

Colour Management for Photographers

Introduction

This guide is intended to provide photographers who use Adobe Photoshop with the means to achieve consistent colour between their computer screens, their own prints and prints made by a third party.

The structure of this guide is as follows:

- Provide a simple theoretical basis for understanding why you have to go to the lengths you do to achieve consistent colour
- Explain the need for calibration of monitors and printers
- Explain the menus and settings within Photoshop that influence how colour is managed

Colour and why it's all so hard.

What is colour?

For most of us colour is an everyday experience that we have known all our lives. We learn to name the colours as children and later on at school we learn a few simple facts about light such as "light travels in straight lines", "light is a form of electromagnetic radiation", "light from the sun can be separated into a spectrum in a rainbow or by a prism". What we don't learn at school is just how complicated the subject of colour is.

That's because colour is a subjective experience of human beings brought about by the action of light on the human visual system. The human visual system consists of the eye (itself a complex organ), the optic nerve, and the brain. What every human being experiences is known only to themselves, although it's pretty obvious that we do agree about objects that are red, green or blue. (I am deliberately neglecting people who suffer from one of the forms of colour blindness for the sake of simplicity.) There is no way to know whether what I experience when I look at a green object is the same as you the reader, even though we can agree on the same name. This is what is meant by the statement that colour is a subjective experience.

There are two fundamentally different ways in which we see coloured things: by reflected light or by direct (transmitted light). We see the vast majority of things by reflected light. For example light from the sun hits your clothes and our eyes see what is reflected from them. A few things are seen by transmitted light: that is they are light sources. Neon signs, Cathode Ray Tubes, and LCD screen are examples.

When we view an object by reflected light, the colour that we see is not fixed! That is, an object does not have the property of absolute colour. This seems strange at first, because fire trucks are routinely painted "red" and how can that possibly vary? The variation arises because the colour that we see is dependent on the quality of the light that illuminated the object of interest. Sunlight at daybreak and at sunset has a quite different colour than mid-day sunlight because when the sun is low in the sky, its light is filtered by the earth's atmosphere.

In the same way if we illuminate a fire truck with incandescent light, with light from an LED torch, or look at it under fluorescent tubes, the truck will appear to be a different colour: in fact it WILL be a different colour.

This complexity is made far worse because the human visual system does its level best to compensate for changes in the quality of light. A piece of white paper looks white to us whether we observe it outdoors, indoors, with a torch or under a fluorescent lamp. Human beings are the worst possible judge of an absolute colour! This is all because colour is a subjective experience. However, the moment we put two objects side by side, we can instantly detect whether or not they have the **same** colour. In other words, humans have very good relative or differential judgement about colour.

Now let's think about viewing an image on a computer screen: an LCD monitor for example. In this case the images that we see are formed by transmitted not reflected light. The colour of these images is nevertheless influenced by our surroundings. The colour will be different when viewed during the day or at night with a light on in the workroom; especially if the furnishings of the workroom are strongly coloured. But, we will not notice the difference because the human visual system makes its auto-correcting adjustments in our brains. In addition to the ambient lighting of the surroundings, the very nature of a light emitting screen means that the colours we see are inevitably slightly different from the same image printed and viewed by reflected light.

Nevertheless as human beings we want to view and edit images on screen and then see them the "same colour" when they are printed. It says a great deal for modern technology that we can come very close to achieving this goal. However, to do so means we have to pay meticulous attention to our working environment, the set up of our computer monitors, the set up of our printers, and the viewing conditions under which we make comparisons.

That's why working with colour is so hard!

Colour Management

The solution to the above difficulties is colour management.

Colour management relies on the construction of mathematical models called colour models. In practical terms, a mathematical model ends up by describing any particular colour with a set of numbers. Each member of the set represents a different colour. There is a set of numbers rather than just a single number because colour needs more than one independent parameter to describe it. The simplest colour models are RGB and CMYK. RGB describes colour as a set of three values: Red, Green and Blue. It's routinely used where we are viewing transmitted light as from a computer monitor. CMYK describes colour as a set of four values: Cyan, Magenta, Yellow and Black. It's used in describing reflected colours from a printed page.

On their own, colour models are not definitive: For example what do we mean by red, green and blue light? Colour models are used in conjunction with another concept: that of colour space. A colour space is just a colour model together with a gamut. A gamut is the range of colours that a particular colour space can represent.

The concept of gamut (or limit) is essential to understanding colour. We can find out by experiment the range of colours that human beings can see. (This occupied physiologists and perceptual

psychologists for many years.) Not every human sees the same gamut, so the "human colour gamut" is the average of a large number of subjects (excluding those who suffer from one of the forms of colour blindness). Having specified the colour space of humans, we can turn our attention to other colour spaces. The reason for the existence of other colour spaces is that it turns out to be impossible to reproduce all of the colours that humans can see using real world machines. That is, a computer monitor can show only some of the colours visible to humans; in the same way prints and paintings are restricted from representing the whole range of human colour experiences. We say that each "device" has its own gamut.

As well as that gamuts associated with physical objects and devices, there are several "theoretical gamuts" that define actual colours. The most common of these are called sRGB and adobeRGB. They are subsets of the human gamut, but they are useful because they can be implemented in real world objects and machines: in a sense they represent the limitations of the mechanical world.

The BIG problem is that each of these colour spaces (remember that a colour space is a subset of the human colour space defined by its gamut), uses a set of three numbers called R, G and B to represent a colour **within its own gamut**. Therefore when we switch from the gamut of a monitor to the working space gamut of sRGB, to the gamut of a particular printer/paper combination, the same set of three numbers represents different absolute colours in each working space! This is clearly a recipe for disaster.

Calibration and Profiles

The solution to the colour space problem is calibration and profiling.

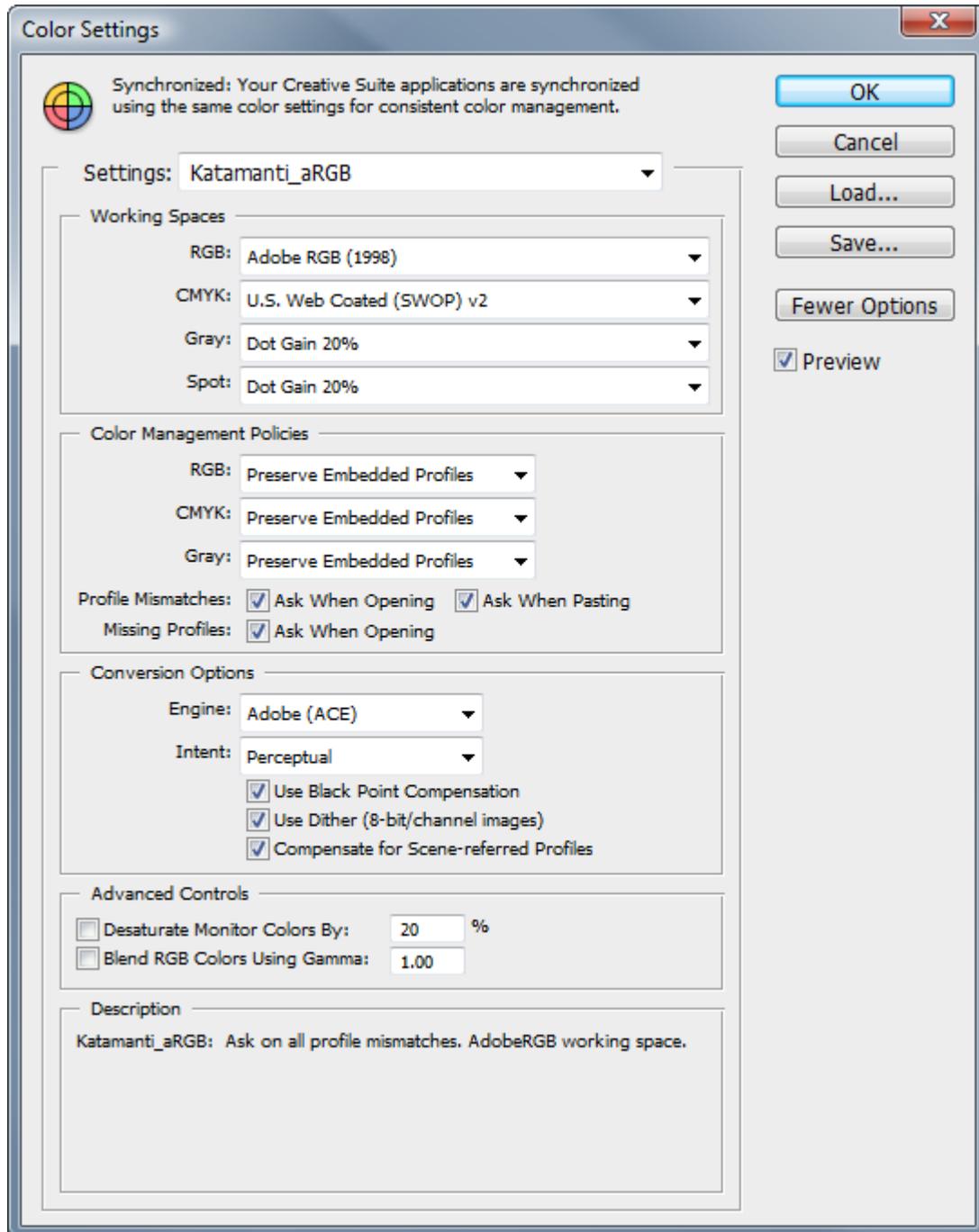
We have to find out what colours each physical device can display. This is the process of calibration. For example, we use an instrument called a colorimeter or (better a spectrophotometer) to measure the colours produced by a monitor when the monitor is instructed to display given RGB values. NB, I really mean RGB values NOT colours. Once we have done that, it's possible to produce a "profile" for the device. A profile is a file containing sets of numbers that describe the performance of the monitor in terms of its calibration data. By the use of a profile, one set of RGB values can be converted to another set of RGB values in a different colour space. Each set of RGB values then specifies the same colour in its own working space.

We can do the same thing with printers and papers. It's called printer profiling and it's very important to understand that you have to do it with each and every printer and paper that you use. In the case of getting a third party to do your printing, the printer may be able to give you a profile so that you can "soft proof" your images on your own monitor.

Now we can understand what happens. Using a calibrated and profiled monitor, adjust your image until you are satisfied with the colours and colour balance. Use the correct paper/printer profile to soft proof the image and make corrections as necessary. Send the corrected image to the printer (your own or your printer's). The resulting print will closely match the image you saw on your screen. The match will NOT be 100%. This is because of the fundamental difference between colours generated by mixing light (your screen), and colours viewed by reflected light (your print).

Setting up Photoshop for consistent colour

Run Photoshop and then choose **Edit/Color Settings** to see the following dialog box.



1. If necessary click on **More Options** to see the above.
2. Under "Working Spaces" choose **Adobe RGB (1998)** (*This is the recommended working space that you should use if you plan to print yourself or plane to use a professional printing service that understand colour spaces. If you plan to use a bureau or a mass market printer, check with them first. If you are in any doubt choose sRGB*) You can leave the three other settings at their defaults.
3. Under "Color Management Policies", set RGB to **Preserve Embedded Profiles**.
4. Under "Color Management Policies", Tick all of the option boxes as shown.

5. Under "Conversion Options", set Engine and Intent as shown and tick all the other boxes.
6. Under "Advanced Controls", accept the defaults as shown.
7. Under "Description" type in a description of the colour settings.
8. Click on the **Save** button and give a name to the settings. Photoshop stores the settings as a file in the default location.

As you gain more experience you may wish to make one or more additional colour settings files for different circumstances. The above settings may feel annoying to newcomers, because it will increase the frequency with which you see warning dialog boxes about absent or mismatched profiles when you open or edit files. However, it's so important that you don't make mistakes in handling colour profiles, that the above settings are strongly recommended.

Now let's look at what each of these settings means:

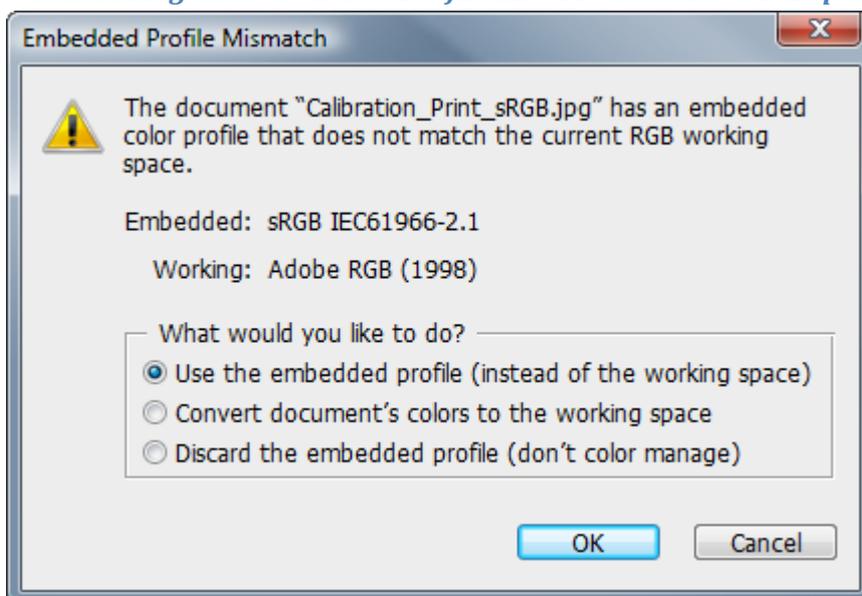
Working Space - Adobe RGB

This setting chooses your working colour space. Adobe RGB is a good choice because it has a relatively wide gamut. That means it can handle, display and possibly print more colours than the only other sensible choice sRGB.

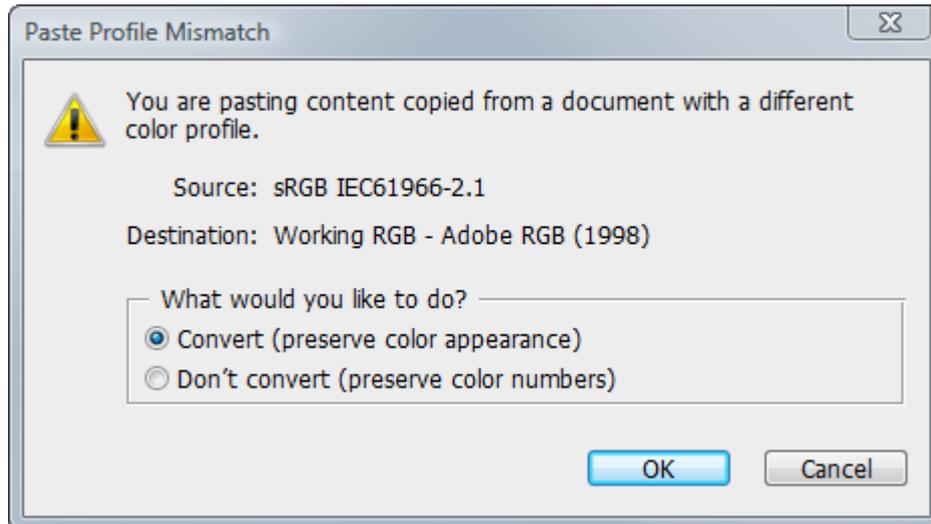
Colour Management Policies - RGB Preserve embedded profiles

This setting keeps whatever profile (if any) that your original file may have. Cameras frequently assign profiles to the images that they provide and if you are working with a JPG image the associated profile is important because it defines the absolute colours that the individual RGB values correspond to. This is not the case for RAW images. By choosing this option together with ticking the check boxes below, Photoshop will warn you of a potential problem and then let you decide what to do.

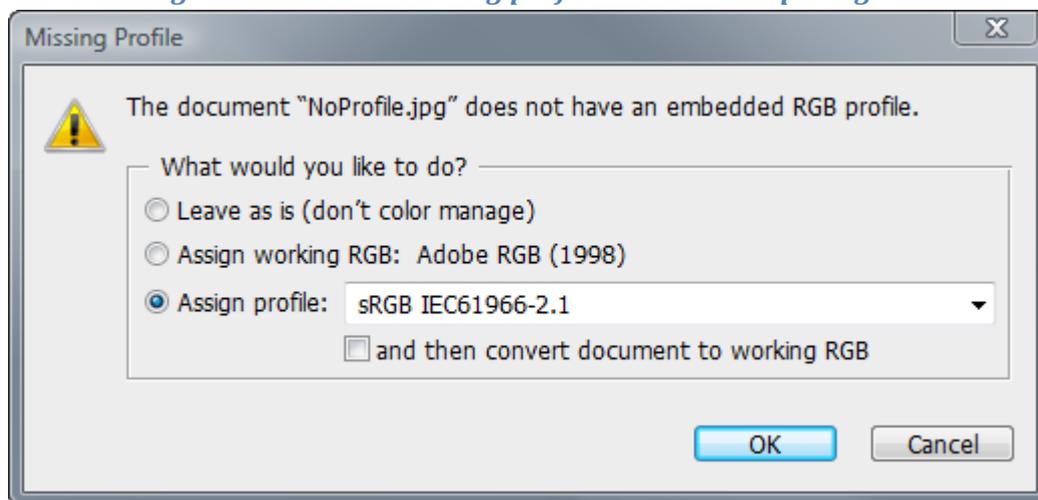
Colour Management Policies - Profile mismatches - ask when opening



Colour Management Policies - Profile mismatches - ask when pasting



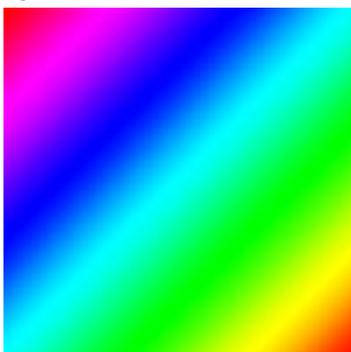
Colour Management Policies - Missing profiles - ask when opening



Does it really matter?

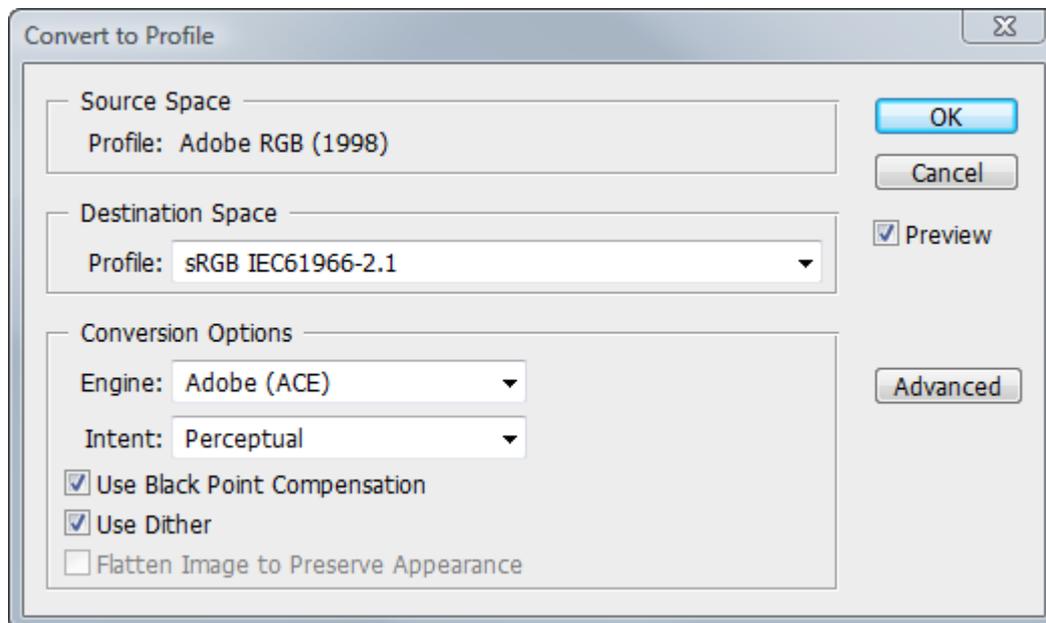
Try out this simple test for yourselves with your own computer.

1. Create a new document using the settings described in " Setting up Photoshop for consistent colour" (ie with and adobe RGB profile) of size 200 x 200 pixels at 72 pixels/inch.
2. Use the gradient tool and the spectrum gradient to draw a gradient from top left to bottom right. It should look like this:

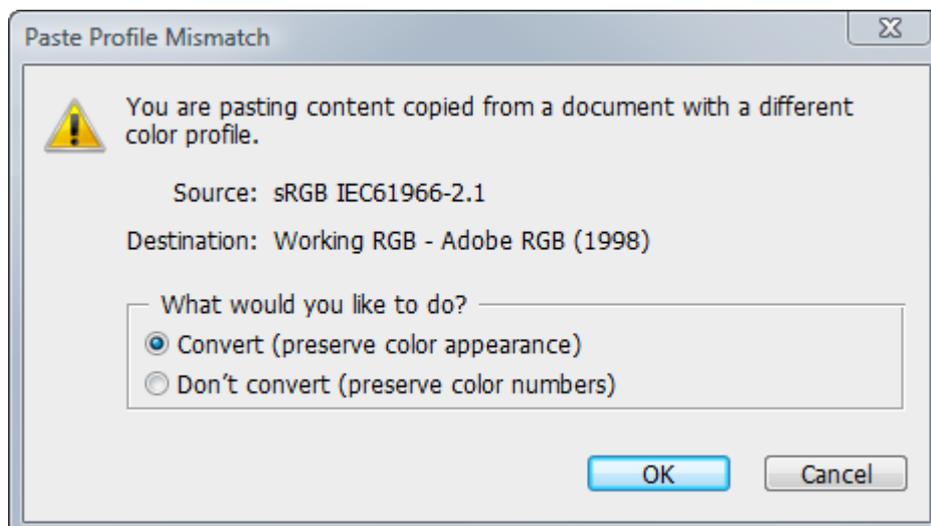


3. Save the file as Test_Colour.psd

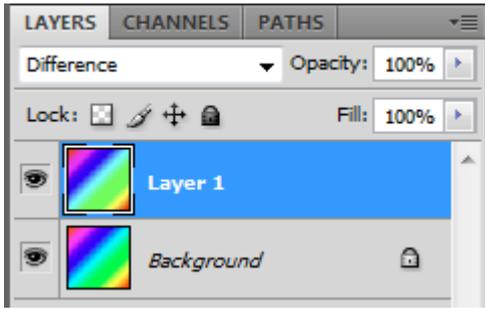
- Now use **Image/Duplicate** to make Test_Colour copy.psd.
- Now use Edit/Convert to Profile. You will see the following dialog box. Under "Destination Space" select sRGB as shown.



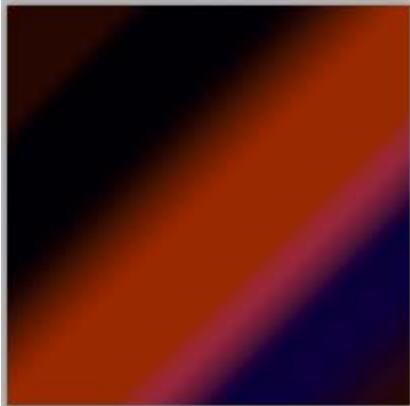
- Alternately select/deselect the Preview box. You can see what a difference changing colour spaces makes to the display. Save the document (Test_Colour copy.psd).
- Still with Test_Colour copy.psd, choose **Select/All** followed by **Edit/Copy**.
- Select the Test_Colour.psd window (it should still be open) and the choose **Edit/Paste**. You see the following dialog box.



- Leave the selection as above and click on OK. The sRGB document is copied into the adobeRGB document.
- If necessary, use **Window/Layers** to display the Layers palette. Use the blending mode pull down to set the blending mode to difference as shown:



11) Look at the image. You should see something like this:



This demonstrates that when working with colour profiles, and especially with documents that have different colour profiles, you really need to exercise extreme care if you want to avoid significant colour issues.

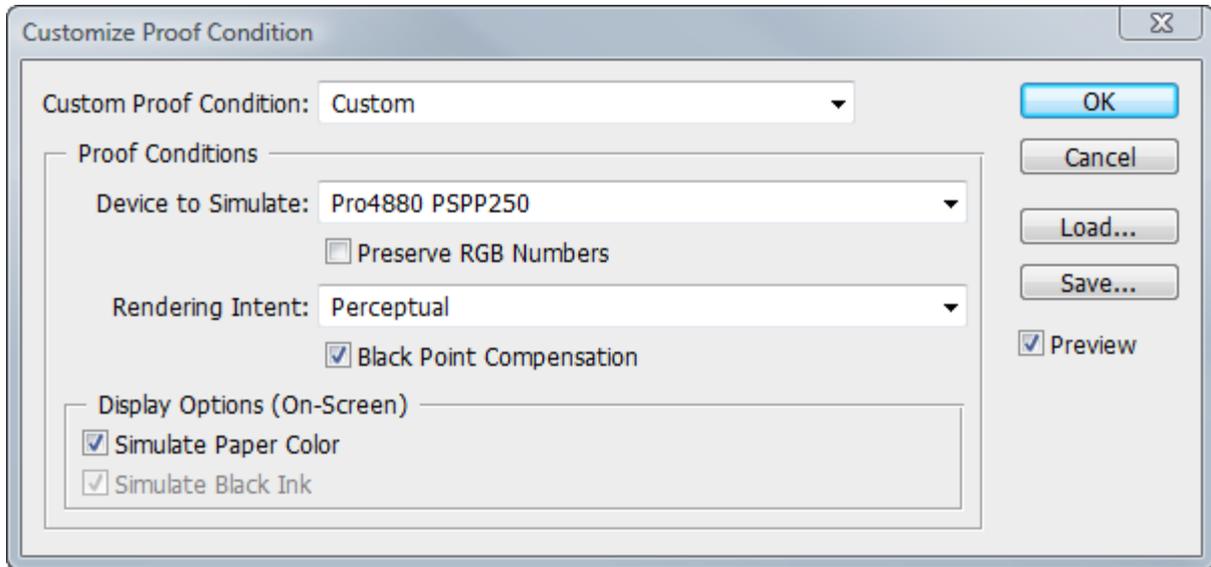
Soft Proofing

Now let's change our emphasis away from problems towards matching what you see on the screen with what you get from your printer. The starting point for this is that you have calibrated and profiled your monitor, and that you have obtained a printer/paper profile for your chosen medium. Printer/Paper profiles are readily available for many combinations from both printer and paper manufacturers as downloads from the web sites. Let's start with the image below:

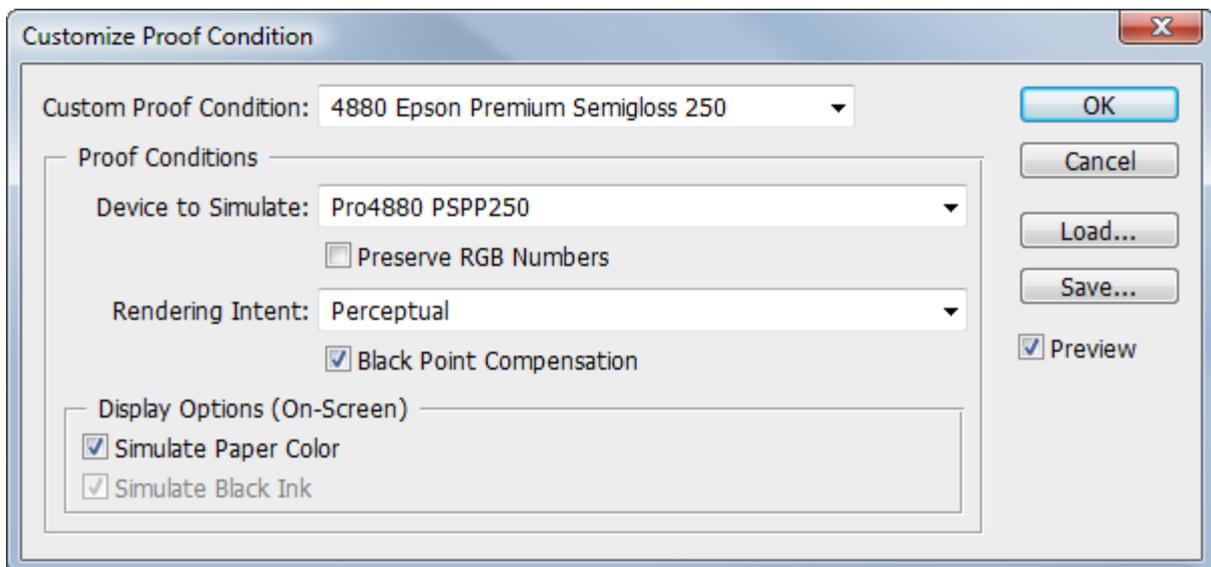


We'll assume that we have worked this image up in and adobeRGB workspace and now we want to print it. The first thing to do is ask the question "What will happen to the colours when they are converted to the colour space of my chosen printer/paper?"

Photoshop lets you do this through the **View/Proof Setup** system. Choose **View/Proof Setup/Custom** to see this dialog box.



Under "Proof Conditions", choose the printer/paper profile that you intend to use: in this case I have chosen a profile for the Epson4880 printer loaded with Ilford Galerie Smooth Pearl Paper. If this is a combination you use frequently, click on the **Save** button and give it a sensible name and save this setup for future use as shown below:



By leaving the Preserve RGB numbers unchecked, you are asking Photoshop to translate the adobeRGB image into the colour space of the printer/paper profile. I recommend that you choose **Simulate Paper Color** from the "Display Options" section. Finally click on **OK** to see a "soft proof" of what your image will look like when printed. NB. I will discuss "Rendering Intent" later.

You can switch between **View/Proof Setup** and normal mode by pressing Ctrl-Y.

You may be quite alarmed at the difference between the two views. This is normal. You have two choices: accept what you see and print, or do something about it. The best way to do something is to add an adjustment layer - typically a Curves adjustment layer. However before you do that you need to be able to see the before and after versions side by side.

Use **Image/Duplicate** to make a duplicate copy, and then **Window/Arrange/Tile** to see both images at once. In the duplicate window, make sure that **View/Proof Setup** is Off. Return to the original window and add a Curves adjustment layer (or whatever you feel is appropriate). Typically adding a bit of mid-range contrast will restore the original image (in its View/Proof Setup mode) to the original appearance visible in the duplicate window.

You are almost ready to print, but first you should check whether or not the print/proof version has any out of gamut colours. Remember that colour spaces have widely different gamuts. To do this choose **View/Gamut Warning** (or press Ctrl-Shift-Y). Any colours that are not available in the printer/paper colour space are highlighted as grey. See below.



Look at the blue tiles at the bottom of the picture - they can't be reproduced by the printer!

What to do about Out Of Gamut (OOG) warnings

1) If appropriate you can go back to the original and make subtle changes to the image using a Hue/Saturation adjustment layer. You can refine what colours you adjust by choosing something other than "Master" in the layer adjustment dialog box for example.

2) You can accept the OOG warning and make a choice about "Rendering Intent" in the Print dialog box.

Rendering Intent

One of the final choices you make in the Print dialog box is rendering intent (RI). There are four choices for RI, but photographers need only worry about two of them. A very brief description follows.

Perceptual Rendering Intent deals with OOG colours by altering all colours in the output colour space so that NONE of them are OOG. The colours are shifted relative to each other so that the final result "looks right" even though it's actually different to what's on the screen. This rendering intent is ideal for photographers because it maintains detail in the OOG regions.

Relative Colorimetric Intent maintains better colour accuracy, but it effectively shifts all OOG colours to the nearest available in gamut colour. This has the effect of losing detail in the OOG regions.

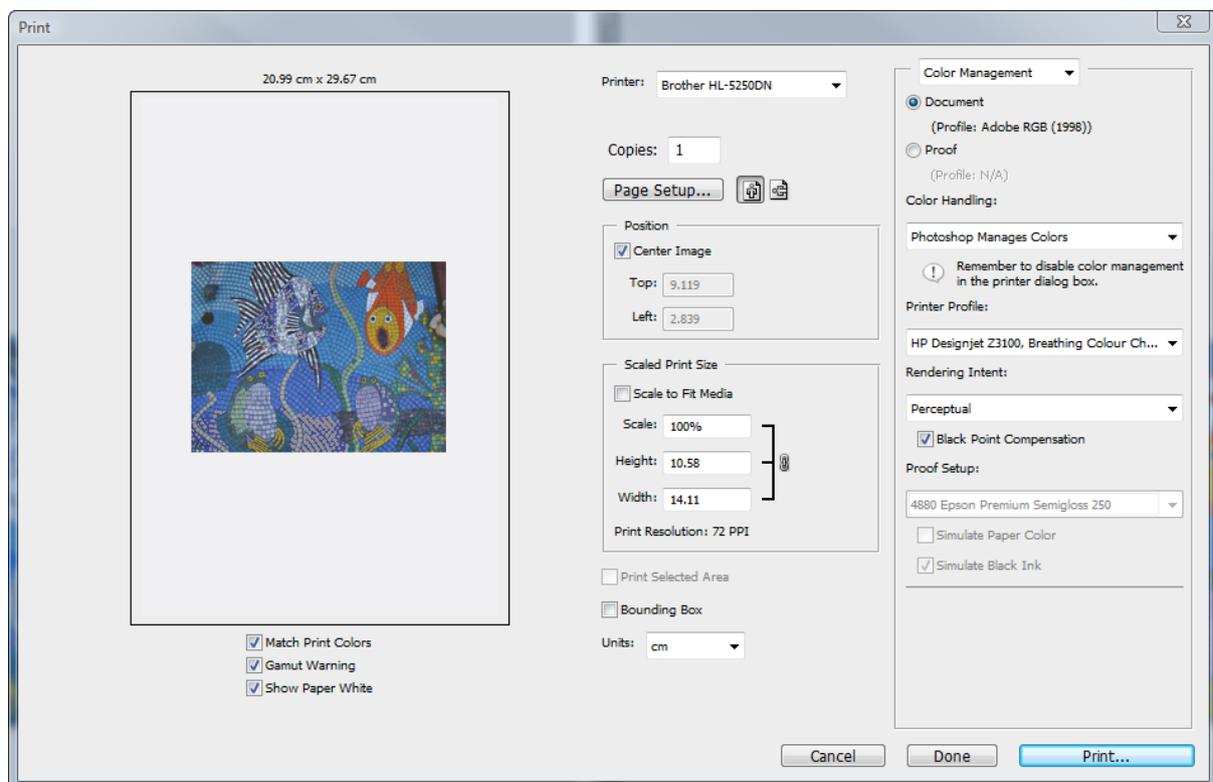
There is no right answer - no best way. You have to make up your own mind!

Finally - printing your image

You've done all the hard work. Now it's time to print. Unfortunately this is one of the most difficult areas. Each version of Photoshop has a slightly different Print dialog box. Worse still, the Photoshop Print dialog box has to work in conjunction with the Printer Driver dialog boxes. These two sets of dialog boxes were made by different manufacturers and there is no common standard. Getting the two to work together may be simple or it may be a nightmare. It all depends on the printer driver.

As a result I can only offer guidelines. There are no recipes!

Here's the **File/Print** dialog box from Photoshop CS4. Starting with Photoshop CS3, Adobe did away with a separate **File/Print Preview** menu item and incorporated it into the Print dialog box. All I can say about this is that sometimes it works! It all depends on the printer driver.



There are several things to notice:

1) The "Printer" shown is your computer's default printer the first time you come to print in a given Photoshop session. Obviously you change it to your desired Photo printer.

2) "Position" - just your own preference.

3) "Scaled Print Size" - Never use this. Make all of your print size decisions inside Photoshop.

4) Color Management - Choose **Document** as shown.

5) Color Handling - Choose **Photoshop Manages Colors**. This is a must unless you are unable to turn off your printer's colour management within its print driver dialog box. If this is the case, all of your hard work has been for nothing. Get another printer!

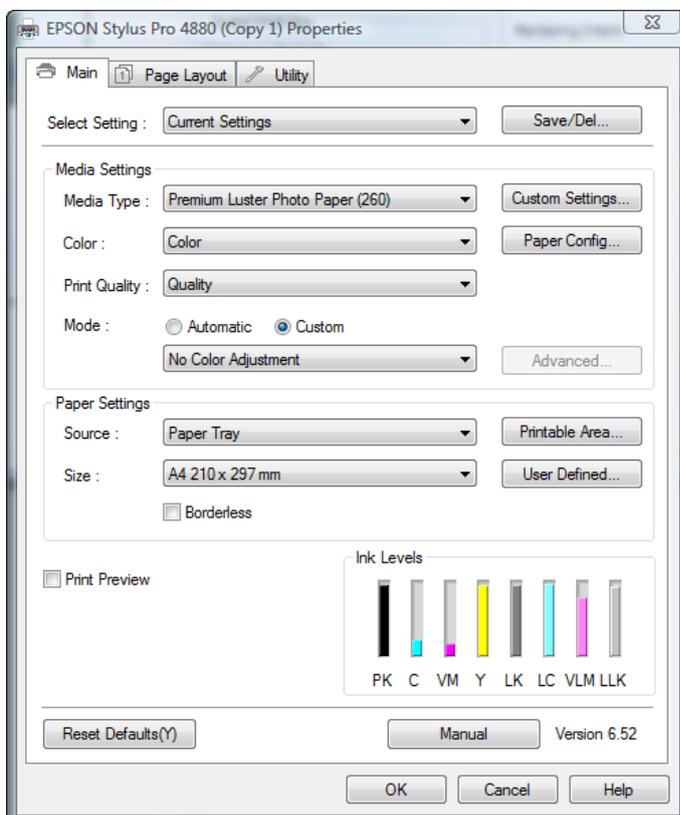
6) Printer Profile - Choose the printer profile that you used for the soft proofing.

7) Rendering Intent. This depends on image content. If you have OOG colours choose **Perceptual**, otherwise choose **Relative Colorimetric**.

8) Black Point Compensation - leave it ticked.

Having chosen your desired printer, turn your attention to the Page Setup button. Notice the two icons next to it. These choose whether you are trying to print a portrait or landscape image. These buttons interact with the Print Driver and *vice versa*. They also influence the Print Preview. You should understand that Photoshop and the Printer Driver sometimes get this right! If you find out that your printer prints the wrong orientation be disappointed, but not surprised.

Finally click on the **Page Setup** button. Your Printer Driver dialog box appears. For example:



No two printer dialog boxes are the same. Not all printers have the same facilities. You will have to go through each Tab in the dialog box and examine all the possible settings to see what you have. What you are looking for are:

1) A way to turn OFF the printer's own colour management. In this example that's the **No Color Adjustment** selection. This is *essential*. This is the setting that allows Photoshop to manage the colours and brings all of your careful colour management into play. Most but not all printers have this capability. If yours doesn't you should change your printer or just accept that you will be unable to use colour management successfully.

2) Choose the Print Quality - a personal preference, but for high quality prints you should select at least 300dpi. (Note that different brands of printers have different native resolutions.) and preferably 600dpi.

3) Match the paper selection to the choices you made in Photoshop.

4) If at all possible turn on Print Preview (this should be ticked in the above dialog box). This is a safety mechanism for the sometimes failure of the printer driver and Photoshop to communicate properly. What will happen is that when you click Print in the Photoshop dialog box, a second Preview screen will appear that is due to the printer driver. This screen seems always to show what will actually happen. Not all printer drivers have this capability.

5) Most everything else is common sense, but do make sure you look at every item. Some printer drivers are so complicated that it may be worth your while to make yourself a "pre-flight Checklist"

Finally click on **OK** to return to Photoshop, and then on **Print** to print your document.

That's it.

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