The Lunar X Files: a fleeting vision near the crater Werner

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Introduction

Every month—or to be more precise, every 29.530589 days—the Moon cycles through its phases and alternately reveals and hides the features on its surface. As experienced lunar observers know, the appearance of a particular surface feature depends on the relief of the feature (that is, the height of the feature above or below the surrounding terrain) and the angle of the illumination of the Sun. The interplay of these two parameters leads to countless lunar landscape views, luring dedicated observers back time and time again to observe, sketch, and photograph the Moon. On any night, good lunar hunting is found at the terminator, that is, the line of demarcation between the dark and light portions of the lunar disk. The term "line" is used very loosely here, as the terminator can become fairly convoluted, especially in rough areas. In extreme cases, one can see mountain peaks and crater walls that have been "caught in a noose of light"[1] and stand out brilliantly against the surrounding blackness. This high contrast is aided by the lack of an atmosphere on the Moon, as there is nothing to scatter sunlight into the shadows and soften the lighting. Are there any astronomers out there who yet to watch sunrise on a prominent lunar feature?

Figure 1: The Moon showing the Werner X taken with a Televue 70 mm Pronto refractor, 2X Barlow, 13 mm Nagler eyepiece, and Canon Digital Rebel XT camera (Dave Lane 2007-01-25, ~2345 UT).

A particularly striking phenomenon occurs at the terminator around First Quarter phase: an illuminated X shape that appears for an hour or so at lunar coordinates (25.5S, 1.1E) just northwest of the crater Werner. (See Fig. 1.) Although it must appear every month, the Werner X does not seem to be well known. There is evidence that the X has been observed (or at least photographed) in the past, but the author has been unable to find any written documentation of the X published before he noticed it in August 2004.[2] The author succeeded in observing the X for a second time in November 2005 and for a third time in January 2007, and just missed observing the X on several other occasions. Others have seen the X on those dates, some dates in between, and evidently beforehand. If one knows when and where to look, the Werner X can be observed by anyone with a modest telescope or even well-supported binoculars.

Since August 2004 there has been a flood of

[1] Edward FitzGerald's translation of the *Rubaiyat of Omar Khayyam* opens with: Awake! for Morning in the Bowl of Night / Has flung the Stone that puts the Stars to Flight: / And Lo! the Hunter of the East has caught / The Sultan's Turret in a Noose of Light.

[2] Note that the author is not claiming to have been the first to see it. He chose his words carefully!

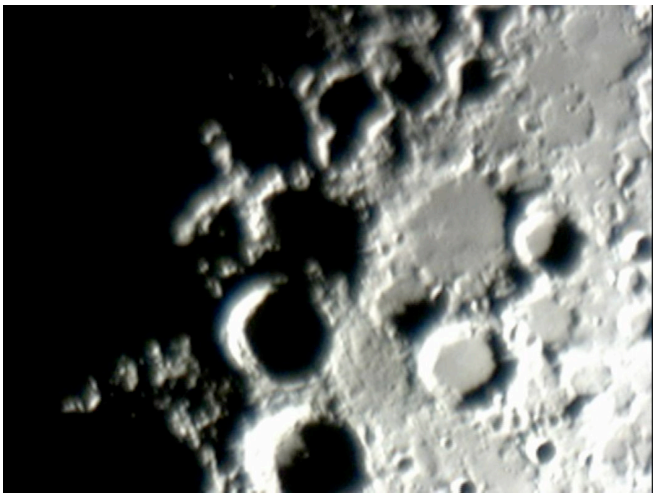

Figure 2: A close-up of the Werner X taken with a Meade C11 and Philips ToUcam PRO II webcam (Randy Attwood, 2007-01-26, 0138 UT).

observations, sketches, photographs, discussions, and predictions of the Werner X posted on the internet., e.g. www.cloudynights.com. The author published a letter on the Werner X in the Nov/Dec 2004 issue of *SkyNews*, along with a photograph by Tony Jones. The author also published an earlier version of this article in the Feb 2006 issue of *Nova Notes*, the newsletter of the RASC Halifax Centre. A selection of photo-graphs and sketches (by others) is posted at:

www.homepage.mac.com/chapmandave/WernerX

How to Find the Werner X

Werner (28.1S, 3.3E, diameter 70 km.) is a near-circular crater with high walls, easily seen on the daylit side of the terminator at First Quarter along with its near-twin Aliancis (30.6S, 5.2E, diameter 79 km.). If one finds this prominent pair (about a third of the way up the terminator from the south limb) and follows the direction they "point" (A to W), one has a very good chance of seeing the X as a dazzling sunlit feature suspended in inky shadow, completely independent of the terminator boundary. (See Fig. 2.) If Werner and Aliancis were 2/3 of a triplet, the X would be the third member! That is where to *find* the X; however, to *observe* the X, timing is critical, as we shall see.

Nomenclature

Regarding nomenclature, the author proposes "Werner X". This name aptly describes the approximate location and appearance of the apparition. It has also been called "The Purbach Cross"—and other casual names—in internet newsgroups. Indeed, two arms of the X are formed by walls of the crater Purbach! The author prefers "Werner X" for the simple reason is that the crater Purbach is almost entirely invisible when the X appears, while Werner is the closest well-lit crater to the X, an obvious beacon to observers. The lack of a standard name is testimony to poor prior awareness of the phenomenon.

In this article, "X" refers strictly to the visual phenomenon described above (fully illuminated X surrounded completely by shadow), not simply to the topography that teams with the Sun to create the X. As the Sun continues to rise, the surrounding shadowed lowlands fill in with light, and the X apparition vanishes. Of course, the

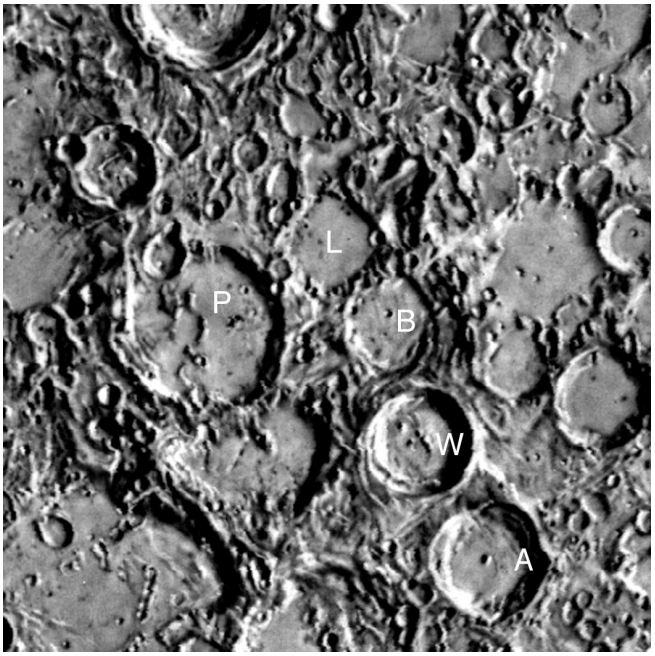

Figure 3: The lunar region centred on the topography that forms the Werner X: Purbach (P), La Caille (L), Blanchinus (B), Werner (W), and Aliancis (A). The area shown is roughly 16 degrees square. Image courtesy of NASA Planetary Data System Imaging Node, U. S. Geological Survey, Flagstaff, AZ)

topography is there, plain to see, and remains visible for the next half month, but the topography alone is not the X. For the mathematically minded, X = topography + illumination.

The Gradual Appearance of the Werner X

The Werner X does not leap out all at once but gradually appears over an interval of 2 hours and 20 minutes as the Sun rises on the spot. Watching this is either excruciatingly slow (if you are in a hurry) or exceedingly quick (if you are attempting to sketch the scene). Remember, the Sun rises about 30 times slower on the Moon! It may be helpful to refer to Fig. 3 (or a good lunar atlas) for what follows. Out of the blackness, the Sun's rays first catch the tallest point: this turns out to be a peak on the SE wall of Purbach. This point lengthens into an arm in the NNE direction towards the common area between Purbach, La Caille, and Blanchinus. Meanwhile, the NE wall of Purbach becomes illuminated and they join to form a corner. Next, the SW wall of Blanchinus catches the light and we see a "T". Finally, the common wall between Blanchinus and La Caille form a NE arm which joins the rest to form the X. There is a little hollow where the three craters join that takes a while to fill in, but it apparently has no designation. All the while, the X arms are surrounded by inky shadow and they are completely detached from the terminator. On the rims of the large craters, there are small craters that interfere with the joining-up process, leading to a fractured appearance. All this can be seen at high magnification; however, for the best "X" effect, lower magnification is best. For about an hour, the appearance of the Werner X peaks, and over the next hour and 10 minutes, the surroundings gradually fill with light, and the effect is lost.

The Significance of the Werner X

Observing the Werner X has a little or no scientific value. It is a curiosity, a trick of the light. The effect is striking, and it is exciting to re-discover. The phenomenon has some educational value, as it compels the observer to think about lunar cycles, daily cycles, selenographic co-ordinates, illumination of lunar features, and the general motion of the Sun-Earth-Moon system. Much of this is somewhat beyond the elementary level. It is a mildly challenging observation, but not difficult to see. Nevertheless, there seems to be continued interest in the phenomenon and there has been a steady stream of observations, images, and enquiries. Reports from first-time X observers are especially gratifying, as they recall the author's original experience.[3] If there is any science in the Werner X, it may lie more in the realm of psychology: for an obscure phenomenon that presumably has been taking place every month for some time, what factors contribute to it suddenly becoming well-known? We will return to this later.

A Summary of Werner X Observations

August 22, 2004: Werner X for the first time

On August 22, 2004, at the Nova East star party at Smiley's Provincial Park near Windsor Nova Scotia, the author trained his TeleVue Ranger 70 mm telescope on the Moon just as dusk was gathering at about 9 p.m. Other amateur astronomers were making their own preparations for an evening under the dark sky, but it was a little too soon for "serious" deep-sky observing. Having a glance at the nearly First Quarter Moon seemed like a good way to start the night. The author focussed his telescope on the terminator and immediately noticed a bright X shape on the dark side of the terminator. Unlike many other astronomical views through a telescope, this observation took no imagination whatsoever, and the surrounding group of astronomers soon joined in the observation. Tony Jones took a picture of the Moon at this time. The discovery of the X was exciting and its appearance was striking. As the phase of the Moon was First Quarter, the Moon was roughly due south at sunset, and proceeded to

[3] It must be said that some experienced lunar observers seem unimpressed by the Werner X. They dismiss it as yet another commonplace geometrical illusion, of which they have seen many, and may no longer feel the thrill that the first-time observer experiences.

set throughout the evening, eventually becoming too low in the sky to comfortably observe.

Previous reports and images of the Werner X

Following the X observation on August 22, 2004, research on the internet and in astronomy books turned up only a little information. An email enquiry to veteran lunar observer and *Sky& Telescope* columnist Chuck Wood elicited the reply "I know what you observed. A couple of people have recently seen this cross, but strangely almost no one mentioned it before. Visit my web site *Lunar Photo of the Day*—www.lpod.org—on Sunday for the answer!" Sure enough, the August 29 *LPOD* turned out to be " X Marks the Spot", a photograph by accomplished lunar observer Carol Lakomiak taken in Wisconsin on June 24, almost exactly 59 days (two lunar months) before the August 22 observation. Word of the X spread, and the author was contacted by Dana Thompson in Hebron, Ohio, who reported seeing an X (in Newark, Ohio) in 1978, but had not seen it (or looked for it) since. Dana recalls that—with the unaided eye—he first saw a point of light on the dark side of the terminator, which turned out to be an X in the telescope. (Dana does not have observing records from that date, but he has correspondence indicating that the event probably took place 324 lunations before the Nova East sighting, on June 12, 1978.) Mike Boschat found a photo of the X in *Dinsmore Alter's Lunar Atlas*, plate 111, page 247. Pat Kelly wondered why the X had not been mentioned before, as observers often concentrate on the terminator, because of the interesting detail to be seen.

Since August 2004, prior photographs of the Werner X—without commentary—have been slowly drifting in, as intrepid internet surfers find more examples. Paul Gray pointed out a nice Werner X on the Moon photo on page 98 of The Nature Company's *Advanced Skywatching*. The author recently found a pretty good Werner X in a Lick Observatory photo of the 7-day Moon, between pages 102 and 103 of the well-known 1962 Dover Publications of Webb's *Celestial Objects for Common Telescopes, Volume One: The Solar System* (revised edition).

A digression on lunar months and solar days

At first thought, one would expect that the Werner X would appear every month, at about the same lunar time just before first quarter. Why would it not be very well known? The answer is primarily a combination of two effects: (1) the peak X effect only lasts about an hour, and (2) the lunar month is not an exact number of 24-hour days. (And then there is the weather!) If one saw the X one evening in a given month, then it would appear again 29 1/2 days later, but the 1/2 day would mean that the First Quarter Moon would have already set at the original observer's location and thus be unobservable from there; however, an observer on the other side of the world would be in a good position to see the X on that occasion.

On the other hand, an interval of 2 lunar months works out to 59 days and 88 minutes. From the first observations, the author reasoned that if the X had been seen 59 days earlier from Eastern North America, then there was a good chance it could be seen again slightly later on the evenings of October 20/21, December 18/19, and perhaps February 15/16. However, at First Quarter, there is only a short interval of time—perhaps 4-5 hours between sunset and moonset—during which the Moon can be observed. The residual 88 minutes means that the Moon would be that much closer to setting at the observer's location each successive time the X appears. Eventually, the X would appear so late in the evening that the Moon would have already set. Because the Moon sets later (in Universal Time) as the observer moves west, this implies that the optimum longitude for seeing the X would gradually move westward by 3 time zones every 4 months. A persistent observer may see the X every other month for several appearances, but then there would be a long hiatus of a year or so during which the X would not be seen. In reality, the motion of the Moon is much more complicated, but it is hoped that this explanation captures the essence.

Spreading the word

A letter by the author featuring the Tony Jones photo appeared in the Nov/Dec 2004 *SkyNews* magazine, alerting observers to the events. The author also posted the relevant information to the RASC national discussion list. The Werner X was discussed in several astronomy newsgroups, but to document these discussions would be a Herculean task! The remaining history is admittedly selective, concentrating on observations by RASC members and a few other personal contacts of the author (listed at the end of the article).

Fall 2004 and Winter 2005

On the night of October 20/21, 2004, it was cloudy in Halifax, but at around 0200 UT Ted Dunphy of Fredericton independently observed the X and took a photograph. Only afterwards did he learn about the author's observation and the *SkyNews* letter. Curt Nason of St. John also saw the X. These sightings were reported in the Autumn 2004 issue of *Horizon*, the newsletter of the RASC Moncton Centre.

On December 18/19, it was again cloudy in Halifax, but Joe Carr and Bill Weir from the RASC Centre in Victoria both observed the X. Note that they observe far to the west of Nova Scotia and New Brunswick.

On February 15/16, 2005, Bill Weir of Victoria made a lengthy and detailed observation of the X: the centre became visible at 0430 UT, and the X was fully illuminated from 0515 UT until at least 0700 UT. These times were well past Moonset in the Maritimes. Bill's observations, and the absence of any observations from the East, confirmed that the optimum longitude for observing the X gradually moves westward from one appearance to the next.

Attempts in July and September 2005

Following the sequence of observations above, there were observations and photos of the X from "down under" in Australia, during odd-numbered months. No details are available. Due to the westward drift of optimum observing longitude, it was only a matter of time before this sequence made its way to North America. On July 12/13, Bill Weir observed the First Quarter Moon in B.C. until midnight, but concluded it was "too soon" for the X. On September 10, the author and others observed in the East, and it was also deemed to be "too soon". These unsuccessful observations are not surprising.

November 8, 2005: the author's second view

On the evening of November 8/9, 2005, the author was able to observe the Werner X at sunset. The Moon was visible earlier, but the poor contrast in daylight made detailed observation of the Moon difficult. Many observers from Eastern Canada supplied reports, drawings, and pictures of the X. These are documented in the RASC Halifax *Nova Notes* newsletter article of February 2006 (available online at halifax.rasc.ca/archive.html), and won't be repeated here. The observation time ranged from 2030 UT to +0215 UT. The X was fully formed at the start of this series of observations, but had "filled in" before 2330 UT. These observations helped define the temporal extent of the phenomenon, but were not definitive, as the commencement was uncertain.

Observations in 2006 and 2007

Since November 2005 there have been two significant observations of the Werner X from North America[4]: March 6/7, 2006 and January 25/26, 2007. The group of observers contributing to the collective has grown, and all the names are included at the end of the article.

On March 6/7, 2006, observers in the East saw the X begin to form from a tiny point of light on the terminator's dark side, but the Moon set before the X fully developed, and they could not see the full expression of the X. In the West, observers missed the very beginning, but saw the full X and

[4] There should have been an opportunity to observe the Werner X on the evening of January 6, 2006, but it was cloudy in Halifax and no other reports were received.

Table I: Circumstances of the Moon at the time of "peak X"

date	time (UT)	selenographic colongitude (degrees)	Sun's elevation at Werner (degrees)	lunar phase (%)
2004-08-23	0130	359.6	1.9	46
2005-02-15	0450	356.3	0.3	52
2005-11-08	2115	358.1	1.7	48
2006-03-07	0520	357.4	0.9	54
2007-01-26	0122	358.4	2.0	51
		358.0 +/- 1.2	*1.4 +/- 0.7*	*50 +/- 3*

the aftermath, when the surroundings fill in with light. Observations spanned the time interval 0345 UT to 0810 UT, representing the coordinated reports of about a dozen observers across the continent. These observations further refined limits on the duration of the phenomenon, which is about 4.5 hours, and on the "peak X" appearance, which is about 1 hour.

With these observations, the team was well-prepared for the 25/26 January 2007 event. The first pin-prick of light was seen at 2130 UT in the East, but it was not too late to see the X itself. By 2305 UT the pinprick had grown to a "T" shape and by about 2345 UT the X was forming nicely. The X was "more or less perfect" by 0120 UT but the scene started to fill in by 0200 UT, according to Central and Western Canadian observers.

Summarizing event timings

It has been a challenge to capture Werner X observations with sufficient precision to aid in prediction. Lunar phase (per cent of disk illuminated) is only a rough indicator, and counting forward from past events in units of synodic month only point to the right day. It has been suggested that selenographic colongitude (i.e. the lunar longitude of the terminator) and/or the elevation of the Sun at the site are appropriate indicators. Indeed, they are better, but there still appears to be some unexplained variation. Table I is a summary of these circumstances for the "peak X" stage of 5 Werner X occurrences, based on the most reliable observations, images, and timings. The selenographic colongitude and Sun elevation were calculated from observed timings using the Excel spreadsheet "Circumstances of the Moon" written by Keith Burnett and available at http://www.bodmas.org/kepler/mooneph.html

Lunar phase is correlated with colongitude, but includes a component due to libration which should not affect illumination of the X. The variation in phase is equivalent to a time uncertainty of +/-15 hours, making it unsuitable as an indicator. Considering the angular variables, the variation in Sun elevation may be due to simple experimental error deriving from the combination of several observers' time estimates of an intrinsically imprecise event. The variation in colongitude is larger, perhaps due to the fact that the Moon's axial tilt is not included in this calculation, where it is for the elevation. For reference, one hour of time is equivalent to about 0.5 degree of colongitude.

Table II shows the statistics of the circumstances for several stages of the entire Werner X event, based on all the reliable observations over 5 instances. It is important to remember that no individual has seen all these stages on a single night! This summary only covers the illumination of the X; it is also essential that the observer can see the Moon when the event takes place.

Predicting the Werner X

Using what we have gathered so far, predicting *when* Werner X events take place is somewhat straightforward, but being able to *see* them is dependent on observer location. For each instance, two questions are posed: (1) when is the X illuminated? and (2) can the observer see the Moon at that date and time? For the purposes of illustration, we use the generic "peak X" values of 358.0 +/- 1.2 for colongitude and 1.4 +/- 0.7 for Sun's elevation at Werner.

Handbook method

Roy Bishop, a former editor of the *RASC Observer's Handbook*—and famous for crying out "It's in the Handbook!" at Halifax Centre meetings—demonstrated in an email how to estimate the date and time of Werner X appearances: In "The Sky Month by Month" section, on the left-hand page for every month, the selenographic colongitude is given for the date 1.0 UT for the month. One can use the fact that the colongitude advances 12.2 degrees per day to estimate the date and time of any event indicated by a colongitude. For January, 2007, we get an estimate of "peak X" of (358.0-53.67)/12.2 +1.0 = 25.94, or January 25 at 2300 UT +/- 2h 20m.

Spreadsheet method

Keith Burnett's Excel spreadsheet, already mentioned, must be used in a manual search mode, but it does not take long. Using the colongitude, the peak X is estimated to occur on January 26, 0040 UT +/- 2h 10m. A similar calculation based on Sun's elevation gives the time January 26, 0005 UT +/- 1h 35m.

Software method

Larry Phillips suggests the freeware program LTVT (Lunar Terminator Visualization Tool) by Jim Mosher and Henrik Bondo: http://inet.uni2.dk/~d120588/henrik/index.html. The program can be set to automatically search for events. Using a Sun elevation of 1.5 degrees at Werner, he finds a peak X time of January 26, 0014 UT.

Ed Kotapish has a home-grown program based on algorithms from Jean Meeus' *Astronomical Algorithms, 2nd Edition*, written in the language QBASIC. He also searches automatically, but prefers to use a range of solar elevations to define an observing window. Before the event, he predicted January 26, 0110 UT +/- 1h 10m.

All these calculations are in general agreement with what was observed on the night of January 25/26, 2007. As always, observers are cautioned to err on the conservative side and be prepared to look earlier than expected, as to not miss the event.

Table II: Statistical Summary of Circumstances of the Moon at Successive Werner X Stages

X stage	selenographic colongitude (degrees)	Sun's elevation at Werner (degrees)	estimated relative time (hours:min)
first pin-prick of light	356.5 +/- 0.1	0.2 +/- 0.1	-2:55
"T" or partial X	357.0 +/- 0.6	0.7 +/- 0.5	-2:00
earliest X	357.7 +/- 0.2	1.2 +/- 0.3	-0:35
peak X	358.0 +/- 1.2	1.4 +/- 0.7	0:00
latest X	358.2 +/- 0.4	1.6 +/- 0.6	0:25
surroundings filled in	358.8 +/- 0.1	2.3 +/- 0.1	1:35

Upcoming opportunities

Table III shows the Werner X events in 2007 as calculated by Larry Phillips with LTVT based on the elevation of the Sun at Werner. Note the variation in selenographic colongitude. It is up to the individual to determine whether the Moon will be visible from the observing location at these times. Roughly speaking, as it is near First Quarter, if the local time of the event is in the evening before midnight, there is a good chance to see it. LTVT actually has a helpful function that computes viewability based on the observer's coordinates. Ed Kotapish uses an interesting technique enabled by some desktop planetarium programs whereby he transports the observer to the Moon at the appropriate time and looks back at the Earth. The X would be seen by any observer located on the portion of the Earth that is visible. This visualization indicates that southern latitudes in North America are favoured.

Why is the Lunar X not better known?

It is evident that alerted observers have no difficulty finding and observing the Lunar X. However, there seems to be no published evidence of X observations previous to recent times. Perhaps it was observed, but because an observer in a given location may have difficulty repeating the observation, it was not reported. For a start, the X does not appear at every lunation if observed from a given location. Also, from a given location, there is a long interval of time during which the illumination of the X and the appearance of the Moon in the observer's sky do not coincide. The combination of the lunar month and the solar day results in a quasi-periodic, almost random, sequence of opportunities. A possible hypothesis is that an irregularly appearing periodic event is less noticeable or less memorable than one which appears on a regular schedule. Another interesting hypothesis is that the almost instantaneous communication between widely-separated observers made possible by the internet has boosted awareness of such phenomena. Perhaps we experienced a tipping point.[5] Have we entered an era of network-enabled astronomy?

Table III: Werner X Appearances in 2007

date	time (UT)	colongitude (degrees)
2007-01-26	00:14	357.8
2007-03-26	05:35	358.7
2007-05-24	06:51	359.2
2007-07-22	04:20	358.9
2007-09-19	01:39	358.1
2007-11-17	02:50	357.6

Contributors

This project would not have been possible without the contributions of Gilles Arsenault (NS), Randy Attwood (ON), Chris Beckett (NS), Roy Bishop (NS), Mike Boschat (NS), Keith Burnett (UK), Paul Campbell (AB), Joe Carr (BC), Simon d'Entremont (NS), Ted Dunphy (NB), Matthew Emmanuele (ON), Paul Evans (NS), Kevin Fetter (ON), Dave Gallant (ON), Mike Gatto (NS), Paul Gray (NB), Paul Heath (NS), Wes Howie (NS), Clarence Hemeon (NS), Roger Hill (ON), Tony Jones (NS), Ken Kingdon (ON), Ed Kotapish (TX), Dave Lane (NS), Carol Lakomiak (WI), Blair MacDonald (NS), Tony MacDonald (ON), Dean McIntyre (AB), Curt Nason (NB), Larry Phillips (SK), Dana Thomson (OH), Tenho Tuomi (SK), Bill Weir (BC), Alan Whitman (BC), and Charles Wood (USA).

Dartmouth, Nova Scotia, 7 February 2007

[5] *Tipping point* is a sociological term that refers to that dramatic moment when something unique becomes common. See Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference* (Little Brown, 2000).