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Practical Methods of GIS for Archaeologists: Viewshed Analysis - The Kingdom of Pylos Example

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Abstract

Visibility (or Viewshed) Analysis in archeology is a function given through GIS, in purpose to contribute in the field of archaeology and especially in landscape archeology, by reconstituting the visual panorama of a study area of the past. The concept of landscape archeology is a multidimensional research process that is not limited to archaeologists but places a special emphasis on a multidisciplinary approach. Mycenaean Messenia was the area of study and analysis of the visual panorama for two important reasons. First of all, it is a large area, which presents territories of varying heterogeneity in terms of morphology, while having a large sea front and an open observation horizon. Secondly, it is one of the continental regions of the Mycenaean period, which has evoked the largest number of residential facilities, structures and tombs, and also has been extensively studied by archaeologists since the 1920s. The main aim of this paper is to make an effort to identify archaeological information, through the bibliographic references of the archaeologists who studied the area, with the GIS visibility analysis. For that reason, the author tries for those residential locations that have been assigned a role or function of the site by archaeologists, such as an observation station, to be controlled in parallel and on the basis of new technologies (GIS and Viewshed Analysis) if this view is verified.

1. Introduction

Messenia Prefecture is located in the Southwest edge of the Peloponnese (Figure 1), Greece. Messenia was the Kingdom of Pylos during the Mycenaean Era. The river Neda constitutes the conventional northern frontier of the region under study, while the eastern boundary was the plain ground before the mountain Taygetos. Neda is still used today as the boundary between the Prefectures of Messenia and Elis (Liko, 2012; Simpson, 2014).

GIS for archeologists is important, especially in supporting aspects of location and information that are in accordance with the interests of protecting archaeological assets (Lockwood & Masters, 2021). Otherwise, geospatial techniques in GIS can also help in systematic conservation planning to protect historical objects (da Silva et al., 2020). Furthermore, the importance of using GIS has also helped in archaeological conservation, especially for tourism and environment planning, also digital archiving development planning.

Several previous researches used viewshed analysis for spatial observation, especially archaeological conservation efforts. Viewshed are defined as the areas within the key location study area that could be viewed from one or more observation locations. Conversely, the viewshed from a particular site of interest (the areas that can be viewed) are also the areas from which the site can be seen.

The viewshed analysis has been widely accepted by the archaeological community, since many works has been done on this direction (da Silva et al., 2020; Gillings, 2015; Jones, 2006; Lake & Woodman, 2003; Lockwood & Masters, 2021; Wheatley & Gillings, 2002). By looking at the existing developments, this paper has a different

focus, which is more focused on the role of GIS and viewshed analysis, especially in landscape archeology, by reconstituting the visual panorama of a study area of the past. Furthermore, this study aimed to detail aspects of using viewshed analysis in GIS to identify the archaeological landscape according to several archaeological record criteria.

This paper presents the results of viewshed analysis, which was conducted to determine the visibility of selected archaeological habitation sites from a select set of locations. The objectives of this work are to provide an understanding of existing visual conditions and trends in the areas near to the sites of interest; also identify and discuss potential Site interactions with the visual environment. Otherwise, this paper discuss and verify the archaeological studies and reports with the new technologies, such as GIS and viewshed analysis.

2. Data and Method

2.1 Study Area

Messenia is a part of Ancient Greece located in the southwestern Peloponnesian Peninsula. This area is bordered by the Neda River, Mount Elaeum, Mount Nomia, Taygetus, Koskara River, and the ocean. In addition to the territorial boundaries that have not changes since ancient times, the indigenous population of the region is also predominantly Greek and the minority population is Slavic and Albanian. However, the population in Ancient Greece was almost entirely Greek. The Greek dialect that is spoken in Messenia is listed as Doric Greek, but early in its history, the language spoken was Mycenaean Greek. Doric dialects did not appear until the Greek dark ages following the Dorian invasion of the region. The location of Messenia can be seen in Figure 1.

Figure 1. Study area – The Prefecture of Messenia located at the SW of Greece.

2.2 Catalogue of Mycenaean Sites

Initially, bibliographical references from the archaeologists were collected for the selection of the habitation sites. Settlement hierarchy is a basic parameter of the constitution of the Mycenaean settlement network. The hierarchical levels of the settlement network, that is, the tiers of its hierarchy, are classified into Centers (C), Large Villages (L), Villages (V) and farmsteads (F), based on the classifications made by important archaeologists in the area of Messenia. The complete list of classifications (Table 1) is shown below along with the map of physical locations (Figure 2)

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Table 1. Complete Catalogue of all Mycenaean Sites

Code	Name	Code	Name	Code	Name
V1	AyiosFloros-Kamaria	**V48**	Trikorfo-KakoKatarachi	F10	Armenioi-Manna
V2	AyiosFloros	**V49**	Filiatra-Stomio	F11	Artiki-RachiGourtsia
V3	Aetos-Mourlou	**V50**	Filiatra-Kastraki	F12	Valta-Kastraki
V4	AnoKopanaki-Stylari	**V51**	Flesiada-Misorachi	F13	Vasiliko-Veizi
V5	Aris-Mesovouni	**V52**	Chandrinos-PigiKoumpe	F14	VlachopoulosStamatiRachi
V6	Valta-Ay.Paraskevi	**V53**	Charakopio-Petriades	F15	Vrysai-Paleofrygas
V7	Vanada-Kastri	**V54**	Chatzi-Barberi	F16	Vromoneri-Pigadia
V8	Malthi-Dorio	**V55**	Chrysokellaria-Ay.Athanasios	F17	Gargalinaoi-MegaKampos
V9	Valta-Ay.Panteleimon	**L1**	Yialova-Palaiochori	F18	Exochiko-Ay.Nikolaos
V10	Velika-Skordakis	**L2**	Agrilovouno-Ay.Nikolaos	F19	KatoAmpelokipoi
V11	Verga-Kastraki	**L3**	Ay.Dimitrios-Vigla	F20	KatoKopanaki-Chalikia
V12	Vigla-Ay.Ilias	**L4**	Diavolitsi-Loutses	F21	Koryfasio-Portes
V13	Vlachopoulo-Agrilia	**L5**	Kalamata-Kastro	F22	Kynigou-Avarnitsa
V14	Voidokoilia-Paleokastro	**L6**	Kalyvia-PanoChorio	F23	Lampena-Tourkokivouro
V15	Gargalianoi-Ordines	**L7**	Kardamyli-Kastro	F24	Mathia-Pyrgaki
V16	Gargalianoi-Kanalos	**L8**	KatoMelpeia-Krebeni	F25	Mandra-HAznaNotia
V17	Glykorizi-Ay.Ilias	**L9**	Maganiako-Paliampela	F26	Mavromati-Panayia
V18	Daras-Viglitsa	**L10**	Metaxada-Kalopsana	F27	Meligalas-Ay.Ilias
V19	Strefi-Galarovouni	**L11**	Myrsinochori	F28	Mesopotamos-ChiliaChoria
V20	Draina-Koutsoveri	**L12**	Polichni-Ay.Taxiarches	F29	Mesochori-Koutsoveri
V21	Dorio-Kontra	**L13**	Pidima-AyiosIoannis	F30	Metamorphosis-Ay.Sotira
V22	Eva-Nekrotafeio	**L14**	Pyla-Vigles	F31	MikraMantineia-Ay.Georgios
V23	Evangelismos	**L15**	Romanos-POTA	F32	Mila-ProfitisIlias
V24	Iklaina-Katsimigas	**L16**	Sidirokastro-Sfakoulia	F33	Mila-Lakathela
V25	Iklaina-Panayia	**L17**	Stenyklaros-KatoRachi	F34	Myrsinochori-Vaies
V26	Kalamata-Tourles	**L18**	Stoupa-Anc.Leyktra	F35	Pappoulia
V27	Kalochori-Ay.Ilias	**L19**	Foinikounta-Ay.Analipsis	F36	Parapoungi-Ay.Georgios
V28	Kamari-Gouva	**L20**	Filiatra-AyiosIoannis	F37	Perivolakia-Sola
V29	Kamari-Mesovouni	**S1**	Malthi-Gouves	F38	Platanos-Lamprop.Pigi
V30	Karteroli-Ay.Konstantinos	**S2**	Koryfasion-Beylerbey	F39	Platy-Petrogefyra
V31	Katsarou-Ay.Ilias	**S3**	Filiatra-Ay.Christoforos	F40	Pyla-Elitsa
V32	Kefalovrysi-Tsoukeda	**S4**	AncientThouria	F41	Pylos-Vigla
V33	Koghyli-Kastro	**S5**	Mouriatada-Elliniko	F42	Soulinari
V34	Koklas-RachiChani	**S6**	Myrou-Peristeria	F43	Siamou-Paleochori
V35	Koukounara-Palaialona	**S7**	Iklaina-Traganes	F44	Spilia-Britzimpa
V36	Kyparissia-Kastro	**S8**	Koukounara-Katarachaki	F45	Tragana-Voroulia
V37	Logas-Kafirio	**S9**	AnoEglianos	F46	Falanthi-Panoria
V38	Margeli-Koutsoveri	**S10**	Nichoria	F47	Faraklada-Desi
V39	Margeli-Koutsoveri (Garg)	**F1**	Kremmydia-Fourtzovrysi	F48	Filiatra-Korovileika
V40	Mesopotamos-Velevouni	**F2**	AnoKremmydia-Lykorrema	F49	Floka-Panitsa
V41	Mila-Kastro	**F3**	Ay.Isidoros-Lioftakia	F50	Fonissa-AspraLitharia
V42	Neochori-Kounoura	**F4**	Aetos-Paleokastro	F51	Chalazoni-Paleochori
V43	Pera-Karkanos	**F5**	Aetos-Ay.Dimitrios	F52	Chalvatsou-Kastro
V44	Platanos-Merzini	**F6**	Ampelofyto-Lagou	F53	Chandrinos-Platania
V45	Romiri-Avyssos	**F7**	AnoKopanaki-Bafano	F54	Psari-Syntilithi
V46	Sellas-Nekrotafeio	**F8**	Aristodimio-Paliampela	F55	Pylos-Ay.Nektarios
V47	Schoinolakka-Kokkinia	**F9**	Aristodimio-Tourkoskotomeno		

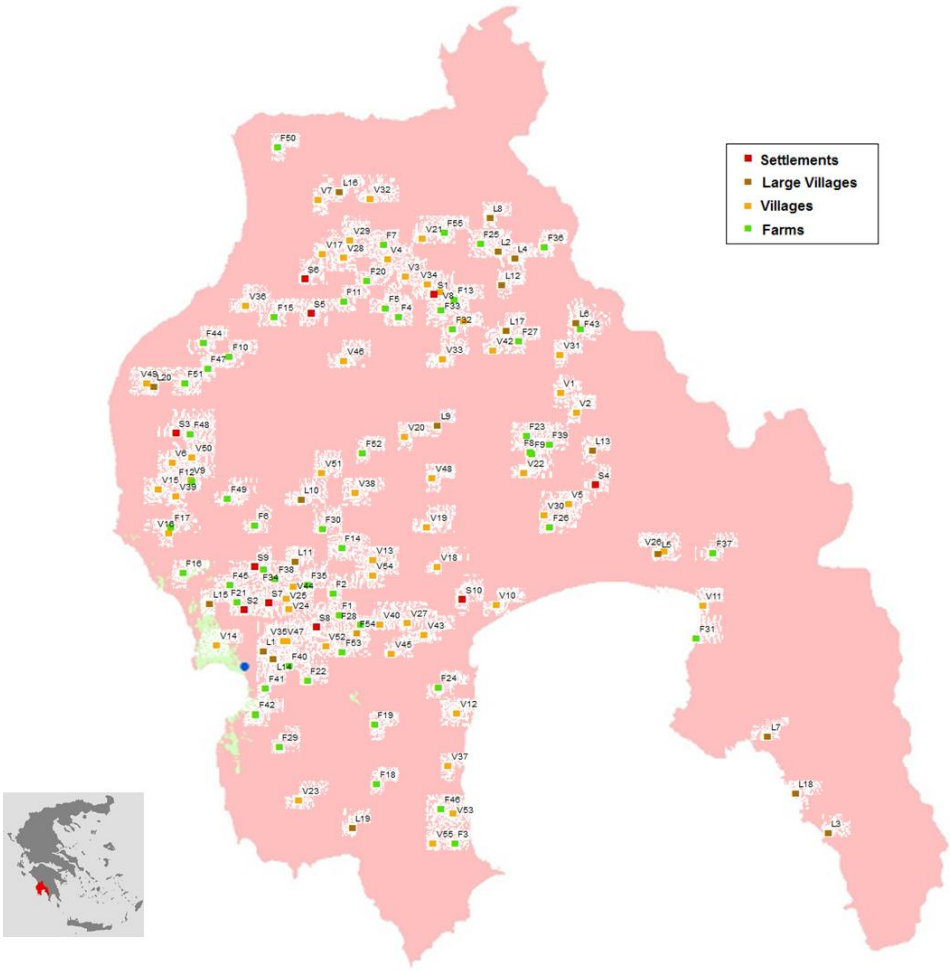

Figure 2. Map of the sites in Kingdom of Pylos (current Messenia Prefecture)

For the verification of the archaeological data, related on visibility conditions and for their characterization as observatories or wide view sites, we created a new table which includes only these sites (Table 2). In order to estimate the coordinates of each site of interest with the highest possible accuracy, we visited the vast majority of the sites and acquired the exact location (via GPS) using the Greek Geodetic Reference System (EGSA '87). In addition, satellite images of high resolution were used (Quickbird 0.6 pixel and IKONOS 1m). The correction of some minor deviations noted lead to the formation of a database of highly accurate points (Malaperdas & Zacharias, 2018).

Viewshed analysis was performed by using the Environmental Systems Research Institute (ESRI) ArcGIS Spatial Analyst Viewshed Analysis tool (ESRI, 2013). This tool uses a Digital Elevation Model for the exact heights and the geomorphology of the ground with estimated archaeological sites height, to determine if the sites may be visible from a variety of viewpoints. In our case, a 4m resolution Digital Elevation Model (DEM) was used as the basis of the analysis. Also, a vertical offset of 1.6 m was applied to each of the located sites, to compensate for the standing observers', as the average height of the residents of the Mycenaean Era. In ESRI ArcGIS software, the dataset was converted into raster dataset files. More specifically, a raster dataset is a grid of locations which includes all that information about each cell of our raster file.

Table 2. Selected Habitation Sites of probable observation function.

L1	**Yialova-Paleochori**	**V36**	**Kyparissia-Kastro**
L2	Agrilovouno-Ay.Nikolaos	**V37**	Logas-Kafirio
L3	Ay.Dimitrios-Vigla	**V38**	Margeli-Koutsoveri
L5	Kalamata-Kastro	**V40**	Mesopotamos-Velevouni
L6	Kalyvia-PanoChorio	**V41**	Mila-Kastro
L7	Kardamyli-Kastro	**V45**	Romiri-Avyssos
L8	KatoMelpeia-Krebeni	**V46**	Sellas-Nekrotafeio
L9	Maganiako-Paliampela	**V51**	Flesiada-Misorachi
L10	Metaxada-Kalopsana	**F3**	Ay.Isidoros-Lioftakia
L12	Polichni-Ay.Taxiarches	**F4**	Aetos-Paleokastro
L14	Pyla-Vigles	**F5**	Aetos-Ay.Dimitrios
L16	Sidirokastro-Sfakoulia	**F7**	AnoKopanaki-Bafano
L17	Stenyklaros-KatoRachi	**F12**	Valta-Kastraki
L19	Foinikounta-Ay.Analipsis	**F14**	Vlachopoulo-StamatiRachi
L20	Filiatra-AyiosIoannis	**F18**	Exochiko-Ay.Nikolaos
V7	Vanada-Kastri	**F24**	Mathia-Pyrgaki
V9	Valta-Ay.Panteleimon	**F27**	Meligalas-Ay.Ilias
V10	Velika-Skordakis	**F31**	MikraMantineia-Ay.Georgios
V11	Verga-Kastraki	**F32**	Mila-ProfitisIlias
V12	Vigla-Ay.Ilias	**F33**	Mila-Lakathela
V14	Voidokoilia-Paleokastro	**F36**	Parapoungi-Ay.Georgios
V17	Glykorizi-Ay.Ilias	**F37**	Perivolakia-Sola
V18	Daras-Viglitsa	**F41**	Pylos-Vigla
V20	Draina-Koutsoveri	**F43**	Siamou-Paleochori
V21	Dorio-Kontra	**F45**	Tragana-Voroulia
V26	Kalamata-Tourles	**F46**	Falanthi-Panoria
V27	Kalochori-Ay.Ilias	**F52**	Chalvatsou-Kastro
V31	Katsarou-Ay.Ilias	**F55**	Pylos-Ay.Nektarios
V33	Koghyli-Kastro		

However, it is worth mentioning that only the DEM file is not enough to give us reliable results on visibility analysis, especially when studying past times. This is mainly for two reasons. The first one has to do with the fact that the vegetation in the area will surely have changed. Except for extremely rare cases that we could know exactly the vegetation existed in some past era, for all others we cannot know if for example an area that the Viewed Analysis model gives significant visibility was covered by some kind of vegetation and which in fact, it would not be visible. The second reason has to do with the topography of the terrain and generalizations that show the model in some direction of visibility when exporting the raster file. So, some areas, depending on the accuracy of the DEM file, when we export the Raster file are generalized. As a result either appears as invisible or some others appear as visible, and in fact they are not. In general, and for the best results of a visibility analysis, we should use the highest Dem analysis as possible, as this reduces the generalizations of the areas presented as visible in the final visibility model.

Finally, it is important to mention that the function of a habitation site as an observatory does not negate the probability, that the site could also have another alternative use. In any case in this paper, we are studying the habitation sites as observatories, leaving even from our analysis the first and most important residential category, that of the Centers, as we consider their main role to be administrative.

3. Result and Discussion

Analyzing the data derived from the results of the Viewshed Analysis for all habitation sites presented in Table 2, it is observed that the visibility, for all 56 sites, is wide and these areas could surely have the role of an observatory. The results of the Viewshed Analysis, are also verifying the archaeological references, thus confirming the use of GIS and visibility analysis in archaeological research (McDonald & Simpson, 1961, 1964, 1969; Rapp & McDonald, 1972; Simpson & Dickinson, 1979; Simpson, 1981, 2014; Zavadil, 2014) . More specifically, the Viewshed Analysis data for each individual site is presented below, by showing the high visibility areas with green color and the areas where there is no visibility with pink color. Maps of visibility and non visibility areas for Yialova-Paleochori, Agrilovuono-Ay.Nikolaos, Ay.Dimitrios-Vigla, and Kalamata-Kastro can be seen in Figure 3.

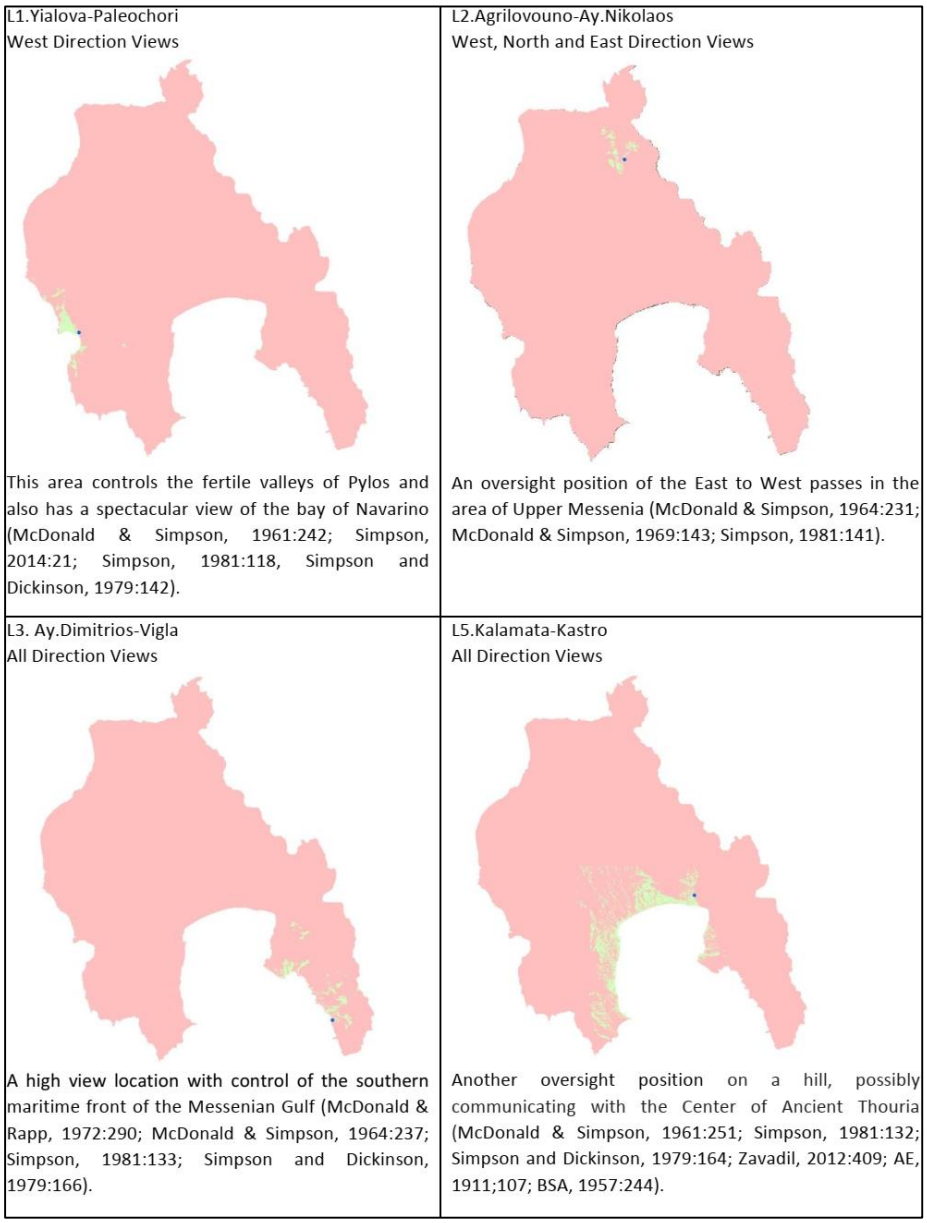

Figure 3. Map of visibility area for Yialova-Paleochori (L1), Agrilovouno-Ay.Nikolaos (L2), Ay.Dimitrios-Vigla (L3), and Kalamata-Kastro (L5)

Maps of visibility and non visibility areas for Kalyvia-PanoChorio, Kardamyli-Kastro, KatoMelpeia-Krebeni, and Maganiako-Paliampela can be seen in Figure 4 (McDonald & Simpson, 1969; Rapp & McDonald, 1972; Simpson & Dickinson, 1979; Simpson, 1981).

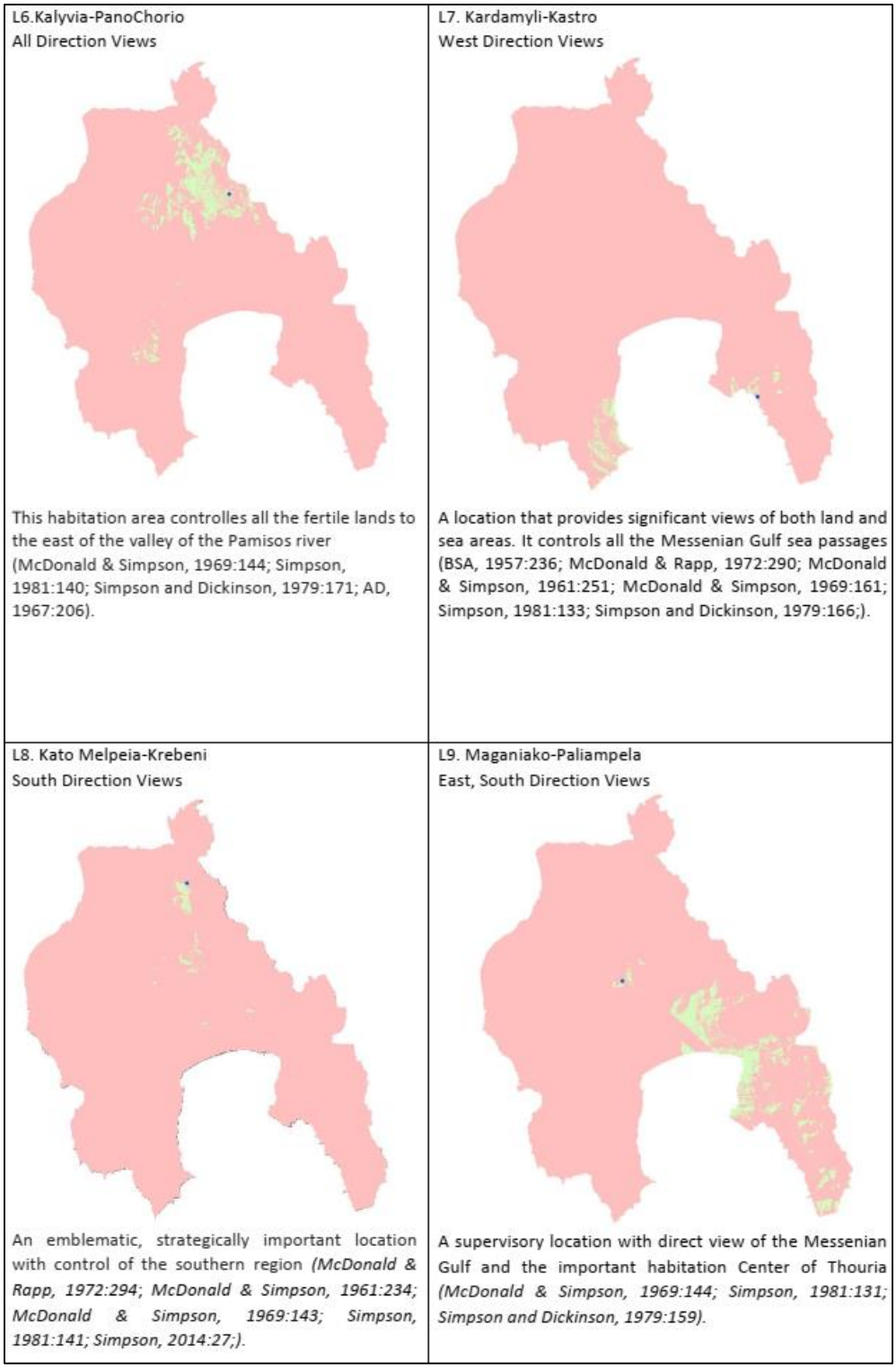

Figure 4. Map of visibility area for Kalyvia-PanoChorio (L6), Kardamyli-Kastro (L7), KatoMelpeia-Krebeni (L8), and Maganiako-Paliampela (L9)

Maps of visibility and non visibility areas for Metaxada-Kalopsana, Polichni-Ay.Taxiarches, Pyla-Vigles, and Sidirokastro-Sfakoulia can be seen in Figure 5 (McDonald & Simpson, 1961, 1969; Simpson & Dickinson, 1979; Simpson, 1981; Valmin, 1930).

Figure 5. Map of visibility area for Metaxada-Kalopsana (L10), Polichni-Ay.Taxiarches (L12), Pyla-Vigles (L14), and Sidirokastro-Sfakoulia (L16)

Maps of visibility and non visibility areas for Stenyklaros-KatoRachi, Foinikounta-Ay.Analipsis, Filiatra-AyiosIoannis, and Vanada-Kastri can be seen in Figure 6 (Boyd, 1999; McDonald & Simpson, 1961, 1969; Simpson & Dickinson, 1979; Simpson, 1981, 2014; Valmin, 1930).

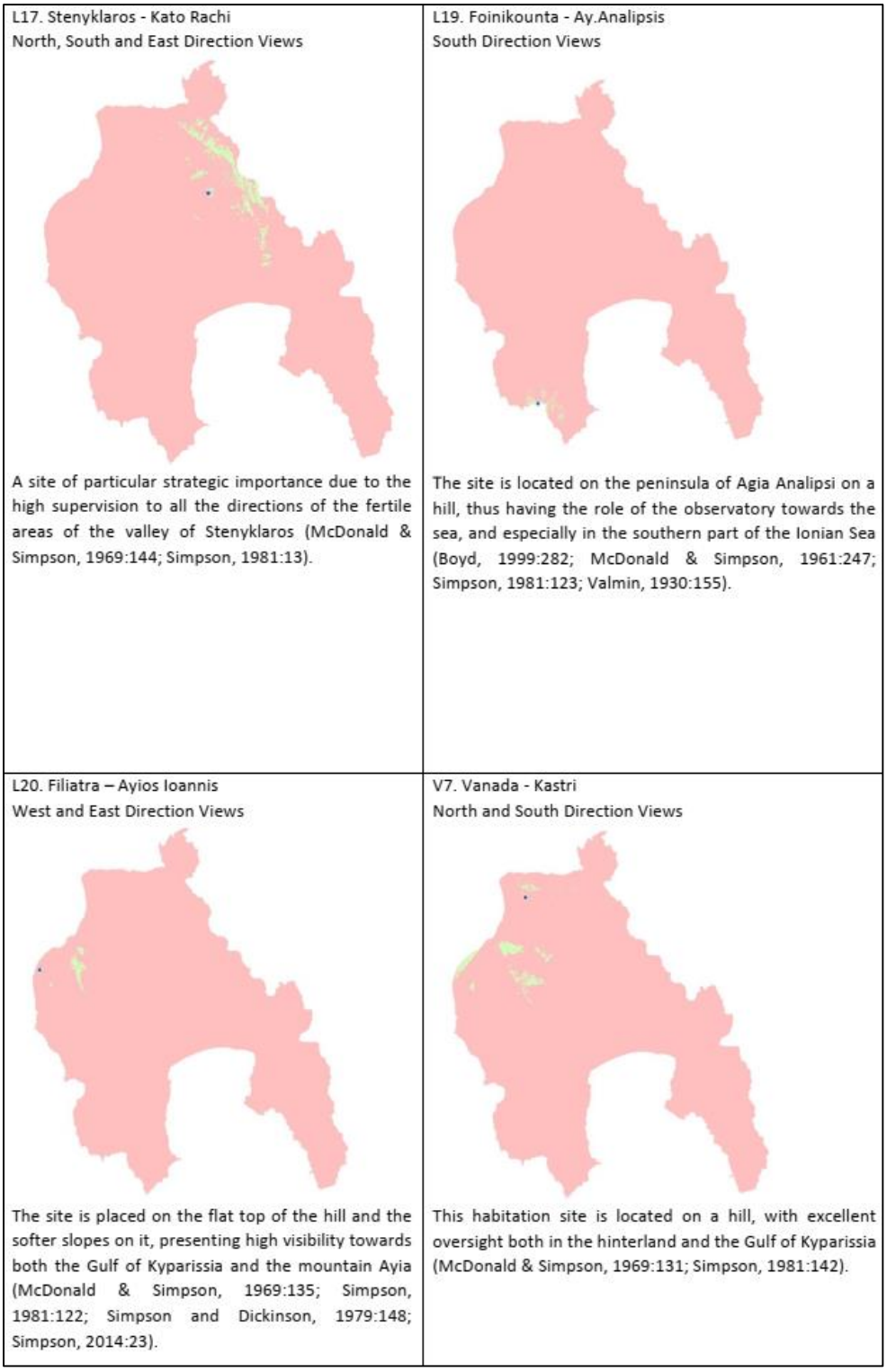

Figure 6. Map of visibility area for Stenyklaros-KatoRachi (L17), Foinikounta-Ay.Analipsis (L19), Filiatra-AyiosIoannis (L20), and Vanada-Kastri (V7)

Maps of visibility and non visibility areas for Valta-Ay.Panteleimon, Velika-Skordakis, Verga-Kastraki, and Vigla-Ay.Ilias can be seen in Figure 7 (McDonald & Simpson, 1969; Rapp & McDonald, 1972; Simpson & Dickinson, 1979; Simpson, 1981).

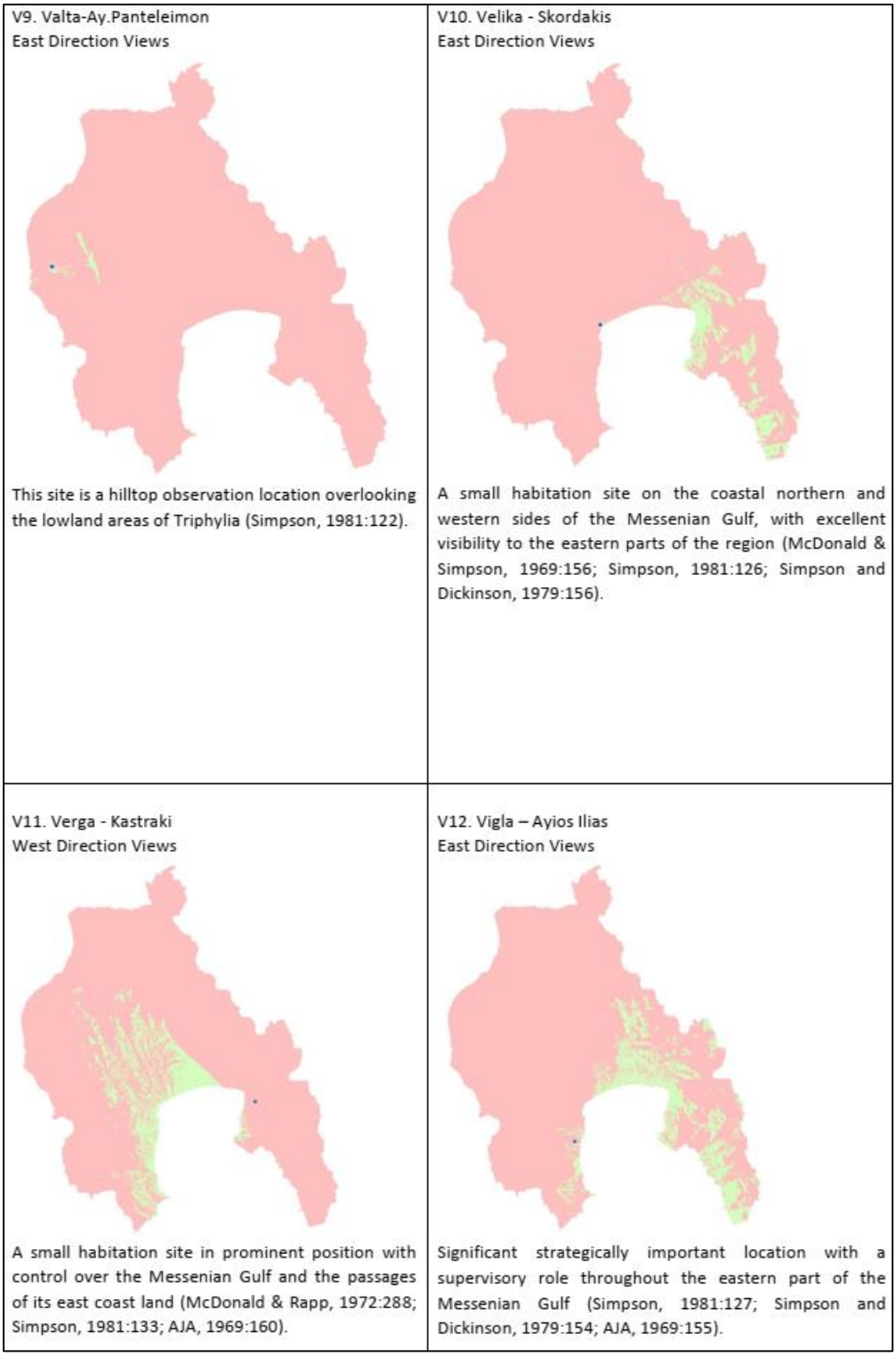

Figure 7. Map of visibility area for Valta-Ay.Panteleimon (V9), Velika-Skordakis (V10), Verga-Kastraki (V11), and Vigla-Ay.Ilias (V12)

Maps of visibility and non visibility areas for Voidokoilia-Paleokastro, Glykorizi-Ay.Ilias, Daras-Viglitsa, and Draina-Koutsoveri can be seen in Figure 8 (McDonald & Simpson, 1961, 1964, 1969; Simpson & Dickinson, 1979; Simpson, 1981; Zavadil, 2014).

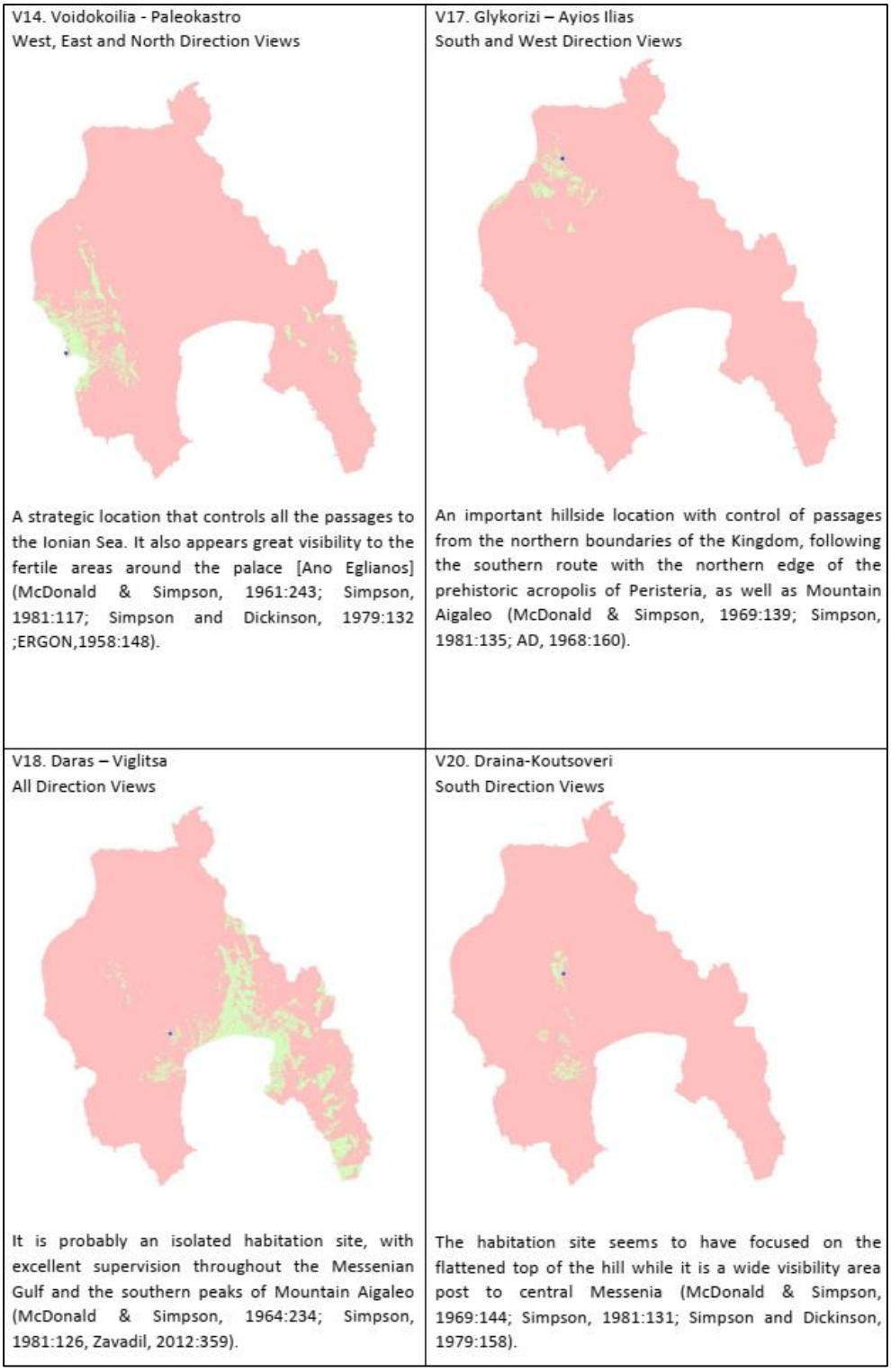

Figure 8. Map of visibility area for Voidokoilia-Paleokastro (V14), Glykorizi-Ay.Ilias (V17), Daras-Viglitsa (V18), and Draina-Koutsoveri (V20)

Maps of visibility and non visibility areas for Dorio-Kontra, Kalamata-Tourles, Kalochori-Ay.Ilias, and Katsarou-Ay.Ilias can be seen in Figure 9 (McDonald & Simpson, 1964, 1969; Simpson & Dickinson, 1979; Simpson, 1981, 2014; Zavadil, 2014).

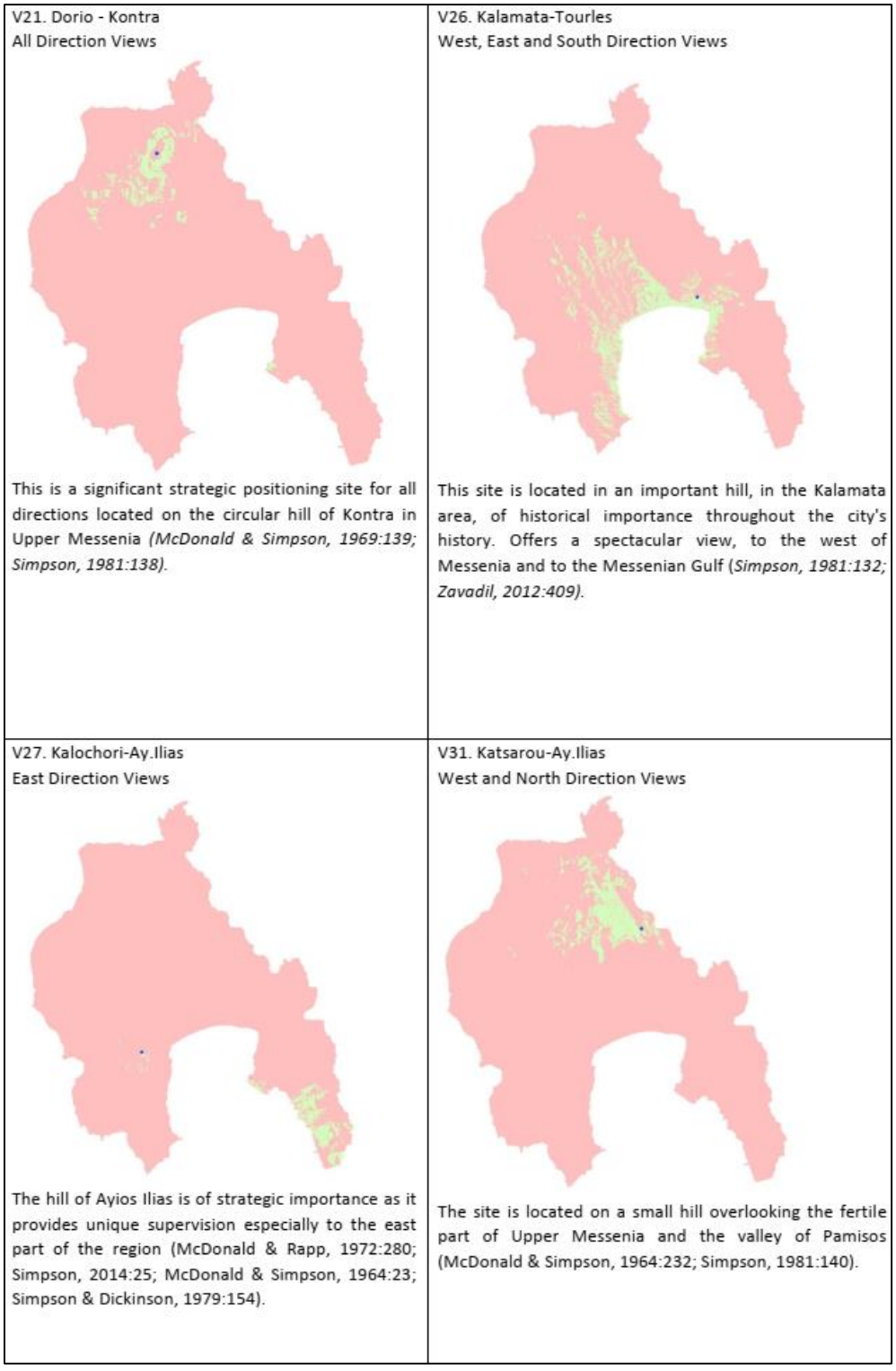

Figure 9. Map of visibility area for Dorio-Kontra (V21), Kalamata-Tourles (V26), Kalochori-Ay.Ilias (V27), and Katsarou-Ay.Ilias (V31)

Maps of visibility and non visibility areas for Koghyli-Kastro, Kyparissia-Kastro, Logas-Kafirio, and Margeli-Koutsoveri can be seen in Figure 10 (McDonald & Simpson, 1961, 1969; Simpson & Dickinson, 1979; Simpson, 1981).

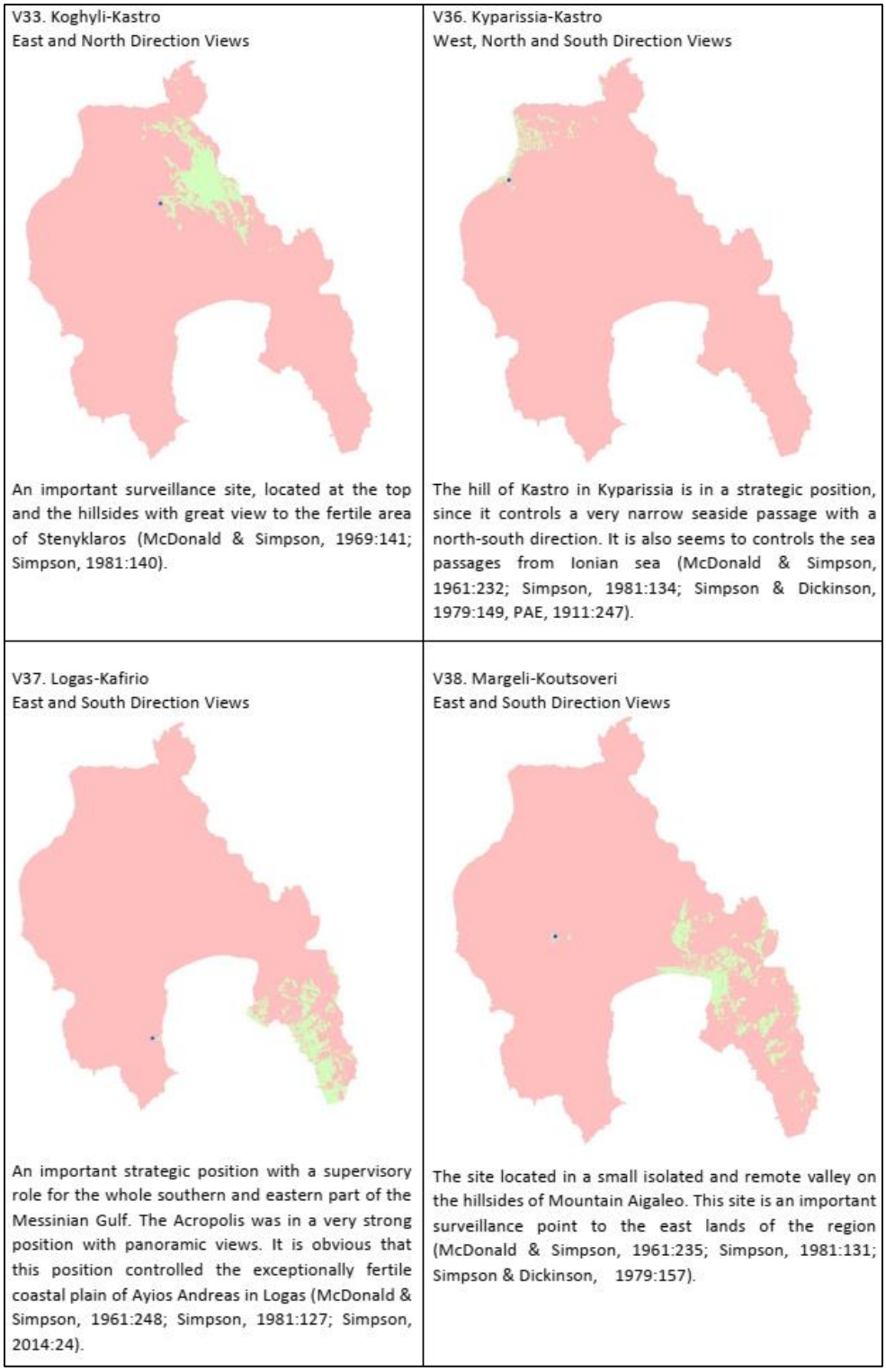

Figure 10. Map of visibility area for Koghyli-Kastro (V33), Kyparissia-Kastro (V36), Logas-Kafirio (V37), and Margeli-Koutsoveri (V38)

Maps of visibility and non visibility areas for Mesopotamos-Velevouni, Mila-Kastro, Romiri-Avyssos, and Sellas-Nekrotafeio can be seen in Figure 11 (McDonald & Simpson, 1964, 1969; Simpson & Dickinson, 1979; Simpson, 1981).

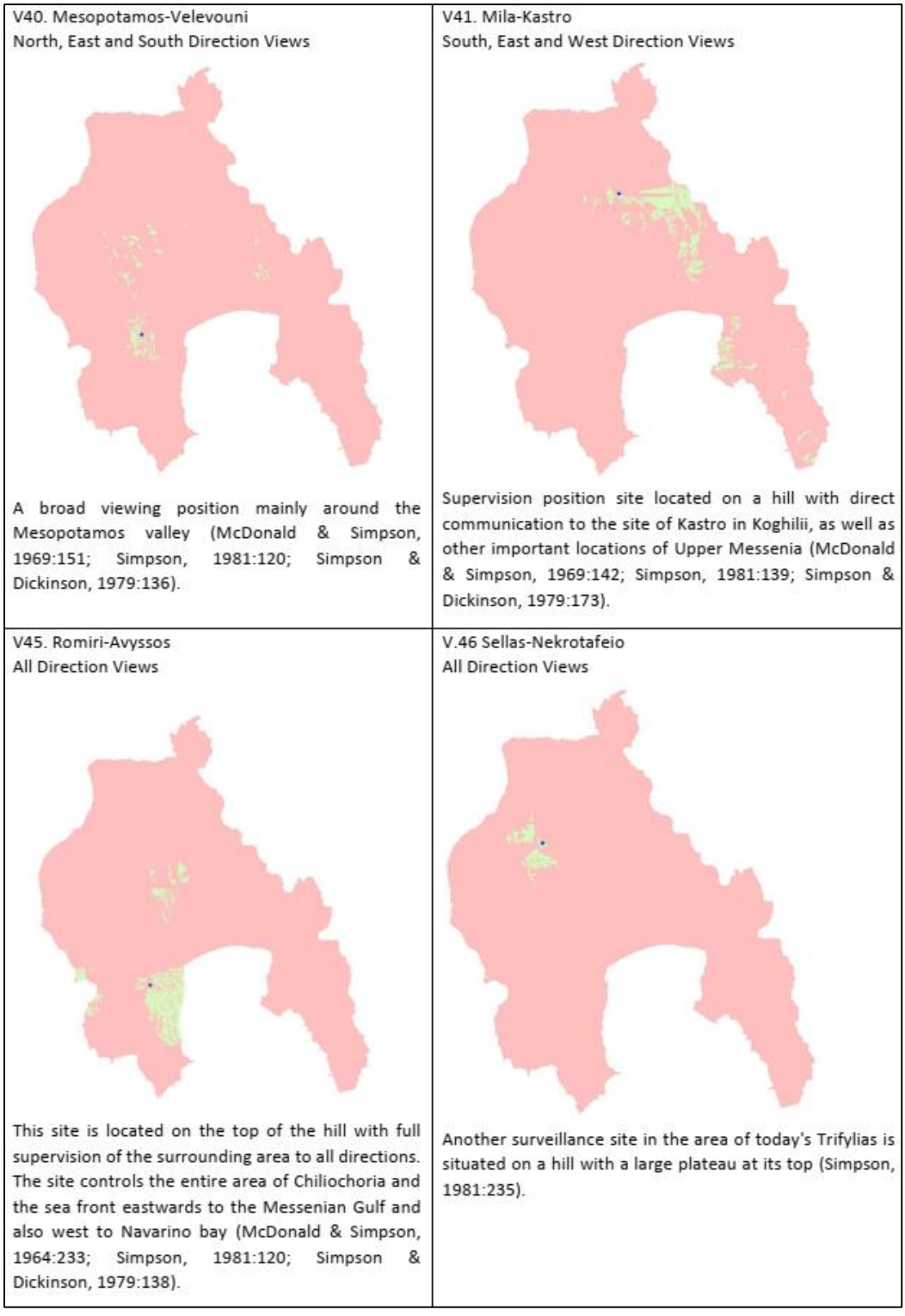

Figure 11. Map of visibility area for Mesopotamos-Velevouni (V40), Mila-Kastro (V41), Romiri-Avyssos (V45), and Sellas-Nekrotafeio (V46)

Maps of visibility and non visibility areas for Flesiada-Misorachi, Ay.Isidoros-Lioftakia, Aetos-Paleokastro, and Aetos-Ay.Dimitrios can be seen in Figure 12 (McDonald & Simpson, 1961, 1969; Rapp & McDonald, 1972; Simpson & Dickinson, 1979; Simpson, 1981).

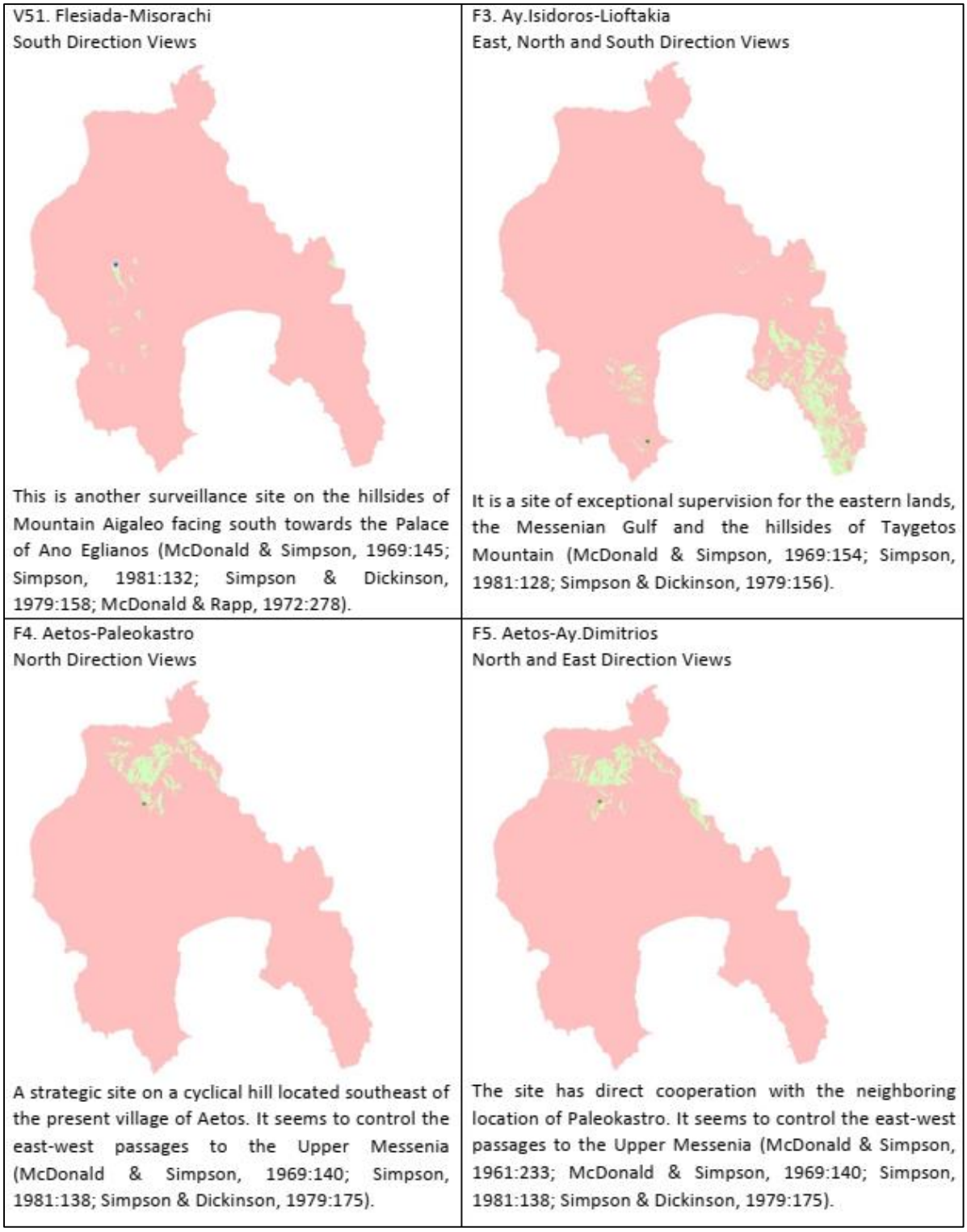

Figure 12. Map of visibility area for Flesiada-Misorachi (V51), Ay.Isidoros-Lioftakia (F3), Aetos-Paleokastro (F4), and Aetos-Ay.Dimitrios (F5)

Maps of visibility and non visibility areas for AnoKopanaki-Bafano, Valta-Kastraki, Vlachopoulo-StamatiRachi, and Exochiko-Ay.Nikolaos can be seen in Figure 13 (Boyd, 1999; McDonald & Simpson, 1969; Rapp & McDonald, 1972; Simpson & Dickinson, 1979; Simpson, 1981; Zavadil, 2014).

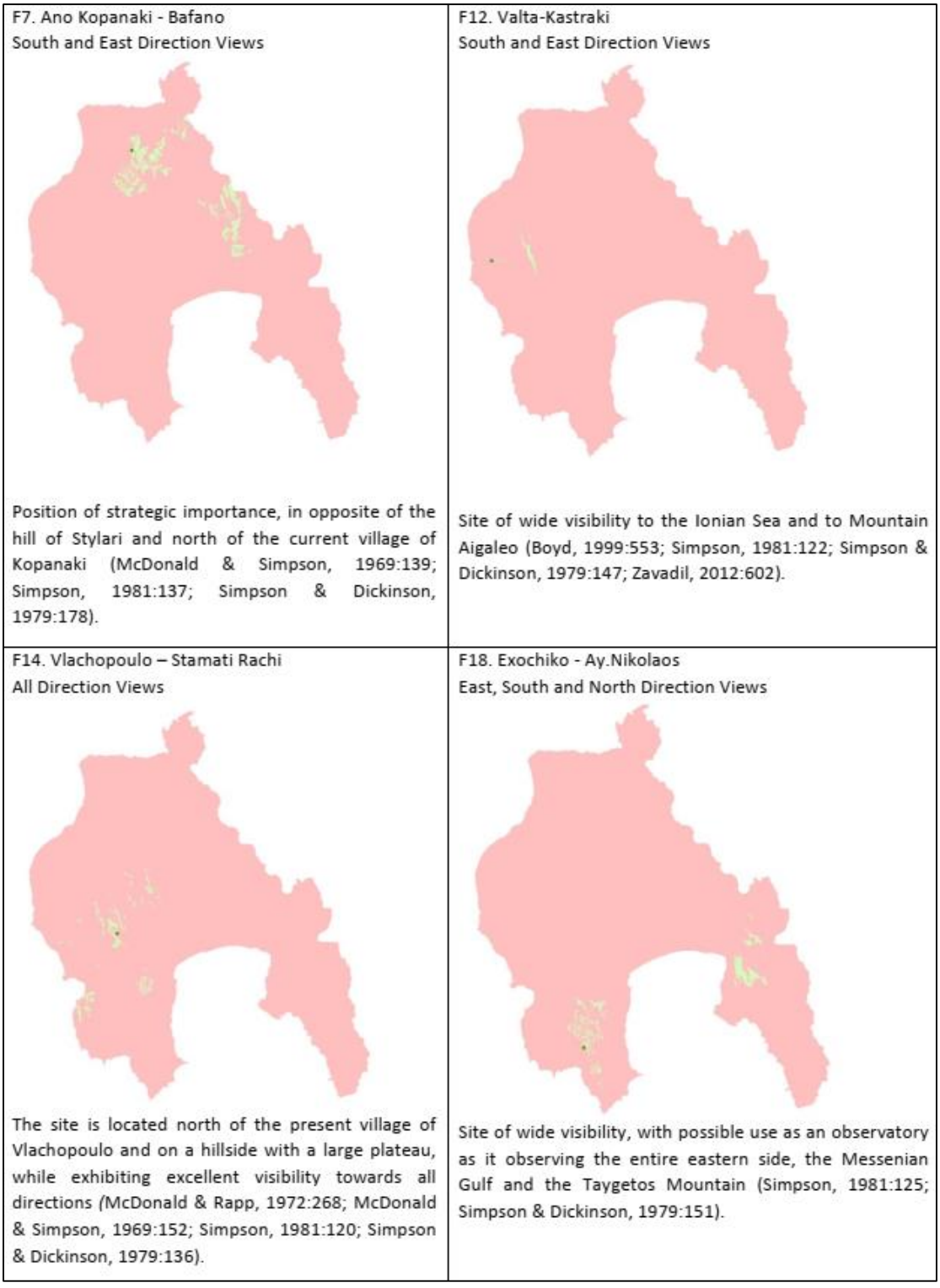

Figure 13. Map of visibility area for AnoKopanaki-Bafano (F7), Valta-Kastraki (F12), Vlachopoulo-StamatiRachi (F14), and Exochiko-Ay.Nikolaos (F18)

Maps of visibility and non visibility areas for Mathia-Pyrgaki, Meligalas-Ay.Ilias, MikraMantineia-Ay.Georgios, and Mila-ProfitisIlias can be seen in Figure 14 (McDonald & Simpson, 1961, 1969; Rapp & McDonald, 1972; Simpson & Dickinson, 1979; Simpson, 2014; Simpson, 1981).

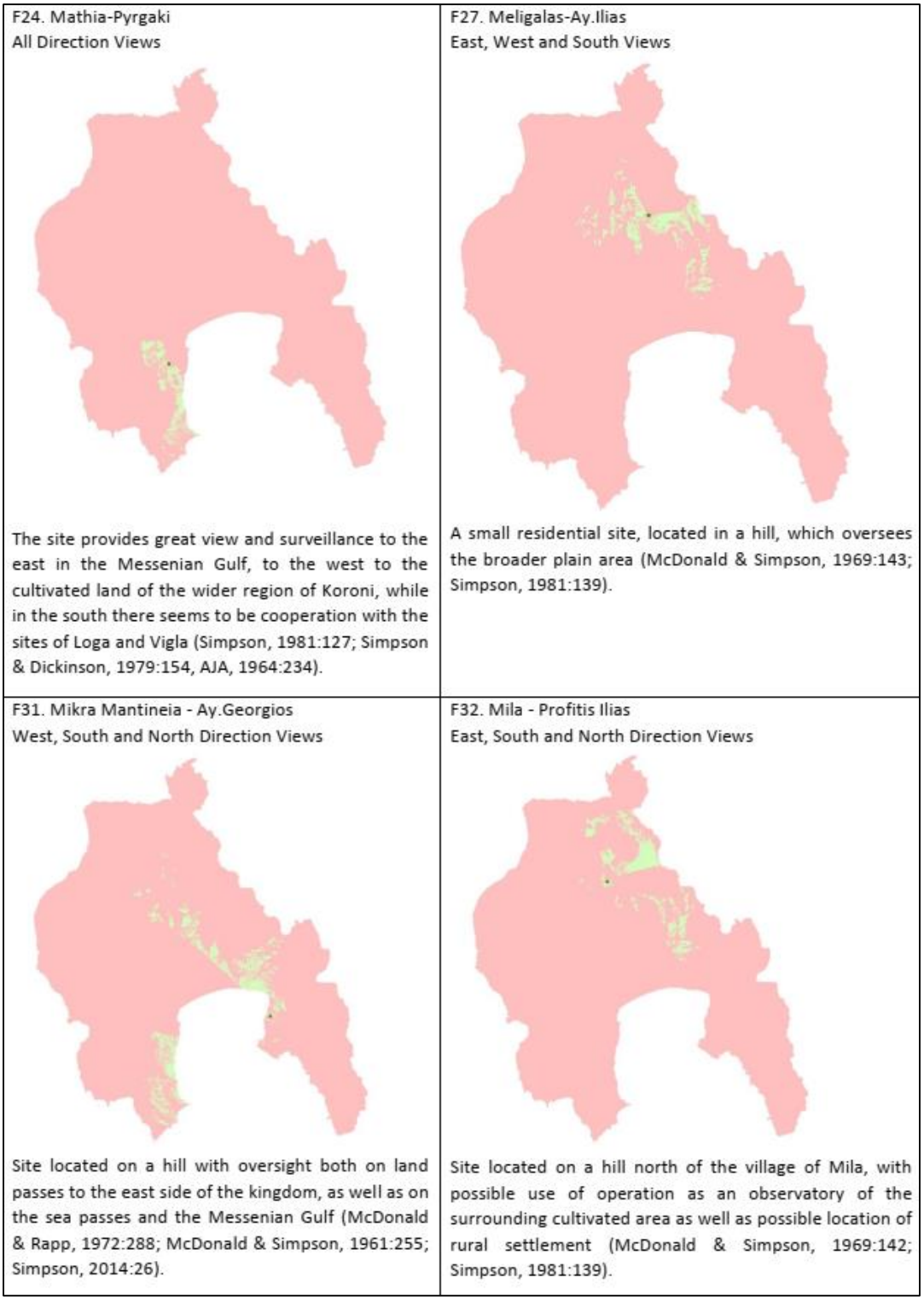

Figure 14. Map of visibility area for Mathia-Pyrgaki (F24), Meligalas-Ay.Ilias (F27), MikraMantineia-Ay.Georgios (F31), and Mila-ProfitisIlias (F32)

Maps of visibility and non visibility areas for Mila-Lakathela, Parapoungi-Ay.Georgios, Perivolakia-Sola, and Pylos-Vigla can be seen in Figure 15 (McDonald & Simpson, 1961, 1964, 1969; Simpson & Dickinson, 1979; Simpson, 1981).

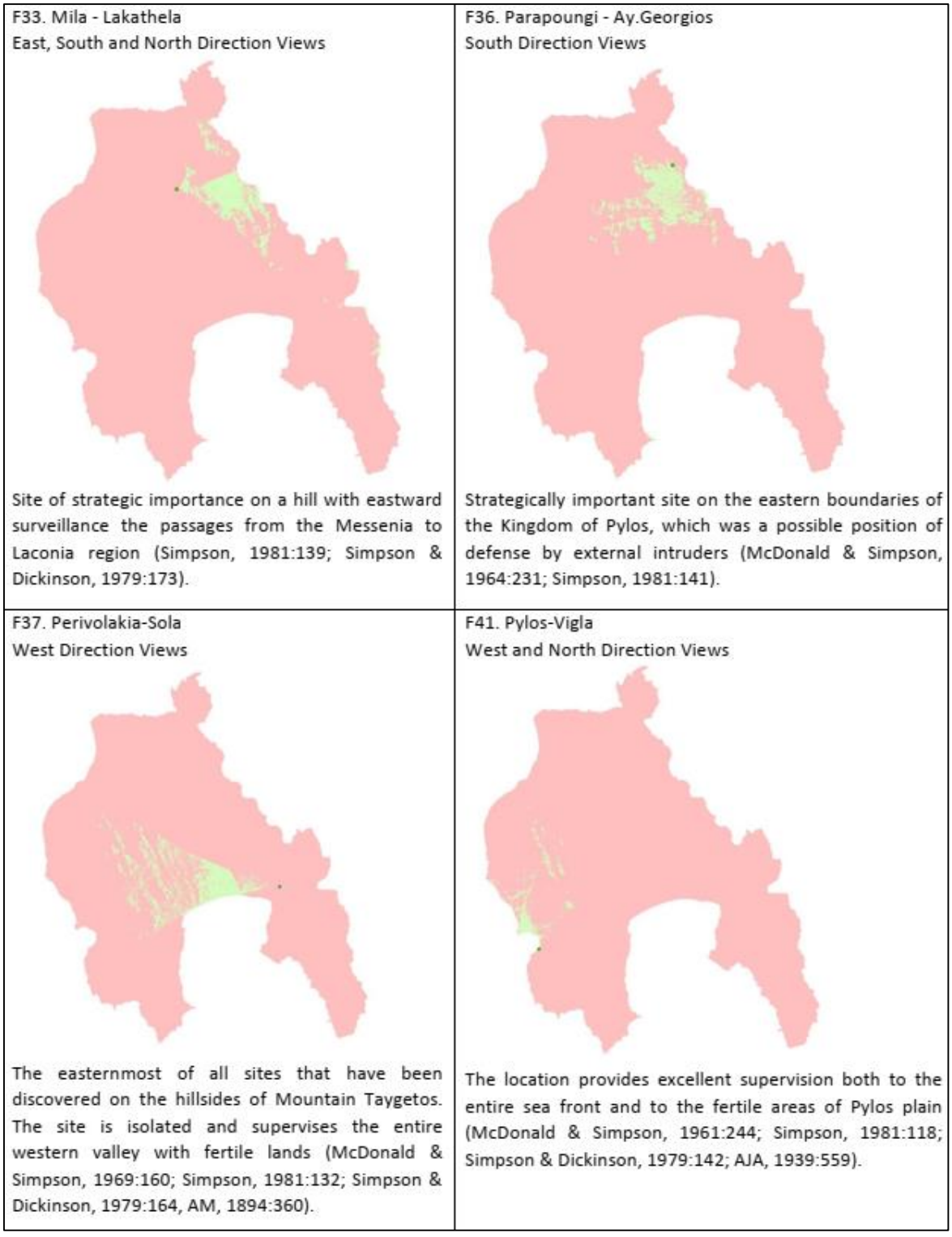

Figure 15. Map of visibility area for Mila-Lakathela (F33), Parapoungi-Ay.Georgios (F36), Perivolakia-Sola (F37), and Pylos-Vigla (F41)

Maps of visibility and non visibility areas for Siamou-Paleochori, Tragana-Voroulia, Falanthi-Panoria, and Chalvatsou-Kastro can be seen in Figure 16 (McDonald & Simpson, 1961, 1969; Simpson & Dickinson, 1979; Simpson, 2014; Simpson, 1981; ERGON, 1955)

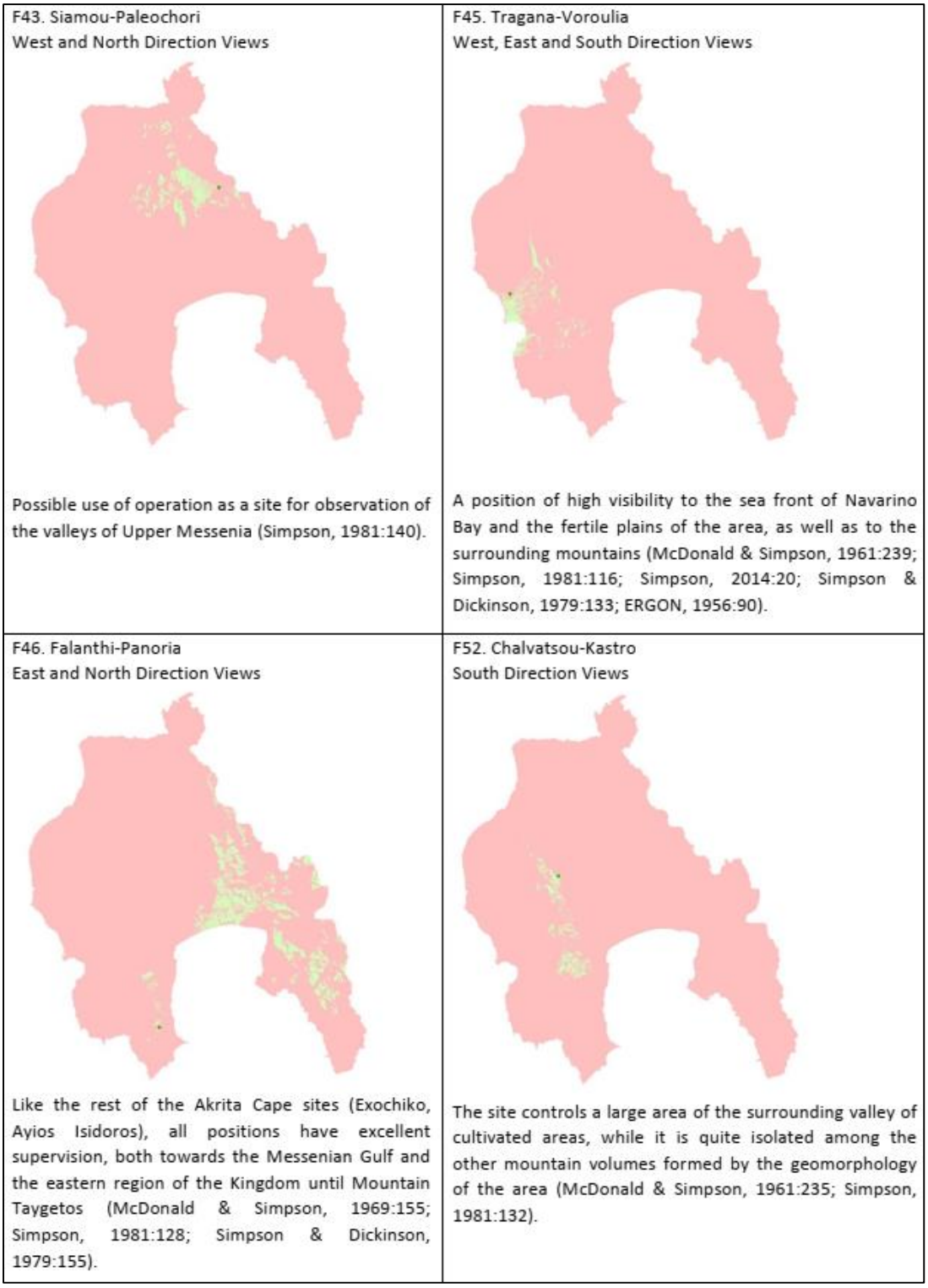

Figure 16. Map of visibility area for Siamou-Paleochori (F43), Tragana-Voroulia (F45), Falanthi-Panoria (F46), and Chalvatsou-Kastro (F52)

Maps of visibility and non visibility areas for Pylos-Ay.Nektarios can be seen in Figure 17 (Simpson & Dickinson, 1979; Simpson, 1981).

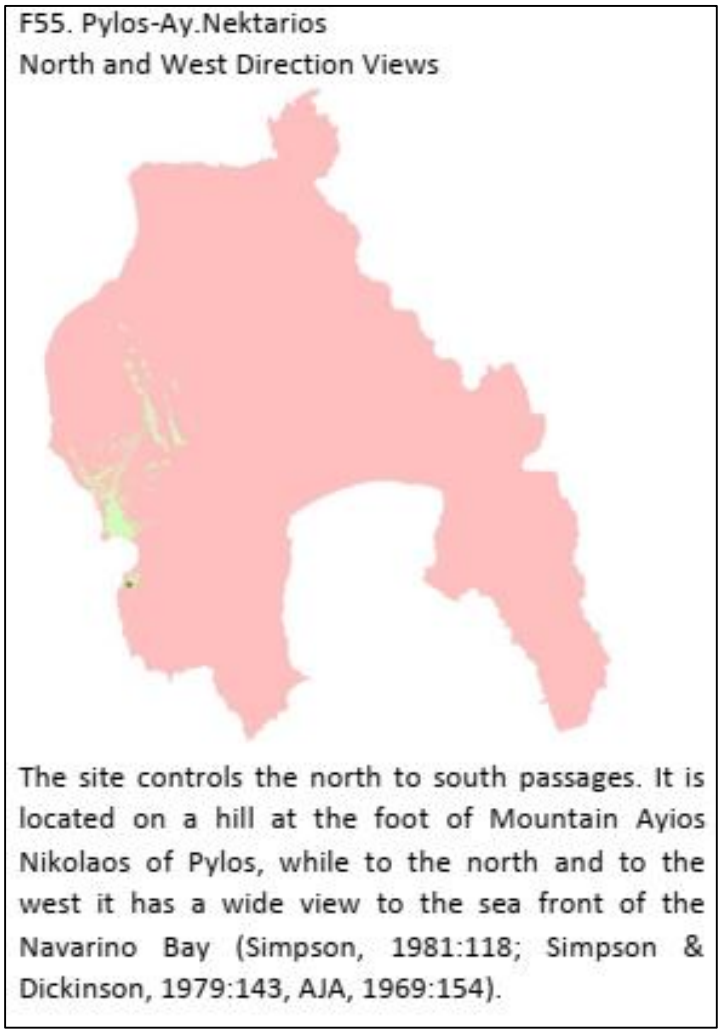

Figure 17. Map of visibility area for Pylos-Ay.Nektarios (F*55*)

4. Conclusion

In Viewshed Analysis, we must understand that this type of analysis will show us the trend and those directions on the horizon that are more likely to see from a viewing point towards the wider area and vice versa. Keeping this rule, we look at their positions and functions, and even if we have very small discrepancies, depending on the specific territorial areas of visibility or not, based on the extent of observation we can cross-check if a location could actually function as an observatory or not, verifying the archaeological data.

The present work combines the results of archaeological research and GIS via Viewshed Analysis and applies new technologies in order to confirm the results of the archaeologists. The main focus of this work is to highlight the significance of the application of GIS in archaeology for the corroboration of the archaeological record.

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