

Evaluation of the Effectiveness of the Pheromone MCH (3-methyl-2-cyclohexene-1-one) in Flake Form for Control of the Douglas-fir Beetle (*Dendroctonus pseudotsugae*) in Sierra la Magdalena, State of Chihuahua, Mexico

Report to the USDA Forest Service, Forest Health Protection International Activities Team

April 29 – May 8, 2011

Connie Mehmel, Forest Entomologist, Wenatchee, Washington



Above: Dr. Guillermo Sánchez Martínez with boxes of MCH laminated flakes, Basaseachi, Chihuahua

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Sierra la Magdalena, State of Chihuahua, Mexico**

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Objective: Validate the effectiveness of the antiaggregation pheromone MCH in flake form (Hercon Environmental, Emigsville, Pennsylvania, USA) to protect Douglas-fir trees from attacks by Douglas-fir beetle in the State of Chihuahua, Mexico

Cooperating Agencies:

- Instituto Nacional de Investigaciones Agropecuarias y Forestales (INIFAP) (National Institute of Agricultural and Forestry Research), Mexico
- Comision Nacional Forestal (CONAFOR) (National Forestry Commission), Mexico
- Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) (Secretariat of Environment and Natural Resources), Mexico
- Silvicultores Unidos de Occidente de Chihuahua (forestry consultants for Ejido Santa Edwiges), Basaseachi, Estado de Chihuahua
- Ejido Santa Edwiges
- United States Department of Agriculture, Forest Service, Forest Health Protection, International Activities Program
- United States Department of Agriculture, Forest Service, Pacific Southwest Research Station



Photo 1: Left to right: Ing. Sergio Robles, Ing. Luis Vitella, Ing. José Luis García, MC Ernesto González, Rafael Hernández, Connie Mehmel, MC Juan Antonio López, Dr. Guillermo Sánchez. Not pictured: MC Marco Chamorro, Ing. Sergio Quiñones, Ing. Antonio Olivo, Capt. Jorge David Coughanour, Catalina Rodríguez, Fausto Pérez, Jeff Webster, Sylvia Mori, Nancy Gillette

Participants (Photo 1):

- Dr. Guillermo Sánchez Martínez, Principal Investigator, INIFAP, Campo Experimental Pabellón, Pabellón de Arteaga, Estado de Aguascalientes, MX
- MC Ernesto González Gaona, INIFAP, Campo Experimental Pabellón, Pabellón de Arteaga, Estado de Aguascalientes, MX
- Rafael Hernández Ávila, Técnico, Ayudante de Entomología, INIFAP, Campo Experimental Pabellón, Pabellón de Arteaga, Estado de Aguascalientes, MX
- MC Marco Antonio Cortés Chamorro, Mecanización e Instrumentación, INIFAP, Campo Experimental Pabellón, Pabellón de Arteaga, Estado de Aguascalientes, MX
- MC Juan Antonio López Hernández, INIFAP, Red de Manejo Forestal Sustentable, Campo Experimental “Valle del Guadiana”, Durango, Estado de Durango, MX
- Ing. José Luis García Pérez (José Luis), Auxiliar de Investigación (INIFAP), Durango, Estado de Durango, MX
- Ing. José Luis Aguilar Vitela (Luis), Secretaría de Recursos Naturales y Medio Ambiente, Gobierno del Estado de Durango, MX
- Ing. Sergio Quiñones Barraza, CONAFOR, Durango, MX
- Ing. Antonio Olivo Martínez, CONAFOR, Chihuahua, MX
- Ing. Sergio Robles, Salud Forestal, Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), Gobierno Federal México
- Capitan Jorge David Coughanour Buckenhofer, Application Pilot, Chihuahua, Chihuahua
- Catalina Rodríguez García, Silvicultores Unidos de Occidente de Chihuahua
- Fausto Pérez Hernández, Silvicultores Unidos de Occidente de Chihuahua
- Connie Mehmel, Forest Entomologist, USDA Forest Service, Wenatchee, WA, USA
- Jeff Webster, RPF and Aerial Application Specialist, Redding, CA
- Sylvia Mori, Statistician, USDA Forest Service, Pacific Southwest Research Station, Berkeley, CA (statistical review of the study proposal)
- Dr. Nancy Gillette, USDA Forest Service, Pacific Southwest Research Station, Berkeley, CA (provided consultation regarding study design and MCH flakes for implementation)

Background

Douglas-fir in Mexico

Douglas-fir (*Pseudotsuga menziesii*) reaches the southernmost extent of its range in the Sierra Madres of northern Mexico, where it can be found in the states of Chihuahua and Durango, and the Sierra Madre Oriental as far south as Mexico City. Although the state of Chihuahua is 40% desert, Douglas-fir grows and reproduces well on north-facing slopes at high elevation where environmental conditions are favorable. We saw abundant reproduction in shaded forest openings (Photo 2).



Photo 2: Douglas-fir reproduction, Sierra la Magdalena

Douglas-fir is a legally protected species in Mexico. Cutting of live trees is not allowed. The Douglas-fir beetle, *Dendroctonus pseudotsugae*, is the most important damaging insect to populations of Douglas-fir in the Mexican states of Durango, Chihuahua and Coahuila. Douglas-fir beetle activity was high and many large trees were killed during the 1990s and 2000s. The primary method of control has been monitoring and prompt salvage, while larvae and adults are in the cambium. After cutting, the logs and stumps are debarked and treated with insecticide. When properly implemented, this has been an effective treatment. Local foresters report that many trees will survive a single year of attack. Therefore, policy states that Douglas-firs cannot be cut until the foliage has begun to turn yellow. Live larvae are often found in trees with yellow foliage. This is different from the Douglas-fir beetle life cycle generally observed in Washington and Oregon, where few trees survive mass attack and most larvae complete their development and fly from the attacked tree before the needles turn yellow.

Land managers in Mexico continue to seek out ways to reduce the amount of tree killing. There is substantial interest in using the antiaggregation pheromone MCH to prevent attacks by Douglas-fir beetles. MCH is currently available in two formulations:

1. Plastic “bubble capsules” are designed to be stapled to trees in a grid pattern throughout the area to be protected. A 12 meter by 12 meter grid is equivalent to 29.6 g. of active ingredient (AI) per hectare, a rate which has been demonstrated effective in the United States. The bubble cap formulation was tested and found effective in the State of Durango in 2009, and in the State of Chihuahua in 2010.
2. A plastic laminated flake formulation is available for application over large or remote areas, or where steep terrain makes application of bubble caps impractical. The flakes are 6.25 mm² and each flake contains 3.88 mg. MCH at the time of production. An application rate of 0.25 k/ha is equivalent to 29.6 g AI/ha. Flakes can be applied aerially using helicopter or fixed-wing aircraft. They can also be hand-applied using fertilizer spreaders. The flakes are produced by Hercon Environmental of Emigsville, Pennsylvania. They were registered by US EPA in 2008 to be applied at a maximum rate of 741 g AI/ha, equivalent to 6.34 kg of flakes per ha.

Prior to registration, MCH flakes were tested in Chelan County, Washington at three application rates: 29.6, 185.3, and 741 g AI/ha. All three levels interrupted beetle flight into treated blocks and reduced the number of attacked trees to near zero.

Study Site

The study was carried out in Sierra la Magdalena near the town of Basaseachi, Ejido Santa Edwiges, State of Chihuahua. The forests of Sierra la Magdalena receive an average of 600-700 mm of rain during the months of June through August. The average elevation is 2,000 to 2,300 meters. The terrain is rugged, with rock outcroppings and slopes exceeding 70%. Douglas-fir at this extent of its range has narrow microclimate requirements, commonly growing mid-way up steep, rocky, north-facing slopes. It grows in association with *Pinus arizonica*, *P. ayacahuite*, *P. engelmannii*, *Populus tremuloides* and juniper.

Role of USDA Forest Service, Forest Health Protection International Activities Program

In June 2008, forest entomologist Debra Allen-Reid and I accompanied representatives of INIFAP and CONAFOR on a reconnaissance trip to the Sierra Madres to view potential MCH test sites and discuss plans for installing a trial to support possible registration of MCH in Mexico. In April 2009 we returned to the Sierra Madres to assist in implementing the initial test of MCH bubble caps. Both trips were funded by the Forest Health Protection (FHP) International Activities Program.

In May 2011, with support from the International Activities Program, I assisted Dr. Guillermo Sánchez Martínez in the implementation of a test of aerial application of MCH flakes. The test took place in Sierra la Magdalena, Basaseachi, Chihuahua. The application aircraft was a Piper Pawnee with a Venturi system piloted by Capt. Jorge David Coughanour Buckenhofer. Assistance in aircraft calibration was provided by Jeff Webster of Redding CA. Jeff was instrumental in carrying out dose tests of MCH flakes in Chelan County, Washington prior to EPA registration.

Methods

The trial was set up to evaluate four application rates:

- 29.6 gm AI/ha (0.25 kg/ha, 0.8 flakes/m²)
- 185.3 gm AI/ha (1.6 kg/ha, 5.2 flakes/m²)
- 741 gm AI/ha (6.34 kg/ha, 20.7 flakes/m²)
- Control (no treatment).

Variables of interest were:

- number of Douglas-fir trees successfully attacked in the current season
- number of Douglas-fir beetles captured in baited traps.

Each treatment was replicated four times. Four plots of approximately 1 ha each had been selected by Dr. Sánchez in advance of my trip based on available host and Douglas-fir beetle activity in the vicinity. GPS units were used to navigate to plot centers and to record location coordinates. Douglas-fir beetle attacks will be monitored on a sub-plot (*la parcela útil*) in the center of each treatment and control plot, an area of 0.12 ha.

Immediately after treatment, two Lindgren funnel traps baited with Douglas-fir beetle attractant pheromone will be placed near the center of each treatment and control plot to monitor beetle flight. Beetles will be collected weekly by an employee of *Silvicultores Unidos de Occidente de Chihuahua* under contract with INIFAP.

Summary of Activities

Saturday, April 30

I arrived at Aguascalientes International Airport at 7:55 p.m. My luggage was searched upon arrival. I was carrying 15 kg of blank laminated flakes (flakes containing no MCH) to be used in calibration of the aircraft. Dr. Sánchez had provided me with a letter of introduction explaining the nature and purpose of the flakes, which satisfied the *agente aduanal*. I was able to proceed with no difficulty. Dr. Sánchez and his wife, María met me at the airport and took me to my hotel.

Sunday, May 1

At the time I made my reservations we had discussed the possibility of traveling to the field site today, but the travel day was changed to Monday. This gave me a day to walk around Aguascalientes. I visited *Parque de los Héroes*, a nature/sports park established in 1989, and the *Centro Cultural*.

Monday, May 2

I arrived at the INIFAP office with Dr. Sánchez at 8:00. We met MC Ernesto González, MC Marco Chamorro and Rafael Hernández and packed equipment for the MCH test. We began traveling to Chihuahua at 9:30 a.m.

We arrived at the Hotel Mirador in Chihuahua in the evening. There we met with MC Juan Antonio López and Ing. José Luis García from the INIFAP office in Durango. They worked with us all week.

Tuesday, May 3

We left the Hotel Mirador at 8:30, purchased food for our stay in Basaseachi, and stopped at the office of the Comisión Nacional Forestal (CONAFOR) to meet with Antonio Olivo, one of the participants in the 2009 bubble cap test. Antonio traveled with us to Basaseachi and worked with us all week.

We stopped at Ejido Santa Edwiges to talk with Fernando, a local resident who assisted Guillermo during MCH bubble cap testing last year. Fernando had indicated an interest in collecting beetles from traps to be placed in test plots this year, but today he told Guillermo that he now has another job and is no longer available.

We arrived at Sierra la Magdalena at 5:00 p.m. We spent the next three hours marking the centers of plots 1 through 5. In the evening we traveled to Cabañas el Rincón at Basaseachi, where we rented cabins for the next four nights. We were joined by Ing. Sergio Robles of SEMARNAT, who worked with us for several days. SEMARNAT is the agency that gives official permission for this experiment.

Wednesday, May 4

This morning we stopped at the office of *Silvicultores Unidos de Occidente de Chihuahua* in Basaseachi, where Guillermo arranged for a technician to collect beetles from the traps in the study plots. Collections will be made weekly.

The *Silvicultores* work station includes a nursery where pine seedlings are grown for post-fire restoration. The nursery suffered heavy seedling mortality during an unusually cold winter this year. Temperatures in February dropped to -22° C for several days, a cold event that happens approximately once every 50 years. Trees and shrubs were damaged in many parts of the state.

We spent Wednesday marking corners of test plots, attempting to make the corners visible from the air (Photo 3). The pilot will have GPS center points for each plot, but he will not have files in AgNav. The small size of the test plots (1 ha) makes it unworkable to use AgNav for aerial application using a fixed wing aircraft with a Venturi application system.



Photo 3: Dr. Sánchez tying flagging in a tall Douglas-fir. A “net” of flagging was suspended over the road to make this plot corner visible to the pilot.

Thursday, May 5

This morning Guillermo, Antonio, Sergio Robles and I drove to the Basaseachi airstrip and met with Capt. Jorge David Coughanour Buckenhofer. Jorge arrived in Basaseachi this morning to discuss tomorrow’s scheduled calibration, and to take a reconnaissance flight over the test area in his Cessna 180 (Photo 4). He reported that he was able to see most of the plot corners we put up yesterday.

At noon we joined the rest of the crew (Ernesto, Rafael, Marco, Luis, José Luis, Sergio Quiñones, Catalina Rodríguez and Fausto Pérez) at Sierra la Magdalena to continue marking plot corners.

At 6:30 p.m. Guillermo, Marco, Antonio and I left Sierra la Magdalena and traveled to Chihuahua where calibration was to take place on Friday. We drove in two vehicles. We arrived in Chihuahua at midnight and checked into the Hotel Mirador.



Photo 4: Sierra la Magdalena test site as seen from the air.

Friday, May 6

At 7:00 this morning we met with aerial application specialist Jeff Webster of Redding, California, who arrived in Chihuahua last night. The four of us traveled together to a nearby airstrip east of the city, arriving at 9:00 a.m. There we met with Rafael, a colleague of Jorge David, who calibrated the Pawnee Piper.

The Piper was equipped with a Venturi application device. The Venturi provides suction at the drop gate but does not provide any positive control of material flow. Calibration required considerable trial and error. For each calibration attempt, the pilot would set the drop gate aperture to some agreed-upon point. The aperture settings were numbered one through five with several intermediate markings; “one” being the narrowest aperture and “five” being the widest. We would place a known weight of material into the hopper. The pilot would fly over the airstrip at a speed of 150 km/hr and a height of 45 m, holding the drop gate open for approximately three seconds. Seconds were measured by counting (“one Mississippi, two Mississippi, three Mississippi”). We laid weed barrier fabric on the airstrip so we could see the distribution of flakes (Photo 5). When the pilot landed we weighed the material remaining. We were able to estimate the rate of application by measuring the swath width and length, and determining the amount of material released. We did this repeatedly until we were able to determine aperture settings that would (approximately) achieve each of the three desired rates of application, assuming flight altitude of 45 m and speed of 150 km/hr. We were unable to achieve the lowest desired rate (0.25 kg/ha). Using the smallest possible aperture the rate was approximately 0.325 kg/ha. It was also difficult to find an aperture setting for the highest dose (6.35 kg/ha). We finally settled on 4.32 kg/ha. We were only able to achieve satisfactory calibration for the moderate dose (1.6 kg/ha).

Capt. Jorge David arrived in the early afternoon to observe the calibration and discuss plans for application on Saturday. Guillermo decided to start application with the highest dose (4.32 kg/ha). Jorge David would apply 4.34 kg of MCH flakes to plots 1, 6, 7 and 13. He would then do all of the medium dose plots. The low dose plots would be done last. Each plot would require three swaths at 150 km/hr at a height of 45 m.

The calibration process took nine hours. Guillermo, Marco, Antonio, Jeff and I left Chihuahua at 6:00 p.m. to return to Basaseachi. We arrived at Cabañas el Rincón at midnight.



Photo 5:
Calibrating the Piper at the Chihuahua airstrip. We laid black weed barrier fabric on the ground so we could see the distribution of flakes.

Saturday, May 7

We left Cabañas el Rincón at 5:00 a.m. Jeff, Antonio and Marco went to the Basaseachi airstrip to work with Jorge David and the aircraft. I went to Sierra la Magdalena with Guillermo and the rest of the crew, arriving just after daylight. Guillermo divided us into 12 two-person crews, one crew for each treatment plot. Guillermo and I went to plot 1, which was the first plot scheduled for treatment. I placed four, three m² pieces of weed barrier cloth in the plot – one in the center, two on the east interior boundary and one on the west interior boundary – in order to monitor the distribution of flakes (Photo 6). At 8:00 I positioned myself on the road at the southwest outer plot corner in order to signal the pilot if he had trouble seeing the corner mark. While I waited

for the aircraft I strung flagging back and forth across the road for additional visibility. Guillermo was positioned on the road at the south east corner with the truck. He covered the top of the truck with bright red fabric for additional visibility. We had no radio communication with the pilot while he was in the air. Guillermo was able to communicate with the airstrip by cell phone from a few spots at the test site. My cell phone did not work at all at the test site.

Jorge David flew over the plot at 9:00. He was carrying 4.32 kg of flakes; enough to treat one high dose plot with three 1.44 kg swaths. I flashed a signal mirror in order to catch his attention. He flew over several times, finally completing a single swath before returning to the airstrip. He dropped most of the flakes above the road, although the entire plot was below the road. Jorge David returned to the airstrip carrying 3.02 kg of flakes. This means he applied 1.33 kg, or 90% of the target amount for one swath. Guillermo talked with the pilot by cell phone after the aircraft landed. Jorge David reported that he had been unable to see me, Guillermo, or any of the plot corners.



Photo 6: Flake distribution at the center of Plot 1 after treatment. Target flake distribution was 20.7 flakes per m².

At the airstrip Jeff and Marco loaded 14.26 kg of flakes into the hopper. Jorge David took off for the second time carrying a total of 17.28 kg; enough to treat all four high dose plots. He returned to Plot 1 and treated it successfully. He flew to the vicinity of Plot 6 and attempted to treat it, but he was not able to locate the corners. He was able to see a hectare of Douglas-firs with evidence of bark beetle damage, so he applied MCH flakes to that hectare. He finished treating the second hectare at 10:50. By that time the wind was blowing at 8-16 km/hr. He returned to the airstrip at 10:57, unable to continue application because of high wind.

The aircraft had 1.99 kg of flakes in the hopper when it returned to the airstrip. If two plots had been treated with 4.32 kg each, there should have been 8.64 kg remaining in the hopper. Jeff and Jorge David concluded that an error occurred in the pilot's timing. In other words, Jorge David held the drop gate open for 4.5 seconds per swath instead of the approximately 3 seconds used during calibration. This seems like an adequate explanation, but there is no way to be sure.

At 1:00 p.m. Guillermo and I returned to the airstrip for a closeout meeting with Jorge David, Jeff and Marco. Guillermo and Jorge David agreed to try again on Sunday, with an earlier start. Rather than try again to apply flakes in Plot 6, Guillermo decided to move the plot to coincide with the area where today's application actually took place.

Unfortunately, Jeff and I both had planes to catch on Sunday. Marco would monitor aircraft loads on Sunday.

In the afternoon Jeff, Marco and I met at Cabañas el Rincón so Jeff and Marco could go over the details of loading the aircraft and calculating application rate. Since Jeff speaks only English and Marco speaks only Spanish I did my best to translate for them.



Photo 6: Post-application closeout meeting. Left to right: Guillermo, Jorge David, Antonio, Marco, Jeff

At 5:00 p.m. Antonio, Jeff and I left Basaseachi and headed for Chihuahua, where Jeff and I would catch our departing flights on Sunday. Antonio had agreed to drive us, as he lives in Chihuahua. We arrived in Chihuahua at 10:00 p.m. and checked into the Hotel Mirador.

Sunday, May 8

Jeff and I both boarded Continental Airlines flight 2313 to Houston, Texas at 8:00 a.m. From Houston we boarded flights to our home units.

Outcomes/Next Steps

On Monday, May 9 Jorge David attempted to apply MCH to plots 7 and 13. Unfortunately he was unable to locate plot corners, and all of the flakes were applied outside the plots. Guillermo decided to treat the remaining plots by hand-applying flakes using fertilizer spreaders. During

the week of May 23 Guillermo, Ernesto, Rafael, Juan Antonio and Luis completed the application, set up beetle traps and collected detailed stand structure information with assistance from two employees of INIFAP Chihuahua. The beetle traps will be checked and the catch collected weekly.

In October each interior plot will be re-surveyed to determine the number of new Douglas-fir beetle attacks. Dr. Sánchez has requested assistance from FHP International Activities in post-treatment surveys, if funding is available. Data will be analyzed during the winter of 2011-2012.

We experienced the following problems during our test:

- We were unable to control or determine the actual rate of application. This can be corrected if the application aircraft has a positive flow control device.
- The pilot was unable to locate the target area. This can be corrected by providing the pilot with a good topographic map and shape files in a format to fit his GPS swathing system (AgNav, Satloc, etc). Shape files can be prepared ahead of the application date if internet access is not available on site. Without such a system, a pilot flying in steep, forested terrain will find it very difficult to locate the target area with any precision.

If MCH flakes are demonstrated effective at providing stand-level protection to Douglas-firs at risk from bark beetle attack, they could represent a valuable tool in the protection of rare stands of Mexican Douglas-firs. The next step would be to develop adequate aerial application technology.

For long term protection of Mexican Douglas-firs, thinning to increase the vigor of regeneration may be warranted. At present such treatment is not allowed under Mexican law, but it could have significant merit. Increasing stand vigor by reducing stress due to overstocking may have greater long term benefits than yearly or periodic application of MCH during Douglas-fir beetle outbreaks caused by drought or other environmental disturbance.