Using Photoshop and Color Management for Printing

It is important to remember that in general, the image on your monitor will never exactly match the output from your printer. This is due to many factors including the way the monitor displays color (with light), and the way the printer delivers color (with inks). The way the image was created (digital camera, scanner, etc.), and the type of output device you are going to use. While you may not get an exact match, you can get very close when everything on your system is tweaked to work together.

Color management allows you to control how your monitor, Photoshop, and printer work together. Because these images will be printed at your desktop, or in our computing sites, you are working in a relatively controlled work environment. So, your chances of getting a closely matched print are very good.

When we talk about color management, we often call to mind expensive devices that are placed on the monitor, measuring colors of input and output, and you can still do that if you want to. But, by making a few simple adjustments in Photoshop, and making a few test pints you can get very good results in just a few.

Color Management System (CMS)
In the early 90's a number of companies (e.g., Apple, Adobe, and Microsoft) got together to try to eliminate this problem. So they created an open, cross-platform scheme for getting consistent colors across these devices, and they encouraged everyone to use them. They are known as the International Color Consortium (ICC). Any device or profile that uses ICC in its name indicates that it meets ICC standards.

At the most basic level, CMS offers a controlled method of rendering color across different devices. It interprets how the input profile (scanner, digital camera) should look on the monitor. Then it interprets how the image you see on the monitor gets sent to the profile of the target output device (printer, film recorder etc.).

There are three parts to this system: device profiles, a device independent color space, and a Color Management Module (CMM).

Device Independent Color Space or Reference Space
The ICC settled on two related device independent colors spaces. For monitors it's called CIE's XYZ (for color measurements), and for printers it is called LAB (for profiles). CIE stands for Commission International de l'Éclairage (CIE), which is an international body charged with setting standards for illumination in the 1930s. These spaces are based on how the human eye interprets color, not how RGB devices or CMYK inks represent color.

LAB uses mathematics to translate the amounts of Light (L), red and green (A), and yellow and blue (B) in the image, and then converts it to a color space large enough to reproduce all the colors the average human eye can see.

Device Profiles
An ICC device profile describes each device's capabilities and limitations. Apple uses the term, ICC profile; Windows use ICM (Image Color Matching) for these profiles. I have seen these profiles best described by Harold Johnson in Mastering Digital Printing as "the device's fingerprint."
It is a Look Up Table (LUT), and when used with the Device Independent Color Space, one profile's values can be accurately mapped to another device profile for accurate color rendering across various devices. 1

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Color Management Module (CMM)
CMMs (also sometimes called Color Engines) are the part of the CMS system that does the actual work of translator. It converts the out-of-gamut colors from the source device to the range of colors that can be produced by the destination device, keeping the color consistent from device to device. They use the device's profiles and Rendering Intents, to map out of gamut color to colors that are reproducible on the next device in the chain.

Because a color monitor can display a larger range (larger gamut) of colors than printer inks can reproduce, you can use the monitor to soft proof the image. You can view a reasonably faithful simulation.

How a true CMS works - from Harold Johnson's Mastering Digital Printing
1. Transforms display RGB values to device-independent values (CIE XYZ) using information from the monitor's ICC device profile.

2. Transforms the intermediary CIE display values to CMYK (or its variations) values using information from the printer's ICC device profile.

3. Evaluates the color gamut of the source and compares it with the destination and maps the colors according to the chosen rendering intent.

Apple, Microsoft, and Adobe have different color architecture, but all rely on CMMs and ICC standard device profiles.
Photoshop can use both ColorSync (Mac) and ICM 2 (Windows) but uses its own color engine for its built-in engine for its CMM.

There are many web sites that will give you detailed information on all of the above. To find them just, search on ICC color profiles, Color Management, CIE XYZ and LAB, rendering intents, etc.

Setting up your work space in Photoshop

Work Space or Color Modes
One problem lies in the fact that there a number of RGB color modes (working space), and there is no set RGB standard for digital devices. What this means is that the RGB mode your device uses is set by the manufacturer of that product. You may have heard of them: sRGB, Adobe RGB, Apple RGB, ColorMatchRGB. (CMYK is also a working space.)

Many input devices are using the more limited color space of sRGB working space. When printing photographic or painterly images, you will almost always want to be in a larger working space to get the largest color range. At this point in time, this working space is Adobe RGB.

About Changing Color Work Space
The first thing you should do, after calibrating your monitor, is to open Photoshop and change the default Color Settings from sRGB to Adobe RGB. By setting Adobe RGB as the default Work Space in the Color Settings preferences, you will be telling Photoshop to open all files in the expanded color space of Adobe RGB.

Once this preference has been set, whenever Photoshop is asked to open a mismatched (non-Adobe RGB), you will be asked what to do with it. In most cases you will want to convert it to Adobe RGB.

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What happens when you change a file's color space
Photoshop's CMM module will make the workspace conversion for you, based on the preference settings you have chosen. This module will look at the image and change the pixel colors using the larger LAB color space. The module works by mapping the original color space to the new one specified in your preference settings, making the color adjustments needed to keep colors consistent among devices.

It is important to remember to covert your image's color space as few times as possible. If you change to a space with a more limited gamut (e.g., RGB to CMYK, or sRGB), you will lose color information forever. You can never get it back.

Here is a reduced glossary of terms from CreativePro's web site
(http://www.creativepro.com:80/story/feature/11132.html)

Color Matching Method - CMM: A software component that adjusts the numerical values that get sent to, or received from, different devices so that the perceived color they produce remains consistent. The "engine" in color management systems.

CMS - Color Management: A set of software technologies that seeks to match color across input, display, and output devices by referencing their color behavior to a known standard by means of device profiles. The signals each device receives are adjusted in such a way that the perceived color remains consistent.

CIE (Commission Internationale de l'Eclairage): The international standards organization responsible for setting standards for color and color measurement. (The French name translates to "International Commission on Illumination.")

CIE XYZ (1931): The first of a series of mathematical models produced by the CIE that describe color in terms of synthetic primaries based on human perception. The primaries are imaginary mathematical constructs that model our eyes' response to different wavelengths of light. Such models allow us to specify perceived color unambiguously, unlike models such as RGB and CMYK, which define amounts of colorants rather than actual colors.

CIELAB (CIE L* a* b*, CIE Lab): A mathematical derivative of CIE XYZ (1931) that describes colors using three synthetic primaries: L* (which indicates Lightness), a* (which indicates red-greenness), and b* (which indicates yellow-blueness).

ICC (International Color Consortium): A group of hardware and software vendors dedicated to developing cross-platform standards for color communication and consistency.

ICC Profile: A standard format developed by the ICC for a data file that describes the color behavior of an input, display, or output device, or a color model, by referencing it to a device-independent color model such as CIE XYZ or CIELAB. Used in almost all current color-management systems.

Workspaces or Color Model: A means of specifying color numerically, usually in terms of varying amounts of primary colors. Examples include RGB, CMYK, and CIELAB.

Profile: A data file that describes the color behavior of a physical device (such as a scanner, monitor, or printer) or that defines the color of an abstract color space (such as Adobe RGB 1998 or ColorMatch RGB) in terms of a device-independent color model (such as CIELAB or CIE XYZ). Used by color-management systems to define and match color.

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Gamut: The range of color a device can produce, or the range of color a color model can represent.

Gamut Compression: The process where a large color gamut (for example, that of transparency film) is reduced to fit the smaller gamut of a print or display process (for example, color printing).

Metamerism: The phenomenon where two color samples appear to match under one light source, and differ under another. Two such samples are called a metameric pair.

Rendering Intent: A method of handling out-of-gamut colors when matching one color space to another. The ICC profile specification specifies four rendering intents: Perceptual, Absolute Colorimetric, Relative Colorimetric, and Saturation.

Perceptual Rendering: One of the four ICC-specified rendering intents used for handling out-of-gamut colors in color matching. Perceptual rendering attempts to compress the gamut of the source space into the gamut of the destination space in such a way that the overall relationships between the colors -- and hence the overall image appearance -- is preserved, even though all the colors may change in the process.

Relative Colorimetric Rendering: One of the four ICC-specified rendering intents used for handling out-of-gamut colors in color matching. Relative Colorimetric rendering first scales the white of the source space to the white of the target space, adjusting all other colors relative to that white. Then it matches the adjusted colors in the source space that are inside the gamut of the target space exactly, and clips out-of-gamut colors to the nearest reproducible hue, sacrificing lightness and saturation.