

Dynamism of viticultural systems in Mendoza (1988–2008)

M. Eugenia Van den Bosch^{1,a}, Adriana Bocco², and M. Cecilia Ruiz³

¹ EEA Mendoza, INTA Mendoza, San Martín 3853, M. Drummond, Mendoza República, Argentina

² CONICET INTA, EEA Mendoza, San Martín 3853, M. Drummond, Mendoza República, Argentina

³ Dirección de Estadísticas e Investigaciones Económicas, Gobierno de Mendoza República, Argentina

Abstract. Viticulture holdings of Mendoza Argentina, were classified by the allocation and the stratum size according to their total acreage based on the data of the last three National Agricultural Censuses (1988, 2002 and 2008). There are different behaviors in each stratum according to each growing zone. It has been observed that in all “oasis” smaller is the holding, higher is the rate of shrinkage. On the other hand the bigger sizes grow and the acreage concentration of these units has increased significantly. Behaviors were clustered according to their path: taking into account its relationship with both zonal and provincial level stratum averages. Areas like the Oasis Sur have suffered a major a regressive process that has involved almost all the strata. The Uco Valley has shown a significant dynamism in units of more than 25 ha, while the small holdings have moved back, but with lower rates than the average of these strata. The Oasis Norte has also been subject to a bipolar process where a significant loss of small vineyards with the rise of new big holdings. Oasis Este is the only one that remains with lower regression rates.

1. Introduction

The Province of Mendoza is the main wine production region of Argentina. Located in Cuyo region, “*land of the sands*”, it has been inhabited since 1700 BC, according to various authors as Michieli [1] by a small tribe dedicated to fishing, growing vegetables and hunting, which along time was configured as the Huarpes. The foundation of the City of Mendoza in 1561 didn't have any goal of agricultural production, but for local supply. The Oasis Norte preserved pre-Columbian crops. The first vineyards from raisins seeds [2] were planted, also new parishes implanted grapevines from imported stakes. Over the years local production supplied not only Mendoza but surrounding provinces consumption.

During the 2nd half of the 19th Century the railroad arrived, thousands of European immigrants came to work, the system of collection and distribution of irrigation water was improved and new oasis were annexed [2].

The 20th century was marked by cyclical processes of overproduction and shortage [3], reaching in 1980 an acreage of about 250 thousands ha. However, the following decade was signed by decay and abandonment [4].

New viticulture emerged during the nineties. Technological innovations were adopted and competition in land use, primarily from the urban sector, became evident. Like it happened in other countries, the number of vineyard farms decreased. The acreage has also been reduced but it was not at the same rate than the frequency. This fact led to suppose differential behaviors as a result of different

vulnerabilities and capacities of response to changing factors.

The agrarian structure describes the configuration of an agro ecosystem. This configuration includes some attributes such as: land tenure [5,6], social organization [7–12], farming system [10,13,14], capitalization level [7–9,11,15], within this criteria is the size of the holding [11,12,15,16].

A spatial process is a change in system configuration toward a particular direction. The following may be present in this region: 1) Globalization expansion to primary activities [17–21], 2) The fragmentation of farms in units of smaller size, many with smallholder characteristics [22]. 3) Lack of generational change [23]. 4) Abandonment and rural exodus [24,25]. 5) Urban sprawl towards urban rural fringe [26–29]. 6) Polarization between capitalized companies and family farms [12]. 7) Expansion of the agricultural frontier to the edges of the oasis [30]. 8) Increased proletarian labor [31].

The persistence and growth of some of these units, assessed according to the size of the production unit – planted acreage- are analyzed in this paper, under the assumption that these differences may confer adaptability, stability or resilience facing context switches during the passing of the years [32–34]. Several conceptual frameworks are available to study the dynamics of rural systems, but they often lack a clear description of the structural changes and a comprehensive analysis of system properties, which are key aspects of the resilience theory [35]. The need arises to focus over some variables, underlying many times, that can explain the ability to provide system recovery and survival [36]. Finding these

^a Corresponding author: vandenbosch.maria@inta.gob.ar

variables one may be able to recognize productive systems of differential persistence or growth capacity and then designing development strategies [37]. It is therefore essential to characterize these aspects.

This work is a part of a broader project that studies the structure of Mendoza agro ecosystem. The aim is to recognize the historical trajectory from 1988–2008 of vine growers of different strata and allocation, assessed by frequency and area share, under the assumption that the economic size of the holding, measured by the planted acreage is an explanatory factor of differential behaviors. This knowledge is useful for the assessment of sustainability parameters such as vulnerability, resilience, flexibility and stability, to be applied to prospective studies and the design of development strategies. Also, the general characterization of the dynamics allows the formulation of hypotheses of temporal and spatial processes to be addressed in specific strategies of further work.

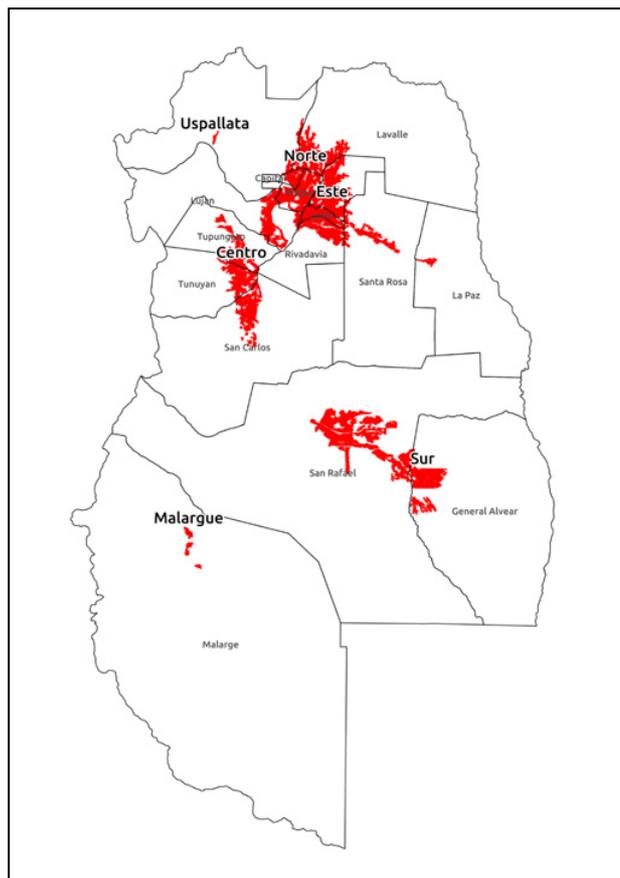
2. Materials & methods

2.1. The Oasis of mendoza province

Mendoza is located in the Central West Argentina; both human settlements and agro industrial activities are settled in anthropogenic oasis developed from glacial water. Each oasis is linked to a river basin, and it is considered an homogeneous agro economic zone: 1) Oasis Norte, the oldest, preexisting of Spanish conquest but developed after it during the 16th century. It includes the Metropolitan Area of Mendoza City (AMM) and comprises the irrigated areas of the Departments of Luján de Cuyo, Maipú, Guaymallén, Las Heras and Llaville. It is watered by the surface and groundwater basin of Rio Mendoza 2) Oasis Este, irrigated by the Lower Rio Tunuyán and partially by Rio Mendoza (Canal St. Martín); it historically was developed as an expansion of the Oasis Norte. Includes the Departments of San Martín, Junín, Rivadavia, Santa Rosa and La Paz. 3) Valle de Uco or Oasis Centro consists of the Departments of Tunuyán, Tupungato and San Carlos and it is irrigated by the Rio Tunuyán Superior and a profuse network of creeks. 4) Oasis Sur aroused late last century. It consists of the irrigated areas of the departments of San Rafael and General Alvear. Water resources are provided by Rios Diamante and Atuel (See Map 1). There are also two minor “oasis”, one corresponding to the Malargüe River and the Valley of Uspallata in the Department of Las Heras.

2.2. Viticulture systems

The data was provided by the user bases of the last three National Agricultural Censuses (CNA) of the Province of Mendoza for the years 1988, 2002 and 2008. Agricultural Farm (EAP) is the unit of analysis, beyond the number of plots (non-contiguous land), each EAP has the same direction or management and the means of production and part of the labor used is the same. It is closer to the figure of the vine grower more than the plot or vineyard. For the purposes of this paper it is agreed that a farm is belonging to Viticulture System when the grapevine is the main crop



Mapa 1. Los Oasis de la Provincia de Mendoza.

(vineyards acreage is bigger than any other area used for other activities that may be present on the farm).

2.3. Size strata

The variable Total Area of the holding includes land of different uses and suitability, with and without water availability. The variable Planted Area is considered better indicator as it accurately reflects the economic dimension. The size strata evaluated were: Very Small (0–4.9 ha), Small (5 to 9.9 ha), Medium (10 to 24.9 ha), Medium-Large (25 to 49.9 ha), Large (50 to 99.9) ha and Very Large over 100 ha.

2.4. Dynamics of farming systems

The intercensal analysis is focused on two attributes: the frequency of EAP and the total planted area as an indicator of the spatial extent of the system. The change was established by comparing the growth or reduction rate of each strata and zone with the average rate of the provincial strata and zone. Table 1 describes the identified trajectory styles, based on the overall dynamics of the whole. In this way it was possible to detect those groups with different behaviors, when they were compared to the average, and this allowed suggesting that this attributes can determine evolutionary strengths or weaknesses.

Table 1. Trajectories according to growth or decreasing rate.

Trajectory	General Trajectory	Group rate compared with general
Very Dynamic	Dynamic	Growth rate higher than general
Dynamic	Dynamic	Growth rate equal than general
Lesser Dynamic	Dynamic	Growth rate lower than general
Stable	Stable	Stable
Lesser Regressive	Regressive	Decreasing rate lower than general
Regressive	Regressive	Decreasing rate equal than general
Very Regressive	Regressive	Decreasing rate higher than general
Dynamic countercyclical	Regressive	Growth rate
Regressive countercyclical	Dynamic	Decreasing rate

Table 2. Provincia of Mendoza. Intercensus evolution of Viticultural EAP by stratus (EAP).

Stratus	Viticulture EAP		
	1988	2002	2008
Total	15.267	10.205	8.549
Very Small	7.930	4.593	3.495
Pequeñas	3.415	2.286	1.872
Medium	2.614	2.059	1.890
Medium Large	815	786	742
Large	348	337	371
Very Large	145	144	179

2.5. Multivariate analysis of trajectories

A data base for each case (stratus and oasis) was performed. The columns are the growth or decreasing rates calculated of the frequency and acreage, compared with zonal and stratum averaged rates. Then it was possible to cluster these trajectories using statistical multivariate analysis procedures, following the recommendations of Hair et al. [38]. From initial variables collinear ones were withdrawn using a correlation test. Then Principal Components were generated and the resulting axes were used for the final classification by cluster analysis using the Average Linkage method. This classification technique allows grouping data with multiple attributes such that the Euclidean distance is minimum within the cluster and maximum among clusters; so homogeneous and different groups were formed.

3. Results

3.1. Evolution at provincial scale

According to Table 2 56% of winegrowers recorded 20 years ago persist; the acreage reduction was not significant as it is held to 94% (Table 3). These figures show that the disappearance is skewing toward smaller ones. The decreasing rates of Very Small and Small

Table 3. Provincia of Mendoza. Intercensus evolution of the planted area in Viticultural EAP by stratus (ha).

Stratus	Planted Area (ha)		
	1988	2002	2008
Total	166.623	138.054	139.903
Very Small	19.032	11.855	9.166
Small	25.558	17.445	14.309
Medium	41.554	33.106	30.434
Medium Large	28.400	27.542	26.259
Large	23.988	23.226	25.535
Very Large	28.091	24.881	34.198

Table 4. Oasis Norte Provincia of Mendoza. Intercensus evolution of Viticultural EAP by stratus (EAP).

Stratus	Viticultural EAP		
	1988	2002	2008
Total	4.006	2.319	2.104
Very Small	2.189	1.236	852
Small	826	628	407
Medium	650	332	467
Medium Large	218	74	209
Large	79	28	107
Very Large	44	20	62

holdings have a Very Regressive behavior when their frequency and acreage were compared with the provincial rate. The frequency rates of Medium ones behave Less Regressive but the acreage rate is Very Regressive. Medium Large rates are Less Regressive. On the other hand the Large and Very Large vineyards exposed a Dynamic Countercyclical behavior. The acreage involved by these two strata increased from 31% to 43% during this period.

3.2. Evolution at oasis scale

3.2.1. Oasis Norte

Only 53% of the EAP persists, following a similar pattern to provincial rates, with more severe retraction in strata from Very Small to Medium. On the other hand, the growth of Large and Very Large ones was higher than average highlighting a polarization process.

The total acreage was not as affected as frequency due to the expansion of the Large and Very Large ones, and it behaves as less recessive than provincial average. The retraction of the area of Very Small and Small was very Regressive, while in the Medium ones it was Less Regressive. Medium Large behave dynamic countercyclical. The concentration of the two biggest grew from 33% to 49%.

3.2.2. Oasis Este

In this zone the amount reduced was less than the provincial average. The most acute reduction is observed also on Very Small farms (Table 6), the others expose a Less Regressive pace, while the Very Large ones show a Dynamic Countercyclical when they face the zonal averages. The reduction rates of all Medium Large are less

Table 5. Oasis Norte Provincia of Mendoza. Intercensus evolution of the planted area in Viticultural EAP by stratus (ha).

Stratus	Planted Area (ha)		
	1988	2002	2008
Total	43.233	36.916	39.951
Very Small	4.912	2.652	2.109
Small	6.170	3.863	3.156
Medium	10.351	8.194	7.579
Medium Large	7.578	7.370	7.616
Large	5.425	6.501	7.411
Very Large	8.797	8.335	12.080

Table 6. Oasis Este Provincia of Mendoza. Intercensus evolution of Viticultural EAP by stratus (EAP).

Stratus	Viticultural EAP		
	1988	2002	2008
Total	6.300	4.830	4.256
Very Small	3.131	2.095	1.707
Small	1.268	1.005	899
Medium	1.234	1.100	1.018
Medium Large	397	396	379
Large	198	176	176
Very Large	72	58	77

Table 7. Oasis Este Provincia of Mendoza. Intercensus evolution of the planted area in Viticultural EAP by stratus (ha).

Stratus	Planted Area (ha)		
	1988	2002	2008
Total	78.018	67.008	66.971
Very Small	7.077	5.260	4.367
Small	9.556	7.712	6.819
Medium	19.938	17.785	16.528
Medium Large	14.005	13.909	13.129
Large	13.506	12.354	12.153
Very Large	13.937	9.987	13.974

recessive than those exposed at the provincial level. The Large farms exhibited a Regressive Countercyclical path down in frequency and extent with respect to the provincial average where they grew. The acreage rate of Medium ones is Very Regressive with respect to zonal average and the concentration of Very Large and Large units grew from 35% to 39%.

3.2.3. Valle de Uco

A slight growth in the number of holdings is registered, unlike in the other zones. These global figures mask regressive processes in lower strata with the important expansion of the biggest, which show a countercyclical path dynamics, comparing with provincial averages all sizes are Less Recessive or have countercyclical dynamics.

The extension of these systems grew by 87%, this expansive process did not reach the Small and Very Small, who lost participation (countercyclical recessive with respect to the area), but they lost fewer area than provincial averages Stratus (Less recessive). Medium and Medium

Table 8. Valle de Uco Provincia of Mendoza. Intercensus evolution of Viticultural EAP by stratus (EAP).

Stratus	Viticultural EAP		
	1988	2002	2008
Total	543	618	559
Very Small	201	176	127
Small	141	150	128
Medium	108	128	131
Medium Large	57	105	87
Large	24	37	60
Very Large	12	22	26

Table 9. Valle de Uco Provincia of Mendoza. Intercensus evolution of the planted area in Viticultural EAP by stratus (ha).

Stratus	Planted Area (ha)		
	1988	2002	2008
Total	8.864	14.075	16.546
Very Small	586	554	420
Small	1.070	1.182	1.022
Medium	1.719	2.110	2.109
Medium Large	2.035	3.772	3.176
Large	1.836	2.525	4.171
Very Large	1.619	3.931	5.649

Table 10. Oasis Sur Provincia of Mendoza. Intercensus evolution of Viticultural EAP by stratus (EAP).

Stratus	Viticultural EAP		
	1988	2002	2008
Total	4.418	2.319	1.630
Very Small	2.409	1.236	809
Small	1.180	628	438
Medium	622	332	274
Medium Large	143	74	67
Large	47	28	28
Very Large	17	21	14

Large holdings have countercyclical surface dynamics in relation to average values of the stratus because they rose, while the rest declined and the elderly surface was more dynamic than the average of stratus, noting that the most significant growth in this group is located in this zone. Concentration in Large to Very Large farms increased from 39% to 59%.

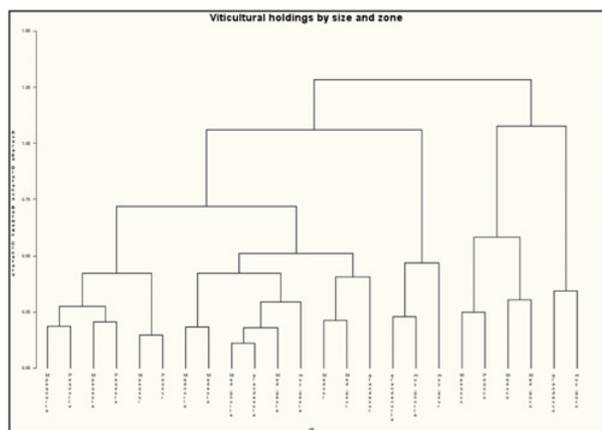
3.2.4. Oasis Sur

In Oasis Sur, only 37% of the holdings seen at the start of the analysis persist, the most important loss at zonal value. Very Small EAP retreated still more (Very Regressive). The rest were less recessive than the zone average.

All the strata of Oasis Sur have very regressive dynamics when compared with the provincial strata average; the large are Counter-Cyclical Regressive (Table 10). The rates of the areas have the same meaning as set forth in frequency properties as shown in Table 11.

Table 11. Oasis Sur Provincia de Mendoza. Intercensus evolution of the planted area in Viticultural EAP by stratus (ha).

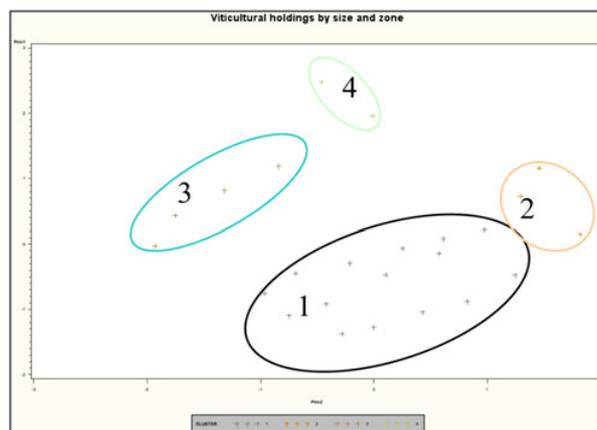
Stratus	Ha Vitícolas y Mixto Vitícolas		
	1988	2002	2008
Total	36.508	20.056	16.435
Very Small	6.458	3.389	2.271
Small	8.763	4.687	3.313
Medium	9.546	5.017	4.218
Medium Large	4.783	2.490	2.338
Large	3.221	1.846	1.801
Very Large	3.738	2.627	2.495

**Figure 2.** Viticultural EAP of Mendoza. Clustering Dendrogram by dynamic rates of stratus and zones.

3.3. Comparing dynamic rates and clustering

Each file in the data base (case) was formed by stratus and oasis; the selected variables to evaluate the dynamic were: 1) rate of growth or reduction of EAP of case/ rate of growth or reduction of EAP of zone 2) rate of growth or reduction of EAP of case/ rate of growth or reduction of EAP on the Stratus 3) Average rate of zone 4) Average rate of Stratus 5) Importance Frequency case. The relative changes in area were collinear and were excluded from the analysis. Four groups emerged as a result of the classification identifying various behaviors. These are described in Table 8. The clustering procedure is exposed in Fig. 2.

Figure 3 shows the distribution of cases according to the resulting clusters. Cluster 1) are holdings of zones with regressive behavior and each one shows Very Regressive or Regressive trajectories, farms Very Small to Medium Large sited in Oasis Norte, all ones in the Oasis Este and the Very Small to Large in Oasis Sur comprise this agglomeration. Cluster 2) is formed by holdings with trajectories slightly higher or lower than the zonal averages and stratus, Large and Very Large vineyards of Oasis Norte and Very Large ones in Oasis Sur were set in this group. Cluster 3) results of grouping cases of recessive dynamic of dynamic areas like Valle de Uco's smaller holdings. The fourth Cluster is composed by Very Dynamic forms in dynamic areas, formed by establishments Large and Very Large in the Valle de Uco.

**Figure 3.** Viticultural EAP of Mendoza. Clustering procedure of sizes and zones by dynamic rates.

4. Conclusions

The variable farm size, assessed by the implanted area showed differential dynamics. It is a factor to be considered in the vulnerability analysis. It is clearly seen that the smaller the holding is, higher is their disappearance rate at the provincial level. This can be explained both by the lack of competitiveness inherent to its smallholder nature, and also to the proximity to urban areas – this group is the oldest and therefore the most “splitted”- and these units become attractive to real estate development. Analyzing the zonal peculiarities, in the Oasis Norte it is observed an increasing polarization process which reduces the number of the most Small and grow Large ones, these processes are carried out at different sectors of the Oasis; peri-urban agriculture yield land of the Small farms while new vineyards are allocated in the foothills of the southern sector and surrounding areas because of agro ecological potential and land structure that fit to larger management units. The two larger sizes changed from 33% concentration of the implanted area to 49%. In this area not only the Large and Very Large units advanced, but also Medium Large, which is not observed in other areas of the Province.

The Oasis Este is the main wine region of Argentina. Although the regression processes are present, Small and Very Small units have reduced, but this rate is less acute than in neighboring Oasis Norte. This fact can be attributed to greater distances to Mendoza Metropolitan Area, which reduces the opportunity cost of land, as well as competition for other resources such as human. Unlike the previous area, it is not observed expansive processes in Large and Very Large holdings and the concentration of area of these grew only by 4%.

This analysis has revealed behavioral differences in the Uco Valley in relation with the provincial values, different dynamics are attributed to both the recognition of their suitability for the wine production of higher ranges, as a low baseline, as the Valley was historically oriented towards the production of pome fruits, horticulture and forestry. However, inward differential phenomena are observed between Small and Large holdings, the first are not involved in the expansion process of the others,

but they decreased at lower rates than the same in other zones. The growth was concentrated in larger farms with dimensions of Medium to Very Large. The concentration in units Large to Very Large shifted from 39% to 59%. Like the Oasis Norte, both processes were spatially separated, the Small ones render up the land to other uses, or were abandoned in traditional areas, and the others scattered on the foothills or located in old areas with other previous activities.

It is in the Oasis Sur where agricultural involution is more remarkable, only one-third of the registered units 20 years before remains. The Very Small vineyards of Oasis Sur constitute the most vulnerable group of all provincial vineyard agro ecosystems. The rest strata are Very recessive, almost all over Mendoza averages. The causes of this phenomenon are assigned as both economic and environmental, due to the high incidence of hail and frost. The demand of land for urban or touristic use is rising, since this activity has grown significantly.

This work is a quantitative first approach; it is a starting point for a qualitative analysis using appropriate tools to explore in an appropriate scale the meanings, logic or family trajectories, which provide better interpretation to this description and improve the explanatory power that by their nature the database of census is insufficient.

While several of the above phenomena are publicly recognized, this paper advances in assessing the magnitude and appreciation of peculiarities. The knowledge achieved here complements the work done in the trajectory analysis of social types.

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