

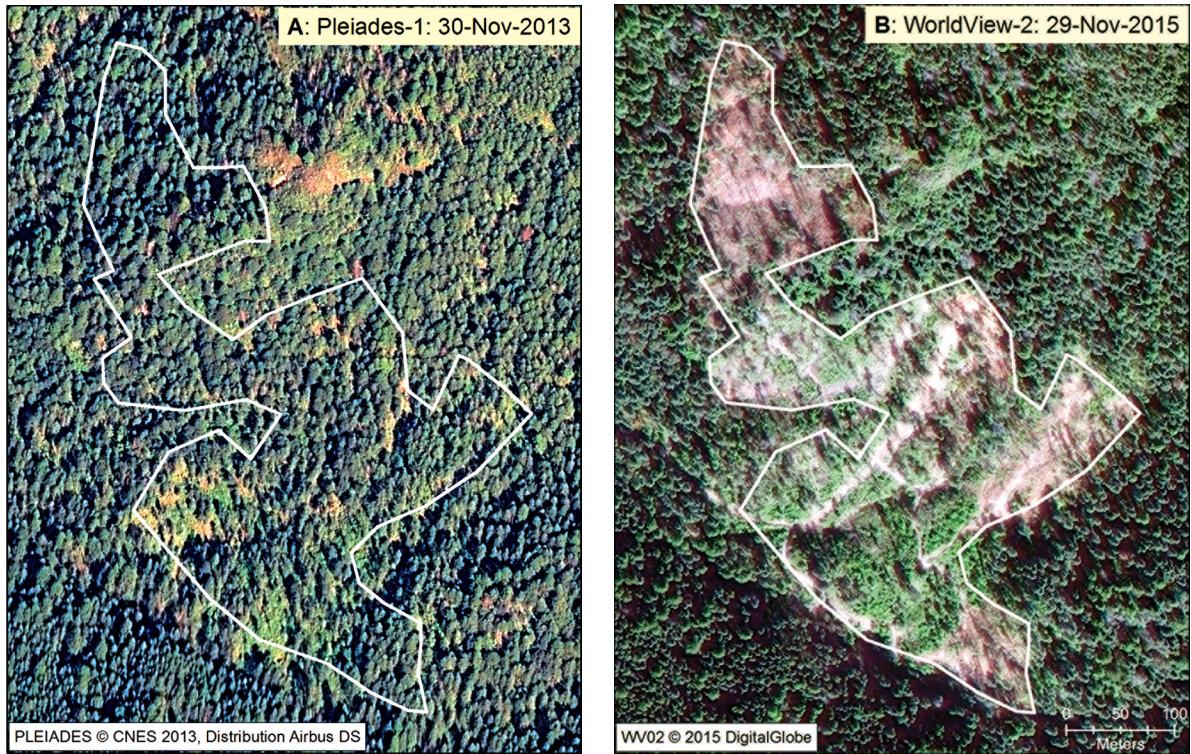
# Illegal Logging of 10 Hectares of Forest in the Sierra Chincua Monarch Butterfly Overwintering Area in Mexico

LINCOLN P. BROWER, DANIEL A. SLAYBACK, PABLO JARAMILLO-LÓPEZ,  
ISABEL RAMIREZ, KAREN S. OBERHAUSER, ERNEST H. WILLIAMS, AND LINDA S. FINK

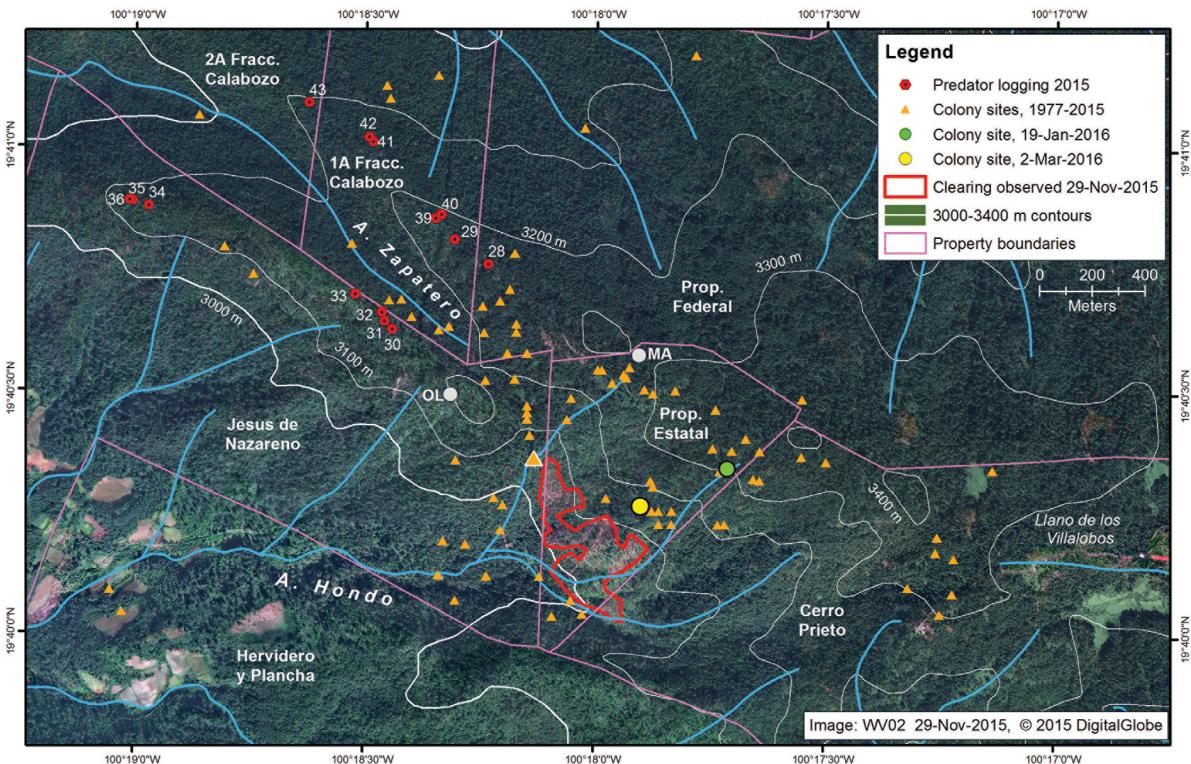
**A**s far as we are aware, the first observation in 2015 of an illegal logging operation in the Sierra Chincua overwintering area within the core zone of the Monarch Butterfly Biosphere Reserve in Mexico was made in April by a local environmentalist who notified Reserve personnel on 10 May (Moisés Acosta, personal communication). A public announcement that the logging was occurring in an undesignated area of the Sierra Chincua was made in a local news article on 26 May 2015 (Rebollo 2015). Several months passed before an official government announcement of the illegal logging was made in a Mexico City press conference on 8 October 2015 (PROFEPA 2015). Rafael Pacchiano, Secretary of SEMARNAT, the federal environmental agency, and Guillermo Haro, Director of PROFEPA (the federal environmental enforcement agency), reported that the Mexican army and police had raided the area and arrested 35 loggers between March and May and confiscated 147 cubic meters of wood that had been illegally logged in the Reserve. The report did not specify where the logging occurred; neither did another press release posted on 21 October (Mejía 2015). On 18 November, Brower received an e-mail from Homero Aridjis, President of the Grupo de los Cien, who was told by a member of a local community that there had been severe cutting in the Sierra Chincua. On 21 November, Mexico News Daily stated that

landowners from the Cerro Prieto and Jesús de Nazareno ejidos (communal agricultural landholdings) in the heart of the Sierra Chincua overwintering area claimed that 9 ha had been clear-cut (Mexico News Daily 2015). Neither we nor other individuals were granted permission to visit the area in order to witness the logging, but we became aware of its severity when we examined current satellite imagery. On 18 December 2015, two of us presented preliminary results of this report describing the location and extent of the incursion to the Third International Symposium on the Monarch Butterfly, held in Morelia, Michoacán. The location of the logging was finally made public on 19 January 2016 (Caballero 2016) and was subsequently acknowledged in a letter to the first author from the National Forestry Commission on 3 February (Rescalá-Pérez 2016). Here we document the logging operation and its potential negative impact on the spring remigration of the monarch butterfly.

**Location, area, and timing of the logging.** We compared a high-resolution satellite image of the Sierra Chincua taken two years before the logging, on 30 November 2013, with another taken after the logging, on 29 November 2015 (Figs. 1A and B; Fig. 2). Inspection of the images indicated that the center of the logged area was at  $100^{\circ}18'1.4''W$  by  $19^{\circ}40'11.4''N$  and that a mosaic of clear-cuts was made in an approximately 10 ha area. Fig. 2 is a



**Fig. 1.** The fir and pine forest in the Sierra Chincua in the Monarch Butterfly Biosphere Reserve showing the area illegally logged in 2015 (outlined in white) which is approximately 10 ha in extent. (A) High-resolution satellite image taken on 30 November 2013, before the logging. (B) The same area on 29 November 2015, after the logging. The operation occurred during April to August 2015. See text for details.



**Fig. 2.** Map of the western Sierra Chincua in the Monarch Butterfly Biosphere Reserve showing the recent ~10 ha clearing. Background is a 29 November 2015 WV02 image (Digital Globe). Also shown are two overwintering areas (the Arroyo Zapatero and Arroyo Hondo); historical overwintering sites; predatory logging sites; property boundaries and names; 100 m elevation contours at and above 3,000 m; and 2016 colony location and its movement downslope. Colony photograph in Fig. 3 is indicated by white-outlined triangle, just northwest of the cleared area.



zoomed-out view (4 km wide by 3 km high) of the same 29 November 2015 image to which we have added several features to clarify how the logging may disrupt the spring remigration of the butterflies. First, Fig. 2 shows the two main overwintering areas in the western portion of the Sierra Chincua, with the Arroyo Hondo to the south and the Arroyo Zapatero located slightly over the ridge to the north. The white lines are 100 m elevation intervals above the 3,000 m contour, increasing to include three peaks above 3,400 m. The blue lines are stream tributaries. Note that the headwaters of both arroyos are at about 3,200 m elevation. The newly logged 10 ha area (as enlarged in Fig. 1B) is outlined in red. Note that the logged area extends from 3,000 to 3,100 m elevation, indicating the severe steepness of the operation (about a 33% slope). The purple lines are boundaries of seven adjoining property parcels within the core zone of the Reserve. Five of these are ejido lands (communally owned or controlled; Honey-Rosés 2009): one is an approximately 70 ha parcel acquired by the state of Michoacán in 1985 (Prop. Estatal), and one is a federal land parcel (Prop. Federal), of approximately 561 ha. Of particular note is the fact that the loggers almost completely avoided the ejido parcels and concentrated their logging on the state land. The area was one of the few with mature forests in the Reserve (Navarrete et al. 2011). It is bordered by the federal property to the north and by the ejidos of Jesús de Nazareno (to the west), Cerro Prieto (to the east), and Hervidero y Plancha (to the south).

**Fig. 3.** Aerial photograph of a 1.34 ha colony taken above the Arroyo Hondo on 11 February 2007. The butterfly colony is indicated by the brownish cast covering the pine and fir trees in the center of the image. This photograph exemplifies the movement of the colonies down the Arroyo Hondo as the winter progresses. The colony location is shown as the large orange triangle in Fig. 2. The overlook labeled OL in Fig. 2 is above the colony in the left center of this image. See text for details. Image by L. Brower, D. Slayback, and I. Ramirez.

**Threat to the butterflies.** To emphasize why the incursion into the Arroyo Hondo is a threat to the integrity of the overwintering phenomenon, we plotted 94 colony locations (orange triangles in Fig. 2) indicating that overwintering in the area has occurred yearly back to the 1977–1978 overwintering season. The single large triangle is the location of the center of the colony shown in the aerial photograph (Fig. 3). OL, the white circle (elevation 3,200 m) also visible in the left center of Fig. 2, is the location of a cliff commanding a view of the headwaters of Arroyo Hondo and is directly above the butterfly colony in the upper left of the aerial image (Fig. 3). MA, the white circle to the right of OL, is the location of a large boulder, a boundary marker known as the Mojonera Alta at an elevation of 3,295 m that is close to where tourists visit the colonies when they are at the top of Arroyo Hondo. To the right center of the image is the Llanos de los Villalobos, where the ecotourism center is located. The extent and location of the logging documented in these figures threatens the integrity of the ecosystem and the monarch colonies.

**When the logging took place.** To estimate when the logging took place, we also examined three Landsat images taken on 15 April 2015, 13 August 2015, and 22 September 2015. These low-resolution images indicated that most of the cutting occurred between April and August. We were informed by the Reserve personnel at the 18 December 2015 symposium that the logging had ceased.

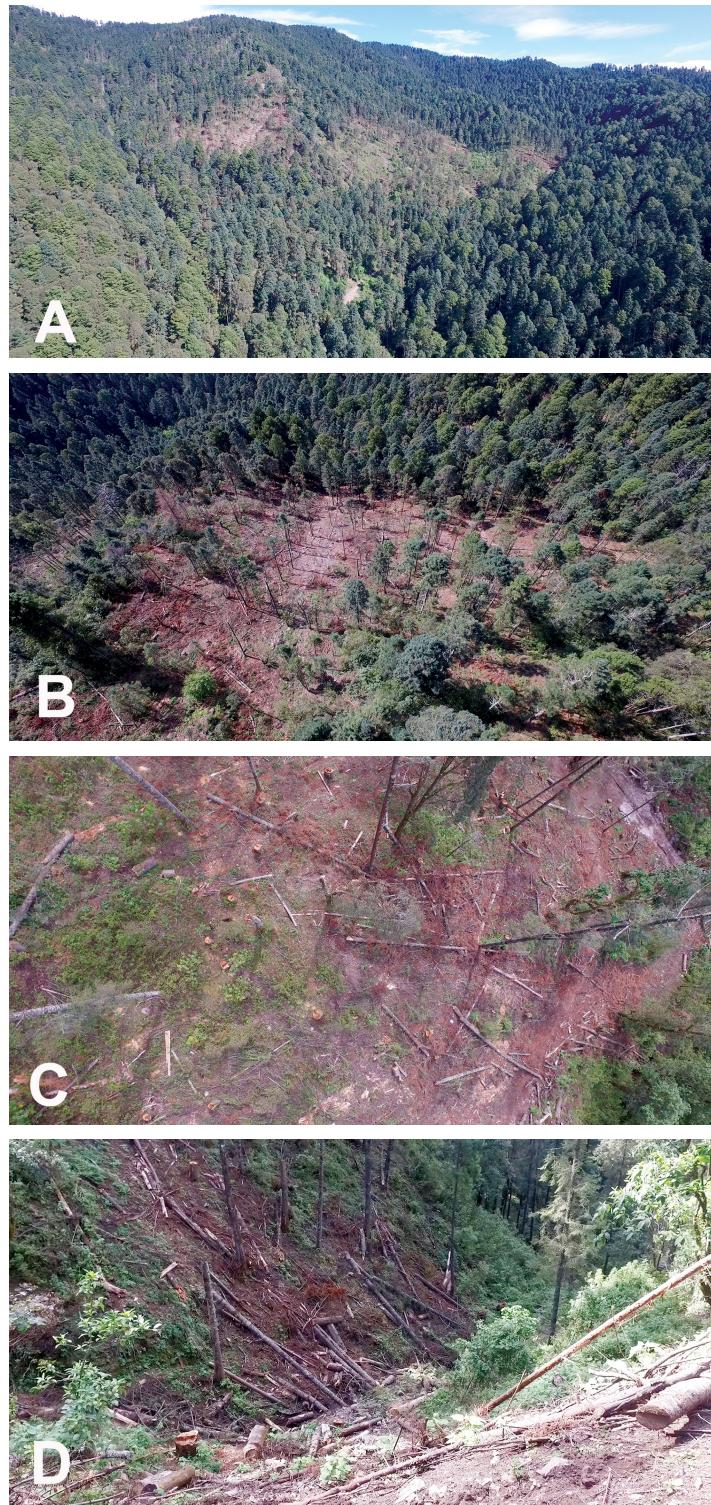
**Severity of the logging.** We obtained high-resolution drone images of the area taken on 9 January 2016 that further document the severity of the operation. The drone was manufactured by DJI (Model Inspire 1, Quadcopter). Fig. 4A is a view of the Sierra Chincua from the west across the massif's southwestern face, showing the logged area on the steep ridge between two stream branches in the Arroyo Hondo (see location in Fig. 2). Figure 4B contrasts a damaged area with the adjacent, intact fir and pine forest. Fig. 4C is a clear-cut area showing numerous tree stumps and logging debris. Fig. 4D shows extensive logging on a ravine and illustrates the extreme damage done to the native vegetation on the steep terrain.

**Historical fidelity of overwintering in this location.** The deterioration of this area is especially egregious because numerous publications dating back to 1977 have documented that monarch butterfly colonies form at the headwaters of these Sierra Chincua arroyos in November and then, as the season advances, move down the slope through mid-March into the area where the logging occurred, and shortly thereafter remigrate to the southern United States (Brower 1977; Calvert and Brower 1986; Malcolm et al. 1993; Brower 1995; Missrie 2004; Rendón et al. 2014). For example, an aerial photograph taken of a 1.34 ha colony on 11 February 2007 (Fig. 3; and located at the large orange triangle in Fig. 2) exemplifies this movement down into a western tributary of the Arroyo Hondo. The butterfly colony can be seen as the brownish cast on the pine and fir trees in the center of the image. As can also be seen in Fig. 2, the clear-cut extends into the area that had been occupied by this 2007 colony and by many other colonies over the past four decades. Fidelity to the area is further emphasized by the fact that on 19 January 2016, a colony was located at the undisturbed headwaters of this same arroyo (the green circle in Fig. 2, GPS location, N 19° 40' 20.6" by W 100° 17' 42.6"). We returned to the area on 2 March 2016 and determined that the colony had moved (as predicted) 350 m downslope adjacent to the logged area (GPS location, N 19° 40' 15.9" by W 100° 17' 53.9"; yellow circle in Fig. 2).

**Potential impact on the spring remigration.** The location of the logging is of particular concern because monarchs consistently move downslope at the end of the winter as spring advances. We do not know what

will happen as this and future years' colonies encounter the now logged area. It is possible that the butterflies will remigrate toward the United States prematurely and fail to recolonize the Gulf Coast states. Alternatively, they may be forced into forested areas with less microclimatic protection. These potential impacts on adult survival and migratory movement are particularly troubling.

**Predatory logging.** In addition to the major clear-cutting operation, ongoing small-scale logging is also



**Fig. 4. Drone images taken in Arroyo Hondo, Sierra Chincua, on 9 January 2016.** (A) View of the Sierra Chincua from the west across the massif's southwestern face showing the 10 ha logged area on the steep ridge between two stream branches in the Arroyo Hondo. (B) Contrast of the damaged area with the adjacent, intact fir and pine forest. (C) Clear-cut area with tree stumps and logging debris. (D) Logging on a steep-sided ravine, illustrating extreme damage to the local rugged terrain. See text for details.



**Fig. 5.** Examples of two trees cut illegally by predatory logging on the Sierra Chincua at locations 28 and 32 in Fig. 2. Images by P. Jaramillo, 2 June 2015.

occurring in the area. In the northwestern portion of Fig. 2 (top left), there are numbered red circles. These are locations in and adjacent to Arroyo Zapatero where, on 2 June 2015, we recorded 16 instances of low-intensity predatory logging (the periodic theft of individual logs as opposed to clear-cutting). This is an ongoing problem in the Reserve (Vidal et al. 2014) that, according to Vidal and Rendón-Salinas (2014), had been halted. These observations indicate that it has not. Figs. 5A and 5B are examples of the predatory logging at locations 28 and 32 in Fig. 2. Predatory logging has also been ongoing on Cerro Pelón: the entire west face of this mountain, where the overwintering was first discovered (Urquhart 1976), has been seriously degraded by several years of predatory logging. We observed that it was still occurring on Pelón on 14 January 2015, and it was again reported in November 2015 (Ellen Sharp, personal communication).

**Biological and aesthetic significance of the area.** Much of what we know about the northeastern North

American monarch butterflies' overwintering behavior, physiology, and ecology comes from published research that international scientific researchers have conducted in these two areas of the Sierra Chincua dating back to 1977. The Arroyo Hondo is also an area of extraordinary beauty; it was, for example, the location of a BBC documentary on the butterflies filmed in 2006 (Barrington 2009). Also, along with the El Rosario, Pelón, and Herra-dá colonies, the area is annually visited by national and international tourists (an estimated 228,000 during the 2014–2015 overwintering season (MiMorelia.com 2015). The Sierra Chincua is a jewel in the crown of overwintering monarch butterflies in Mexico and the severe damage we report here is very disturbing. Studies of monarchs in both their wintering (Brower et al. 2011) and summering habitats (Pleasants et al. 2016 in response to Davis and Dyer 2015) illustrate the importance of the overwintering conditions in these colonies.

**Conclusion.** Examination of satellite and aerial imagery indicates that protection of the Monarch Butterfly Biosphere Reserve, designated as a World Heritage Site in 2008 (UNESCO 2008), has to be improved. The Sier-ra Chincua, Cerro Pelón, and Rosario colony areas have been the three most important overwintering massifs for monarchs since their discovery in 1975. If the migratory and overwintering phenomenon is to persist (Brower et al. 2012), forest protection must be enforced year-round in the entire Reserve. We hope that the U.S. and Canada will join with the people, government, and scientific community of Mexico to provide whatever support is needed to ensure that an effective level of enforcement takes place. In conjunction with measures in the U.S. and Canada to protect and restore breeding and migratory habitat, this support would help to ensure that increasing numbers of monarchs return to the Reserve every winter. We understand that the social and economic pressures in the over-wintering region are complex, and offer our knowledge and support to the current leadership of the Reserve and other individuals and organizations working in this area.

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- Lincoln P. Brower**, Research Professor of Biology at Sweet Briar College and Distinguished Service Professor of Zoology Emeritus at the University of Florida, is applying biological knowledge gained from 62 years of research on the monarch butterfly to the conservation of its endangered overwintering habitat in Mexico. **Daniel A. Slayback** is a research scientist with Science Systems and Applications Inc., at the NASA Goddard Space Flight Center in Greenbelt, MD. His research interests include applications of satellite imagery for land-cover mapping and monitoring. **Pablo Jaramillo-López** is Associate Professor at the National Autonomous University of Mexico (UNAM) in Morelia and conducts research on ways to improve degraded soils and recover deforested areas using organic and semi-organic soil amendments in the Monarch Butterfly Biosphere Reserve in Mexico. **M. Isabel Ramírez** is Research Professor in Environmental Geography at the National Autonomous University of Mexico (UNAM) in Morelia and is conducting research in land use in the Monarch Butterfly Biosphere Reserve and the state of Michoacán. **Karen S. Oberhauser** is Professor of Fisheries, Wildlife, and Conservation Biology at the University of Minnesota and has been studying monarch biology and conservation since 1985. She is the director of the Monarch Larva Monitoring Project, an 18-year citizen science project. **Ernest H. Williams** is the William R. Kenan Professor of Biology Emeritus at Hamilton College, Clinton, NY. He conducts research on the ecology, population biology, and conservation of monarchs and other butterflies. **Linda S. Fink**, Duberg Professor of Ecology at Sweet Briar College, VA, is interested in the physiological constraints on monarch butterfly overwintering.

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