6. ANKARA INTERNATIONAL AEROSPACE CONFERENCE
14-16 September 2011 - METU, Ankara TURKEY

AIAC-2011-073

APPLICATION OF A FIXED-WING UNMANNED AERIAL VEHICLE (UAV) IN REFORESTATION OF LEBANON CEDAR *(CEDRUS LIBANI A. RICH)*

Mustafa ŞAHİN[1]
Erzincan University
Erzincan, Turkey

M. Tülin YILDIRIM[2]
Erciyes University
Kayseri, Turkey

ABSTRACT

Studies and development of Unmanned Aerial Vehicles (UAVs) started shortly after the first controlled, powered, heavier-than-air human flight in 1903. UAVs have many advantages over piloted aircraft, such as minimizing human risk, flying economically, and flying for extended periods of time. Early UAVs were mostly developed for military purposes, but modern development encompasses both military and civilian uses and is now pursued worldwide.

While UAVs serve a number of important civilian functions such as traffic control, pipeline observation, road maintenance, dam surveillance, forest fire search/observation, dispersal of insecticides on rice paddies and determination of harvest periods of agricultural products, their potential in reforestation efforts is untested. They are a promising, highly efficient and practical means of seed dispersal, particularly in hard-to-reach areas. In Turkey, UAVs stand to play a vital role in the ongoing reforestation efforts of cedar trees. Cedars are one of the most valuable and versatile trees in Turkey and have suffered from severe overcutting, as well as overgrazing by livestock over many years. In this study, a civilian UAV was developed specifically for cedar tree reforestation. A model aircraft was modified, and an originally designed and produced seed dispersal system was mounted on the UAV. Two test flights at different altitudes were carried out in Golbasi, Ankara, July 12, 2011.

According to the test flight results, at altitudes of 9 meters and 6 meters, seed dispersal reached widths of 45 and 30 meters, respectively. Further, the density of seed distribution for both tests was compatible with favorable conditions for seed germination. When the test results are examined, the UAV is proven to be a versatile, economical, safe and highly effective tool in reforestation efforts.

Keywords: Unmanned Aerial Vehicle (UAV), Reforestation, Lebanon cedar (*Cedrus libani A. Rich*)

[1] Lecturer in Department of Aviation Management, Email: msahin@erzincan.edu.tr
[2] Assist. Prof. Dr. in Department of Aircraft Electrical and Electronics, Email: tulin@erciyes.edu.tr

INTRODUCTION

Although there are many definitions of Unmanned Aerial Vehicle (UAV) by different aviation authorities [23], it can be defined as a single- or multi-engine-powered aircraft which does not carry a pilot, uses aerodynamic forces to provide lift, can be remotely controlled or can fly autonomously according to a pre-programmed flight plan or with complex dynamic automation systems, and has fixed or removable payloads which are lethal or non-lethal, depending on the nature of the task [10, 13, 15, 21, 24].

Studies and the development of UAVs started in 1916, shortly after the first controlled, powered, heavier-than-air human flight in 1903 [18]. UAVs have many advantages over piloted aircraft. Thus, their usage has gradually risen in both military and civilian applications [20]. Because UAVs do not carry pilots and fly for long periods of time, they were first used and advanced mostly for military aims. The absence of a pilot allowed for flight missions that minimized or eliminated human risk [20]. Later, their usage was broadened into civilian purposes. Though many civil applications have been examined, there is no doubt that many more applications are waiting to be discovered [16]. Originally, UAVs were developed by very few countries, but more recently development in both military and civilian applications has expanded to many countries [18]. As a civilian task, UAVs can have an important potential role in reforestation activities. A prime example of this is the forest service's effort to sow Lebanon cedar trees in Turkey, which are one of the most valuable and versatile evergreen trees in the country. These cedars have suffered from a number of problems in Turkey, such as severe overcutting, as well as overgrazing by livestock. In this study, a civilian UAV was developed specifically for use in the reforestation of Cedar trees.

About Lebanon cedar (*Cedrus libani A. Rich*)

Lebanon cedar (*Cedrus libani A. Rich*) is an evergreen tree, also known Taurus cedar and "katran" in its natural growing areas in Turkey [8]. It is drought resistant, has a tall trunk and can have a lifespan over 1,000 years. It can reach tremendous size and appearance, with a diameter at breast height of up to 2.49 m, height of 46 m [25]. In Turkey, the tree can be mostly seen between 800 and 2,100 meter elevations in the Taurus Mountains. To a lesser extent it is also found at lower (500-600 m) and higher (2,400 m) elevations. Lebanon cedar forms the highest of border forests in the area. Sparse populations of Lebanon cedar are also found in areas such as Sultandağı-Afyon and in the Black Sea Region (Çatalan-Erbaa and Akıncıköy-Niksar) [22, 28].

Cedar trees can be propagated conventionally by means of sowing seeds, planting seedlings and grafting [27]. Sowing is achieved by broadcast seeding, a way that requires spreading seeds either by hand or mechanical spreaders over a relatively large area in agriculture, gardening and forestry [4, 6]. In Turkey, broadcast seeding of Lebanon cedar has been carried out mostly by hand, and recently by helicopters. For example, in 1984, 300 hectares of area were successfully sown in Turkey's first extensive broadcast seeding reforestation project, in Armutkırı, Anamur, Mersin. Its results were positive and triggered the Turkish Forest Service to use broadcast seeding widely, and 40,457 ha of bare karstic lands were effectively seeded between 1984 and 2005 in the Taurus Mountains. Karstic lands are defining as having shallow or medium soil depths and bed cracks. In these conditions, broadcast seeding has many advantages over planting seedlings, as at least one or a few seeds are likely to elongate into the cracks, whereas it is less likely that a seedling will find and penetrate cracks [22]. The Taurus Mountains are nearly 200 km wide, are characterized by high, sharp peaks, deep valleys and narrow gorges, and contain significant karstic terrain [22]. Before and after reforestation by broadcast seeding in karstic land is shown in Figure 1.

a) b)

Figure 1: Karstic land, a) Deforested karstic land in Armutkırı, Mersin, Turkey, b) The same karstic land after reforestation by broadcast seeding, with 16-year-old Lebanon cedar trees (photos by M. Boydak)

Usage of the Lebanon cedar by Humans

Lebanon cedar is important for its aesthetic, cultural, historical, scientific, ecologic and economic influences in Turkey [12, 22, 25]. The wood of the Lebanon cedar is highly durable against rot and atmospheric conditions, and has a unique smell and color. It is easy to process the wood by hand and machine tools. These valuable features always lead it to be in demand, resulting in the destruction of Lebanon cedar forests [22, 25]. Among the evergreen trees, Lebanon cedar is one of the most magnificent and its wood has been of great commercial importance for millennia. Many old civilizations used its wood through the centuries to build homes, temples, ships, railways, fuel wood and palaces. For example, in ancient times, Egyptians bought timbers of Lebanon cedar from southwestern Turkey as early as 2600 B.C. to construct palaces for pharaohs in exchange for papyrus, silver, and gold [14, 17, 19]. Cedar wood also contains a variety of useful chemicals, and as a result it is resistant to insects and pathogens. Thus, the Egyptians also used it widely, including in the mummification process of pharaohs [14]. Nowadays the wood is used for furniture, joinery, fence posts, home and ship construction, paper, fiber, cellulose wood, bridge construction, saunas, paneling, ladders, closets and protective chests that repel vermin, pencils, beehives and the manufacture of chipboard and so on [1, 9, 29]. Today, 1m^3 of cedar wood costs over 600 USD [2].

The Current State of Reforestation Efforts of Lebanon cedar in Turkey

Central Anatolia is within the Mediterranean ecosystem but has the poorest forest cover of all regions in Turkey. To date, some 30 percent of afforested lands in this region are Lebanon cedar, and potential forestation there reaches 1.7 million hectares [11]. Serious rehabilitation and reforestation of Lebanon cedar by the Ministry of Environment and Forestry in Turkey dates back to the 1980s [7]. At that time in Turkey there were 99,325 hectares of Lebanon cedar forests; 67,850 hectares of this region were considered healthy and 31,475 hectares of this region were considered damaged. 61,611 ha. were subsequently planted in the years between 1983 and 1989 [26]. Currently, forest coverage in Turkey covers approximately 21.2 million ha. However, about half of the forests are in distorted conditions. The Ministry launched new reforestation mobilization efforts in the 2000s under the name Action Plans for Forestation and Erosion. One of the action plans was the rehabilitation and reforestation of Lebanon cedar [3]. Extensive reforestation of Lebanon cedar is being carried out not only inside but also outside its natural range in Turkey and other countries such as Italy, Iran and Bulgaria for commercial, soil protection and aesthetic purposes. The Turkish Forest Service planted about 115,000 ha. of Lebanon cedar by the end of 2005; 58,500 ha. inside and 56,500 ha. outside its range [22, 25].

In nature, Lebanon cedars disperse their seeds in winter, starting in late November, and subsequent snowfall protects the seeds from predators and enhances seedling survival. Thus, it follows that the ideal time for broadcast seeding should duplicate this natural cycle. Ideally, broadcast seeding should occur just before a snowfall or on the snow [25]. As noted above, helicopters have been used successfully to sow Lebanon cedar seeds since 2004 for hard-to-reach areas [3]. Broadcast seeding was applied to deforested areas near and within cities such as Mersin, Adana, Antalya, Kahramanmaras, Kayseri, Amasya, Denizli, Mugla and Konya. Until the end of 2010, 101,428 ha of area had been sown. According to the Lebanon cedar action plan mentioned above, between the years 2005 and 2014, it is proposed that 100 billion seeds will be sown in areas suffering from a lack of Lebanon cedar and able to support their growth [3, 5]. One example of broadcast seeding by helicopter is Mount Erciyes in Kayseri in October 2009. Seedlings from that effort are now over 10 cm. in height [2]. As described above, broadcast seeding efforts to date in Turkey have been limited to hand distribution and helicopters. Both methods pose challenges that can be better addressed by the UAV developed and detailed in this study.

a)

b)

Figure 2: Broadcast seeding a) by helicopter in Turkey (photo by Turkish Forest Service Website), b) laborers working in severe conditions (Photo by I. PERAŞAN)

For example, hand distribution has a number of limitations. Because seeds are best applied in winter, workers must often negotiate cold temperatures and terrain that is covered in deep snowfall and extremely difficult to traverse. Further, mountainous terrain is often steeply inclined and highly rugged, as well as covered in brush. An example of this severe condition is shown in Figure 2. Another factor is the amount of the seeds dispersed by hand and the rate of seed distribution. Unskilled workers often deposit seeds unevenly, resulting in areas with too many seeds and areas with too few or none. Thus organization is always necessary for even and thorough seed distribution. Besides, workers are unable to cover large tracts of land on foot, particularly in rugged terrain. Broadcast seeding by helicopter can also result in uneven seed distribution, as the distribution mechanism relies on simple gravity, rather than mechanical, controlled seed dispersal. Moreover, it is economically difficult to use helicopters in this task because of their high operating and maintenance costs.

Rationale for Using UAVs in Reforestation

A UAV with a seed dispersal system has many advantages over distribution by hand or helicopter. A mechanized and controlled seed distribution system, such as that found on the UAV that is the subject of this study, also delivers seeds at a controlled, pre-determined, and highly consistent rate. This is in contrast to manual distribution, which is highly variable. On-board monitoring system also allows for highly accurate seed dispersal, with a camera providing clear sight for the ground control pilot in choosing the best sites for seed delivery. Moreover, as UAVs are able to fly over rugged terrain as easily as smooth terrain, they are an efficient means of transporting seeds in bulk to remote areas that are not served by roads or footpaths. This is far preferable to the current situation, in which tractors, trucks, and even horses are employed to transport seeds to dispersal sites, and in which Forest Services must sometimes construct expensive and environmentally destructive access roads. UAVs offer the distinct advantage of minimizing risk to human life, since they are remotely piloted. Further, this advantage is compounded when applied to reforestation of Lebanon cedar, since seeds are best applied in winter, when unpredictable and extreme weather make both hand distribution and piloted flight much more difficult and dangerous. When compared to manual distribution, UAV seed dispersal is also faster by a great margin. Their horizontal speed far surpasses that of laborers negotiating terrain on foot, and their vertical operational field – anywhere from a few meters to an intended altitude, enables seeds to be dispersed simultaneously in a wide swath. In conclusion, modern UAVs have many duties in civilian applications, including the potential to serve in reforestation efforts, because they are multi-purpose, highly efficient, simple, safe, adaptable to highly specialized tasks, inexpensive to produce and operate, and easy to fly when compared to more traditional aircraft.

METHOD

The investigation into the effectiveness of a UAV in Lebanon cedar reforestation was conducted using a model aircraft as a platform. This aircraft was chosen because of its high durability, stability, suitable wing area to produce sufficient lift, and room for both aircraft avionic systems/components and seed dispersal system. To achieve the aim of the study - the effective and economical dispersal of cedar seeds over large areas - a seed storage and dispersal system was specially designed and mounted inside and under the fuselage of the aircraft, and necessary modifications and design changes on the aircraft were carried out as needed. Following are more detailed specifications of the aircraft, its systems and the seed dispersal apparatuses:

Platform

As a platform, a fixed wing, balsa wood model aircraft was used. This aircraft has suitable room both for avionics systems/components such as camera, video transmitter and standard radio receiver, and also for a seed storage tank and seed spreader. Specifications of the aircraft are as follows:

Wing Span	: 1845 mm	**Max. Operational Range**	: 1000 m
Wing Area	: 58.69 dm^2	**Max. Endurance**	: 25 minutes
Length	: 1414 mm	**Max. Operation Altitude**	: 1000 m
Max. Take-off Weight	: 4500- 5000 gr.	**Visual Range. for F. Controller**	: 300 m
Payload Capacity	: 3000 gr.	**Operation Altitude**	: Up to 50 m
Payload Weight	: 450 gr.	**Payloads**	: Camera, Seed Dispersal System
Max. Cruise Velocity	: 75 km/h	**Landing gears**	: Non-retractable

Avionics Systems/Components

The layout of the aircraft avionics systems on the UAV is shown in Figure 3. A standard radio control receiver was used both for flight controls and to control a pan/tilt camera as well as the seed dispersal system. In addition, the UAV was equipped with a CCD camera and wireless A/V (Audio/Video) transmitter to aid in aircraft navigation.

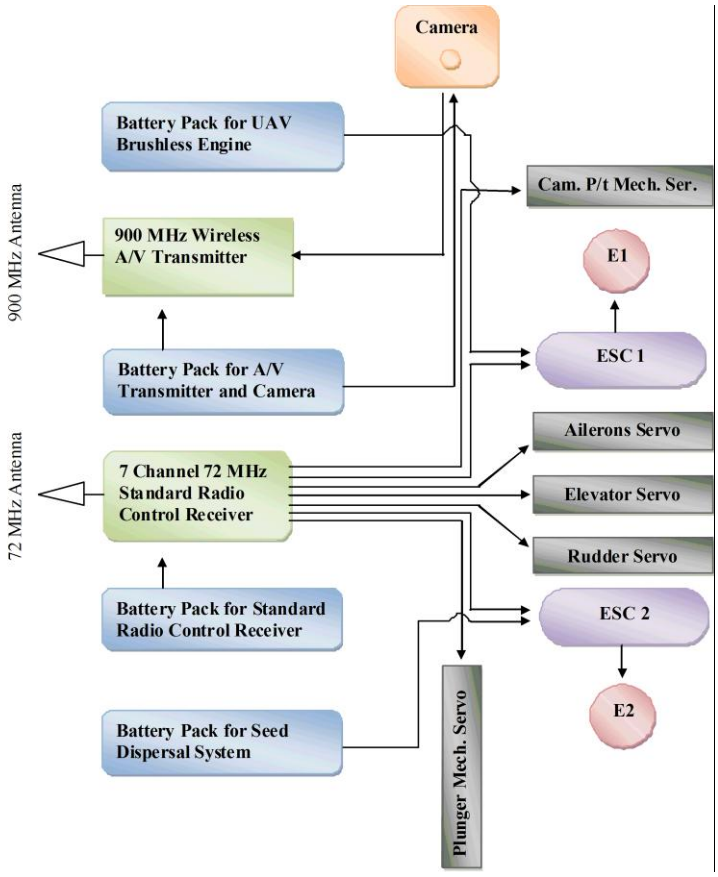

Figure 3: The layout of the aircraft avionics systems

The frequencies of the video transmitter (900 MHz) and the standard 7 channel radio receiver (72 MHz) were purposely different and were physically separated from each other to prevent interference, as shown in Figure 4. The standard receiver was installed on the middle of the aircraft. The antenna of the A/V transmitter was mounted in the aircraft near the front. A wireless A/V receiver captured video information at the Ground Control Station (GCS) via an A/V transmitter antenna and informed the UAV pilot by means of a portable monitor. A camera was used to help the UAV pilot to navigate the craft, to assure the pilot that the seed dispersal system was functioning according to its design, and to inform the pilot when the storage tank was depleted. The camera was mounted on a pan/tilt mechanism allowing for vertical movement, 15 cm away from the seed spreader under the fuselage of the aircraft. A brushless engine (E1) with a propeller controlled via Electronic Speed Controller (ESC1) is used to generate enough thrust force. The flight control surfaces - ailerons, rudder and elevator - were controlled individually by three standard servos, as was the nose landing gear (NLG) steering.

Figure 4: The UAV developed for reforestation of Lebanon cedar

Seed Dispersal System

The seed dispersal system, which was constructed from durable, single-ply cardboard and balsa wood and laminated to increase its rigidity, consists of two main parts: a seed storage tank inside the aircraft's fuselage, and a seed spreader mounted under the fuselage. The seed dispersal system is shown in Figure 5.

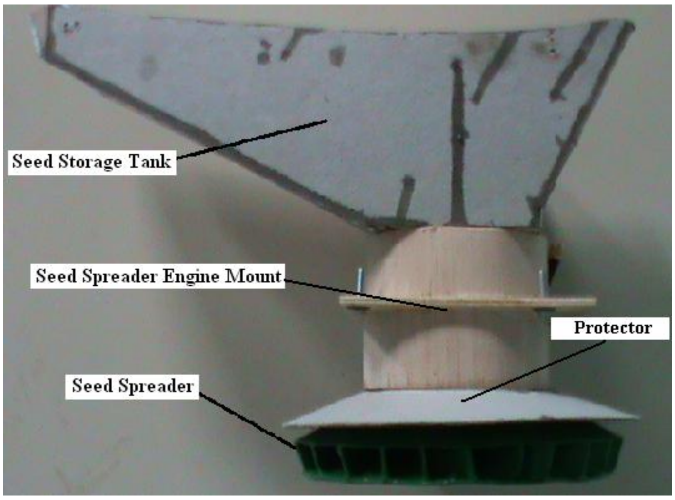

Figure 5: Seed Dispersal System

Seed Storage Tank

The seed storage tank was installed inside the fuselage of the aircraft; most of the fuselage was used for this purpose. The tank volume is 2000 cm^3, holding 570 gr. or about 9,000 cedar seeds. At the base of the tank, there is a plunger mechanism controlled by a servo mounted as shown in Figure 6 below. This serves to control the flow of seeds from the tank.

a) b) c)

Figure 6: Tank a) Seed Storage Tank b) Tank installed on UAV c) Plunger Mechanism

The Seed Spreader

The seed spreader is a circular disk containing a number of interior channels, shown in Figure 7. The disc rotates rapidly and thus discharges the seeds both horizontally and downward, creating a path of even seed distribution as the aircraft advances. The walls of the interior channels are curved in the direction of disc rotation, significantly increasing the centrifugal force on the seeds as they pass through the channels, thus maximizing horizontal distribution and ground coverage of the seeds.

a) b) c)

Figure 7: Seed Spreader a) Top View Without Cover, b) Top View With Cover, c) Bottom/Side View

The seed spreader has a protector (2 mm above the spreader) attached to the spreader engine mount. The spreader is powered by a brushless engine (E2) via an ESC (ESC2), and the rate of rotation is controlled by the UAV pilot at the GCS and determines the width and rate of seed distribution.

Ground Control Station

The GCS is a system that consists of three main parts: a wireless A/V receiver, a 7-Channel standard radio control transmitter, and a monitor. The A/V receiver is used to capture video information from the UAV to navigate and also for the dispersal system. The receiver runs under 12 DC voltages and by means of a cable; the video information is sent to the monitor.

Test Flights of UAV

The first flight of the modified UAV without the seed dispersal system was tested in Talas, Kayseri in February 2011. The flight was successful, confirming that the UAV can be used as a platform for a reforestation study. The aircraft's high durability, stability, ease of operation, economy of use, etc. made it an attractive platform. Later, two different test flights with the seed dispersal system were conducted on July 12, 2011 in Golbasi, Ankara at altitudes of 6 and 9 meters. During the test flights, the aircraft performed suitably, with electronic components transmitting data to the ground station in order to facilitate guidance and seed dispersal. The communication between the UAV and the standard radio control transmitter was significant, so ailerons, rudder, elevator, camera, seed spreader and the pan/tilt mechanism were controlled simultaneously. There were no interferences in avionics and flight controls during either test flight.

Figure 8: Test Flight, July 12, 2011, Golbasi, Ankara

The district was flat. It was a sunny day and the weather conditions were given Table 1

Table 1: Weather Conditions on Test Flight Day

Weather Forecast	Temperature	Wind Speed	Wind Direction
	14,7 °C	5,5 m/s (At around 8 meters)	From the North

Three people were involved in the test flights, one for flying the UAV, one for taking pictures and recording videos and the third for taking notes on aircraft altitude, speed and seed distribution. After two different flight legs, test flight results are shown in Table 2, below.

Table 2: Test Flight Results

Flight Tests	Duration of Seed Dispersal	Position of Plunger	Aircraft Ground Speed*	Altitude*	RPM	Density of Seed Distribution	Width of Seed Coverage	Total Area of Seed Coverage
Test 1	3 sec.	Fully open	45 km/h	9 meters	1800 RPM	20-70 cm	45 m	1700m^2
Test 2	2.5 sec.	Fully open	60 km/h	6 meters	2200 RPM	10-40 cm	30 m	1500m^2
* Estimated values								

The most important criterion to be considered in analyzing the test flight results is the density of seed distribution, which bears a direct relationship to the potential effectiveness of this and any reforestation effort. In the case of the two test flights conducted for this study, several factors influenced the test results, as detailed below.

In Test Flight #1, the aircraft ground speed was 45 km/h, altitude was 9 meters, and RPM was 1800, whereas in Test Flight #2, the speed was 60 km/h, altitude was 6 meters, and RPM was 2200. Generally, all three factors affect the density of seed distribution. The faster the aircraft ground speed, the lower the density of seed distribution. Likewise, the higher the altitude of the aircraft, the lower the density of seed distribution. Finally, the higher the RPM, the lower the density of seed distribution, but the wider the width of seed coverage. Thus, the density of seed distribution can be controlled and predicted by properly combining these factors, with slower speed/lower altitude/slower RPM resulting in greater seed density but less total area of coverage, and higher speed/higher altitude/higher RPM resulting in lower seed density but greater total area of coverage. Total area of coverage depends on flight speed and the position of the plunger inside the seed storage tank, which controls the rate of flow of the seeds. In both test flights, the plunger mechanism was fully open and flight duration was sufficient to measure the effectiveness of the UAV, yet also short enough to conserve the limited number of seeds available for the tests. In Test Flight #1, the total area of coverage was 1700 m^2 meters squares, while in Test Flight #2, it was 1500 m^2 meters squared. It should be noted that both aircraft ground speed and altitude affect the total area of coverage, with higher speed and altitude increasing the area of coverage. Another significant factor is the capacity of the seed storage tank. When the average distance (50 cm) between seeds, aircraft speed, and seed tank capacity are examined for the Test Flight #1, it is estimated that the seed storage tank would reach depletion in approximately 4 seconds, and total ground coverage would be about 2250 meters squared. Figure 9 shows the seed distribution on the ground from the second flight.

Figure 9: Seeds Dispersed by the UAV from the Second Test Flight

CONCLUSION

The objective of this study and the test flights was to determine the overall effectiveness of a specially developed UAV to disburse Lebanon cedar seeds in a manner appropriate for successful and sustainable reforestation efforts. Test results indicate that the apparatus performed according to expectations and that the use of UAVs in reforestation is a viable alternative to existing methods using manual and helicopter distribution. With the most important criteria focusing on the effectiveness of seed distribution, the test aircraft and its seed dispersal system clearly met the expectations of the study and succeeded in proving the effectiveness of UAVs in reforestation efforts. With the many advantages described in this study that are above and beyond basic seed dispersal - such as the economical operation and safety of UAVs - we can conclude that UAVs offer the potential to greatly expand successful reforestation efforts in Turkey and beyond.

ACKNOWLEDGMENT

This work is supported by Erciyes University Scientific Research Projects Unit (Project No: FBA-08-572

References

[1] *“Sedir Ormanlarının Rehabilitasyonu Eylem Planı 2005-2014”*, http://www.ogm.gov.tr/silvikultur/projeler/SEDIR.pdf, 21.05. 2011.

[2] *“Gül'ün serptiği sedir tohumları filizlendi.”,* http://www.zaman.com.tr/haber.do?haberno=1021240, 01.04.2011.

[3] KAHVECİ, O., *“Röportaj-Daha Yeşil Bir Türkiye İçin”*, http://web.ogm.gov.tr/Dkmanlar/roportaj.pdf, 31.03.2011.

[4] *“Slice Seeding vs. Broadcast Seeding”*, http://www.ehow.com/facts_7794825_slice-seeding-vs-broadcast-seeding.html, 17 Şubat 2011, 19.03.2011.

[5] *“Bir Yılda 11 Milyar Sedir Tohumu”*, http://emedya.cumhuriyet.com.tr/?hn=198354, 10 Aralık 2010, 19.03.2011.

[6] *“Broadcast Seeding”*, http://en.wikipedia.org/wiki/Broadcast_seeding, 19.03.2011.

[7] *“ Sedir Ağacı Serüveni Başladı.”*, http://web.ogm.gov.tr/birimler/bolgemudurlukleri/mersin/Haberler/HaberGoruntule.aspx?List=879c6028%2D38a7%2D46a3%2Dbe13%2D117f6d2c0385&ID=115, 14.09.2010, 06.03.2011.

[8] *“Trees of Taurus Cedar (Cedrus libani A. Rich)”*, http://turkonde.cukurova.edu.tr/common/object_show.aspx?id=886, 24.02.2011.

[9] *“Sedir-Cedrus Libani A. Rich. (Familya: Pinaceae)”*, http://www.ogm.gov.tr/agacturleri/agac3.htm, 22.02.2011.

[10] *“Unmanned Aerial Vehicle”*, http://www.theuav.com, 27.08.2010.

[11] GÜLCÜ, S., GÜLTEKIN H. C., ÖLMEZ Z., *“The Effect of Sowing Time and Depth On Germination and Seedling Percentage of The Taurus Cedar (Cedrus libani A. Rich)”*, African Journal of Biotechnology Vol. 9(15), p: 2267-2275, April 2010.

[12] ÖZCELİK, R., and ÜNAL, E., *“Effects of release cutting on the development of young natural Lebanon cedar (Cedrus libani A. Rich) stands of western Mediterranean region of Turkey”*, Journal of Environmental Biology., 30, p: 179-182, March 2009.

[13] ÇAKICI, F., *“Modeling, stability analysis and control system design of a small-sized tiltrotor UAV”*, M.Sc. Thesis, The Graduate School of Natural And Applied Sciences, Middle East Technical University, February 2009.

[14] KURT, Y., KAÇAR, M. S., IŞIK K., *“Traditional Tar Production from Cedrus libani A. Rich on the Taurus Mountains in Southern Turkey”*, Economic Botany, 62 (4), p: 615-620, 2008.

[15] KARGIN, V., *“Design of an autonomous landing control algorithm for a fixed wing UAV”* , M.Sc. Thesis, The Graduate School of Natural And Applied Sciences, Middle East Technical University, October 2007.

[16] NONAMI K., *“Prospect and Recent Research & Development for Civil Use Autonomous Unmanned Aircraft as UAV and MAV”*, Journal of System Design and Dynamics, Vol. 1, No. 2 p:120-128, 2007.

[17] FONTAİNE, M., AERTS, R., ÖZKAN, K., MERT A., GÜLSOY, S., SÜEL, H., WAELKENS M., MUYS, B., *"Elevation and exposition rather than soil type determine communities and site suitability in Mediterranean forest of southern Anatolia, Turkey"*, Forest Ecology and Management 247, p: 18-25, 2007.

[18] COOK, K., L., B., *"The Silent Force Multiplier: the History and Role of UAVs in Warfare"*, Aerospace Conference, IEEE, p: 1-7, March 2007.

[19] YAMAN, B., *"Anatomy of Lebanon Cedar (Cedrus libani A. Rich.) Wood With Indented Growth Rings"*, Acta Biologica Cracoviensia, Series Botanica 49/1, p:19–23, Polish Academy of Sciences, Cracow 2007.

[20] ATAÇ, S., *"GPS Based Altitude Control of An Unmanned Air Vehicle Using Digital Terrain Elevation Data"*, M.Sc. Thesis, The Graduate School of Natural And Applied Sciences, Middle East Technical University, June 2006.

[21] OLLERO, J. R. MARTÍNEZ-DE-DİOS, L MERİNO, *"Unmanned Aerial Vehicles as Tools for Forest-Fire Fighting"*, V International Conference on Forest Fire Research D. X. Viegas (Ed.), 2006.

[22] BOYDAK, M., *"Reforestation of Lebanon Cedar (Cedrus libani A. Rich) in Bare Karstic Lands by Broadcast Seeding in Turkey"*, In: V. Leone and R. Lovreglio (eds), Options méditerranéennes, Series A: Mediterranean Seminars Number 75, 2007

[23] DEGARMO, M. T., *"Issues Concerning Integration of Unmanned Aerial Vehicles in Civil Airspace"*, sponsored by Federal Aviation Administration, The MITRE Corporation, McLean, Virginia, 2004.

[24] FERİT, M., AKYOL, Y., *"İnsansız Hava Aracı Sistemlerinin Dünyadaki Gelişimi ve Uygulamalar"*, Kayseri V. Havacılık Sempozyumu- HaSeM 2004, s: 234-239 , Kayseri, 2004

[25] BOYDAK, M., *"Regeneration of Lebanon Cedar (Cedrus Libani A.Rich.) on Karstic Lands in Turkey"*. Forest Ecology and Management 178, p: 231-243, 2003.

[26] YAHYAOĞLU, Z., DEMİRCİ, A., BİLİR, N., GENÇ, M., *"Comparison of 22 Taurus Cedar (Cedrus libani A. Rich.) Origins by Seedling Morphological Distance."*, Turkish Journal of Biology, Vol: 25, p: 221-228, 2001.

[27] KHURİ, S., SHMOURY M. R., BAALBAKİ R., MAUNDER M., TALHOUK S. N., *"Conservation of The Cedrus Libani Populations in Lebanon: History, Current Status And Experimental Application of Somatic Embryogenesis"*, Biodiversity and Conversation Vol: 9,Num 9, p: 1261-1273, 2000.

[28] YEŞİLKAYA, Y., *"Sedir- Sedirin Ekolojisi"*, Ormancılık Araştırma Enstitüsü Yayınları, s: 53-79, Ocak 1994.

[29] ÖKTEM E., SÖZEN M. R., *"Sedir-Sedir Odununun Anatomik ve Teknolojik Özellikleri ve Kullanım Yerleri"*, Ormancılık Araştırma Enstitüsü Yayınları, s: 287-297, Ocak 1994.