asadiar et al. 2013; Zhang et al. 2018). The species endures through water scarcity by using groundwater (Katz and Shafroth 2003). Along with its desirable ecological characteristics, Russian-olive possess aesthetic values such as its beautiful oval crown, arching branches, silver leaves and shiny dark red fruits. Therefore *E. angustifolia* is particularly suitable for urban landscapes in arid regions such as Iran. This tree can be used to create sustainable green spaces in urban climates of Iran.

**MATERIALS AND METHODS**

**Study area and species**

Iran is located in Western Asia between 24˚-40˚ N and 44˚-64˚ E. Due to its habitat diversity and phytogeographic variety, Iran hosts rich biodiversity. Over 8,000 species of plants are found in Iran, of which 1,810 are endemic (Ghahraman and Attar 2000; Willis 2001). Russian-olive is a deciduous tree, sometimes with a shrubby habit, in the family Elaeagnaceaee (Saboonchian et al. 2014). This species naturally grows in central and eastern Asia and southern Europe. Russian-olive grows quickly, reaching a maximum height of 10 m and maximum trunk diameter of 30 cm. Trees usually bear fruit after 5-6 years (Katz and Shafroth 2003).

**Species distribution models**

SDMs were developed in Biomod2 package (Thuiller et al. 2009, 2014) in R version 3.1.25 (R Core Team 2014). 10 different algorithms were used to study the species (Tab. 1). The algorithms can be categorized as: regression, machine learning, classification and enveloping algorithms. Regression-based algorithms include generalized linear models (GLMs) and generalized additive models (GAMs) which generate linear and non-linear equations between presence data and environmental variables, respectively. Machine learning algorithms include artificial neural networks (ANN), boosted regression trees, (BRT), multivariate adaptive regression splines (MARS), maximum
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| SDM   | Variable                                | Type   | Reference               | TSS   |
|-------|-----------------------------------------|--------|-------------------------|-------|
| ANN   | Artificial neural networks              | P/A    | Lek and Guégan (1999)   | 0.71  |
| BRT   | Boosted regression trees                | P/A    | Elith et al. (2008)     | 0.71  |
| CART  | Classification and regression trees     | P/A    | Vayssières et al. (2000)| 0.60  |
| FDA   | Flexible discriminant analysis          | P/A    | Hastie et al. (1994)    | 0.72  |
| GAM   | Generalized additive models             | P/A    | Guisan et al. (2002)    | 0.60  |
| GLM   | Generalized linear models               | P/A    | Guisan et al. (2002)    | 0.70  |
| MaxEnt| Maximum entropy                          | P/B    | Phillips et al. (2006)  | 0.80  |
| MARS  | Multivariate adaptive regression splines| P/A    | Friedman (1991)          | 0.61  |
| RF    | Random forest                           | P/A    | Breiman (2001)          | 0.65  |
| SRE   | Surface range envelope                  | P/B    | Busby (1991)            | 0.65  |
| Ensemble | -                                     | -      | Araújo and New (2007)   | 0.85  |

P: Presence; A: Absence; B: Background.

Variable importance was calculated by a permutation procedure used in biomod, which is independent of the modelling technique. Once the models were trained (i.e., calibrated), a standard prediction was made. Then, one of the variables was randomized and a new prediction was made. The correlation score between the new prediction and the standard prediction was calculated and gave an estimation of the variable importance in the models (Thuiller et al., 2009).

Models were evaluated using the True Skill Statistic (TSS). TSS is the sum of sensitivity and specificity minus 1, and does not depend on prevalence (Allouche et al. 2006; Fielding and Bell 1997). TSS was used to create an ensemble-forecasting framework, as per Araújo and New (2007). All models contributed to the ensemble model. However, those with better performance, as indicated by TSS, were given more weight (Thuiller et al. 2009). A threshold value was defined by maximizing training sensitivity and specificity in order to create a binary (presence/absence) map from outputs of the algorithms (Liu et al. 2005; Liu et al. 2011). Sensitivity and specificity are statistical index of the performance of a binary classification analysis. Sensitivity calculate the proportion of actual presences which are correctly predicted as such, while specificity calculate the proportion of pseudoabsences which are predicted as absences. By maximizing the sum of sensitivity and specificity, the associated threshold corresponds to the point on the ROC curve (i.e. sensitivity against 1-specificity) whose tangent slope is equal to 1 (Kaivanto 2008; Jiguet et al. 2011). The approach was selected to calculate the threshold for presence/absence predictions in biomod2 (Liu et al. 2005).

**Presence data and environmental variables**

Occurrence records and distribution of the species were obtained from herbariums of Ferdowsi University of Mashhad, Tehran University, and University of Birjand. Flora Iranica (Rechinger, 1963-2015) and Flora of Iran (Assadi et al. 1988-2017). Herbaria data were obtained from field samplings between 2009 and 2019. The coordinates of all the occurrence points were recorded using a hand-held multichannel Global Positioning System (GPS) receiver with a positional accuracy of ±5 m. The spatially correlated presence points were removed using spatial autocorrelation and Moran’s I test. The number of presence points was 83 (Fig. 1).

Topographic, geographic, edaphic, and climatic variables were used as input for the algorithms. Topographic variables were obtained from the national cartographic center of Iran (NCC) at 1-km spatial resolution. Geological survey and mineral exploration of Iran (GSI) provided the geographic data at 1-km spatial resolution. Edaphic variables were accessed from the agricultural research, education and extension organization of Iran (AREEEO) at 1-km spatial resolution.

Mean elevation and mean slope for all raster cells in a 1-km radius were the two topographic variables used in modeling. Geographic and edaphic variables included soil orders and lithology, respectively. An initial set of 20
climatic variables, including precipitation, temperature, and solar radiation were obtained from the Worldclim database (http://www.worldclim.org). Climatic variables were used at a resolution of 30” (~ 1km). The correlation between all pairs of variables was tested. If -0.7 > r > +0.7, one of the two variables was excluded from the input data. The correlation tests reduced the number of variables to 12, which were subsequently used to model habitat suitability (Tab. 2).

**RESULTS**

All ten models showed a relatively good performance predicting the distribution of Russian-olive (Tab. 1). The results of modeling evaluation based on the TSS values showed that the combination of models performed relatively better than each individual model. Moreover, a model evaluation test showed that ensemble model performed better than other distribution models. The distribution map obtained from the ensemble model has been presented in Fig. 1. Our results showed that most of the suitable habitats for Russian-olive are located in the north of Iran. Only 9.5 percent of the country was suitable to grow this species (Fig. 1).

Suitable habitats based for each province have been presented in a separate map (Fig. 2). North Khorasan had the highest, and Ilam and Bushehr had the lowest proportion of suitable habitats among all provinces (Fig. 2). The

**Table 2.** Environmental predictors and their relative contributions to ensemble model of *E. angustifolia.*

| Environmental variables | Mean +SD | Relative contribution (%) |
|-------------------------|----------|---------------------------|
| **Climatic variables**  |          |                           |
| Mean Diurnal Range¹ (°C) | 38.01±3.08 | 4.0                        |
| Temperature Seasonality² | 8162.63±995.89 | 0.3                        |
| Mean Temperature of Warmest Quarter (°C) | 27.26±4.49 | 22.3                       |
| Mean Temperature of Coldest Quarter (°C) | 6.39±5.87 | 1.0                        |
| Annual Precipitation (mm) | 208.13±140.89 | 0.1                        |
| Precipitation of Wettest Quarter (mm) | 111.34±64.48 | 0.4                        |
| Precipitation of Driest Quarter (mm) | 5.86±13.09 | 1.1                        |
| Annual solar radiation (kJ m⁻² day⁻¹) | 10743.56±1906.88 | 10.2                      |
| **Topographic variables** |          |                           |
| Altitude (m) | 1251.24±686.64 | 0.2                        |
| Slope (degree) | 6.20±7.93 | 0.6                        |
| **Geographic variable** |          |                           |
| Lithology | 557 classes | 50.2                       |
| **Edaphic variable** |          |                           |
| Soil order | 20 classes | 8.5                        |

¹ Mean of monthly (max temp - min temp).
² Standard deviation × 100.

Fig. 1. Habitat suitability of *E. angustifolia* and its suitable habitats in Iran using ensemble model (a: continuous map, b: categorical map).
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Relative importance of environmental variables changed based on different models. According to ensemble model, the most important environmental variables to predict habitat suitability for this species were lithology (50% of the contribution), mean temperature of the warmest quarter (22% of the contribution), annual solar radiation (10% of the contribution) and soil order (8% of the contribution) (Tab. 2).

Response curves for the four dominant environmental factors are shown in Fig. 3. There are unimodal relationships between habitat suitability and annual solar radiation. Peak presence probability was observed at 8150 kJ m$^{-2}$ day$^{-1}$. The relationship between the habitat suitability values and mean temperature of the warmest quarter was best described by an exponential decay with the peak response at 5-7 °C. The results also demonstrated that any increase in mean temperature of the warmest quarter and...
annual solar radiation led to a decrease in habitat suitability for Russian-olive.

The relationship between the habitat suitability values with soil order and lithology showed that this species could grow in different soil and rock classes. However, the highest presence probability is observed in rocky lands and high-level piedmont fan and valley terrace deposits (Fig. 3).

**DISCUSSION**

Iran is a large country, containing a variety of climates. While the northern regions have a temperate climate, southern regions are dry and frequently experience droughts and water scarcity (Abbaspour et al., 2009; Bannayan et al., 2010). Our results show the prominent role of mean temperature of warmest quarter, annual solar radiation, lithology, and soil order in creating a suitable habitat for Russian-olive. The contribution of other variables was not considerable. Previous studies have shown that Russian-olive is capable of growing under both flooded and drought conditions in its native range (Asadian, et al., 2013, Stannard et al., 2002) as well as its introduced range (Katz and Shafroth, 2003; Reynolds and Cooper, 2010). *E. angustifolia*'s extensive root network allows it to utilize moisture stored in deep soil or groundwater (Cui et al., 2015; Dubovyk et al., 2016). Owing to insufficient hydro-geological data, we could not use these variables in our study. Nevertheless, we recommend including them in future studies when they become available for Iran.

Our findings also reveal the importance of environmental variables such as soil (soil orders) and lithology in determining suitable habitats for Russian-olive, which supports the findings of previous studies (Zitzer and Dawson, 1992; Carman and Brotherson, 1982; Khamzina et al., 2009; Collette and Pither, 2015). The results demonstrate how Russian-olive can survive only under certain climatic conditions but can continue to grow on a number of soil orders and lithological formations (Lesica and Miles 2001; Katz and Shafroth, 2003; Reynolds and Cooper 2010; Collette and Pither, 2015). This makes Russian-olive a good candidate for shelterbelts in different regions (Olson and Knopf 1986; Pearce et al., 2009).

Roughly 9% of Iran is suitable habitat for Russian-olive, stretching along the Alborz and Koppeh-Daggh mountain ranges (Fig. 1). The Alborz and Koppeh-Dagh are comparable with temperate European mountain ranges such as the Alps in terms of endemism (Tribisch and Schonswetter 2003; Noroozi et al. 2008, 2018). Iranian provinces vary regarding habitat suitability for Russian-olive. All provinces, with the exception of Ilam and Bushehr (in the west and south of Iran, respectively), contained suitable habitats for Russian-olive. North Khorasan (64.7%), Qazvin (44.8%), and Alborz (42.4%) had the highest proportion of suitable habitats for Russian-olive. Suitability maps can inform future urban development and predict the future range of Russian-olive.

Therefore, it is suggested to protect the critical habitats of Russian-olive and use this species in urban green spaces. Russian-olive is not a demanding species and can survive for 50–80 years in different conditions. *E. angustifolia* is used as a soil stabilizer, a hedge plant, and a fragrant ornamental. Due to its characteristics, Russian-olive is used in shelterbelts and urban landscapes (Kolesnikov, 1974; Kiseleva and Chindyaeva, 2011).

Russian-olive can become invasive (Reynolds and Cooper, 2010; Collette and Pither, 2015). After its introduction as an ornamental plant, Russian-olive became invasive in the US and Canada in the early 20th century (Katz and Shafroth 2003). The species negatively affected riparian forests and, as a result, was declared a noxious species in Colorado and New Mexico (Katz and Shafroth 2003; Collette and Pither, 2015). Introduction of this species to areas outside its native range should be done with caution. However, such considerations are not needed when planting Russian-olives in its native range since the species will not disrupt the natural processes of its native ecosystems (Strauss et al., 2006; Marsh-Matthews et al., 2011; Zhang et al., 2018). Moreover, native species can be advantageous to the local economy. As a result, we recommend the use of Russian-olive in urban landscapes in northern Iran.

A common assumption among SDMs is that species can only establish in areas that are ecologically similar to their native range (Kearney 2006). However, a species niche might change (Broennimann et al., 2007). As a result, the output of SDM algorithms is an approximation of species’ niche in new environments. The differences in bioclimatic conditions between native areas and those we are making predictions for might lead to an underestimation of actual suitable areas. Thus, more accurate predictions can only be made by taking into account both biotic and abiotic variables and their interactions. These studies can be further improved through comparisons with areas under invasion by alien invasive species. In the meantime, the mere presence of suitable habitats for a species should not encourage managers to use the species before more extensive investigations are performed. However, the efficiency of SDMs is affected by several parameters (Allouche et al. 2008) such as the characteristics of environmental data (e.g. type, variance data; Aguirre-Gutiérrez et al. 2013), characteristics of species data (e.g. geographical accuracy, sample size, field survey constraints, or auto-correlation structure; Huettemann and Diamond 2006), species ecology (e.g. distribution range, abundance,
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nichie limits of species; Saupe et al., 2012), computer power (i.e. too many cells may be too demanding on computer resources), model (e.g. presence only/presence-absence; Aguirre and Gutiérrez et al., 2013), and spatial resolution (Farashi and Naderi 2017). Despite their shortcomings, SDMs can still help us grasp the biological history of a species distribution (Silva Rocha et al., 2015). Further investigation is needed to study niche shift, distinguish the most influential variables, and pinpoint the role of other factors in determining distribution of the species.

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**REFERENCES**

Abbas N, Wasimi S, Al-Ansari N, Sultana N 2018 Water resources problems of Iraq: Climate change adaptation and mitigation. Journal of Environmental Hydrology 26.

Abbaspour KC, Faramarzi M, Ghasemi SS, Yang H 2009 Assessing the impact of climate change on water resources in Iran. Water resources research 45(10).

Abreu-Harbich LV, Labaki LC, Matzarakis A 2015 Effect of tree planting design and tree species on human thermal comfort in the tropics. Landscape and Urban Planning 138: 99–109.

Aguirre-Gutiérrez, J., Carvalheiro, L. G., Polce, C., van Abreu-Harbich LV, Labaki LC, Matzarakis A 2015 Effect of tree planting design and tree species on human thermal comfort in the tropics. Landscape and Urban Planning 138: 99–109.

Bichai F, Ryan H, Fitzgerald C, Williams K, Abdelmoteleb A, Brotchie R, Komatsu R 2015 Understanding the role of alternative water supply in an urban water security strategy: An analytical framework for decision-making. Urban Water Journal 12(3): 175-189.

Bocchini O, Treier, UA, Müller-Scharer H, Thuiller W, Peterson AT, Guisan A 2007 Evidence of climatic niche shift during biological invasion. Ecology letters 10(8): 701-709.

Carman JG, Brotherson JD 1982. Comparisons of sites infested and not infested with saltcedar (*Tamarix pentandra*) and Russian olive (*Elaeagnus angustifolia*). Weed Science 30(4): 360-364.

Collette LK, Pither J 2015 Russian-olive (*Elaeagnus angustifolia*) biology and ecology and its potential to invade northern North American riparian ecosystems. Invasive Plant Science and Management 8(1): 1-14.

Cui Y, Ma J, Sun W, Sun J, Duan Z 2015 A preliminary study of water use strategy of desert plants in Dunhuang, China. Journal of Arid Land 7(1): 73-81.

Djuma H, Bruggeman, A, Eliades M Lange, M A 2016 Land suitability assessment for afforestation with *Elaeagnus angustifolia* L. In degraded agricultural areas of the lower Amudarya river basin. Land Degradation Development 27(8): 1831-1839.

Dubovyyk O, Menz G, Khazmazina A 2016 Land suitability assessment for afforestation with *Elaeagnus angustifolia* L. In degraded agricultural areas of the lower Amudarya river basin. Land Degradation Development 27(8): 1831-1839.

Elith J, Leathwick JR 2009 Species distribution models: ecological explanation and prediction across space and time. Annual review of ecology, evolution, and systematics 40: 677-697.

Farashi A, Alizadeh-Noughani M 2018 Effects of models and spatial resolutions on the species distribution
model performance. Modeling Earth Systems and Environment 4(1): 263-268.

Farashi, A., & Naderi, M. (2017). Predicting invasion risk of raccoon Procyon lotor in Iran using environmental niche models. Landscape and Ecological Engineering, 13(2), 229-236.

Fielding AH, Bell JF 1997 A review of methods for the assessment of prediction errors in conservation presence/absence models. Environmental conservation 24(1): 38-49.

Ghahraman A, Attar F 2001 Biodiversity of plant species in Iran. Published by Tehran University, 1, pp. 1210.

Guida RJ, Abella SR, Smith Jr WJ, Stephen H, Roberts CL 2014 Climatic change and desert vegetation distribution: Assessing thirty years of change in southern Nevada’s Mojave Desert. The Professional Geographer 66(2): 311-322.

Guisan A, Thuiller W 2005 Predicting species distribution: offering more than simple habitat models. Ecology letters 8(9): 993-1009.

Guisan A, Zimmermann NE 2000 Predictive habitat distribution models in ecology. Ecological modelling 135(2): 147-186.

Hannah L, Midgley G, Davies I, Davies F, Ries L, Thuiller W, Stoms D 2015 BioMove-Improvement and Parameterization of a Hybrid Model for the Assessment of Climate Change impacts on the Vegetation of California.

Haq SMA 2011 Urban green spaces and an integrative approach to sustainable environment. Journal of environmental protection 2(05): 601.

Haq SMA 2015 Urban green spaces and an integrative approach to sustainable environment. Urban Ecology: Strategies for Green Infrastructure and Land Use; Etingoff, K., Ed, 147-16.

Hemsing L, Bryn A 2012 Three methods for modelling potential natural vegetation (PNV) compared: A methodological case study from south-central Norway. Norsk Geografisk Tidsskrift-Norwegian. Journal of Geography 66(1): 11-29.

Hu Z, Guo K, Jin S Pan H 2018 The influence of climatic changes on distribution pattern of six typical Kobresia species in Tibetan Plateau based on MaxEnt model and geographic information system. Theoretical and Applied Climatology 1-16.

Huetmann, F., & Diamond, A. W. (2006). Large-scale effects on the spatial distribution of seabirds in the Northwest Atlantic. Landscape Ecology, 21(7), 1089-1108.

Jiguet, F., Barbet-Massin, M., & Chevallier, D. (2011). Predictive distribution models applied to satellite tracks: modelling the western African winter range of European migrant Black Storks Ciconia nigra. Journal of Ornithology, 152(1), 111-118.

Kaivanto, K. (2008). Maximization of the sum of sensitivity and specificity as a diagnostic cutpoint criterion. Journal of clinical epidemiology, 61, 516-518.

Karimi Afshar N, Karimian Z, Doostan R, Habibi Nokhandan M 2018 influence of planting designs on winter thermal comfort in an urban park. Journal of Environmental Engineering and Landscape Management 26(3): (232-240).

Katz GL, Shafroth PB 2003 Biology, ecology and management of Elaeagnus angustifolia L. (Russian olive) in western North America. Wetlands 23(4): 763-777.

Kearney M 2006 Habitat, environment and niche: what are we modelling? Oikos 115(1), 186-191.

Khamzina A, Lamers JP, Vlek PL 2009 Nitrogen fixation by Elaeagnus angustifolia in the reclamation of degraded croplands of Central Asia. Tree physiology 29(6): 799-808.

Kiseleva TI, Chindyava LN 2011 Biology of oleaster (Elaeagnus angustifolia L.) at the northeastern limit of its range. Contemporary Problems of Ecology 4(2): 218-222.

Klich MG 2000 Leaf variations in Elaeagnus angustifolia related to environmental heterogeneity. Environmental and Experimental Botany 44: 171–183.

Kolesnikov AI 1974 Dekorativnaya dendrologiya [Decorative dendrology]. Moscow: Lesnaya promyshlennost’[in Russian].

Kumar S, Stohlgren TJ. 2009 Maxent modeling for predicting suitable habitat for threatened and endangered tree Canacomyrica monticola in New Caledonia. Journal of Ecology and the Natural Environment 1(4): 94-98.

Lesica P, Miles S 2001 Natural history and invasion of Russian olive along eastern Montana rivers. Western North American Naturalist, 1-10.

Liang CT, Stohlgren TJ. 2011. Habitat suitability of patch types: A case study of the Yosemite toad. Frontiers of Earth Science, 5: 217-228.

Liang CT, Grasso RL, Nelson-Paul JJ, Vincent KE, Lind AJ 2017 Fine-Scale Habitat Characteristics Related to Occupancy of the Yosemite Toad, Anaxyrus canorus. Copeia 105(1): 120-127.

Liu C, Berry PM, Dawson TP, Pearson, RG 2005 Selecting thresholds of occurrence in the prediction of species distributions. Ecography, 28(3): 385-393.

Liu C, White M, Newell G 2011 Measuring and comparing the accuracy of species distribution models with presence–absence data. Ecography 34(2), 232-243.

Marsh-Matthews E, Matthews WJ, Franssen NR 2011. Predictive distribution models applied to satellite tracks: modelling the western African winter range of European migrant Black Storks Ciconia nigra. Journal of Ornithology, 152(1), 111-118.
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from simplicity versus complexity in species distribution models? Ecography 37(12): 1267-1281.

Mikalajczak A, Maréchal D, Sanz T, Isenmann M, Thierion V, Luque S 2015 Modelling spatial distributions of alpine vegetation: A graph theory approach to delineate ecologically-consistent species assemblages. Ecological informatics 30: 196-202.

Modarres R, da Silva VDPR 2007 Rainfall trends in arid and semi-arid regions of Iran. Journal of arid environments 70(2): 344-355.

Noroozi J, Akhani H, Breckle SW 2008 Biodiversity and phytogeography of the alpine flora of Iran. Biodiversity and Conservation 17(3): 493-521.

Noroozi J, Talebi A, Doostmohammadi M, Rumpf SB, Linder HP, Schneeweiss GM 2018 Hotspots within a global biodiversity hotspot-areas of endemism are associated with high mountain ranges. Scientific reports 8.

Olson T E, Knopf FL 1986 Naturalization of Russian-olive in the western United States. Western Journal of Applied Forestry 1(3): 65-69.

Pearce CM, Smith DG, VanDevender TR, Espinosa-Garcia F, Harper-Lore BL, Hubbard T 2009 Rivers as conduits for long-distance dispersal of introduced weeds: example of Russian olive (*Elaeagnus angustifolia*) in the northern Great Plains of North America. Invasive Plants on the Move: Controlling Them in North America 410-427.

Peterson AT, Papes M, Klua DA 2003 Predicting the potential invasive distributions of four alien plant species in North America. Weed Science 51(6): 863-868.

Rechinger KH, (ed.) 1963–2015 Flora Iranica, vols. 1–181. Akademische Druck- u. Verlagsanstalt, Graz; vol. 175. Akademische Verlagsgesellschaft, Salzburg; vols. 176–181. Verlag des Naturhistorischen Museums, Wien.

Reynolds LV, Cooper DJ 2010 Environmental tolerance of an invasive riparian tree and its potential for continued spread in the southwestern US. Journal of Vegetation Science 21(4): 733-743.

Rooper CN, Sigler MF, Goddard P, Malecha P, Towler R, Williams K, Zimmermann M 2016 Validation and improvement of species distribution models for structure-forming invertebrates in the eastern Bering Sea with an independent survey. Marine Ecology Progress Series 551: 117-130.

Saboonchian F, Jamei R, Sarghein SH 2014 Phenolic and flavonoid content of *Elaeagnus angustifolia* L. (leaf and flower). Avicenna journal of phytomedicine 4(4): 231.

Saupe, E. E., Barve, V., Myers, C. E., Soberón, J., Barve, N., Hensz, C. M., ... & Lira-Noriega, A. (2012). Variation in niche and distribution model performance: the need for a priori assessment of key causal factors. Ecological Modelling, 237, 11-22.

Silva Rocha I, Salvi D, Sillero N, Mateo JA, Carretero MA 2015 Snakes on the Balearic Islands: an invasion tale with implications for native biodiversity conservation. PloS one 10(4): e0121026.

Stannard M, Ogle D, Holzworth L, Scianna J, Suleaf E 2002 History, biology, ecology, suppression of Russian olive (*Elaeagnus angustifolia* L.). Boise, ID: USDA-NRCS 1-14.

Stratu A, Costică N, Costică M 2016 Wooden species in the urban green areas and their role in improving the quality of the environment. PESD 10(2): 173-184.

Strauss S., Webb CO, Salamin N 2006 Exotic taxa less related to native species are more invasive. Proceedings of the National Academy of Sciences 103(15): 5841-5845.

Thoma JK, Couttsa AM, Broadbenta AM, Tapper NJ 2016 The influence of increasing tree cover on mean radiant temperature across a mixed development suburb in Adelaide, Australia, Urban Forestry & Urban Greening 20: 233–242.

Thuiller W, Georges D, Engler R 2014 biomod2: Ensemble platform for species distribution modeling. 3:1-64.

Thuiller W, Lafourcade B., Engler R., Araújo M.B. 2009. BIOMOD—a platform for ensemble forecasting of species distributions. Ecography 32(3): 369-373.

Tribsch A, Schönswetter P 2003 Patterns of endemism and comparative phylogeography confirm palaeoenvironmental evidence for Pleistocene refugia in the Eastern Alps. Taxon 52(3): 477-497.

Willis AJ 2001 Endangered plants in Iran. New phytologist 149(2): 165-165.

Zhang X, Li G, Du S 2018 Simulating the potential distribution of *Elaeagnus angustifolia* L. based on climatic constraints in China. Ecological Engineering 113: 27-34.

Zhang X, Mi F, Lu N, Yan N, Kuglerova L, Yuan S, Ma OZ 2017 Green space water use and its impact on water resources in the capital region of China. Physics and Chemistry of the Earth, Parts A/B/C 101: 185-194.

Zhang ZD, Zang RG, Convertino M 2013 Predicting the distribution of potential natural vegetation based on species functional groups in fragmented and species-rich forests. Plant Ecology and Evolution 146(3): 261-271.

Zitter SF, Dawson JO 1992 Soil properties and actinorhizal vegetation influence nodulation of *Alnus glutinosa* and *Elaeagnus angustifolia* by Frankia. Plant and Soil 140(2): 197-204.
### Lithology legend

| ID | Geo unit | Description |
|----|----------|-------------|
| 1  | Ewf      | Flysch with exotic blocks of Eocene limestone, Cretaceous limestone and ophiolitic components |
| 2  | gb       | Gabbro      |
| 3  | gb       | Layered and isotropic gabbro |
| 4  | gsch     | Glaucophane schist |
| 5  | h        | Contact metamorphic rocks: two mica Hornfels; cordierite Hornfels; andalusite-sillimanite Hornfels and locally metamorphosed carbonate rocks |
| 6  | hz       | Harzburgite |
| 7  | Island   | Unknown     |
| 8  | Ja.bv    | Andesitic and basaltic volcanic rocks |
| 9  | Ja.bvt   | Andesitic to basaltic volcanic tuff |
| 10 | Jav      | Andesitic volcanic |
| 11 | Javs     | Andesitic volcano sediment |
| 12 | Javt     | Andesitic volcanic tuff |
| 13 | Jbash    | Shale with intercalations of sandstone |
| 14 | Jbd      | Dark grey, well-bedded, oolithic, amnonitiferous limestone, sandstone and shale |
| 15 | Jbg      | Pale-green silty shale and sandstone |
| 16 | Jbv      | Basaltic volcanic |
| 17 | am       | Amphibolite |
| 18 | ba       | Basalt and basaltic andesite pillow lavas |
| 19 | Cag      | Grey thick-bedded to massive limestone and dolomite |
| 20 | Cb       | Alternation of dolomite, limestone and argillaceous shale |
| 21 | Cd       | Dolomite, quartzarenite, shale and limestone containing Trilobite |
| 22 | Cg       | Limestone, shale, dolomite and gypsum |
| 23 | Cl       | Dark red medium-grained arkosic to subarkosic sandstone and micaceous siltstone |
| 24 | Cm       | Dark grey to black argillaceous limestone with subordinate black shale |
| 25 | COm      | Dolomite platy and flaggy limestone containing trilobite; sandstone and shale |
| 26 | Cs       | Light olive-green shale with intercalations of quartzarenite and fossiliferous limestone |
| 27 | Cz       | Dark red, micaceous siltstone and fine-grained sandstone |
| 28 | CzI      | Undifferentiated unit, composed of dark red micaceous siltstone and sandstone |
| 29 | D2met    | Alternation of marble, micaschist, amphibolite and quartzite |
| 30 | db       | Diabase     |
| 31 | Db       | Grey and black, partly nodular limestone with intercalations of calcareous shale |
| 32 | Db-sh    | Undifferentiated limestone, shale and marl |
| 33 | DC2met   | Mica schist, green schist, graphite schist, and minor marble |
| 34 | DCkh     | Yellowish, thin to thick-bedded, fossiliferous argillaceous limestone, dark grey limestone, greenish marl and shale, locally including gypsum |
| 35 | DCsh     | Alternation of shale, marl and limestone |
| 36 | di-gb    | Gabbro to diorite, diorite and trondhjemite |
| 37 | Dp       | Light red to white, thick bedded quartzarenite with dolomite intercalations and gypsum |
| 38 | Ds       | Black and grey dolomite |
| 39 | Dsb      | Dolomite, limestone and shale |
| 40 | Dsh      | Alternation of shale, marl and fossiliferous limestone, clay with intercalations of quartz arenite |
| 41 | du       | Dunite |
| 42 | E        | Undivided Eocene rocks |
| 43 | E1-2f    | Lower-Middle Eocene flysch-sandstone, shale volcanoclastic sandstone, coarse grained siliceous sandstone minor limestone and pebble conglomerate |
| 44 | E1c      | Pale-red, polygenic conglomerate and sandstone |
| 45 | E1f      | Silty shale, sandstone, marl, sandy limestone, limestone and conglomerate |
| 46 | E1l      | Nummulitic limestone |
| 47 | E1m      | Marl, gysiferous marl and limestone |
| 48 | E1s      | Sandstone, conglomerate, marl and sandy limestone |
| 49 | E2-3f    | Sandstone, calcareous sandstone and limestone |
| 50 | E2c      | Conglomerate and sandstone |
| 51 | E2f      | Sandstone, calcareous sandstone and limestone |
| 52 | E2l      | Nummulitic limestone |
| 53 | E2m      | Pale red marl, gysiferous marl and limestone |
| 54 | E2mg     | Gysiferous marl |
| 55 | E2s      | Sandstone, marl and limestone |
| 56 | E2sh     | Tuffaceous shale and tuff |
| 57 | E3c      | Conglomerate and sandstone |
| 58 | E3f      | Sandstone-shale sequence with siltstone, mudstone, limestone and conglomerate |
| 59 | E3m      | Marl, sandstone and limestone |
| 60 | E3sm     | Sandstone and marl |
| 61 | Ea.bv    | Andesitic and basaltic volcanic |
| 62 | Ea.bvs   | Andesitic to basaltic volcano sediment |
| 63 | Ea.bvt   | Andesitic to basaltic volcanic tuff |
| 64 | Eabvb    | Andesitic to basaltic volcanic breccia |
| 65 | Easv     | Andesitic subvolcanic |
| 66 | Eat      | Andesitic tuff |
| 67 | Eav      | Unknown |
| 68 | Eav      | Andesitic volcanic |
| 69 | Eavb     | Andesitic volcanic breccia |
| 70 | Eavs     | Andesitic volcanic sediment |
| 71 | Eavt     | Andesitic volcanic tuff |
| 72 | Ebt      | Basaltic tuff |
| 73 | Ebv      | Basaltic volcanic rocks |
| 74 | Ebvs     | Basaltic volcano sediment |
| 75 | Ebvt     | Basaltic volcanic tuff |
| 76 | Ed.asv   | Dacitic to andesitic subvolcanic rocks |
| 77 | Ed.at    | Dacitic to Andesitic tuff |
| 78 | Ed.avb   | Dacitic to Andesitic volcanic breccia |
| 79 | Ed.av    | Dacitic to Andesitic volcanic sediment |
| 80 | Edav     | Dacitic to Andesitic volcanic |
### ID  Geo unit  Description

| ID | Geo unit | Description |
|----|----------|-------------|
| 81 | Edavt    | Dacitic andesitic volcanic  
| 82 | Edi      | Diorite |
| 83 | Edsv     | Rhyolitic to rhyodacitic subvolcanic |
| 84 | Edt      | Rhyolitic to rhyodacitic tuff |
| 85 | Edv      | Rhyolitic to rhyodacitic volcanic |
| 86 | Edvb     | Rhyolitic to rhyodacitic volcano breccia |
| 87 | Edvs     | Rhyolitic to rhyodacitic volcano sediment |
| 88 | Edvt     | Rhyolitic to rhyodacitic volcanic tuff |
| 89 | Ef       | Eocene flysch in general, composed of shale, marl, sandstone, conglomerate and limestone |
| 90 | EfV      | Silty shale, marl, thin-bedded limestone, tuffaceous sandstone and basaltic volcanic rocks |
| 91 | Egb      | Gabbro |
| 92 | Egr      | Granite |
| 93 | Egr-di   | Granite to diorite |
| 94 | Eja      | Grey and brown weathered, massive dolomite, low weathered thin to medium-beded dolomite and massive, feature forming, buff dolomitic limestone |
| 95 | Ek       | Well bedded green tuff and tuffaceous shale |
| 96 | Ek.a     | Calcareous shale with subordinate tuff |
| 97 | Egky     | Gypsum |
| 98 | Ekh      | Olive-green shale and sandstone |
| 99 | Ekn      | Tine-bedded argillaceous limestone and calcareous shale |
| 100 | Ekv1     | Early-Eocene, sandstone, siltstone and shale with nummulitic limestone intercalation |
| 102 | Ekv2     | Middle-Eocene, lower part composed of sandstone, siltstone and shale |
| 103 | Ekv3     | Middle-Eocene, upper part composed of sandstone, siltstone and shale with limestone intercalation |
| 104 | EMas-sb  | Undivided Asmari and Shabazban Formation |
| 105 | EOa-bv   | Andesitic to basaltic volcanic |
| 106 | EOAs-ja  | Undivided Asmari and Jahrum Formation, regardless to the disconformity separates them |
| 107 | EOasv    | Eocene-Oligocene andesitic subvolcanic |
| 108 | EOav     | Eocene-Oligocene andesitic lava flows |
| 109 | EObv     | Eocene-Oligocene basaltic lava flows |
| 110 | EOd      | Eocene-Oligocene diorite |
| 111 | EOd-av   | Dacitic to Andesitic volcanic |
| 112 | EOdsv    | Eocene-Oligocene rhyolitic to rhyodacitic subvolcanic |
| 113 | EOdv     | Rhyolitic to rhyodacitic volcanic rocks |
| 114 | EOF      | Rutymically bedded sandstone and shale with volcanoclastic sandstone, minor limestone and tuff |
| 115 | EOGr     | Eocene-Oligocene granite and granodiorite |
| 116 | EOGr-d   | Eocene-Oligocene granite to diorite |
| 117 | EOgy     | Gypsum |
| 118 | EOSa     | Salt dome |
| 119 | EOSc     | Sandstone, siltstone, shale and conglomerate |
| 120 | EOT      | Ignembrite and tuff |
| 121 | Eph      | Phyllite |
| 122 | Esl      | Red shale and pelagic limestone |
| 123 | Eslv     | Red shale, pelagic limestone and amigdaloidal basic volcanic rocks |
| 124 | Jch      | Dark grey argillaceous limestone and marl |
| 125 | Jld      | Well-bedded to thin-bedded, greenish-grey argillaceous limestone with intercalations of calcareous shale |
| 126 | Jdavs    | Dacitic to Andesitic volcano sediment |
| 127 | Jdav     | Jurassic dacite to andesite lava flows |
| 128 | Jdt      | Rhyolitic to rhyodacitic tuff |
| 129 | Jdvt     | Rhyolitic to rhyodacitic volcanic tuff |
| 130 | Je       | Massive, light-grey reef limestone |
| 131 | Jel      | Reefal limestone |
| 132 | Jf       | Flysch turbidites sandstone, shale, conglomerate, volcanic rocks and limestone; this unit transgresivly overlies the metamorphic rocks |
| 133 | Jh       | Alternation of sandstone and sandy to argillaceous shale with intercalations of coal and carbonaceous shale |
| 134 | Jk       | Conglomerate, sandstone and shale with plantremains and coal seams |
| 135 | JKav     | Andesitic flows and their associated pyroclastics with or without intercalations of limestone |
| 136 | JKbl     | Grey, thick-bedded, oolitic, fetid limestone |
| 137 | Jkc      | Honogenous, well rounded quartzos conglomerate |
| 138 | JKdi     | Diorite |
| 139 | JKkgp    | Undivided Khami Group, consist of massive thin-bedded limestone comprising the following formations: Surmeh, Hith Anhydrite, Fahlian, Gadvan and Dariyan |
| 140 | JKkgp-bgp| Jurassic to Cretaceous undivided sedimentary rocks including Khami and Bagestan Groups |
| 141 | JKI      | Crystalized limestone and calc-schist |
| 142 | Jks      | Alternation of sandstone and shale |
| 143 | Jksj     | Pale red argillaceous limestone, marl, gysiperous marl, sandstone and conglomerate |
| 144 | JLI      | Light grey, thin-bedded to massive limestone |
| 145 | Jmnz     | Grey thick-bedded limestone and dolomite |
| 146 | Jph      | Phyllite, slate and meta-sandstone (Hamadan Phyllites) |
| 147 | Jq       | Sandstone, shale, thin-bedded limestone and calcareous shale |
| 148 | Jr       | Red manganiferous chert |
| 149 | Js       | Shale with intercalations of conglomerate, sandstone, radiolarite, limestone and volcanic |
| 150 | Jsc      | Conglomerate |
| 151 | JSLSs    | Sandy to silty gluconitic limestone and calcareous limestone |
| 152 | JSM      | Thick-bedded to massive dolomitic limestone, thin-bedded argillaceous limestone and marl |
| 153 | JSS      | Sandstone |
| 154 | JUav     | Andesitic volcano sediment |
| 155 | JUavt    | Andesitic volcanic Tuff |
| ID | Geo unit | Description                                                                 |
|----|----------|-----------------------------------------------------------------------------|
| 156 | Jlb      | Sandstone, siltstone, Pectinid limestone, marl, gyspum                     |
| 157 | Juc      | White, quartzous conglomerate                                               |
| 158 | Judi     | Upper Jurassic diorite                                                      |
| 159 | JUdv     | Rhyolitic to rhyodacitic volcanic                                           |
| 160 | Jugu     | Granite gneiss normally with augen structure                                |
| 161 | Jurg     | Upper Jurassic granite including Shir Kuh Granite and Shah Kuh Granite      |
| 162 | Jurg-di  | Upper Jurassic granite to diorite intrusive                                  |
| 163 | Jum      | Gypsum                                                                       |
| 164 | Jus      | Red sandstone and siltstone                                                 |
| 165 | K        | Cretaceous rocks                                                            |
| 166 | K1-2lm   | Albian-Cenomanian marl and argillaceous limestone                           |
| 167 | K1a.bv   | Andesitic and basaltic volcanic rocks                                       |
| 168 | K1avt    | Andesitic volcanic tuff                                                     |
| 169 | K1bl     | Grey, thick-bedded to massive oolitic limestone                             |
| 170 | K1blv    | Early-Cretaceous basaltic lava flows                                        |
| 171 | K1bvt    | Basaltic volcanic tuff                                                      |
| 172 | K1c      | Red conglomerate and sandstone                                              |
| 173 | K1I      | Massive to thick-bedded orbitolina limestone                                |
| 174 | K1m      | Limestone, argillaceous limestone, tile red sandstone and gyspiferous marl |
| 175 | K2a.bv   | Andesitic and basaltic volcanic rocks                                       |
| 176 | K2asv    | Andesitic subvolcanic                                                      |
| 177 | K2av     | Andesitic volcanic                                                          |
| 178 | K2bv     | Basaltic volcanic                                                           |
| 179 | K2c      | Conglomerate and sandstone                                                  |
| 180 | K2d.av   | Dacitic to andesitic subvolcanic rocks                                      |
| 181 | K2d.av   | Dacitic to Andesitic volcanic                                               |
| 182 | K2di     | Diorite                                                                      |
| 183 | K2gb     | Gabbro                                                                       |
| 184 | K2gr     | Granite                                                                      |
| 185 | K2I      | Hydropite bearing limestone                                                  |
| 186 | K2l      | Limestone, marl and sandstone                                               |
| 187 | K2l      | Hydropite bearing limestone                                                 |
| 188 | K2l      | Thick-bedded to massive limestone                                           |
| 189 | K2l      | Pale-red marl, gyspiferous marl and limestone                               |
| 190 | K2l      | Marl, shale and detritic limestone                                          |
| 191 | K2lm     | Shale calcareous shale and sandstone with intercalations of limestone       |
| 192 | K2m,l    | Andesitic to basaltic volcanic                                               |
| 193 | K2m,l    | Blue-grey marl and shale                                                    |
| 194 | K2m,l    | Rhythmically bedded sandstone, calcareous sandstone, mudstone, gyspiferous  |
| 195 | K2m,l    | Sandstone, siltstone, conglomerate, shale, mudstone and shell beds          |
| 196 | M2-3s    | Gypsum                                                                       |
| 197 | M2-3s    | Andesitic to basaltic volcanic                                               |
Predicting the potential habitat of Russian-Olive (*Elaeagnus angustifolia*) in urban landscapes

| ID  | Geo unit   | Description                                           |
|-----|------------|-------------------------------------------------------|
| 238 | Oa.bvs     | Andesitic to basaltic volcanic sediment               |
| 239 | Oasv       | Andesitic subvolcanic                                 |
| 240 | Oat        | Andesitic tuff                                        |
| 241 | Oav        | Oligocene andesitic lava flows                        |
| 242 | Oavt       | Andesitic volcanic tuff                               |
| 243 | Obv        | Basaltic Volcanic                                     |
| 244 | Oc         | Polymictic conglomerate, sandstone and siltstone      |
| 245 | Od.asv     | Dacitic to andesitic subvolcanic rocks                |
| 246 | Od.av      | Dacitic to andesitic volcanic                          |
| 247 | Odi        | Diorite                                               |
| 248 | Odi-gb     | Diorite to gabbro                                     |
| 249 | Odsv       | Rhyolitic to rhyodacitic subvolcanic                  |
| 250 | Odv        | Rhyolitic to rhyodacitic volcanic                      |
| 251 | Odvb       | Rhyolitic to rhyodacitic breccia                      |
| 252 | Odvs       | Rhyolitic to rhyodacitic sediment                     |
| 253 | Odvt       | Rhyolitic to rhyodacitic tuff                         |
| 254 | Ogb        | Gabbro                                                |
| 255 | Ogr        | Granite                                               |
| 256 | Ogr-di     | Granite to diorite                                    |
| 257 | Ogrsv      | Granite subvolcanic                                   |
| 258 | Olat       | Rhyolitic to rhyodacitic volcanic rocks                |
| 259 | Olc.s      | Conglomerate and sandstone                            |
| 260 | Olgr       | Oligocene granite and granodiorite                    |
| 261 | Olgy       | Gypsum                                                |
| 262 | Olm.s,c    | Red and green silty, gypsiferous marl, sandstone and  |
|       |            | gysumper                                               |
| 263 | om1        | Tectonized association of peridotites, gabbro, diorite,|
|       |            | trondhjemite, diabase and basic volcanic              |
| 264 | om2        | Tectonized association of pelagic limestone,          |
|       |            | radiolarian chert, radiolarian shale with basic       |
|       |            | volcanic and intrusive rocks of ophiolitic rocks       |
| 265 | om3        | Pelagic limestone, radiolarian chert and shale in     |
|       |            | association with basalt and basaltic andesite pillow  |
|       |            | lava                                                  |
| 266 | OMa.bv     | Andesite and andesitic lava flow                      |
| 267 | OMap       | Andesitic pyroclastic rocks                           |
| 268 | OMas       | Cream to brown-weathering, feature-forming, well-     |
|       |            | jointed limestone with intercalations of shale        |
| 269 | OMat       | Andesitic tuff                                        |
| 270 | OMav       | Andesitic volcanic                                    |
| 271 | OMavs      | Andesitic volcanic sediment                            |
| 272 | OMbt       | Basaltic tuff                                         |
| 273 | OMbv       | Basalt and subvolcanic                                |
| 274 | OMbvb      | Basaltic volcanic breccia                             |
| 275 | OMbvs      | Basaltic volcanic sediment                             |
| 276 | OMc        | Basal conglomerate and sandstone                      |
| 277 | OMd.at     | Dacitic Andesitic tuff                                |
| 278 | OMd.av     | Dacitic Andesitic volcanic                             |
| 279 | OMdi       | Diorite                                               |
| 280 | OMdi-gb    | Diorite to gabbro                                     |
| 281 | OMdsv      | Rhyolitic to rhyodacitic subvolcanic                  |
| 282 | OMdv       | Rhyolite and rhyodacite                               |

| ID  | Geo unit   | Description                                           |
|-----|------------|-------------------------------------------------------|
| 283 | OMdvs      | Rhyolitic to rhyodacitic volcanic sediment            |
| 284 | OMdvt      | Rhyolitic to rhyodacitic tuff                         |
| 285 | OMf        | Rhytymically bedded sandstone and shale, with minor   |
|       |            | siltstone and mudstone                               |
| 286 | OMgb       | Oligo-Miocene gabbro and microgabbro                  |
| 287 | OMgr       | Oligo-Miocene granite and granodiorite                |
| 288 | OMgr-di    | Granite to diorite                                    |
| 289 | OMI        | Unknown                                               |
| 290 | OMq        | Limestone, marl, gypsiferous marl, sandymarl and      |
|       |            | sandstone                                            |
| 291 | OMq1       | Massive to thick-bedded reefal limestone              |
| 292 | OMqmd      | Marl with intercalations of limestone                 |
| 293 | OMr        | Red, grey, and green silty marls interbedded with     |
|       |            | subordinate silty limestone and minor sandstone ribs |
| 294 | OMrb       | Red Beds composed of red conglomerate, sandstone,    |
|       |            | marl, gypsiferous marl and gypsum                     |
| 295 | OMssh      | Yellow-green shale and sandstone locally with         |
|       |            | limestone intercalation                               |
| 296 | OMz1       | Alternation of varigated siltyclay shale with         |
|       |            | sandstone                                             |
| 297 | OMz2       | Massive to thick bedded tuffaceous sandstone and      |
|       |            | varigated shale                                       |
| 298 | OMz3       | Alternation of sandstone with siltstone and claystone|
| 299 | OPLavs     | Andesitic volcanic sediment                           |
| 300 | OS         | Undifferentiated Ordovician and Silurian rocks        |
| 301 | P34        | Unknown                                               |
| 302 | P          | Undifferentiated Permian rocks                        |
| 303 | PAav       | Andesitic volcanic                                    |
| 304 | PAbv       | Basaltic volcanic                                     |
| 305 | PAbvt      | Basaltic volcanic Tuff                                |
| 306 | PAdv       | Rhyolitic to rhyodacitic volcanic                      |
| 307 | PAEa.bv    | Andesitic to basaltic volcanic                         |
| 308 | PAEa.bvt   | Andesitic to basaltic volcanic tuff                   |
| 309 | PAEav      | Andesitic volcanic                                    |
| 310 | PAEavb     | Andesitic volcanic breccia                            |
| 311 | PAEavsi    | Andesitic volcanic sediment                           |
| 312 | PAEavt     | Andesitic volcanic tuff                               |
| 313 | PAEavt     | Andesitic volcanic tuff                               |
| 314 | PAg        | Granite                                               |
| 315 | PAg-di     | Granite to diorite                                    |
| 316 | pC-C       | Late proterozoic–early Cambrian undifferentialed      |
|       |            | rocks                                                 |
| 317 | pC-Cd      | Recrystalised dolomite and fetid limestone; violet-   |
|       |            | red micaceous sandstone and siltstone; gypsum         |
| 318 | pC-Ch      | Rock salt, gypsum & blocks of contorted masses of     |
|       |            | sedimentary material such as black laminated fetid   |
|       |            | limestone, brown cherty dolomite, red sandstone &     |
|       |            | varigated shale in association with igneous rocks     |
|       |            | such as diabase, basalt, rhyolite and trachyte       |
| 319 | pC-Cs      | Thick dolomite and limestone unit, porty cherty       |
|       |            | with thick shale intercalations                       |
| 320 | pCa.bv     | Andesite and basalt                                   |
| 321 | pCam       | Amphibolite                                           |
| ID | Geo unit   | Description                                                                 |
|----|------------|-----------------------------------------------------------------------------|
| 322 | pCav      | Andesitic volcanic                                                          |
| 323 | pCbr      | Dolomite and sandstone                                                      |
| 324 | pCdi      | Precambrian diorite                                                         |
| 325 | pCdv      | Rhyolitic to rhyodacitic volcanic                                           |
| 326 | pCgn      | Gneiss, granite gneiss and locally including migmatite                      |
| 327 | pCgr      | Precambrian granite to granodiorite                                         |
| 328 | pCgr-di   | Granite to diorite                                                          |
| 329 | pCr       | Dull green grey slaty shales with subordinate intercalation of quartzitic sandstone |
| 330 | pCmb      | Marble                                                                      |
| 331 | pCmt1     | Medium-grade, regional metamorphic rocks                                    |
| 332 | pCmt2     | Low-grade, regional metamorphic rocks                                       |
| 333 | pCph      | Phyllite                                                                    |
| 334 | pCr       | Dolomite and limestone, partly cherty; redish sandy shale and sandstone, volcanic rocks and tuffs |
| 335 | pCrr      | Acidic volcanic rocks                                                       |
| 336 | pC       | Peridotite including harzburgite, dunite, lerzolite and websterite          |
| 337 | Pd        | Red sandstone and shale with subordinate sandy limestone                     |
| 338 | pD       | Ultrabasic rocks                                                            |
| 339 | Pda       | Limestone, dolomite, dolomitic limestone and thick layers of anhydrite in alternation with dolomite in middle part |
| 340 | Peasv     | Andesitic subvolcanic                                                       |
| 341 | Pec       | Conglomerate and sandstone                                                  |
| 342 | PeEck     | Limestone, marl and gysiferous marl                                         |
| 343 | PeEck-kh  | Undifferentiated unit, including limestone, marl                              |
| 344 | PeEf      | Flysch turbidite, sandstone and calcareous mudstone                         |
| 345 | PeEm      | Marl and gysiferous marl locally gysiferous mudstone                        |
| 346 | PeEpdi    | Blue and purple shale and marl interbedded with the argillaceous limestone  |
| 347 | PeEph     | Phyllite                                                                    |
| 348 | PeEps-ck  | Undifferentiated unit, including conglomerate, sandstone, limestone and marl |
| 349 | PeEs      | Arkosic to subarkosic sandstone                                             |
| 350 | PeEsA     | Pale red marl, marlstone, limestone, gysiferous and dolomite                 |
| 351 | PeEsh     | Shale and calcareous shale                                                  |
| 352 | PeEts     | Grey and brown, medium-bedded to massive fossiliferous limestone            |
| 353 | PeEz      | Reef-type limestone and gysiferous marl                                     |
| 354 | PeI       | Medium to thick-bedded limestone                                            |
| 355 | Pen       | Marl, gysiferous marl and limestone                                         |
| 356 | Pems      | Mudstone calcareous shale, limestone and minor sandstone                    |
| 357 | Peps      | Red well consolidated conglomerate, sandstone and mudstone                  |
| 358 | Pes       | Sandstone, calcareous shale and mudstone                                    |
| 359 | Pgf       | Polygenic conglomerate, red sandstone and sandy mudstone                    |
| 360 | Pgc       | Light-red coarse grained, polygenic conglomerate with sandstone intercalations |
| 361 | Pgr       | Plagiogranite                                                               |
| 362 | Pj        | Massive to thick-bedded, dark-grey, partly reef type limestone and a thick yellow dolomite band in the upper part |
| 363 | Pia.bv    | Andesitic to basaltic volcanic                                              |
| 364 | Plasv     | Pliocene andesitic subvolcanic                                              |
| 365 | Plat      | Andesitic tuff                                                             |
| 366 | Plav      | Andesitic lavas with minor basaltic andesite, tuff and breccias interbedded with volcanoclastic sandstone and boulder conglomerate (Bazman Volcanism) |
| 367 | Plbk      | Alternating hard of consolidated, massive, feature forming conglomerate and low-weathering cross-bedded sandstone |
| 368 | Plbv      | Basaltic lava flows                                                         |
| 369 | Plc       | Polymictic conglomerate and sandstone                                        |
| 370 | Plc       | Polymictic conglomerate and sandstone                                        |
| 371 | Plld.avs  | Dacitic to andesitic subvolcanic rocks                                       |
| 372 | Plld.at   | Dacitic andesitic tuff                                                      |
| 373 | Plld.av   | Dacitic andesitic volcanic                                                   |
| 374 | Plldavs   | Dacitic andesitic volcanic sediment                                          |
| 375 | Plldsv    | Pliocene rhyolitic to rhyodacitic subvolcanic                               |
| 376 | Plldt     | Rhyolitic to rhyodacitic tuff                                               |
| 377 | Plldv     | Rhyolitic to rhyodacitic volcanic                                            |
| 378 | Plldvt    | Rhyolitic to rhyodacitic volcanic tuff                                       |
| 379 | Plgr      | Granite                                                                     |
| 380 | Plgr-di   | Granite to diorite                                                          |
| 381 | Plmb1     | Pyroclastics and claystone with vertebrate fauna remains                    |
| 382 | Plmb2     | Ash flows and associated rocks                                               |
| 383 | Plmb3     | Ash flows and associated pyroclastic rocks, conglomerate, sandstone and shale |
| 384 | Plms      | Marl, shale, sandstone and conglomerate                                      |
| 385 | PlQabv    | Andesite, andesitic basalt and olivine basalt                               |
| 386 | PlQap     | Silty clay, sand, gravel and volcanic ash                                    |
| 387 | PlQav     | Andesitic volcanic                                                           |
| 388 | PlQavs    | Andesitic volcanic in association with sedimentary rocks                     |
| 389 | PlQbv     | Basaltic volcanic                                                            |
| 390 | PlQc      | Fluvial conglomerate, Piedmont conglomerate and sandstone                    |
| 391 | PlQd.avt  | Dacitic andesitic volcanic tuff                                              |
| 392 | PlQdv     | Rhyolitic to rhyodacitic volcanic                                            |
| 393 | PlQhu     | Unfolded, poorly cemented, unindurated sandstone and mudstone                |
| 394 | PlQm      | Lacustrine terraces fine grained deposits and lake sediments                |
| 395 | PlQms     | Poorly cemented, unindurated sandstone and mudstone                          |
| 396 | Pmb       | Marble                                                                      |
Predicting the potential habitat of Russian-Olive (Elaeagnus angustifolia) in urban landscapes

| ID  | Geo unit   | Description                                                                 |
|-----|------------|-----------------------------------------------------------------------------|
| 397 | Pml        | Slightly metamorphosed fossiliferous (Fusulinid) limestone, locally crystalline limestone |
| 398 | Pn         | Dark grey limestone and shale                                               |
| 399 | Pr         | Dark grey medium-bedded to massive limestone                                |
| 400 | Psch1      | Metamorphosed turbidite including phyllite, crystalline limestone calc-schist |
| 401 | Psch2      | Metamorphosed turbidite in associated with met ultrabasic and basic rock    |
| 402 | PTR        | Undifferentiated Permo-Triassic sedimentary rocks                           |
| 403 | px         | Pyroxenite                                                                  |
| 404 | Pz         | Undifferentiated lower Paleozoic rocks                                      |
| 405 | Pz1a.bv    | Andesitic basaltic volcanic                                                 |
| 406 | Pz1av      | Andesitic volcanic                                                           |
| 407 | Pz1di      | Lower Paleozoic diorite                                                     |
| 408 | Pz1gn      | Gneiss and anatectic granite                                                |
| 409 | Qft1       | High level piedmont fan and valley terrace deposits                         |
| 410 | TRml       | Meta- limestone, meta-quartzarenite, phyllite and meta- volcanic             |
| 411 | Pz2        | Undifferentiated Upper Paleozoic rocks                                      |
| 412 | PZ2a.bv    | Andesitic basaltic volcanic                                                 |
| 413 | PZ2av      | Andesitic subvolcanic                                                        |
| 414 | PZ2bv      | Basaltic volcanic                                                           |
| 415 | PZ2bvt     | Basaltic volcanic tuff                                                      |
| 416 | PZ2gr      | Granite                                                                     |
| 417 | Pzkb       | Undifferentiated basic schist pelitic schist, psammitic schist, calc-silicate rocks, amphibolite, recrystalized limestone, marble and phyllite |
| 418 | Qabv       | Andesite to basaltic volcanic                                               |
| 419 | Qabvs      | Andesitic basaltic volcano sediment                                         |
| 420 | Qal        | Stream channel, braided channel and flood plain deposits                    |
| 421 | Qasv       | Andesitic subvolcanic                                                       |
| 422 | Qat        | Andesitic tuff                                                              |
| 423 | Qav        | Andesitic volcanic Basaltic volcanic                                        |
| 424 | Qavsv      | Andesitic basaltic volcano sediment                                         |
| 425 | Qba        | Silty clay, sandy tuff and fresh water limestone                            |
| 426 | Qbv        | Olivine basalt and basalt related to Bazman Volcanism and partly related to Taftan Volcanism |
| 427 | Qbvs       | Basaltic volcano sediment                                                   |
| 428 | Qcf        | Clay flat                                                                   |
| 429 | Qcsm       | Clay salt marsh                                                             |
| 430 | Qcu        | Cultivated area                                                             |
| 431 | Qdi        | Diorite                                                                     |
| 432 | Qdt        | Rhyolitic to rhyoladitic tuff                                               |
| 433 | Pz1gr      | Lower Paleozoic granite, including Zarigan granite and Narigan granite      |
| 434 | Pz1mt      | Gneiss, anatectic granite, amphibolite, kyanite, staurolithic schist, quartzite and minor marble |
| 435 | Qft1       | High level piedmont fan and valley terrace deposits                         |
| 436 | Qft1       | High level piedmont fan and valley terrace deposits                         |
| 437 | Qft2       | Low level piedmont fan and valley terrace deposits                          |
| 438 | Qft2       | Low level piedmont fan and valley terrace deposits                          |
| 439 | Qr2        | Low level piedmont fan and valley terrace deposits                          |
| 440 | Qr2        | Low level piedmont fan and valley terrace deposits                          |
| 441 | Qr2        | Low level piedmont fan and valley terrace deposits                          |
| 442 | Qr2        | Low level piedmont fan and valley terrace deposits                          |
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| 444 | Qr2        | Low level piedmont fan and valley terrace deposits                          |
| 445 | Qr2        | Low level piedmont fan and valley terrace deposits                          |
| 446 | Qr2        | Low level piedmont fan and valley terrace deposits                          |
| 447 | Qr2        | Low level piedmont fan and valley terrace deposits                          |
| 448 | Qgb        | Gabbro                                                                      |
| 449 | Qgr        | Granite                                                                     |
| 450 | Qtid       | Intertidal deposits                                                         |
| 451 | Qm         | Swamp and marsh                                                             |
| 452 | Qmt        | Undifferentiated marine terraces                                            |
| 453 | QPLavt     | Andesitic volcanic tuff                                                     |
| 454 | QPLdasv    | Dactic to andesitic subvolcanic rocks                                       |
| 455 | Qs         | Sand dunes and sand sheet                                                   |
| 456 | Qs,d       | Unconsolidated wind-blown sand deposit including sand dunes                 |
| 457 | Qsf        | Salt flat                                                                   |
| 458 | Qsl        | Salt Lake                                                                   |
| 459 | Qsw        | Swamp                                                                       |
| 460 | Qtr        | Teraertine                                                                  |
| 461 | Qvc        | Coarse grained fanglomerate composed of volcaniclastic materials locally with intercalation of lava flows |
| 462 | sea        | Unknown                                                                     |
| 463 | sm1        | Sedimentary melange-sheared and boudined sediments with no recognizable stratigraphy containing tectonic blocks of Cretaceous to Eocene age |
| 464 | sm2        | Sedimentary melange-sheared and boudined sediments with no recognised stratigraphy, containing tectonic blocks of Cretaceous to Miocene age |
| 465 | Sn         | Greenish grey, shale, sandstone, sandylime, coral limestone and dolomite    |
| 466 | sp         | Splitic rocks locally with pillow structure                                 |
| 467 | sp1        | Splitic spilitic andesite and diabassic tuff                               |
| 468 | spr        | Sub-marine, vesicular basalt, locally with pillow structure in association with radiolarian chert |
| 469 | sr         | Serpentinite                                                                 |
| 470 | tm         | Tectonic melange-association of ophiolitic components, pelagic limestone and chert and shale with or without Eocene sedimentary rocks |
| 471 | TRa.bv     | Triassic, andesitic and basaltic volcanic                                   |
| 472 | TRav       | Andesitic Volcanic                                                          |
| 473 | TRavt      | Andesitic volcanic tuff                                                     |
| 474 | TRba       | Red to light green conglomerate and microconglomerate with intercalations of sandstone and shale |
| 475 | TRb1       | Basaltic volcanic                                                           |
| 476 | TRdl       | Crystaline limestone and dolomite                                           |
| ID | Geo unit     | Description                                                                 |
|----|-------------|----------------------------------------------------------------------------|
| 477 | TRe         | thick bedded grey oolitic limestone; thin-platy, yellow to pinkish shaly limestone with worm tracks and well to thick-bedded dolomite and dolomitic limestone |
| 478 | TRe1        | Thin bedded, yellow to pinkish argillaceous limestone with worm tracks       |
| 479 | TRe2        | Thick bedded dolomite                                                       |
| 480 | TRJa,bv     | Andesitic to Basaltic Volcanic                                             |
| 481 | TRJir       | Grey, thin to thick bedded, partly cherty, neritic limestone intercalation of radiolarian shale and chert |
| 482 | TRJs        | Dark grey shale and sandstone                                               |
| 483 | TRJvm       | Meta-volcanic, phyllites, slate and meta- limestone                          |
| 484 | TRkk-nz     | Thin to medium-bedded, dark grey dolomite; thin-bedded dolomite, greenish shale and thin-bedded argillaceous limestone |
| 485 | TRKubl      | Kuh Bistoon limestone                                                       |
| 486 | TRKurl      | Purple and red thin-bedded radiolarian chert with intercalations of neritic and pelagic limestone |
| 487 | TRmi        | Shale and sandstone with coal seams                                         |
| 488 | Qf61        | High level piedmont fan and valley terrace deposits                         |
| 489 | TRn         | Sandstone, quartz arenite, shale and fossiliferous limestone                 |
| 490 | TRn1        | Grey green shale, siltstone and feldspathic sandstone underlain by pisolithic iron laterite horizon |
| 491 | TRn2        | Shale, Heterastridum bearing limestone and reddish-brown sandstone          |
| 492 | TRn3        | Shale interbedded with thin sandstone beds                                  |
| 493 | TRn4        | Black limestone, shale and sandstone                                        |
| 494 | TRn5        | Shale, siltstone, sandstone and thin sandy limestone with thin coal seams   |
| 495 | TRqa        | Red to brown shale, sandstone and conglomerate                              |
| 496 | TRs         | Calcareous red shale                                                        |
| 497 | TRsh        | Well-bedded, dense, yellow dolomite                                         |
| 498 | TRsi        | Tuffaceous sandstone, tuffaceous shale with intercalations of limestone, marl and conglomerate |
| 499 | TRuJm       | Transitional zone composed of phyllite with intercalations of crystalized limestone and acidic volcanic horizons |
| 500 | Kad         | White-cream Inoceramus bearing cherty and glauconitic argillaceous limestone |
| 501 | Kad-ab      | Undifferentiated unit including argillaceous limestone, marl and shale      |
| 502 | Kat         | Olive green glauconitic sandstone and shale                                |
| 503 | Kav         | Andesitic volcanic                                                           |
| 504 | Kavt        | Andesitic volcanic tuff                                                     |
| 505 | Kbgp        | Undivided Bangestan Group, mainly limestone and shale, Albian to Companian, comprising the following formations: Kazhdumi, Sarvak, Surgah and Ilam |
| 506 | Kbsl        | Dark grey slightly phyllitized shale with intercalations of sandstone and limestone |
| 507 | Kbv         | Basaltic volcanic                                                           |
| 508 | Kbvt        | Basaltic volcanic tuff                                                      |
| 509 | Kda         | Dacitic to Andesitic volcanic                                               |

| ID | Geo unit     | Description                                                                 |
|----|-------------|----------------------------------------------------------------------------|
| 510 | Kda-fa      | Grey to brown, partly oolitic, massive limestone; limestone in alternation with marl and thick-bedded to massive orbitolina bearing limestone |
| 511 | Kdi         | Diorite                                                                    |
| 512 | Kdzsh       | Marl, shale, sandstone and limestone                                        |
| 513 | KEpd-gu     | Grey and brown, medium-bedded to massive fossiliferous limestone           |
| 514 | Kf61        | Dark grey argillaceous shale                                               |
| 515 | Kgb         | Gabbro                                                                     |
| 516 | Kgr         | Granite                                                                    |
| 517 | Kgu         | Bluish grey marl and shale with subordinate thin-bedded argillaceous -limestone |
| 518 | Kk          | Buff, thick-bedded limestone, marlstone and marl                            |
| 519 | Kkz         | Grey to dark grey bituminous shale with intercations of limestone           |
| 520 | KI          | Lower Cretaceous undifferentiated rocks                                    |
| 521 | Klav        | Andesitic volcanic rocks                                                   |
| 522 | Klsm        | Marl, shale, sandy limestone and sandy dolomite                             |
| 523 | Klosl       | Grey thick-bedded to massive orbitolina limestone                           |
| 524 | Knl         | Massive grey to black limestone                                            |
| 525 | Kns         | Red sandstone and conglomeratic sandstone                                   |
| 526 | Knsb        | Dark green calcareous sand        |
| 527 | Knz         | Gloconitic sandstone                                                       |
| 528 | KPAavs      | Andesitic Volcano sediment                                                  |
| 529 | KPeam       | Dark olive-brown, low weathered siltstone and sandstone                    |
| 530 | KPedu       | Undifferentiated limestone, basic to intermediate lava and pillow lava, metavolcanic, phyllite, schist, sediments, metasediments with minor tuff and intrusive rocks |
| 531 | KPef        | Thinly bedded sandstone and shale with siltstone, mudstone limestone and conglomerate |
| 532 | KPefv       | Crystal tuff, tuffaceous sandstone, recrystalized limestone and sandy limestone, red chert and pillow lava |
| 533 | KPegr       | Late Cretaceous-Early Paleocene granite                                    |
| 534 | KPegr-di    | Late Cretaceous-Early Paleocene granite to diorite intrusive rocks          |
| 535 | KPepe       | Phyllite                                                                    |
| 536 | KPvs        | Volcanic and volcanoclastic rocks including tuff, basalt, minor conglomerate and slamp breccia |
| 537 | Ksm,l       | Marl and calcareous shale with intercalations of limestone                  |
| 538 | Ksn         | Grey to block shale and thin layers of siltstone and sandstone             |
| 539 | Ksr         | Ammonite bearing shale with interaction of orbitolin limestone              |
| 540 | Ksv         | Grey, thick-bedded to massive limestone with thin marl intercalations in upper part |
| 541 | Ktb         | Massive, shelly, cliff-forming partly anhydritic limestone                  |
Predicting the potential habitat of Russian-Olive (*Elaeagnus angustifolia*) in urban landscapes

| ID  | Geo unit | Description                                                                 |
|-----|----------|-----------------------------------------------------------------------------|
| 542 | Ktl      | Thin to medium bedded argillaceous limestone and thick bedded to massive, grey orbitolina bearing limestone |
| 543 | Ktr      | Grey oolitic and bioclastic orbitolina limestone                             |
| 544 | Ktzl     | Thick bedded to massive, white to pinkish orbitolina bearing limestone        |
| 545 | Ku       | Upper cretaceous, undifferentiated rocks                                    |
| 546 | Kuabv    | Late-Cretaceous andesitic and basaltic lava flows                            |
| 547 | Kuavs    | Andesitic Volcano sedimentary                                              |
| 548 | Kuf      | Unknown                                                                      |
| 549 | Kuf      | Flysch type sediments including shale, sandstone, limestone and conglomerate|
| 550 | Kufsh    | Mudstone, shale and sandstone                                               |
| 551 | Kuft     | Flysch turbidites                                                           |
| 552 | Kufv     | Flysch-volcanic rocks                                                       |
| 553 | Kugr     | Granite and granodiorite                                                    |
| 554 | Kugr-di  | Granite to Diorite                                                           |
| 555 | Kupl     | Globotheca limestone                                                         |
| 556 | Kur      | Radiolarian chert and shale                                                 |
| 557 | Kurl     | Undifferentiated pelagic limestone and radiolarian chert                     |
| 558 | Kus      | Flysch turbidite sandstone with interbed calcareous mudstone and shale      |
| 559 | Kussh    | Dark grey shale                                                             |
| 560 | Kussh    | Dark grey shale                                                             |
| 561 | I        | Massive, recrystallized limestone with minor phyllite and schist            |
| 562 | L.E-Oa.  | Andesitic to basaltic volcanic                                               |
|     | bv       | Andesitic to basaltic volcanic tuff                                         |
| 563 | L.E-Oa.  | Andesitic volcanic                                                           |
|     | bvt      | Basaltic volcanic                                                           |
| 564 | L.E-Oav  | Andesitic volcanic                                                           |
| 565 | L.E-Obv  | Basaltic volcanic                                                            |
| 566 | L.E-Obav | Dacitic to andesitic tuff                                                    |
| 567 | L.E-Obav | Dacitic to andesitic volcanic                                               |
| 568 | L.E-Obav | Dacitic to andesitic volcanic breccia                                        |
| 569 | L.E-Obav | Dacitic to andesitic volcanic tuff                                           |
| 570 | L.E-Obav | Diorite                                                                      |
| 571 | L.E-Odsv | Late Eocene-Early Oligocene rhyolitic to rhyodacitic subvolcanic rocks      |
| 572 | L.E-Odav | Rhyolitic to rhyodacitic volcanic                                            |
| 573 | L.E-Of   | Feldespatoidal intrusive rock                                                |
| 574 | L.E-Ogr  | Late Eocene-Early Oligocene granite                                          |
| 575 | Lake     | Unknown                                                                      |
| 576 | Lv       | Listvinite                                                                   |
| 577 | M1-2f    | Thickly bedded sandstone with interbedded siltstone and shale                |
| 578 | M1-2m    | Shale, gysiferous shale, gysiferous mudstone and silty shale with minor sandstone and limestone |

Soil order legend

| ID  | Soil order            |
|-----|-----------------------|
| 1   | Inceptisols/Vertisols |
| 2   | Inceptisols           |
| 3   | Entisols/Inceptisols  |
| 4   | Entisols/Aridisols    |
| 5   | Aridisols             |
| 6   | Rock outcrops/Inceptisols |
| 7   | Rock outcrops/Entisols|
| 8   | Playa                 |
| 9   | Rocky lands           |
| 10  | Kalut                 |
| 11  | Dune lands            |
| 12  | Marsh                 |
| 13  | Coastal sands         |
| 14  | Bad lands             |
| 15  | Molisols              |
| 16  | Water body            |
| 17  | Urban                 |
| 18  | Salt plug             |
| 19  | Salt flats            |
| 20  | Alfisols              |